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Za 46. hrvatski i 6. međunarodni simpozij agronoma prihvaćena su 419 priloga koji će biti prezentirani usmeno ili kao poster, od toga 203 iz Hrvatske i 216 iz inozemstva. Zastupljeni su prilozima iz 27 država: Srbija (58), Iran (22), Bosna i Hercegovina (21), Mađarska (21), Slovenija (18), Rumunjska (14), Makedonija (11), Turska (9), Bugarska (8), Češka (7), Poljska (4), Grčka (4), Libija (4), Austrija (2), Kosovo (1), Pakistan (1), Estonija (1), Albanija (1), Slovačka (1), Njemačka (1), Egipat (1), Velika Britanija (1), Urugvaj (1), Cipar (1), Tajland (1), Rusija (1) i Crna Gora (1).

Teme simpozija vezane su uz sve grane poljoprivrede, a izlaganja će se održati u okviru devet sekcija: 1) Agroekologija i ekološka poljoprivreda, 2) Agroekonomika i agrosociologija, 3) Genetika, oplemenjivanje bilja i sjemenarstvo, 4) Povrčarstvo, ukrasno, aromatično i ljekovito bilje, 5) Ratarstvo, 6) Ribarstvo, lovstvo i pčelarstvo, 7) Stočarstvo, 8) Vinogradarstvo i vinarstvo i 9) Voćarstvo. Radovi iz područja: zaštite bilja, poljoprivredne tehnike i tehnologije te sigurnosti hrane uvršteni su u jednu od postojećih sekcija sukladno temi prispjelog rada. U plenarnim izlaganjima posebna pozornost pridana je ulasku Hrvatske u EU i položaju poljoprivrede u EU, bioenergiji i ruralnom razvoju te značajkama međusobnog utjecaja budućeg kanala Dunav – Sava i poljoprivrede na agroekosustave.

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Zagreb, 25. siječnja 2011.

Prof.dr.sc. Milan Pospišil

Glavni urednik

## A Word from the Editor

Dear Colleagues,

In your hands are another Book of Abstracts and the Proceedings of the Symposium on Agriculture, which I hope you will find useful in your work.

As many as 419 contributions have been accepted for oral or poster presentations at the 46th Croatian and 6th International Symposium on Agriculture, of which 203 from Croatia and 216 from other countries. Papers come from 27 countries: Serbia (58), Iran (22), Bosnia and Herzegovina (21), Hungary (21), Slovenia (18), Romania (14), Macedonia (11), Turkey (9), Bulgaria (8), Czech Republic (7), Poland (4), Greece (4), Libya (4), Austria (2), Kosovo (1), Pakistan (1), Estonia (1), Albania (1), Slovak Republic (1), Germany (1), Egypt (1), United Kingdom (1), Uruguay (1), Cyprus (1), Thailand (1), Russian Federation (1) and Montenegro (1).

Symposium themes cover all branches of agriculture and are divided into nine sections: 1) Agroecology and Ecological Agriculture, 2) Agricultural Economics and Rural Sociology, 3) Genetics, Plant Breeding and Seed Production, 4) Vegetable Growing, Ornamental, Aromatic and Medicinal Plants, 5) Field Crop Production, 6) Fisheries, Game Management and Beekeeping, 7) Animal Husbandry, 8) Viticulture and Enology, and 9) Pomology. Papers dealing with plant protection, agricultural engineering and technology and food safety are included into one of the offered sections in accordance with their topics. Plenary lectures address accession of the Republic of Croatia to the EU, the status of agriculture in the EU, bioenergy, rural development and joint impact of the future Danube-Sava canal and agriculture upon the existing agroecosystems.

Full texts of the submitted communications (239 papers) or their abstracts (180 abstracts) are available in paper form (book) or in electronic form (CD and web <http://sa.agr.hr>). Each paper included in the Proceedings was reviewed by two referees. Abstracts were read by relevant section moderators and slightly revised, without changing the meaning of sentences. Unfortunately, due to the short time for reviewing, text authorization was not possible and I apologize for the errors that might have slipped in.

I hope that the papers will be useful to many agriculturalists and to those engaged in related fields and enable better collaboration of scientists, researchers and professionals from Croatia and abroad, as well as to the producers from Croatia, Europe and the World, in their common sphere of interest – transfer of scientific and professional achievements into agricultural production and practice. I thank all the authors, reviewers, section moderators and colleagues for their help in editing the Proceedings.

Special thanks go to the Ministry of Science, Education and Sports, Ministry of Agriculture, Fisheries and Rural Development and Ministry of Regional Development, Forestry and Water Management of the Republic of Croatia under whose auspices the Symposium is held as well as to the co-organizers for their unselfish collaboration and comprehensive support.

Zagreb, 25 January 2011

Prof. Milan Pospišil, PhD  
Editor-in-Chief





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# Optimistički pogled na ulazak u EU: poljoprivrednicima može biti bolje

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## Sažetak

Neposredno prije očekivanog hrvatskog ulaska u EU, ciljevi i mjere Zajedničke poljoprivredne politike se reformiraju u pravcu intenziviranja tržišnih načela u poljoprivrednom poslovanju, ali i povećanja naknada za očuvanje okoliša i doprinos općim javnim dobrima. Najnovija istraživanja pokazuju kako velik dio hrvatskih poljoprivrednika upravo u nepoljoprivrednim aktivnostima vidi mogućnost za opstanak i napredak. Svjesni komparativnih prednosti hrvatskih ruralnih područja, očekuju da će se u skoroj budućnosti, ulaskom u EU, ostvariti uvjeti za povećanje produktivnosti, bolje funkcioniranje poljoprivrednog tržišta i učinkovitije korištenje državnih potpora namijenjenih poljoprivredi i ruralnom razvoju. Mogućnosti povećanja poljoprivrednog dohotka vide u kvalitetnim prirodnim resursima, ostvarivanju dodane vrijednosti u poljoprivredi i oplemenjivanju poljoprivrede kroz turističke aktivnosti.

Ključne riječi: Hrvatska, Europska unija, poljoprivreda, poljoprivrednici, poljoprivredna politika

## Optimistic view on the entrance to the EU: things could be better for farmers

### Abstract

Close to the expected Croatian membership in the EU, goals and measures of the Common Agricultural Policy are reforming towards further intensifying of market principles in agricultural business, but also increasing compensations for environment services and general public benefits. Recent research shows that great part of vital Croatian farmers sees their opportunities for business survival and growth in non-agricultural activities in rural areas. Aware of their rural comparative advantages, they expect that forthcoming entrance in the EU will result in increased farm competitiveness, better market functioning and more efficient use of support for agriculture and rural development. Possibilities for improvements of agricultural income they find in quality natural resources, producing of value added farm products and tourist activities.

Key words: Croatia, European Union, agriculture, farmers, agricultural policy

### Uvod

Već više od desetljeća hrvatska se poljoprivredna politika postupno prilagođava europskoj, u nastojanju da se što bolje pripremi za uključivanje domaćeg poljoprivrednog sektora u jedinstvena pravila Zajedničke poljoprivredne politike (ZPP) Europske unije. Stoga je u trenutku kada je pridruživanje Uniji izvjesno u najskorijoj budućnosti, a osobito nakon intenziviranja prilagodbe sustava poljoprivredne potpore (gotovo do izjednačavanja s EU modelima) unazad dvije godine - gotovo nemoguće govoriti o velikim formalnim

razlikama između hrvatske i europske poljoprivredne i ruralne politike. Ipak, očito je da primjena europskih modela u Hrvatskoj ne protječe jednostavno i bez problema - svakodnevno se govori o problemima zbog niskog stupnja samodostatnosti domaće proizvodnje, niske konkurentnosti domaće proizvodnje zbog visokih proizvodnih troškova, nekontroliranog uvoza uz istodobnu nemogućnost plasmana domaćih proizvoda; seljaci opetovano prosvjeduju, očekujući veći angažman centralne vlasti u reguliranju cijena, otkupa, uvoza i izvoza, poticaja... često i do mjere koju više nije moguće zadovoljiti zbog ograničenja u okviru međunarodnih sporazuma.

Štoviše, svaka sljedeća reforma Zajedničke poljoprivredne politike izaziva sve više neslaganja i među poljoprivrednicima (farmerima) same Unije. Poljoprivrednici sjevera nemaju ista očekivanja kao poljoprivrednici mediteranskih zemalja, stočari se natječu s ratarima u ostvarivanju prava, sitni poljoprivrednici prigovaraju zbog dominacije velikih gospodarstava, ekološki proizvođači ne slažu se s konvencionalnim proizvođačima, a mladi poljoprivrednici lakše prihvaćaju promjene od starijih (Zahrnt, 2009).

Prve procjene ekonomskih koristi i troškova za hrvatsku poljoprivredu također upozoravaju da članstvo u Uniji neće za naše poljoprivrednike proći bezbolno. Tako studija očekivanih ekonomskih učinaka pridruživanju EU (EIZ, 2007) predviđa da će se hrvatska poljoprivreda morati prilagoditi politici tzv. "rasparenih plaćanja" (što se najnovijim reformama upravo i dogodilo), a novi sustav potpora i njihova niža razina u odnosu na stare članice u prvim godinama članstva mogao bi se odraziti na pad ukupne i dodane vrijednosti domaće poljoprivredne proizvodnje. Ovakvog scenarija se pribojavaju i domaći poljoprivrednici, svjesni da su u nezavidnom položaju u odnosu na svoje europske kolege zbog ekonomski loše strukture poljoprivrede u kojima prevladavaju mala gospodarstva. Znatno dio, osobito manjih gospodarstava, namjerava stoga odustati od poljoprivredne proizvodnje jer smatraju da nisu sposobni natjecati se u novim europskim uvjetima (Mollers i sur., 2008; Franić i sur., 2009).

Rezultati nekih istraživanja šireg socio-demografskog i socio-ekonomskog pristupa pokazuju da problemi postoje, ne samo u poljoprivrednoj proizvodnji, već i u većini segmenata života na hrvatskom selu, od lošeg gospodarskog stanja do slabo razvijene društvene i fizičke infrastrukture (Kovačić i sur., 2007). Pokazalo se da zbog ozbiljnih ekonomskih problema današnjih stanovnika sela, ponajprije visoke nezaposlenosti i općenito lošijih životnih uvjeta u odnosu na grad, više od petine stanovnika ruralnih područja ima namjeru napustiti selo i pronaći bolje životne uvjete u gradovima. S obzirom da su to uglavnom mlađe i obrazovnije osobe, to bi moglo dodatno pogoršati dobnu i obrazovnu strukturu na selu i smanjiti izgleda za osuvremenjivanje poljoprivrede (Žutinić i sur., 2010).

Prema svemu do sada istaknutom, budućnost je neizvjesna i uglavnom ne daje previše uporišta za optimizam hrvatskim poljoprivrednicima. Ipak, u ovom istraživanju polazimo od pretpostavke kako *za razvoj hrvatske poljoprivrede postoji, osim dobre resursne osnove, dobar agrarno-politički okvir usklađen s europskim modelima*. Jednako tako, unatoč općenito očekivanih poteškoća u prilagođavanju domaće poljoprivrede europskoj konkurenciji, *postoji određeni segment poljoprivrednika koji, temeljem svojih socio-ekonomskih obilježja, dosadašnjih proizvodnih rezultata, znanja, stupnja informiranosti i motiviranosti, može profitirati od integracije u zajedničko europsko tržište*. Temelj ovoj pretpostavci je u činjenici da ista istraživanja koja upozoravaju na teškoće za hrvatsku poljoprivredu pri ulasku u EU istodobno ističu kako krupnija i vitalnija gospodarstva u pristupu Uniji vide izazov i pozitivna očekivanja u vidu urednijeg poslovanja, korist od otvaranja tržišta i organiziraniji odnos države prema poljoprivredi (Mollers i sur., 2008; Franić i sur., 2009). Pri tome je kvalitetno upravljanje gospodarstvom, dobra organizacija i usavršavanje proizvođača ono što poljoprivrednike kvalificira za konkurentan nastup na europskom tržištu (Hadelan i Franić, 2006), a komercijalna gospodarstva koja teže ekonomskoj veličini posjeda vide se kao ona koja najviše mogu utjecati na ukupan rast hrvatske poljoprivrede (Radinović i Žutinić, 2007). Osnovu za umjereni optimizam daju i rezultati studije EIZ (2007) po kojima se može zaključiti da se uspješnim korištenjem pretpristupnih fondova i preustrojem poljoprivrednog sektora mogu smanjiti troškovi pristupa Uniji i očekivani pad vrijednosti i dodane vrijednosti poljoprivredne proizvodnje u prvim godinama članstva.

Zbog svega navedenog, cilj ovog rada je ustanoviti postoje li potencijali u hrvatskoj poljoprivredi, ruralnom prostoru i poljoprivrednoj politici na koje se mogu osloniti hrvatski poljoprivrednici zainteresirani za opstanak u uvjetima članstva u EU i pod pravilima ZPP-a. Identificirane mogućnosti koje prepoznaju hrvatski poljoprivrednici mogu donositeljima poljoprivredne politike pomoći u osmišljavanju mehanizama kojima će se maksimalno iskoristiti prednosti koje nudi ZPP, ali istodobno i kreiranju vlastitih razvojnih politika dopuštenih u okviru EU.

## Metode istraživanja

Osim na sekundarnoj analizi dosad objavljenih radova o očekivanjima poljoprivrednika od ulaska u EU, rad se temelji i nalazima empirijskog istraživanja. Namjera anketnog istraživanja bila je ustanoviti kako poljoprivrednici i ostali akteri ruralnom prostoru koji su svojim poslom izravno vezani uz pitanja poljoprivrede doživljavaju i ocjenjuju hrvatsku poljoprivredu, uspješnost dosadašnjih politika i s kakvim nadanjima dočekuju skori ulazak Hrvatske u Europsku uniju. Terensko anketno ispitivanje provedeno je tijekom svibnja 2010. godine na uzorku od 150 ispitanika (80% poljoprivrednika, 20% djelatnika Hrvatskog zavoda za poljoprivrednu savjetodavnu službu i djelatnika regionalnih razvojnih agencija), a ispitivanjem je ravnomjerno obuhvaćen prostor svih hrvatskih županija izuzev Dubrovačko-neretvanske (zbog organizacijskih ograničenja). U ispitivanje je uključena dobna skupina od 25 godina (pretpostavljajući da je riječ o samostalnim osobama s formiranim mišljenjima i stavovima) do 55 godina (pretpostavljajući da u toj dobi ljudi još uvijek planiraju svoje poslovne aktivnosti i zbog toga imaju interes za politike i razvoj u budućih pet do deset godina). Polustrukturirani anketni upitnik imao je, pored općih pitanja o socio-ekonomskim obilježjima ispitanika, 50 pitanja grupiranih u pet cjelina: (1) ocjena stanja ruralne ekonomije, (2) ocjena politika za razvoj poljoprivrede i ruralne ekonomije, (3) ocjena socio-demografskog stanja u mjestu/županiji, (4) ocjena primijenjenih socio-demografskih politika u ruralnom prostoru (mjestu ili županiji) i (5) prijedlozi poboljšanja.

Zahtjevna pitanja u upitniku nisu bila primjerena za stanovnike ruralnog prostora koji nisu informirani o ciljevima i mjerama dosadašnje hrvatske agrarne politike i suvremenim reformama u pravcu prilagodbe europskim standardima. Stoga je uzorak ispitanika iz kategorije poljoprivrednika bio namjerno izabran, temeljem preporuke djelatnika HZPSS-a, a preporučeni ispitanici bili su iz redova ljudi zainteresiranih za ostanak u ruralnim područjima i njihov razvoj. Podaci su obrađeni standardnim statističkim tehnikama kojima su analizirane distribucije frekvencija, postoci i prosječne vrijednosti.

## Okvir poljoprivredne politike u EU i očekivane promjene

Priopćenje komisije s konca 2010. godine o Zajedničkoj poljoprivrednoj politici ususret 2020. godini i dalje ističe jasnu određenost europske agrarne politike kroz dva stupa, uz zadržavanje modela izravnih isplata i potpore ruralnom razvitku (European Commission, 2010b). To znači da su i nadalje osnovni okviri agrarne, odnosno ruralne politike Uredba Vijeća 1698/2005 o podršci ruralnom razvoju iz Europskog fonda za poljoprivredu i ruralni razvoj (Council Regulation, 2005) te Uredba Vijeća 73/2009 o shemama izravne potpore poljoprivrednicima u okviru ZPP-a (Council Regulation, 2009), kojom se ustanovljuju zajednička pravila za programe izravne potpore za poljoprivrednike u okviru ZPP-a.

Politika ruralnog razvitka ima pritom zadaću pratiti i nadopunjavati politike potpore tržišta i dohotka poljoprivrednika u okviru ZPP-a, uzimajući u obzir specifičnu prirodu poljoprivrednih aktivnosti koje rezultiraju iz socijalne strukture poljoprivrede i iz strukturnih i prirodnih dispariteta između različitih ruralnih područja. Mjere kojima se nastoji ispuniti tu zadaću obuhvaćaju modernizaciju poljoprivrednih gospodarstava, povećanje ekonomske vrijednosti šuma, dodavanje vrijednosti poljoprivrednim i šumarskim proizvodima, promicanje razvoja novih proizvoda, procesa i tehnologija u poljoprivrednom, prehrambenom i šumarskom sektoru, ulaganja u ruralnu infrastrukturu, ili obnavljanje poljoprivredne proizvodnje u slučajevima prirodnih nepogoda. Suradnja među poljoprivrednicima, kao i s akterima u prehrambenoj industriji i preradi sirovina se pritom osobito ohrabruje.

Programi ruralnog razvitka bit će sve važnija stavka u financiranju i poljoprivrede i ruralnog prostora u Europi, već i zato što je trend u segmentu izravnih potpora poljoprivrednicima takav da će se još više proširiti nevezanost potpore uz proizvodnju. Uz već poznate zahtjeve koje treba zadovoljiti pri ostvarivanju prava na potpore (poput "unakrsne sukladnosti"), novim se prijedlozima nastoji uspostaviti ravnoteža između instrumenata politike kojima se promiče održiva poljoprivreda i onih kojima se promiče ruralni razvoj. Sustav modulacije se ne bi trebao primjenjivati na poljoprivrednike u novim državama članicama, sve dok se iznosi izravnih plaćanja u tim državama ne izjednače iznosima koje primaju poljoprivrednici u "starim" članicama. Posebnim odredbama omogućit će se državama članicama primjenjivanje specifičnih graničnih vrijednosti koje će odražavati njihov poseban položaj.

Za iduće programsko razdoblje do 2020. godine razmatraju se različite političke opcije u tri osnovna segmenta politike: izravna plaćanja, tržišne mjere i ruralni razvitak. Izravna plaćanja će se, po svemu sudeći, intenzivnije vezati za specifična pitanja zaštite okoliša i vezana javna dobra, kao i uz otežane prirodne uvjete,

uz uvođenje veće jednakosti u njihovoj distribuciji među zemljama članicama. Tržišne mjere će se snažnije oslanjati na instrumente upravljanja rizikom, dok se politikom ruralnog razvoja teži odgovoriti na izazove vezane uz klimatske promjene, vodne resurse, biološku raznolikost i obnovljivu energija te inovacije.

### Mogućnosti za hrvatske poljoprivrednike

U ovako predviđenim okvirima Hrvatska bi trebala pronaći mjesto za svoju poljoprivredu i poljoprivrednike. Postavljamo si pitanje: s obzirom na izvjesne disproporcije u strukturi hrvatske poljoprivrede u odnosu na gospodarski razvijene članice Unije, kako otkloniti ograničenja za rast i razvoj naše poljoprivrede u kontekstu nove europske poljoprivredne politike? Prvi korak u rješavanju tog složenog problema jest ustanoviti osnovne razloge zaostajanja naše poljoprivrede.

Jedan od temeljnih izazova u prilagodbi hrvatske poljoprivrede standardima ZPP-a jest u različitoj razini općenitog gospodarskog razvoja u odnosu na razvijene zapadnoeuropske ekonomija s kojima se uspoređujemo u trenutku prihvaćanja istih ciljeva. Hrvatska poljoprivreda ne pati od viškova proizvodnje; naprotiv, samodostatnost još uvijek nije na zadovoljavajućoj razini i zbog toga europski model izravnih potpora, kao ni načela liberalne trgovine nije jednostavno prihvatiti u nas. Nadalje, različite povijesne okolnosti rezultirale su time da poljoprivrednici ne predstavljaju jednaku društvenu skupinu u razvijenim zapadnoeuropskim zemljama (gdje poljoprivredno pučanstvo čini 2-3% u ukupnom a sektor više od pola stoljeća funkcionira na industrijskim i tržišnim načelima) i u Hrvatskoj<sup>1</sup>, gdje je još i danas poljoprivrednicima nejasno što se od njih i pod kojim uvjetima očekuje. Hrvatski poljoprivrednici uglavnom ne raspolažu s poduzetničkim vještinama, ekonomskim znanjima i voljom za suradnjom, udruživanjem i pokretanjem inicijativa na lokalnoj razini nužnih za uspješno korištenje modela potpore ruralnom razvitku. Ukoliko se agrarnopolitičke mjere usmjere na rješavanje ovakvih ograničenja, hrvatskim poljoprivrednicima otvaraju se nove mogućnosti u okviru ZPP-a.

Sudeći po rezultatima javne rasprave (European Commission, 2010a) te mogućnosti su na tragu djelomičnog povratka na sustave kompenzacija koji bi bili vezani uz proizvodnju, ali uz uvažavanje multifunkcionalne uloge poljoprivrede i ostvarivanje javnih dobara, poput usluga u zaštiti okoliša. "Industrijalizirana" poljoprivreda više neće biti prioritet ZPP-a, a podrška će se vjerojatno usmjeravati prema primateljima koji je više trebaju - područjima otežanih proizvodnih mogućnosti, planinskih područja, ekološkim proizvođačima, proizvođačim grupama, lokalnim strategijama i programima školovanja i usavršavanja.

### Rezultati ankete: Zašto hrvatskim poljoprivrednicima može biti bolje?

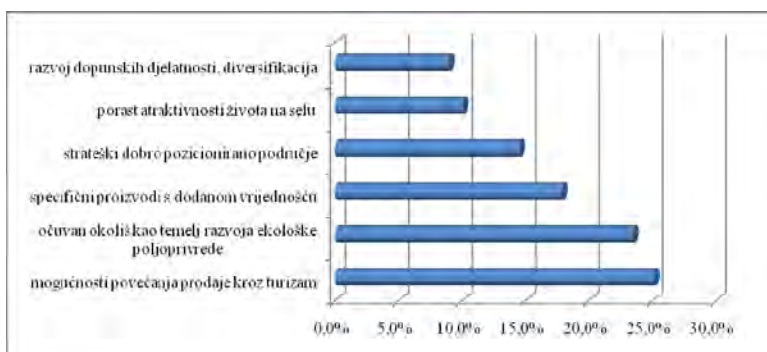
Koliko su hrvatski poljoprivrednici i ostali akteri u ruralnom prostoru svjesni svojih mogućnosti i prilika na koje će se moći računati u okviru ZPP-a, ispitali smo izravno na terenu diljem Hrvatske. S obzirom na to da namjera pri izboru uzorka nije bila dati sliku prosječnog poljoprivrednika i/ili žitelja u ruralnom prostoru Hrvatske, prosječna dob ispitanika bila je znatno niža od prosječne dobi u ruralnim područjima - tek nešto više od 40 godina, a bili su i obrazovaniji: 44,1% ima završenu srednju školu, 42,6% završenu višu školu, 11,8% završen fakultet, a tek 1,5% ispitanika završenu samo osnovnu školu. Kroz pet poglavlja ispitanici su ocjenjivali sadašnje stanje u poljoprivredi i izgled za razvoj ruralne ekonomije (s naglaskom na poljoprivredu) u uvjetima pristupa EU, a prema svojim spoznajama ocjenjivali su i učinkovitost postojećih i potencijalnih politika poljoprivrednog i ruralnog razvoja. U ovom radu izdvajamo nekoliko osnovnih nalaza koji će potkrijepiti pretpostavke istraživanja.

Ispitanici su sadašnje stanje u poljoprivredi i ruralnoj ekonomiji ocijenili s razmjerno niskom ocjenom 2,09<sup>2</sup> iako uglavnom dobro uočavaju komparativne prednosti svoje regije. Odabir odgovora potvrđuje i službeni stav politike kojim se poljoprivreda treba oplemeniti kroz razne oblike turizma i proizvodnju specifičnih proizvoda veće dodane vrijednosti (ekološke, tradicionalne i sl.) za što osnovicu pruža očuvan okoliš (grafikon 1).

<sup>1</sup> s 5,5% poljoprivrednog pučanstva po posljednjem Popisu stanovništva iz 2001. godine, ali još uvijek visokim udjelom zaposlenih u ovoj primarnoj djelatnosti.

<sup>2</sup> Pri čemu je ocjena 1 predstavljala loše, a 5 odlično stanje.

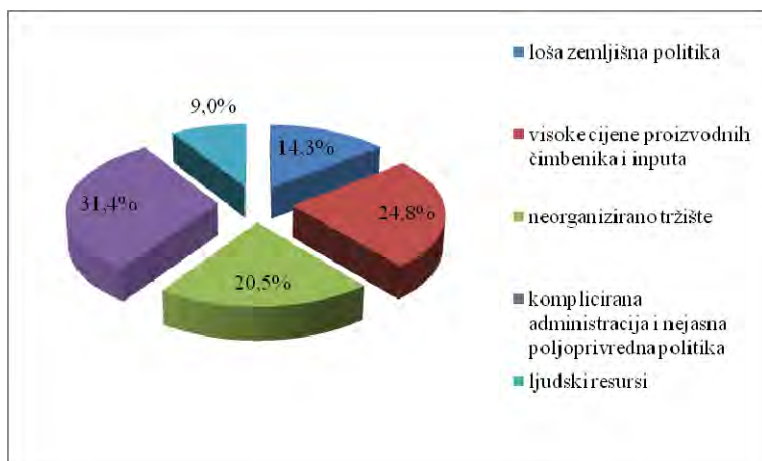
## Optimistički pogled na ulazak u EU: poljoprivrednicima može biti bolje



**Grafikon 1:**  
Najčešće isticane komparativne prednosti ruralnog prostora Hrvatske

Izvor: Anketa

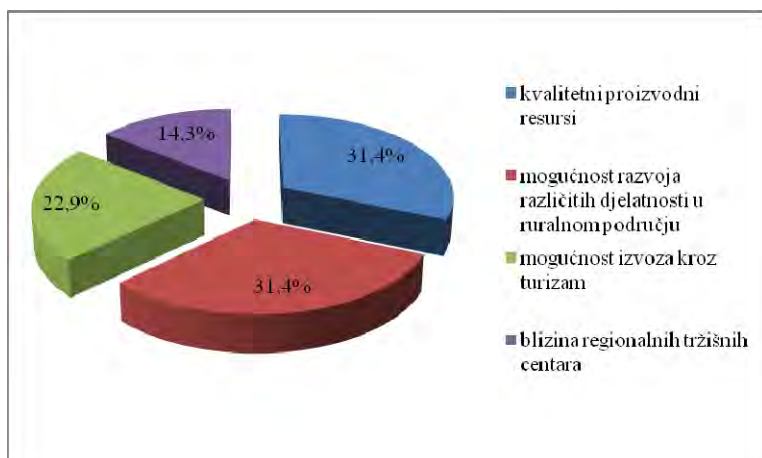
U interpretaciji loše ocjene za poljoprivredni sektor, ispitanici najčešće ističu probleme na tržištu poljoprivrednih proizvoda (nesređeno i nestabilno tržište, nekontroliran uvoz - problemi za čije postojanje krivca pronalaze u državnoj politici - grafikon 2). Tek manji broj ispitanika vidi da su problemi u samim poljoprivrednicima koji nisu dovoljno upoznati s načelima uspješnog poslovanja.



**Grafikon 2:**  
Razlozi lošeg stanja u poljoprivredi prema mišljenju ispitanika

Izvor: Anketa

Iako su ispitanici svoj osobni standard procijenili čak i blago iznad prosjeka (prosječna ocjena bila je 3,3), tek je manji dio pronašao razloge dobrog stanja u poljoprivredi i ruralnom prostoru. Prema njihovom mišljenju, glavni razlozi za uspješno bavljenje poljoprivredom i život u seoskim sredinama su kvalitetni prirodni resursi i mogućnost razvoja različitih djelatnosti u ruralnom području, potom mogućnost izvoza kroz turizam ili prodaje zbog blizine većih regionalnih tržišnih centara (grafikon 3).

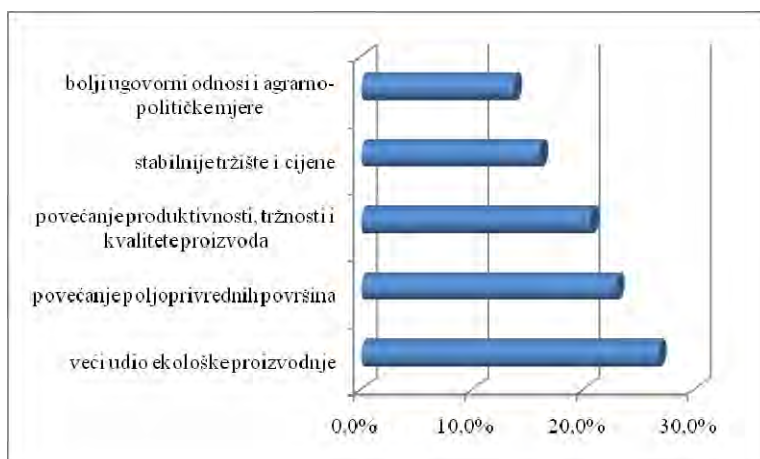


**Grafikon 3:**  
Razlozi dobrog stanja u poljoprivredi prema mišljenju ispitanika

Izvor: Anketa

Ubrzane pripreme za ulazak u Uniju razlog su zašto nas je zanimalo očekuju li poljoprivrednici i drugi akteri u ruralnom prostoru promjene u poljoprivredi i u selima s ulaskom Hrvatske u EU. Većina ispitanika - njih

76,5% - odgovorilo je da, naravno, očekuje promjene i to pozitivne (grafikon 4). Nadaju se da će se u uvjetima Unije bolje urediti tržište i uvesti veća kontrola uvoza, međutim, velik dio ispitanika očekuje da će, pod pritiskom konkurencije s europskog tržišta, nestati mali proizvođači.



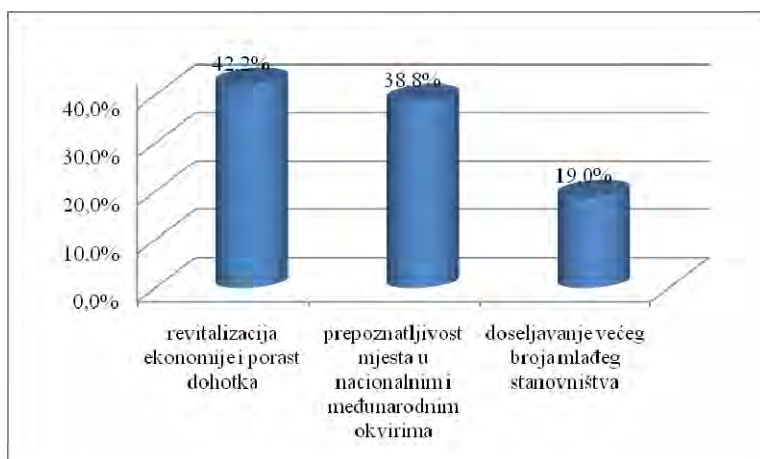
**Grafikon 4: Najčešće očekivane promjene u poljoprivredi Hrvatske u idućih pet godina**

Izvor: Anketa

Očekivanja konkretnih promjena u strukturi poljoprivredne proizvodnje pod utjecajem postojećih politika i pridruživanja EU potvrđuju i rezultate nekih prijašnjih istraživanja: najviše ispitanika, njih 69% opet očekuje bolje funkcioniranje tržišta i poštivanje ugovornih odnosa, više od polovice očekuje smanjenje broja poljoprivrednika u Hrvatskoj, uglavnom praćeno povećanjem površina po poljoprivredniku. Jedna četvrtina uočava mogućnost da će se ugasiti neke poljoprivredne proizvodnje, a jednako toliko - kao protuteža tom pesimizmu - vjeruje da će se prinosi povećati i proširiti asortiman prerade vina, pa tako i dohodak poljoprivrednika. Gotovo tri četvrtine ispitanih smatra da je preusmjeravanje većih površina na eko-proizvodnju prilika za bolje pozicioniranje Hrvatske na tržištu EU, pri čemu predlažu/očekuju intenzivniju edukaciju zainteresiranih proizvođača o samim načelima eko-proizvodnje, kao i podizanje opće svijesti o prednostima ekoloških proizvoda.

Najpopularniju agrarno-političku mjeru u nas - izravne proizvodne poticaje - ispitanici u jednakom broju ocjenjuju kao pozitivnu i negativnu. Svjesni da im ova mjera nadoknađuje dio proizvodnih troškova i održava proizvodnju, prigovaraju nedostatku kontrole ovih isplata koje su se davale bez jasnih kriterija i onima koji ih nisu opravdavali svojom proizvodnjom. Za sada je nemoguće ocijeniti kakve će rezultate polučiti novi model jedinstvenog plaćanja po gospodarstvu, međutim, kritički osvrt ispitanika koji ozbiljno shvaćaju svoj rad i poljoprivrednu proizvodnju, daje nam razloga vjerovati da će, unatoč bolnim rezovima u sustavu, korisnici izravnih plaćanja biti zadovoljniji, jer će i potpore biti usmjerenije na ono za što trebaju služiti - kao naknada poljoprivrednom dohotku.

Na kraju, ispitanici su bili upitani da istaknu željeni cilj za mjesto ili županiju u kojoj žive. Očekivano, ispitanici u svim županijama na prvo mjesto stavljaju revitalizaciju ekonomije i porast dohotka, čime bi se ostvarili i drugi ciljevi - prepoznatljivost mjesta/regije i doseljavanje većeg broja mlađeg stanovništva, za što više od 25% ispitanika optimistično vjeruje da će se i dogoditi tijekom idućih pet godina (grafikon 5). Pomoć u ostvarivanju ovih ciljeva (odnosno želja) vide ponajprije u suradnji s lokalnom samoupravom (80% ispitanika), njih 60% smatra da bi najodgovornije trebalo biti resorno ministarstvo, a tek 54% ispitanika misli da bi poljoprivrednici sami trebali biti glavni nositelji razvoja. Neznatan broj ispitanih ističe da je potrebna suradnja svih dionika u ruralnom prostoru kako bi se znatnije iskoristile prednosti ruralnih programa na koje možemo računati kao buduća članica Unije.



Grafikon 5: Najčešće isticani željeni ciljevi za ruralni prostor u idućih pet godina

Izvor: Anketa

### Zaključak

Zajednička poljoprivredna politika EU, složeni administrativni sustav u stalnoj mijeni, veliki je izazov za hrvatsku poljoprivredu, poljoprivrednike i političare. U razdoblju neposredno prije očekivanog hrvatskog ulaska u EU, ciljevi, mjere i primijenjeni instrumenti europske agrarne politike ponovo se preispituju. Ono što se može sa sigurnošću očekivati jest da se poljoprivredni sektori zemalja članica i nadalje moraju prilagođavati tržišnim zakonitostima, a manje oslanjati na državnu pomoć i intervencije. Međutim, sve su intenzivnije rasprave na tragu intenziviranja nadoknada članicama zbog poštivanja strogih okolišnih sigurnosnih standarda u okviru zakonodavstva Natura 2000 i područjima s ekološkom proizvodnjom, kao i svim ostalim oblicima poljoprivrednih i nadopunjujućih aktivnosti koje pridonose javnim dobrima (Zahrnt, 2009).

Prema rezultatima prijašnjih istraživanja (Mollers i sur., 2008, Franić i sur., 2009.), kao i najnovijeg terenskog istraživanja provedenog sredinom 2010. godine, upravo će nepoljoprivredni sektor u ruralnim područjima odigrati ključnu ulogu u razvoju hrvatskih ruralnih krajeva. Velik dio poljoprivrednika upravo u nepoljoprivrednim aktivnostima vidi mogućnost za opstanak i napredak. Svjesni komparativnih prednosti hrvatskih ruralnih područja, očekuju da će se u skoroj budućnosti, ulaskom u EU, ostvariti uvjeti za povećanje produktivnosti, bolje funkcioniranje poljoprivrednog tržišta i učinkovitije korištenje državnih potpora namijenjenih poljoprivredi i ruralnom razvoju. Mogućnosti oplemenjivanja poljoprivrednog dohotka vide u kvalitetnim prirodnim resursima, očuvanom okolišu kao osnovici za jačanje ekološke proizvodnje i ostvarivanje dodane vrijednosti u poljoprivredi te oplemenjivanju poljoprivrede kroz turističke aktivnosti.

Ozbiljni poljoprivredni proizvođači koji svoju budućnost vide u poljoprivrednoj djelatnosti misle da su problemi u zemljišnoj politici najveće ograničenje u prilagodbi politike i cijelog sektora europskim standardima. Općenito, nadaju se transparentnijoj i kontroliranijoj državnoj politici spram poljoprivrede (svjesni da se uvjeti za ostvarivanje državne pomoći zaoštravaju), urednijim poslovnim odnosima i organiziranim tržištu. Ispunjavanje ovih preduvjeta osiguralo bi i ispunjavanje željenih ciljeva za poljoprivredu i selo: revitalizaciju ruralne ekonomije i porast dohotka poljoprivrednika i svih drugih aktera u ruralnom prostoru. Time bi se olakšalo i postizanje željene prepoznatljivosti regija u širem nacionalnom kontekstu, ali i hrvatskog ruralnog prostora u europskim okvirima, a moguće bi bilo očekivati i zadržavanje mladih, perspektivnih ljudi u ruralnim sredinama.

Osim što se očekuje odlučniji angažman državne i lokalne vlasti u rješavanju ovih pitanja, donositeljima agrarno-političkih mjera preostaje da se odluče između dvije opcije: hoće li uravnoteženim potporama prema svim poljoprivrednim proizvođačima i dionicima u ruralnom prostoru laganim tempom podizati opću razinu standarda ili će poticati vitalne, ekonomski uspješne poljoprivrednike koji će odigrati ulogu "lokomotive", vratiti i/ili čak umnožiti uloženo, stvarajući tako raspoloživi fond za pomoć slojevima koji nemaju jednake mogućnosti.

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# Poljoprivredna politika u EU nakon pet godina članstva: iskustvo Poljske

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## Sažetak

Cilj rada bio je prikazati iskustvo poljske poljoprivredne politike, radi lakšeg uočavanja smjera kretanja hrvatske poljoprivrede i ruralnog razvoja nakon ulaska u EU. Analizom sekundarnih izvora i deskriptivnom analizom utvrđeno je da Poljska bilježi pozitivne gospodarske rezultate sustavnim provođenjem reformi. Poljoprivreda je jedan od sektora koji se najviše okoristio članstvom u EU u smislu povećanih potpora, a time i dohodaka uz podizanje kvalitete života u ruralnim područjima. Hrvatska kroz iskustvo Poljske može naučiti o korištenju EU fondova i predvidjeti tijek pregovora, te zauzeti odgovarajuće stajalište, uz prethodno poznavanje raspoloživosti resursa i proizvodnih prioriteta.

Ključne riječi: EU, Hrvatska, poljsko iskustvo, poljoprivredna politika

## Agricultural Policy in EU after five years of membership: experience of Poland

### Abstract

The aim of this paper was to represent experience of Poland, for easier direction spotting of agricultural policy and rural development after EU entrance. Using analyses of secondary sources and descriptive analyse it is assessed that Poland shows positive economic results due to systematically implemented reforms. Agriculture is one of the sectors which benefited the most from EU membership in sense of increased subventions and agricultural incomes, as well as rural areas in sense of life quality improvements. Through experience of Poland Croatia can learn about using EU funds, predict the course of negotiations and take adequate position after defining the availability of resources and priorities of production.

Key words: Agricultural policy, Experience of Poland, EU, Croatia

### Uvod

Približavanjem Hrvatske članstvu u Europskoj uniji, u području poljoprivrednog sektora sve je više novina, promjena, ali i nepoznanica koje kod poljoprivrednika najčešće izazivaju bojazan. Prema analizama javnog mišljenja (Kucia, 1999) u sličnoj situaciji su se nalazile i zemlje kandidatkinje u razdoblju 1990.-2004. godine, tj. stanje u poljoprivredi i nužne promjene u gospodarstvu izazivale su reakcije poljoprivrednika kao što je to slučaj danas u Hrvatskoj (protivljenje promjenama u sustavu poticaja, subjektivna predviđanja uništenja "malih" OPG-a, kupovanja domaćeg zemljišta od stranih državljana i sl.).

S obzirom da je od proširenja EU s 10 novih zemalja 2004. godine, prošlo šest punih godina, u literaturi se već mogu pronaći analize petogodišnjih iskustava novih zemalja članica. Među novim članicama osobito se

ističe Poljska kao primjer zemlje koja se iz strogo zatvorenog i kontroliranog gospodarskog sustava uspjela preobraziti u članicu, koja je izvukla koristi od članstva u EU, osobito iskorištenjem dostupnih EU fondova. Isto tako, pozitivna vanjskotrgovinska bilanca poljoprivredno-prehrambenim proizvodima upućuje na prilagodbu Poljske uvjetima otvorenog tržišta, a općeniti ekonomski rast (stopa rasta) pokazuje da je barem zasad izbjegnula recesiju od koje pati većina europskih zemalja.

Stoga je cilj ovog rada prikazati iskustvo poljoprivrede i ruralnog razvoja Poljske, kao zemlje članice koja je povijesno i gospodarski slična Hrvatskoj, a iz čijeg se iskustva može lakše predvidjeti u kojem će smjeru krenuti razvoj hrvatske poljoprivrede i ruralnih područja nakon ulaska u EU.

Također, u radu će se ustanoviti tijek procesa pristupanja Poljske Europskoj uniji, proučiti kakve su se sve reforme morale provesti u poljskoj poljoprivredi i ruralnim područjima i zaključiti s promjenama koje su se dogodile nakon njezina ulaska.

### Materijal i metode

Osnovne metode korištene u ovom radu su analiza sadržaja sekundarnih izvora, odnosno dostupne literature i dokumenata o poljskoj poljoprivredi, prije i nakon ulaska u EU, te deskriptivna analiza statističkih podataka.

Najvažniji izvori podataka su statističke baze EUROSTAT i izvješća Ministarstva poljoprivrede i ruralnog razvoja Poljske (MINROL) te rezultati analize podataka i pripadajuća izvješća o poljoprivredi i poljoprivrednoj politici na projektu EU - FP7: *Enlargement Network for Agripolicy Analysis (AgriPolicy)*. Cilj projekta je bio uspostava mreže stručnjaka u analizama poljoprivrednih politika i ruralnog razvoja u 12 novih zemalja članica i 8 zemalja kandidata i potencijalnih kandidata.

Iako naslov rada upućuje na poljoprivrednu politiku, potrebno je istaknuti da se radi o proširenoj poljoprivrednoj politici koja uključuje i mjere za ruralna područja sukladno praksi u EU, gdje Zajednička poljoprivredna politika (ZPP) nije proširila naziv, ali uključuje niz okolišnih i mjera za ruralni razvoj.

Zaključci za Hrvatsku dodatno su upotpunjeni rezultatima obrade anketa u sklopu projekta *National Rural Development* koji Zavod za ekonomiku poljoprivrede i agrarnu sociologiju (ZEPAS) radi u suradnji s *United Nations Development Programme (UNDP)*. Cilj anketnog istraživanja bio je ustanoviti stvarno stanje među akterima u ruralnom prostoru, uočiti kako doživljavaju i ocjenjuju uspješnost dosadašnjih politika spram poljoprivrede i sela, koliko su spremni i s kakvim nadanjima dočekuju vjerojatni ulazak Hrvatske u Europsku uniju.

### Makroekonomska obilježja Poljske

Nakon pada komunističkog sustava Poljska je počela primjenjivati pretvorbeni program 1989. godine, tzv. "šok terapiju", što je značilo naglo napuštanje strogo kontroliranog gospodarskog sustava, u kojem država kontrolira cijene i tečaj, i prelazak na tržišnu ekonomiju koju karakterizira liberalizacija tržišta i privatizacija državnih dobara. Poljska ekonomija doživljava snažnu recesiju i hiperinflaciju 1990. (negativna stopa rasta od -9,68%, inflacija od 249%) i 1991. godine (negativna stopa rasta od -7,02%, inflacija od 60,4%). U 1992. godini počinje oporavak gospodarstva i BDP postiže godišnji porast od 5,3% u razdoblju 1993.-1995. godine (EC DG-AGRI, 2002).

Najveća stopa rasta zabilježena je 1995. godine (7,1%) nakon čega se smanjuje na niskih 1,2% u 2001. godini zbog financijskih kriza u zemljama važnim trgovačkim partnerima (Češka, Rusija, Njemačka), smanjenja stranih investicija i nedovršene privatizacije, osobito u sektoru teške industrije (Blazica, 2003). U 2002. godini poljska vlada donosi čitav niz mjera za ponovni oporavak gospodarstva čemu pridonose i pretpristupni fondovi EU, što rezultira ponovnim rastom u 2004. godini (Tablica 1).

Dobra makroekonomska anti-inflatorna politika, provedena osobito tri godine prije ulaska u EU, rezultirala je snažnim ekonomskim rastom i oslabljenim inflatornim pritiscima u prvim godinama članstva. Najznačajniji ekonomski rast, zabilježen je 2006. (6,2%) i 2007. godine (6,8%), dok je u 2006. ujedno zabilježena i najniža stopa inflacije nakon ulaska (1,3%). Također, ubrzani rast izvoza i povećanje u domaćoj potrošnji ojačalo je državnu platnu bilancu čime je porasla vrijednost nacionalne valute (*Zloty*). Vrlo visoka stopa nezaposlenosti, koja je tri godine prije članstva bila između 18 i 20%, smanjila se u 2008. na 7,1%, što se može objasniti i otvaranjem granica tj. potpuna liberalizacija tržišta rada unutar EU. Osim toga, novčane pošiljke

poljske radne snage (najviše iz Velike Britanije), prema nekim podacima, pridonose s 2,5% ukupnom BNP-u Poljske (MINROL, 2009).

Prije 1989. godine strana poduzeća nisu poslovala u Poljskoj. Ulaskom Poljske u EU 2004. godine vrijednost investicija se u odnosu na prethodnu godinu povećala za oko 250%, dok je prosječno u ostalim zemljama članicama taj postotak puno manji (oko 6%). Valja također istaknuti da je iz toga proizašao pozitivan učinak otvaranja 1.220.000 novih radnih mjesta.

Tablica 1: Odabrani makroekonomski pokazatelji razvoja; 2000.-2009., Poljska

Pokazatelj	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ekonomski rast -%	7,1	5,0	4,5	4,3	1,2	1,4	3,9	5,3	3,6	6,2	6,8	5,0	1,7
Stopa inflacije -%	14,9	11,8	7,3	10,1	5,3	1,9	0,7	3,6	2,2	1,3	2,6	4,2	4,0
Stopa nezaposlenosti -%	10,2	10,6	15,3	16,1	18,3	20,0	19,7	19,0	17,8	13,9	9,6	7,1	8,2
Strane investicije (mlrd EUR)	...	...	...	...	6.372	4.371	4.067	10.237	8.330	15.741	17.242	9.972	9.863

Izvor: EUROSTAT, Agripolicy i PAIZ, odgovarajuća godišta

### Promjene u poljoprivredi i ruralnim područjima

Važnost poljoprivrede u poljskom gospodarstvu, s obzirom na njezin udio u ukupnom BDP-u pada u pretpristupnom razdoblju, tako da 1988. bilježi 13,1%, 1990. 8,0% i 2000. pada na 3,1%). Taj pad je bio rezultat snažnog ekonomskog rasta u zemlji, ali ujedno i niske proizvodnosti na gospodarstvima koja se može uočiti kroz odnos udjela broja zaposlenih u poljoprivredi i doprinosa poljoprivrednog sektora BDP-u (Choupkova, 2003).

Poljska ima od oko 18 mil. ha korištene poljoprivredne površine u pretpristupnom razdoblju do oko 16 mil. ha u godinama članstva, na kojoj prevladavaju oranice. Najveći udio biljne proizvodnje pripada pšenici, raži, uljanoj repici i krumpiru, a u stočarskoj proizvodnji najveći udio zauzima svinjsko meso. Prosječna veličina poljoprivrednog gospodarstva je porasla od 5,66 ha u 1996. godini do 6,27 ha u 2007. godini. Iz Poljske se najviše izvoze mesni proizvodi, voće i povrće. Države koje čine EU-15 su najvažniji trgovinski partner Poljske, s time da Njemačka prednjači s 30-40% izvoza i oko 30% uvoza u razdoblju prije i nakon poljskog ulaska u EU (Agripolicy).

Situacija u poljoprivredi, u razdoblju 1990.-2003. je bila teška s obzirom na prilagodbu tržišnoj ekonomiji. Bile su potrebne temeljite promjene u poljoprivrednoj strukturi i institucijama zbog smanjenja ili stagnacije poljoprivredne proizvodnje, nepovoljnih cjenovnih dispariteta ulaznih resursa i proizvodnje, smanjenih investicija i rastućeg pritiska strane konkurencije (Wilkin, 2007).

Značajne pozitivne promjene u poljoprivredi najviše se uočavaju kroz analizu vanjskotrgovinske bilance poljoprivredno-prehrambenih proizvoda i dohodaka od poljoprivrede. Tako je od 2003. godine vanjskotrgovinska bilanca pozitivna, a poljoprivredni dohoci su od ulaska uglavnom u porastu u odnosu na 2000. godinu, u najvećem dijelu zahvaljujući porastu subvencija ulaskom u EU (Tablica 2).

Tablica 2: Promjene u poljskoj poljoprivredi (1997.-2009.)

Pokazatelj	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Udio sektora poljoprivrede u BDP-u	4,8	...	...	3,1	3,3	2,7	2,6	4,5	4,1	3,7	3,8	3,9	...
Udio zaposlenih u sektoru poljoprivrede -%	27,4	27,3	27,5	27,8	28,6	16,3	15,3	15,2	16,2	15,8	15,4	13,4	13,4
Korištena poljoprivredna površina (000 ha)	18.457	18.443	18.435	18.413	17.788	16.899	16.169	16.327	15.906	15.657	16.177	...	...
Poljoprivredna vanjsko-trgovinska bilanca (mil EUR)	-353,3	-661,4	-661,9	-567,1	-405,0	-306,9	446,5	835,7	1.654,5	2.076,4	1.970,2	1.500,0	...
Dohodak od poljoprivredne aktivnosti (2000=100)	...	113,7	98,5	100,0	115,0	103,9	96,0	180,8	164,1	181,3	227,7	182,5	...

Izvor: EUROSTAT, Agripolicy i MINROL odgovarajuća godišta

Ruralna područja čine oko 93% Poljske s 14,7 mil. stanovnika 2000. godine čiji se broj povećao na 14,8 mil. u 2008. godini. Loša infrastrukturna opremljenost, niska razina obrazovanosti i općenito visoka stopa siromaštva glavne su karakteristike ruralnih područja početkom devedesetih godina. Iako se situacija u kontekstu kvalitete života poboljšala primjenom brojnih nacionalnih i programa EU, još uvijek ostaje dosta prostora za poboljšanja. Naime, povećanje broja stanovnika u ruralnim područjima proizlazi i iz činjenice da

se doseljava stanovništvo koje izgubi posao u gradu kao i stanovništvo niže razine obrazovanosti, radi lakšeg pronalaska posla. Iako je ekonomska aktivnost i stopa zaposlenosti veća u ruralnim nego u urbanim područjima, podaci ukazuju (MINROL, 2009) da 18,7% stanovništva u ruralnom području živi na rubu egzistencije (nemaju sredstava za osnovnu hranu i žive na vrlo malom prostoru), dok je u gradu taj postotak manji (8,2%).

#### Promjene u poljoprivrednoj politici

Glavni ciljevi poljoprivredne politike Poljske u razdoblju komunizma, tj. prije reforme bili su maksimiziranje poljoprivredne proizvodnje, dostizanje samodostatnosti i sigurnosti opskrbe domaćom hranom, te dostizanje jednakosti poljoprivrednih i nepoljoprivrednih dohodaka. Kako bi se to postiglo, poljska vlada je upotrijebila instrumente plafoniranja cijena i državnog otkupa.

Od 1990. godine glavni srednjoročni cilj vlade bio je preusmjeren u poboljšanje strukture poljoprivrednih gospodarstava. U tom smislu su bile ukinute razne zabrane povećanja gospodarstava, kupnja i najam zemljišta. U otvorenom konkurentskom tržištu poljski proizvođači su bili primorani tražiti povećanu zaštitu, tako da su uvedene zaštitne cijene za pšenicu, raž i mliječne proizvode, kao i povećane carine za uvoz poljoprivrednih proizvoda. Odmicanjem devedesetih godina potpora poljoprivredi je i dalje rasla s obzirom da se poljski poljoprivrednici i dalje nisu mogli natjecati na otvorenom tržištu s proizvođačima iz EU čija potpora je bila puno veća (Chopkulova, 2003).

Od 1996.-2001. godine tržišno-cjenovna politika se sastoji uglavnom od visokog stupnja intervencije, osobito za sektor žitarica i svinjskog mesa. Istovremeno najveći dio poljoprivrednog proračuna (80%) pripada Poljoprivredno-socijalnom fondu sigurnosti tzv. nezarađeni dohodak (poljoprivredne mirovine, plaće za nezaposlene i sl.), dok s manjim udjelom (20%) sudjeluju tržišne mjere, subvencije za kredite, potpora stabilizaciji tržišta, savjetodavna služba, investicije u ruralna područja itd. U navedenom razdoblju posebno su rasle investicije u ruralna područja (2001/1996=321%).

Tranzicijski proces Poljske je obilježilo korištenje PHARE programa (1990.-1999.), koji je uglavnom poslužio za upoznavanje poljske administracije s EU mehanizmima, olakšavanje provođenja zemljišne reforme, povećavanje dostupnosti kredita za ruralna područja, nadogradnju marketing rješenja, potporu ruralnoj infrastrukturi, edukaciji i kontroli bolesti biljaka, životinja i zdravstvenoj ispravnosti hrane. U okviru PHARE programa izdvojeno je 3,9 mlrd EUR (MINROL, 2007).

Pregovori za ulazak u EU započeli su 1998. godine. Od 2002. godine poljski poljoprivrednici i lokalna uprava su stekli pravo na korištenje sredstava iz pretpripravnog fonda SAPARD. Iskorišteno je 95% namijenjenih sredstava, a prioritet potrošnje je bio poboljšanje ruralne infrastrukture. Prihvaćeno je 24.396 prijava i potrošeno 720 mil. EUR iz EU fonda (Wilkin, 2007).

U prvim godinama članstva, prijašnja bojazan poljoprivrednika od strane konkurencije je postepeno nestajala. Poljska je općenito vrlo učinkovito iskoristila izravna plaćanja iz EU, što je povećalo zadovoljstvo poljoprivrednika i stvorilo pozitivan stav prema EU, koji iz godine u godinu raste. Naime, poljsko članstvo nije uzrokovalo traume u poljoprivredi: mala gospodarstva nisu uklonjena, poljsko tržište nije preplavljeno hranom ostalih zemalja članica, stranci ne kupuju masovno poljoprivredno zemljište i poljski poljoprivrednici se ne osjećaju kao stranci u Uniji (Wilkin, 2007).

Poljska, kao i većina novih zemalja članica primjenjuje pojednostavljenu shemu jednokratnih isplata po gospodarstvu (engl. *Single Area Payment Scheme* - SAPS). Porast poljoprivrednih dohodaka kao što je ranije spomenuto, rezultat je utjecaja povećane razine izravnih plaćanja primljenih u okviru te sheme. Naime, subvencije u poljoprivrednom dohotku su u 2003. iznosile 9,4%, a u 2008. 49,9% (Kowalski i sur., 2009). Ipak, porast cijena inputa smanjuju rast profita na gospodarstvu.

Proizvođači stočnih proizvoda su počeli dobro poslovati odmah u prvim godinama članstva kad su se cijene stočarskih proizvoda povećale, a cijene stočne hrane (inputa) smanjile. Proizvođači žita su imali koristi zbog intervencijskih otkupa žita u vrlo rodnoj 2006. godini, i na taj način spriječili poremećaje na tržištu, tj. pad cijena žita. Proizvođači šećera su u početku primali visoku razinu potpore u okviru tržišnih redova, ali sljedeći reforme u sektoru šećera, potpora i profitabilnost su se smanjile.

Poljski potrošači su poboljšali svoj položaj u EU samim time što se otvaranjem tržišta ponuda proizvoda povećala, kao i kvaliteta i sanitarni standardi, a cijene su smanjene zbog već spominjanog porasta vrijednosti nacionalne valute.

Ipak Poljska se kao i druge nove zemlje članice, žali na činjenicu da poljski poljoprivrednik prima manje subvencija nego poljoprivrednici iz EU-15. Naime, u 2004. Poljaci su za poljoprivredu mogli potrošiti 25% razine potpora EU koje koriste stare zemlje članice, uz postepeno povećanje od 5% do 2006. godine od kad se počinje povećavati za 10% da bi 2013. dostigao razinu potpore koju imaju EU-15. Do tada je dozvoljena nadoplata iz nacionalnog proračuna, tzv. *top-up*. plaćanja.

U usporedbi s 2003. godinom, tj. godinom prije ulaska proračun za poljoprivredu i ruralni razvoj se utrostručio u 2005., a fondovi EU povećali za 9 puta (MINROL, 2006). Udio poljoprivrednog proračuna u nacionalnom je u značajnom porastu, npr. od 185% u 2008. godini u odnosu na 2005.).

Nakon ulaska, u ruralnim područjima se događaju promjene u kontekstu ekonomske aktivnosti koja je sve više orijentirana multifunktionalnosti. Fondovi iz zajedničkog proračuna EU preko SAPARD-a i Sektorskog operativnog programa "Rekonstrukcija i modernizacija sektora hrane i ruralni razvoj" za razdoblje 2004.-2006. i 2007.-2013. u funkciji su postizanja multifunktionalnosti, potpore poboljšanju konkurentnosti poljoprivredno-prehrambenog sektora i uvođenja instrumenata za diversifikaciju ekonomske aktivnosti. Svi ti programi imaju zajednički cilj - poboljšanje kvalitete života u ruralnim područjima, razvoj uslužnog sektora i otvaranje alternativnih mogućnosti za zaposlenje, nevezanih uz poljoprivredu (MINROL, 2009).

### Budućnost gospodarske i poljoprivredne politike u Poljskoj

Nakon primjene "*Health Check*", u kontekstu budućnosti ZPP-a nakon 2013. godine, poljska zadržava stajalište o potrebi razdvajanja postavljenih uvjeta za stare i nove zemlje članice u poljoprivredno-prehrambenom sektoru i razvoju ruralnih područja. Prema tome, instrumenti tržišne intervencije bi trebali ostati kao mogućnost prevladavanja kriznih godina za srednje velika gospodarstva, a izravna plaćanja postati jedan od najvažnijih instrumenata ZPP-a, odgovoran za potporu i stabilnost poljoprivrednih dohodaka i nadomjestak za troškove povezane s primjenom visokih standarda kvalitete i načina proizvodnje, okolišnih standarda i očuvanja poljoprivredne proizvodnje u područjima s ograničenim uvjetima gospodarenja.

Također se smatra da politika ruralnog razvoja treba imati vodeću ulogu u procesu stimuliranja strukturnih promjena i suprotstavljanju negativnim klimatskim promjenama, racionalizaciji upravljanja vodenim resursima i očuvanju bioraznolikosti, te upotrebi obnovljivih izvora energije (Kowalski i sur., 2009).

U programskom paketu 2007.-2013. predviđeno je ukupno 17 mlrd EUR za program ruralnog razvoja, 3,2 mlrd EUR godišnje za izravna plaćanja, dok će iz strukturnih i kohezijskih fondova biti izdvojeno ukupno 67 mlrd EUR. Poljska će tako biti korisnica s najviših 19% sredstava iz strukturnih i kohezijskih fondova, unutar zemalja članica, a sredstva će se preusmjeriti za transport (35%), istraživanje i razvoj u kontekstu inovacija (16%), zaštita okoliša i upravljanje rizikom (14%), ljudski kapital (13%) i informacijsko društvo (6%).

### Rasprava o gospodarskim učincima petogodišnjeg članstva u EU

Unutar EU-27 Poljska je jedina zemlja članica koja je u godini krize (2009.) imala pozitivnu stopu rasta od 1,7%, što dokazuje da Poljska, osim pozitivnih rezultata koje bilježi u normalnim ekonomskim uvjetima, vodi odgovarajuću gospodarsku politiku i u uvjetima ekonomskog pada svih zemalja u okolici. Aktualna literatura (Pepliński i sur., 2009) i izvješće svjetskog gospodarskog foruma (WEF, 2010) o razlozima takve uspješnosti uglavnom se podudaraju u nekoliko ključnih točaka koje se odnose na uspješne grane gospodarstva.

Naime, činjenica je da je Poljska u komunističko doba do 1990-tih bila zemlja zatvorena za protok roba, usluga i ljudi u kojoj je prevladavalo centralno-plansko gospodarstvo. Postepenim napuštanjem takvog oblika odlučivanja i donošenjem gospodarskih i socijalnih reformi vidljiv je gospodarski rast i smanjenje hiperinflacije. Gospodarske reforme su podrazumijevale, i još uvijek podrazumijevaju, uspostavu stabilnog bankarskog sustava, plivajući devizni tečaj (u skladu s ponudom i potražnjom na deviznom tržištu), ubrzane investicije u infrastrukturu (zbog sportskih događanja 2012). Uzroci gospodarskog rasta su i povećanje domaće potražnje i veličina domaće tržišta (Poljska ima 38.116.000 stanovnika prema službenom Popisu iz 2007.).

Povećan interes stranih investitora u Poljskoj od ulaska u EU govori u prilog činjenici da Poljska doista ima stabilnu makroekonomsku okolinu, a podaci iz prve polovice 2010. pokazuju da su se investicije povećale tri puta u odnosu na isto razdoblje 2009. godine (Tablica 1), dakle recesija nije u tom smislu načinila štetu poljskom gospodarstvu.

Članstvom u EU Poljska nije ispunila očekivanja u razvoju turizma. Iako se smatralo da će otvaranjem granica, kao članica Schengenskog prostora od 2007. godine postati zanimljivo turističko odredište, danas

BDP od turizma sudjeluje u ukupnom BDP-u sa samo 2%. Nadalje, što ujedno može biti i uzrok slabijim turističkim rezultatima, Poljska ima lošu cestovnu infrastrukturu i nedovoljnu povezanost svojih krajnjih dijelova.

Iako se penje na ljestvici globalne konkurentnosti (WEF, 2010) Poljska u sljedećim godinama ipak treba obratiti pažnju na učinkovitost javnog sektora, povezivanje gospodarstva i znanosti (inovacije), jačanje klastera i poboljšanje fizičke infrastrukture. Zabrinjavajuća je i fiskalna politika koja u svrhu smanjenja javnog duga od 60% BDP-a, uzrokovanog ambicioznim privatizacijskim programom, ne donosi jasne mjere, tj. odgađa se nužna konsolidacija javnih financija.

Iako se stanje u poljoprivredi poboljšalo ulaskom Poljske u EU zbog povećanja subvencija, može se očekivati da će globalna kriza ipak ugroziti poljoprivredu (Pepliński i sur., 2009). Poljska je neto izvoznica, a kriza u okolnim zemljama može utjecati na smanjenje potražnje poljoprivredno-prehrambenih proizvoda (osobito meso, mlijeko gljive, sok od jabuke). Deprecijacija poljske valute može uzrokovati povećanje cijena inputa, a time i smanjiti mogućnost natjecanja na tržištu. Uz to postoji mogućnost smanjenja potražnje za radom i smanjenja plaća, osobito u proizvodnji voća povrća i cvijeća.

Poljski poljoprivrednici još uvijek nisu spremni na potpunu europeizaciju. Istina je da postoji pozitivno stajalište o članstvu u Uniji kad su u pitanju fondovi, ali većina ih se teško prilagođava novim standardima poslovanja i daje prednost tradiciji koja nije uvijek učinkovita u modernom, otvorenom ekonomskom sustavu (USDA, 2009).

### Lekcije za Hrvatsku

Primjena europskih modela u Hrvatskoj ne protječe jednostavno u pretpristupnom razdoblju zbog različite razine gospodarskog razvitka u Hrvatskoj u odnosu na razvijene zapadnoeuropske zemlje, zbog posljedica povijesnih okolnosti i različitosti u potrebama koje se nastoje ostvariti jednakim ili sličnim mjerama i instrumentima. Ankete provedene u 2010. godini (ZEPAS, 2010.) potvrđuju pretpostavku da veliki dio poljoprivrednika još uvijek ne razumije nove standarde međunarodne konkurentnosti i subvencija u poljoprivredi.

Osim što se u pretpristupnom razdoblju Hrvatska treba dobro informirati o složenom sustavu ZPP-a, treba računati i s promjenama u ZPP-u s obzirom na nove okolnosti. U tom kontekstu država treba ocijeniti ulogu vlastitog poljoprivrednog sektora u nacionalnom gospodarstvu i jasnije definirati očekivanja od sektora, ocijeniti raspoložive resurse, odabrati prioritete i modele potpore (osobito za područja s težim uvjetima gospodarenja), snažnije uvažavati regionalni pristup, intenzivirati sve raspoložive oblike informiranja i obrazovanja, istovremeno uz nastojanje da se uoče vlastite posebnosti i ocijeni vlastita proizvodnja osobito u odnosu na zemlje, izravne konkurente u EU.

Primjer Poljske može poslužiti da se otkloni sveopća bojazan o gašenju malih gospodarstva usklađivanjem domaće politike sa ZPP-om, i to naglaskom na mjere ZPP-a kojima se nastoji povećati proizvodnja i ekonomski rezultat, promijeniti struktura proizvodnje i uključiti druge aktivnosti u ruralna područja u svrhu promjene izvora dohotka.

Prihvaćajući europski model poljoprivrede Hrvatska sve više prepoznaje važnost ravnomjerna razvoja ruralnog prostora. Osnovna karakteristika hrvatskih ruralnih područja je loš pristup stanovništva temeljnoj, fizičkoj i društvenoj infrastrukturi koje nisu dovoljno razvijene i ne zadovoljavaju potrebe seoskog stanovništva. U zaposlenosti ne postoji značajna razlika između ruralnih i urbanih područja i udio nezaposlenih osoba u aktivnom stanovništvu ruralnih i urbanih područja je gotovo podjednak. Međutim, obrazovna struktura je jedan od značajnih pokazatelja zaostajanja sela, tj. postoje značajne razlike u obrazovnoj strukturi seoskog i gradskog stanovništva (Mikuš, 2010.).

Na razini ukupnog gospodarstva Hrvatska ima slične probleme kao i Poljska u razdoblju reformi. Hrvatska se također još uvijek prilagođava na tržišni ekonomiju, no interpretirani makroekonomski rezultati (WEF, 2010) pokazuju da Hrvatska ima jače izražene probleme neučinkovitosti javnog sektora, nezdrave makroekonomske okoline potrebne za pokretanje proizvodnje i da je duboko je ušla u krizu (pad stope rasta BDP-a u 2009. za 5,8%).

U sektoru poljoprivrede tijekom prilagodbe teče sporo, što se može vidjeti iz slabe iskorištenosti pretpristupnih fondova. Valja naglasiti da je Hrvatska, za vrijeme poljskih tranzicijskih i pregovaračkih procesa, bila u Domovinskom ratu, što je ostavilo između ostalog posljedice oštećenja ili gubitka poljoprivrednih resursa, minirana zemljišta i sl. Takvi problemi svakako iziskuju dodatne napore pri rješavanju. Međutim, trebalo bi

iskoristiti prednost kasnijeg ulaska u EU uočavajući postupke koje su u novim zemljama članicama rezultirale pozitivnim ili negativnim pomacima u gospodarstvu i sektoru poljoprivrede.

Pretpristupni programi SAPARD i aktualni IPARD najznačajniji su programi za područje poljoprivrede i ruralnog razvoja. Njihova namjera je prvenstveno edukacija javne uprave i krajnjih korisnika o načinu poslovanja u EU i pružanje pomoći u modernizaciji, osnivanju, rekonstrukciji poljoprivrednih gospodarstva, te podizanje kvalitete života u ruralnim područjima. Hrvatska je zasad iskoristila 50% sredstava iz završenog programa SAPARD, što je u usporedbi s Poljskih 95% manje uspješno. Za IPARD su dosad provedena tri natječaja i odobreno 17 projekata, što je manje nego očekivano, s obzirom na iskustvo stečeno kroz provedu SAPARD programa.

Ključna riječ u pripremama za okolnosti tržišta u EU bit će konkurentnost. Hrvatsku očekuje uređivanje u mnogim područjima - tržištu zemljišta i kapitala, strukturi gospodarstava, standardima kakvoće, obrazovanja. Nadalje, reforme Zajedničke poljoprivredne politike, a time i reforme hrvatske poljoprivredne politike u potpunosti mijenjaju poznate sustave potpore poljoprivrednicima. Analitičari upozoravaju kako Hrvatska treba u potpunosti razumjeti ova kretanja, tako da njezina politika u predpristupnom razdoblju ne umanjuje njezine potencijalne koristi kao zemlje članice (Haynes, 2004).

### Zaključci

Početak tranzicijskog procesa Poljske nakon komunističke ere bio je obilježen hiperinflacijom (249%) i negativnom stopom rasta (-9,68%). Bolno i nužno razdoblje privatizacije, koje je rezultiralo visokom stopom nezaposlenosti dugoročno je ipak donijelo pozitivne pomake u gospodarstvu (pozitivna stopa rasta, smanjenje unutarnjih dugovanja, povećanje zaposlenosti i stabilizacija poslovanja privatnog sektora). Ulaskom u EU Poljsko gospodarstvo je dodatno osnaženo fondovima iz EU, stranim investicijama i dodatnim, neprestanim naporima da se planirane reforme provedu.

Poljski poljoprivrednici su bili skupina stanovništva u Poljskoj koja se najviše protivila ulasku Poljske u EU zbog bojazni od nemogućnosti uspješnog poslovanja u uvjetima tržišta EU, koje traži poštivanje visokih standarda kakvoće proizvoda i cjenovnu konkurentnost. Nakon pet godina u Uniji stručnjaci sabiru pozitivna i negativna iskustva. Činjenica je da se vanjskotrgovinska bilanca poljoprivredno-prehrambenih povećala u promatranom razdoblju (1997.-2007.) i to tako da je od negativnih 353,3 mil EUR prešla u pozitivnih 1.970,2 mil EUR. Isto tako povećao se poljoprivredni dohodak zahvaljujući značajno povećanim subvencijama na koje je Poljska stekla pravo kao članica. Uz poljoprivredu, dogodio se pomak i u ruralnom prostoru u smislu povećanja ekonomske aktivnosti i diversifikacije dohodaka te općenito podizanje kvalitete života, zahvaljujući povlačenju sredstava iz pretpristupnih i strukturnih fondova EU.

Ipak, postavlja se pitanje koliko su poljoprivrednici spremni u potpunosti preuzeti "zapadnjački" način života. Naime, zasad se zadovoljstvo članstvom uglavnom objašnjava visokim poticajima, međutim poljoprivrednici ipak daju prednost tradicionalnom obrascima i vrlo sporo usvajaju EU standarde. Također, učinkovitost rada u poljoprivredi je još uvijek niska, a poljski poljoprivredno-prehrambeni proizvodi slabo marketinški popraćeni. Poljska mora uzeti u obzir te probleme u planiranju buduće gospodarske i poljoprivredne politike, s obzirom da se nalazi u okruženju zemalja pogođenih ekonomskom krizom što bi moglo smanjiti potražnju proizvoda.

Prema izvješćima Svjetskog gospodarskog foruma Poljska se penje na ljestvici konkurentnosti, osobito zbog makroekonomske okoline pogodne za nove investicije. Zabrinjavajući je jedino pokazatelj niske učinkovitosti javne uprave, rast javnog duga i nekvalitetna prometna infrastruktura što bi moglo ugroziti gospodarsku stabilnost.

Osim upornosti u provođenju reformi i ažurnosti u korištenju odobrenih sredstava iz fondova EU, Hrvatska kroz iskustvo Poljske ima prilike predvidjeti korake EU u pregovaračkom procesu i sukladno tome unaprijed zauzeti pregovaračku poziciju, osobito u kontekstu vrste i iznosa potpora. Naravno, preduvjet za to je i dobro poznavanje raspoloživosti resursa i proizvodnih prioriteta kako u sektoru poljoprivrede tako i gospodarstvu u cjelini.

## Napomena

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# Situation, experiences and expectation in agriculture and agri-environmental measures after acceptance of European Common agricultural policy (CAP) in Slovenia

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## Abstract

During the recent years of European Common agricultural policy (CAP) Slovenia supports two pillars - direct payments and agri-environmental payments. Agri-environmental support due to Slovenian Agri-environmental programme (SAEP 2003-2006) and Agri-environmental payments (AEP 2007-2013) include 22 and 23 measures, respectively. In Annex 2 of the AEP measures like crop rotation, greening of fields, organic agriculture, soil coverage in water protection areas, etc. are included, which influence the “greening” of agriculture. In Slovenia there were 38.900 measure applications for 286,070.48 ha in 2009 with the total payments of 73,704,057.92 € for agri-environmental measures from 2007-2013 (MKGP, 2010a). Farmers and public opinion supports present and future activities of CAP. However, the agri-environmental measures brought, with restrictive rules, a lot of administrative troubles to the farmers. The CAP needs to be clearly ecological oriented, and will not support partly “green washing” of conventional agriculture or “conventionalisation” of organic farming.

Key words: Common agricultural policy, agricultural payments, public opinion, Slovenian agri-environmental programme, Slovenian farming

## Introduction

Common Agricultural Policy (CAP) is a system of the European Union (EU) agricultural programmes for farmers and rural areas providing them subsidies whose aim at the beginning was to maintain adequate supplies of food and feed, increase productivity and ensure that consumers and producers received a fair deal in the market. But during decades of development these priorities have shifted as environmental and animal concerns, as well as safety and health aspects have become more and more important. As a consequence, the CAP has moved from a production-based structure of subsidies to a market-oriented system, integrating standards for food safety, environment and biodiversity as well as animal welfare, etc. Furthermore, agri-environmental measures became the only obligatory set of measures within a rural development program (RDP) in each EU member country with the highest share of co-financing from the common budget. For many countries also support to less favourable areas (LFA) was/is essential. In Slovenia, out of all agricultural areas, 439,000 ha or 72.5% belongs to LFA (RDPRS 2007).

In the pre-accession period the Slovene agricultural policy decided for the strategy to include as much as possible of land use area into different agri-environmental activities and up to 2004 raise payments per area up to the EU-15 level to increase capacity for using EU funds after accession. It meant investment of national funds and was started with the first supports for organic and integrated production in the late nineties. In the year 2003 by introducing a CAP reform within EU, the amounts of agricultural payments given to the farmers in Slovenia were equal to the other EU-15 members and Slovene agriculture was easily incorporated to the CAP with additional possibilities for modernization and development of the agricultural sector.

The aim of this paper is to give an overview of agri-environmental measures as a part of CAP in EU and to present some experiences from the Slovene perspective. As the EU waits a new financial period 2013-2020 (MKGP, 2010b) and also due to some changes seen on the agricultural markets, some expectations for the future are presented.

### Development of payment eligibility

After CAP reform in 1992 EU member states were required to implement agri-environmental programs (regulation No. 2078/92) as part of a bundle of measures, accompanying this reform. These measures were combined with the support program for farms in less favoured areas into the program for rural development in 1999. This program, dubbed “the second pillar“ of the CAP became a cornerstone of the Agenda 2000 reform. The policy for rural development has become a complement of “the first pillar of the CAP“ (named later axes 1), programs and policies for commodity markets. Since 2000, agri-environmental programs are elements of the program for rural development in the EU member states. In many cases they are designed in such a way, that farmers may choose whether to continue their farming practices using funds only from axes 1, or to join - usually by contract - particular schemes. In general, the programs are for a minimum duration of five years. Programs are established either at member state or sub-national level. Depending on the volume of average regional value added, programs are co financed by EU funds between 50% and 75% (Schmidt and Sinabell, 2006). Payments were mainly based on per hectare or per animal amounts, which were calculated according to costs of compliance with scheme requirements, income forgone and (initially at least) an incentive to participate payment. Unlike the mainstream commodity support programmes, which were 100% EU financed and applicable on a common basis across the EU, the agri-environment programmes could be implemented in different forms in each member state (and in regions within states) and were co-financed by the EU and member states according to fixed rules. As a result a very wide range of schemes and payment rates can be found across the EU (FAO 2010).

Agri-environment measures are specifically aimed at achieving positive environmental management. EU member states can grant support to farmers for a range of environmentally favourable measures, including biodiversity related measures and conservation of high nature value farmland. The total area of agri-environment schemes in 2002 amounted to nearly 30.2 million ha in the EU-15. The share of agricultural land enrolled in agri-environment measures in total utilized agriculture area (UAA) has increased from approximately 20% in 1998 to 24% in 2002. In Finland, Sweden, Luxemburg and Austria large proportions (more than 75%) of the UAA are under agri-environment schemes (EEA 2005). Due to several similarities, part of common history and in some regions also some similarities in agro-ecological conditions and socioeconomic structures (i.e. Alpine part and the other hilly regions, forestry, small farms,..), but also climate conditions, Austria was for Slovenia as an example to learn and to get information and ideas in the pre-accession period. In the year 2002 total agri-environmental compensation in Austria amounted to 600 mil. € and the Austrian agri-environmental program ranks among those with the broadest coverage and attracted many participants. Approximately 60% of land and farms were participating in the basic scheme. In this scheme farmers commit themselves to stricter environmental standards and do not abandon land during the contracting period of five years. The second most important scheme is a soil coverage program which addresses soil erosion and nutrient leakage (Schmidt and Sinabell, 2006). In 2009 in Austria 118,000 farms (75% of all) were applying for payments for around 409,000 agri-environmental measures (on average 3.5 measures per farm) on 2.20 mio. ha or 87% of UAA using 550 mio. € annually. Also nowadays Austria is one of the most successful EU country in this development and found after the evaluation of the program several positive effects like: positive impact of organic farming shown in various studies (e.g. increase in biodiversity of “field weeds” from 35 to 80 over the last years, 18 out of 26 red-list species found on organic fields, etc.), on average humus content increased over the past years and is due to agri-environmental measures now approximately 0,4% higher than in 1993, soil erosion has been reduced up to >85% in vineyards and orchards (48.000 ha), on average soil erosion in Austria has been reduced by 800.000 t annually, better fertilizer-management caused reduction of nitrate leaching by 16% and reduction of phosphorus content in soils (Rebernig, 2010).

The agri-environmental measures were recognised as the most relevant for organic production because they provided the most significant support for organic farming. In quantitative terms, the overall level of support to organic farming is generally beneficial for organic farms compared to the conventional ones, with a positive relative advantage of most organic crops. For example, in Austria and Spain, organic farming

benefits due to the possibility of combining the organic farming measure with other agri-environmental measures, and in Austria the ceiling to payments for farms larger than 100 ha is higher on organic farms. However, similar budgets as for “Organic farming” were spent in Austria on measures which apply only to conventional farms, i.e. the measures “Reduction of Agricultural Inputs” and “Abandonment of Agricultural Inputs”. Furthermore, the closest alternative to organic farming, e.g. integrated farming, in most countries may receive nearly as high payments and is thus an interesting alternative for farmers. However, payments often are not sufficient to cover the income loss of organic compared to conventional production, particularly in horticulture, vine and olive production in Italy (Häring et al. 2004).

While the ideas of remuneration of positive externalities (RPE) and payments for environmental services (PES) have underpinned the EU agri-environment schemes from the outset, the implementation of these ideas has been more complicated in practice, due in part to the difficulties inherent in measuring the environmental outcomes. In practice, the guideline has been that schemes should deliver significant environmental benefits over good agricultural practice. This was reinforced following the 2003 CAP reform agreement and the introduction of cross-compliance and good agricultural and environmental practice (GAEP) requirements for Single Farm Payment eligibility from 2005.

Agri-environmental measures were formally integrated with other rural development measures as a part of the Agenda 2000 reforms from 2000-2006. This has continued in the 2007-2013 framework, with agri-environmental (or land management) measures forming Axis 2 of the rural development programme. In broad terms, the types of instrument envisaged have not changed significantly, although agro-forestry was introduced as an option and has been adopted in a few countries, and options to introduce schemes focusing on animal health and welfare were also introduced (FAO 2010). Cooper et al. (2009) provide a detailed overview of the different schemes currently in place. Based on the experiences from Austria the most important issues for successful introduction of agri-environmental measures are: sufficient funding, scientific proof is necessary for validation of measures, acceptance of measures, education of farmers and evaluation of programme, and administrative costs in relation to impact of measure should be reasonable (Rebernik, 2010).

### **Worldwide agri-environmental payments vs. EU and Slovenian CAP payments**

For the period 2007-2013, the *Commission Regulation (EC) No 1974/2006 of 15 December 2006* is laying down detailed rules for the application of *Council Regulation (EC) No 1698/2005* on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). In its axis 2 the regulation defines under part (a) measures targeting the sustainable use of agricultural land through: (i) Natural handicap payments to farmers in mountain areas; (ii) Payments to farmers in areas with handicaps other than mountain areas; (iii) Nature 2000 payments and payments linked to *Directive 2000/60/EC*; (iv) Agri-environmental payments; (v) Animal welfare payments and (vi) Support to non-productive investments. Under its part (b) for sustainable use of forestry land the regulation provides for payments for: (i) First afforestation of agricultural land; and (ii) First establishment of agroforestry systems on agricultural land.

In EU and other OECD countries a wide range of approaches have been adopted (Table 1), reflecting both local environmental priorities and resource availabilities as well as differing policy perspectives on the roles that markets and policy interventions should play. Several different approaches are being used such as (FAO 2010): (i) Input-limiting schemes, which reduce or prohibit fertilisers and pesticides, for example: Schemes with specific input limitations; Integrated farming and/or organic farming schemes where inputs are restricted along with other requirements; (ii) Extensification schemes, particularly those that restrict livestock numbers on grassland; (iii) Habitat restoration and maintenance schemes, with specific management prescriptions to recreate or maintain habitats or species (including rare breeds); (iv) Land use change, or land retirement schemes, including conversion or crop land to grassland or (agro)forestry and farm woodland establishment schemes - with the increased emphasis on climate change issues, some schemes to reverse previous land drainage for agriculture in order to prevent further degradation of peatlands are also being introduced; (v) Capital investment to support investment in infrastructure for environmental gains, e.g. restoring stone walls and buildings representing cultural landscapes, fencing to protect hedges from browsing, or housing for livestock in winter to reduce damage to pasture; (vi) Catchment areas schemes, which aim to encourage all farmers in an area to participate, for example to maintain water quality.

Beside Slovene measures some Austrian agri-environmental measures could also be interesting for Croatia, i.e. renunciation of yield-increasing inputs on arable areas, renunciation of yield-increasing inputs on arable areas dedicated to green forage and on grassland, renunciation of fungicides on areas dedicated to cereal cropping, environmental friendly management of medicinal and spice plants, alternative crops and seed multiplication, integrated production (IP) of arable areas (potatoes, strawberries and beets from the 1<sup>st</sup> group or from the 3<sup>rd</sup> group cover cropping of arable land, direct seeding and seeding on mulch, underseed under maize and spreading of liquid farm manure and biogas semi liquid manure with a low level of nitrogen loss or some being introduced on the regional level like: regional project for groundwater protection and for the maintenance of grassland, preventive soil and water protection, management of arable areas particularly threatened by erosion and leaching.

But there are still debates whether to choose targeted measures which deliver specific outcomes, or more systems-based approaches delivering on a range of outcomes. Various agricultural economists concluded that systems-focused, multi-objective policies such as organic farming area support payments are not economically sound, as the policy goals could be achieved more efficiently by more flexible and targeted combinations of various specific agri-environmental measures. But Schader (2010) who has analysed this issue more detailed regarding cost effectiveness of organic farming as a tool to deliver agri-environmental goals in Switzerland found out that if provided systems-based approaches are part of a mix of options with targeted approaches, they can be a cost-effective means of delivering agri-environmental outcomes. This also applies to other integrated/sustainable farming systems, as well as to the more traditional farming systems identified by Cooper et al. (2009) as contributing public good provision. The focus on defined production systems may make it easier to link in market-based mechanisms to encourage them, but there is no reason conceptually why a specific standard for bundled eco-system services might not be developed as a basis for remuneration of positive externalities and payments for environmental services policies.

**Table 1. Agri-environmental payments for farming practices in some OECD, some EU countries and EU candidate (Croatia); (Vojtech, 2010; AEP 2001-2013)**

Programme/Country	USA	AUS	AUT	GER	IT	HUN	SLO	CRO
Payments for activity								
Land improvement (liming, soil erosion prevention)	*	*	*	*	*			
Nitrate reduction		*	*	*	*			
Nutrient management plan	*	*			*	*		
Extensive crop production			*	*	*	*		
Organic farming	*		*	*	*	*	*	*
Integrated prod. wine, fruits, vegetable			*			*	*	
Integrated farming			*			*	*	
Traditional methods			*		*	*		
Reduced tillage/Mechanic weed control	*	*	*	*	*	*		
Crop rotation	*			*		*	*	
Biological plant protection measures				*				
Green manure crops		*			*			
Green set aside/fallows	*	*	*			*		
Catch crops, green/winter cover	*		*	*			*	
Extensive management of all land					*	*		
Extensive land management (pastures/meadows)	*			*	*	*		
Conversion of arable land into grassland (pastures/meadows)	*			*	*	*	*	
Grassland/biodiversity/habitat schemes	*	*	*	*	*	*	*	
Biodiversity - local breeds			*	*	*	*	*	*
Biodiversity - local species and varieties of crops			*	*	*		*	*
Maintaince of wetlands and ponds		*			*	*		
Protected environmentally sensitive areas/vulnerable zones	*	*			*	*	*	
Shelter belts/buffer strips	*	*	*	*	*	*		
Landscape elements/Amenities			*		*	*		
Maintaining and improving groundcover	*	*					*	
Water conservation	*							
On-farm energy conservation		*						

Despite the variety of approaches, in general terms, there is broad acceptance of the principle that policy intervention in all these cases may be justified because there is evidence of market failure. This is most clearly the case where positive externalities and environmental services are provided by agricultural producers. These services are typically not purchased in a market framework because the benefits accrue to society as a whole, rather than individual consumers. Even in cases where a market may exist, e.g. consumption of landscapes via tourism, the sellers of tourism services (accommodation, restaurants, travel firms) may not be those that deliver the landscape qualities attracting the tourists (FAO 2010).

In case of Croatian law (MPRRR, 2010), additional to direct payments and rural development, just a few of environmental measures were mentioned like Nature 2000, environmental payments with no detailed information (payment 40 EUR per ha, organic farming and protection of local breeds and races).

With the increased emphasis on climate change and soil and water protection in addition to biodiversity conservation in the CAP Health check of 2008, the emphasis within agri-environmental measures has begun to shift, and may lead to more significant changes as part of the current CAP reform debate (FAO 2010). The CAP needs to be clearly ecological oriented, and will not support partly “green washing” of conventional agriculture or “conventionalisation” of organic farming.

### **Slovenian agri-environmental measures and situation**

Among the measures which were financed from the budget of the RS in the preliminary programming period 2000-2006 it is necessary to point out the Slovene Agri-Environmental Programme 2001-2006 (SAEP) which laid special focus on the environment and was divided into three basic groups: Group I: reduction of negative impacts of agriculture on the environment (9 measures); Group II: preservation of natural features, biodiversity, soil fertility and traditional cultural landscape (8 measures); Group III: maintenance of protection areas (5 measures) and Group IV comprised training and promotion, which were not designed as measures of per area payments.

In that period the SAEP comprised 22 measures and training and promotion. Based on an annual decree at the national level the SAEP was initiated with 10 pilot measures in 2001, in 2002 12 measures were implemented and in 2003 already 14 measures. By 2003 agri-environmental measures were entirely financed from the national budget as state aid. From 2004 onward 21 measures of the SAEP have been implemented under the RDP 2004-2006, whereas training and promotion as technical assistance. The number of the measures was reduced from 22 to 21. The response of producers to the SAEP was relatively high as in the first year of the implementation about 20 percent of all agricultural holdings applied for agri-environmental payments. In total 1,393,680,692 SIT (app. 6 mio €) were disbursed, the most (41%) for the measure sustainable rearing of domestic animals. In 2001 agri-environmental measures were implemented by 11,400 agricultural holdings covering 93,736 ha; in 2002 by 11,859 agricultural holdings covering 110,849 ha and in 2003 by 12,422 agricultural holdings covering 124,838 ha. The extent of agricultural land under agri-environmental measures in 2002 increased by approximately 18% and in 2003 for 33% compared to the year 2001.

In the year 2007 a new Agri-environmental program (AEP 2007-2013) started mostly with increased amounts per ha (Table 2) with exception of integrated vegetable production, where the amount decreased from 241.20 to 184.91 €/ha. Payments in Austria are 250 (vegetable on the field in the year) to 350 €/ha (more vegetables in the same year) for open field production and under tunnel covered by foil 1,000 or by glass 2,000 €/ha. Additionally areas where predators are being used can receive 1,200 €/ha.

In the period 2006-2009 the number of farms in Slovenia included into agri-environmental measures increased up to 50%, although now new applications are not possible except conversion to organic farming. In 2009, 38,900 holdings were covering 286,070 ha or 58% of LUA (MKGP, 2010a). Approx. 25 mio. € is given, mainly as support for greening arable land, integrated field crop production, sustainable rearing of domestic animals and organic farming (Table 3). On average in Slovenia farms are participating in two agri-environmental measures.

Maximal amounts of payments from agri-environmental measures applying for different combinations have been defined and are in the period 2007-2013 for arable land 600 €/ha/ year, permanent crops 900 €/ha/ year and grassland including clover grass mixtures on the fields 450 €/ha/ year. Additional from the axis 2, farmers can also get LFA payments if area is eligible and payment rights for fields, permanent crops and greenhouses amounts to 332 €/ha and 133 €/ha for grassland and extensive orchards from axes 1.

In Slovenia, if the eligible area on a farm is over 100 ha, for areas over 100 ha payments are reduced for 50%, but in Austria payments are from 100 ha to 300 ha 92.5% from 300 ha to 1,000 ha 85.0% for areas more than 1,000 ha 75.0% (Rebernik, 2010), stimulating also bigger farms to enter into the schemes.

Among all above presented agri-environmental measures, beside very strict administrative controls and some site controls according to the EU rules, only integrated and organic farming practise are being inspected regularly at least once per year and certified also as products according to the EU community legislation and/or to national rules.

**Table 2. Payments for different agri-environmental measures in Slovenia for the period 2007-2013 (ULRS, 2007)**

Agri-environmental measure	Payment €/ha/year	Agri-environmental measure	Payment €/ha/year
Preservation of crop rotation	91.84	sustainable rearing of domestic animals	84.46
greening of arable land	172.20	extensive grassland maintenance	48.38
integrated field crop production	197.21	animal husbandry in central areas of appearance of large carnivores	29.11
integrated fruit production	336.61	preservation of special grassland habitats	66.83
integrated vine production	381.71	preservation of grassland habitats of butterflies	66.83
integrated vegetable production	184.91	preservation of litter meadows	143.91
organic farming:		bird conservation in humid extensive meadows in Nature 2000 sites	83.23
- fields	298.07	permanent green cover in water protection areas:	
- vegetables on field	551.45	- fields	83.64
- vegetables in greenhouses	487.90	- permanent crops	184.50
- fruit high density	554.73	- grassland	31.57
- fruit low density	237.80		
- grapes, hop, nurseries	578.92		
- grassland	227.55		
mountain pastures with herdsman	61.09	humpy meadows mowing	132.84
mountain pastures without herdsman	72.57	meadow orchards	93.89
mountain pastures slopes 35-50%	90.20	rearing of autochthonous and traditional domestic breeds	89.38*
Steep mowing slopes >50%	142.27	production of autochthonous and traditional agricultural plant varieties	102.91

\* - per animal unit (500 kg)

**Table 3. Number of Slovenian farms and land area under different agri-environmental measures in the year 2009 and paid support in the period from 2007 to 2009 (MKGP, 2010a)**

Group	Agri-environmental measure	Number of farms in 2009	Area in 2009 (ha)	Payed support 2007-2009 (in €)
I	-reduction of negative impacts of agriculture on the environment			
	preservation of crop rotation	2,072	17,711.17	3,112,723.93
	greening of arable land	4,887	59,876.26	17,683,926.17
	integrated field crop production	1,762	41,740.71	13,216,101.17
	integrated fruit production	855	3,327.96	1,949,171.31
	integrated vine production	2,292	8,432.72	5,638,816.20
	integrated vegetable production	276	895.10	299,190.11
	organic farming	1,740	24,889.38	10,961,700.53
II	- conservation of natural conditions, biodiversity, soil fertility and traditional cultural landscape			
	mountain pastures with herdsman	14	480.58	47,299.52
	mountain pastures without herdsman	117	5,168.73	572,932.44
	mountain pastures	2,136	14,025.05	2,434,861.66
	steep slopes mowing	15	5,374.69	1,472,856.86
	humpy meadows mowing	34	29.18	6,897.91
	meadow orchards	780	696.60	118,980.84
	rearing of autochthonous and traditional domestic breeds	1,151	16,160*	966,802.64
	production of autochthonous and traditional agricultural plant varieties	5,242	5,835.25	956,077.19

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Group	Agri-environmental measure	Number of farms in 2009	Area in 2009 (ha)	Payed support 2007-2009 (in €)
III - maintenance of protection areas				
	sustainable rearing of domestic animals	9,731	77,991.42	12,372,316.51
	extensive grassland maintenance	1,570	9,258.54	805,262.39
	animal husbandry in central areas of appearance of large carnivores	640	8,573.17	401,536.47
	preservation of special grassland habitats	169	420.64	52,006.45
	preservation of grassland habitats of butterflies	68	126.97	15,897.37
	preservation of litter meadows	3,062	26.33	6,526.41
	bird conservation in humid extensive meadows in Natura 2000 sites	20	309.20	39,685.61
	permanent green cover in water protection areas	270	870.83	73,277.28
	Total No. of applications for measures	38,900	286,070.48	73,704,057.92
	Total No. of farms and LUA in Slovenia	77,175 <sup>1</sup>	492,424.00	
	Share (%)	50.4	58.09	

\* - number of animals, <sup>1</sup> - in 2005

### Development and situation of integrated farming

An obtained certificate for integrated production under a national quality scheme (Table 4) assures the consumer that the products were produced under the technological guidelines set out in advance and that they are compliant with the national rules laying down technological requirements and restrictions on integrated production of fruit, crops, grapes and vegetables. The scheme is available to all producers meeting the requirements on integrated production and providing a complete traceability of the products. Each year the producers are controlled by an inspection body appointed on the basis of the regulation governing the technical and organisation conditions (EN 45011) to be fulfilled by an organisation controlling the integrated agricultural products and foodstuffs. The inspection body controls the compliance with the provisions of the technological guidelines and the rules on integrated production (RDPRS, 2007).

**Table 4. Development and situation of integrated production in Slovenia in 2009 as share (%) of area under integrated production, (MKGP 2010c, SURS 2010)**

Year	Fruit		Vegetable		Grape		Field crops	
	No of farms	area (ha)	No of farms	area (ha)	No of farms	area (ha)	No of farms	area (ha)
2003	889	3,941.38	346	910.05	1,714	7,105.70	0	0
2004	1,047	4,373.15	417	1,134.22	2,188	8,540.30	920	28,487.08
2005	1,181	2,187.47	408	1,027.75	2,547	8,553.80	1,394	32,819.78
2006	1,197	3,798.35	379	1,099.26	2,559	8,512.14	1,572	36,459.85
2007	1,091	3,453.66	380	1,094.12	2,640	9,062.53	1,930	43,267.28
2008	1,080	3,273.97	356	1,075.95	2,594	8,910.60	1,882	44,357.92
2009	994	3,475.54	331	1,002.57	2,428	7,630.69	1,823	45,367.84
Total		8,928.00		1,708.00		16,086.00		180,303.00
Share (%)		38.93		58.70		47.44		25.16

As integrated field crop production can be considered as successful, integrated vegetable production is being decreased after EU accession due to not simulative payments and increased imports of vegetables from the other EU countries.

### Development and situation in organic farming

The first organic farms were registered and inspected in Slovenia in 1998. According to DG AGRI reference data in 2002 organic farming was carried out on 15,400 ha of Slovenian agricultural land. In the years 2006/2009 organic farming was carried out on 1,876 / 2,067 agricultural holdings on 26,830.62/29,398.43 ha of agricultural land, respectively. In the recent years the organic agricultural land increased from 2.4 to 6.2% where permanent grassland, field crops and orchards dominated (Table 5), although goal 15% organic LUA up to 2015 probably will not be achieved (APOF, 2006).

Table 5. Land use area (ha) on organic farms in Slovenia in the year 2009 (SURs, 2010)

Land use	Total	organic farming	in conversion	all under organic	share of total (%)
Utilised agricultural area - total	492,424	25,816	3,572	29,398	6.2
Arable land	180,303	2,382	540	2,922	1.6
of which vegetables and strawberries	3,545	112	12	124	3.5
Permanent grassland	285,973	22,669	2,764	25,433	8.9
Orchards	8,928	648	132	780	8.7
Vineyards	16,086	91	113	204	1.3
Olive groves	910	27	23	50	5.5
Nurseries	224	-	-	-	-

According to the RDPS (2007) one of the most efficient ways for sustainable agricultural use of natural resources is organic farming, as it significantly contributes to the provision of public goods, preservation and improvement of biodiversity, preservation of drinking water sources, an increase in working places, conservation of agricultural landscape and environmental protection (Bavec and Bavec, 2006, Bavec et al., 2009, Turinek et al., 2009). Furthermore, it ensures the production of healthy and high-quality food with high nutritional content. Organic farming has the best possible impact on sustainable management of the renewable and non-renewable natural resources with special mission to exerting the principle on adequate animal rearing, well human-being and promoting health. In this way organic farming represents the basic benefit for social change and real green care (Sempik et al., 2010; Dessein and Bock, 2010). According to the mentioned functions organic farming is the basic ecosystem service in agriculture with interdisciplinary functions of whole chain (from biodiversity, to quantity and quality of food, just regional transport, organic food in public kitchens, etc.).

Organic farming is widely perceived as being more environmentally friendly than conventional farming. As a form of sustainable agriculture, it receives substantial support from policy for its contribution to environmental protection as well as the provision of amenities such as biodiversity and cultural landscapes. Consumers are attracted to organic foods as they are produced without synthetic chemicals and comply with higher animal welfare standards. Although organic farming certainly has the potential to fulfil these expectations, studies have shown that some certified organic farms do not. Their practices comply with the regulations, but not with the principles of organic farming and we could describe them as conventionalised organic farms. Assessment is needed whether or not the observed changes comply with the principles and values of organic farming (Danhofer, 2010).

According to the report "Funding for Farmland Biodiversity in the EU" (Farmer et al., 2008) in some countries or regions organic farming can be beneficial for biodiversity, but this is not the underlying objective of supporting such a system. Also due to the opinion of European Economic and Social Committee (NAT/471) the importance of biodiversity maintenance has still not come to the forefront of political discussion and action. With the 2013 reform of agricultural policy, biodiversity maintenance criteria must play a major part in the CAP, in order to resolve the current conflict between economic production and nature conservation. But also in these new document (NAT/471) a lack of some actions between linear linked biotopes, species and/or ecosystem services exists.

The mission of organic farming in Slovenia is (due to mentioned facts, development of organic farming in Slovenia and experiences from the farmer, professional and scientific sides) well established. In general, for an organic "greening" of the CAP a lot of lacks exist, because of very complicated administrative support, undeveloped processing and marketing systems, lack of use of organic foods in public kitchens and undeveloped organic tourism, and "green" care in organic farms. Also field hedgerows and margin strips have many agronomic, environmental, recreational and wildlife functions, but their indicators are very rarely involved into green CAP, and they are often in contradiction with organic farming rules, production and cross-compliance (Bavec and Bavec, 2010).

### **Priorities, performance and expectations of European vs. Slovenian public opinion beyond 2013**

EU General Directorate for agriculture gave the call for public opinion on the 12<sup>th</sup> of April 2010. The aim of public debate was about the future of EU CAP, its principles and aims. The questions were focused on whole public, professional public, corporations and institutes and were placed on a Web portal. About 5,700



answers (also many repeated e-mails) were sent to the Commission. The key questions are as follows: “Why do we need a European common agricultural policy?“, “What do citizens expect from agriculture?“, “Why reform the CAP?“ and “What tools we need for the CAP of tomorrow?“ Main findings were focused on where there was a general consensus among the contributions received, and are that: (i) the 2nd pillar has proved valuable and should be maintained within the CAP; (ii) the preservation of the diversity of farm production systems is essential both for sustainable food production and the delivery of public goods; (iii) it is important to meet environmental objectives and support the vitality of rural areas, both in an integrated perspective; (iv) regional targeting should be more embedded in the policy; (v) Leader and other local approaches should be maintained or reinforced; (vi) greater simplification is required for effective delivery; (vii) coordination with the other EU policies applied in rural areas should be strengthened; and (viii) many specific and more detailed suggestions were made regarding how to improve delivery through existing measures and tools and new measures (PD-CAP, 2010). More relevant is the opinion of Eurobarometer (2010) based on 26,761 face to face interviews at EU level vs. 1,017 interviews of Slovenian citizens. The majority of European/Slovenian citizens (90% vs. 95%) regard agriculture and rural areas as important for the future. But 57% Europeans and 45% of Slovene did not hear about CAP; and additional 28% and 39% of citizens really do not know what it is, respectively. There is an overall preference for the European vs. Slovenian level to manage agricultural issues, particularly environmental protection (65% vs. 72%), securing food supply (53% vs. 65%) and ensuring that agricultural products are of good quality, healthy and safe (51% vs. 43%). The local or regional levels are not preferred for both of the issues measured. However, CAP ensuring fair standard of living for farmers for EU/Slovenian farmers at EU level in 45%/36%, at national level 39%/47% and at regional level 11%/16% according to the asked citizens, respectively. It means that the Slovenian citizens showed more preference for CAP than the EU average. According to the results, the EU needs to help farmers to change the way of work, in order to fight climate change (82% of EU and 91% of Slovenian citizens have this opinion. The questionnaire of priorities and performances of CAP showed that 59% of EU and 72% of Slovenian citizens expect that the CAP is ensuring that agricultural products are good quality, healthy and safe, 41% vs. just 33% ensuring that CAP needs to support a fair standard of living for farmers, respectively. The fact is that in EU and Slovenia citizens have the same opinion that CAP fulfils 32% living standard for farmers under low protection of family farms (47%, 58%) and rather well just 29% vs. 33% according to EU vs. Slovene opinion, respectively. The public opinion favours the CAP policy to support farmers until today and for the next 10 years. 43% Slovenians support the increase of financial support for farmers and 39% agreed with no change in this support, but 11% mentioned that financial support needs to decrease in the future. According to the global crises it is understandable. The fact is that EU agricultural budget represents about 40% of the total EU budget. 48% of EU and 57% of Slovenian citizens agreed that this proportion is adequate, 17% vs. 14% that is too high. The budget is sufficient for 20% of EU and Slovenian citizens.

## **Conclusions**

An overview of Slovenian situation, experiences and expectations in agriculture after acceptance of the European Common agricultural policy shows that:

- (i) In Slovenia CAP plays an important role for financing direct measures for agricultural activities (Axis 1) and decreasing negative environmental impacts (Axis 2), improving the farmers economical situation and living standard.
- (ii) Agri-environmental measures, with the support of 73 mio. € in the period 2007-2009, enable better adaptation to nature protection.
- (iii) Public opinion supports CAP, with good understanding of gaps and benefits.
- (iv) Future of “green“ agriculture depends on initial ideas and development of organic farming, which is the real promoter and the mirror for other production systems, how to manage agriculture more sustainable. Their ecological intensification need to depends on simple and clear ecological oriented CAP, which will not support partly “green washing“ of conventional agriculture or “conventionalisation“ of organic farming.

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# Bio-energy and rural development: findings from a comparative study in Central, Eastern and Southern Europe

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## Abstract

Rising energy prices for fossil fuels, the unreliable supply of energy imports during the last winters and European Union (EU) policies have stimulated national awareness and political action on bio- and renewable energy (RE) among all European countries. In the agricultural policy discussion, RE has been advocated as a way to more rural prosperity. Among the new member states (NMS) of the EU, the share of RE is already slowly increasing. Yet, among the candidate and pre-candidate countries (CC/PCC) the discussion has just started. In both sub-regions an expansion of rape seed cultivation and, to a smaller extent, of the production of wood pellets could be observed. However, overall its impact on agricultural income and employment seems to be marginal up to now.

Key words: bio-energy, agricultural development, rural development, Central, Eastern and Southern Europe

## Introduction

Since early mankind, people have relied on bio- and renewable energy (RE) to facilitate life. People made use of wood and, later on, of wind and water. However in our days, the interest in RE started more seriously when the limits and environmental risks of fossil and nuclear energy became evident. RE was advertised, not only as a way out of the limitations of fossil and nuclear energy but also as a driver of rural prosperity, particularly for the European farmers.

In our analysis we follow the definition of EUROSTAT which defines RE as the sum of specific forms of energies, i.e. hydropower, wind energy, solar energy, biomass and wastes and geothermal energy. Biomass and wastes cover organic, non-fossil material of biological origin, which may be used for heat production, electricity generation and/or as a source of fuel. They comprise wood and wood waste, biogas, municipal solid waste and biofuels. Liquid biofuels mainly cover bioethanol (ethanol produced from biomass) and biodiesel (diesel produced from biomass or used fried oil). Hydropower covers potential and kinetic energy of water converted into electricity in hydroelectric plants (Eurostat, 2009a).

We will focus on the use and expansion of biomass production for bio-energy, particularly of its “modern” forms, i.e. wood pellets and briquettes, municipal solid waste, biogas and biofuels and its impact on agricultural and rural development in the region. The more “traditional” forms of bio-energy, i.e. the use of firewood although still of high importance, will be touched only briefly in this analysis.

### Role of RE and bio-energy in total energy supply

The use of RE in the various countries in total energy demand in 2007 varies quite a bit (Table 1). Among the NMS<sup>1</sup>, there are Malta and Cyprus with a very small share on the one side, and Latvia with more of one third of RE in total energy demand on the other. All the other countries rely on RE to some extent, for instance Bulgaria with a share of 4.9% and Estonia with 12.4%. Hence the reliance on fossil fuels and nuclear energy is quite high. With respect to CC/PCC<sup>2</sup>, the picture looks quite different. For three countries, namely Bosnia & Herzegovina, Montenegro and Albania the share of RE comes up to one fourth or, even, one third of total energy demand. With respect to the other five countries the share comes up to 8% and 11%. Subsequently, a first conclusion can be drawn: RE has a certain share in total energy demand, but in most countries it is not yet very important. In addition, RE is more important in the CC/PCC than in the NMS. When looking at former Yugoslavia, the share is again between 8% (Croatia) and 11% (Kosovo). Just Bosnia & Herzegovina and Montenegro show higher shares with about one third and one fourth, respectively.

**Table 1. Share of renewable energy in total energy demand (%), 2007**

	NMS	CC/PCC
important: > 10%	LVA (37.7), EST (12.4), ROM (11.8)	BIH (32.5), MON* (25.0), ALB (24.2), KOS (10.7)
somewhat: 5 - 10%	SVN (9.9), LTU (8.9), SVK (5.4), CZE (5.2), HUN (5.2), POL (5.1)	TUR (9.5), SER (8.3), MAC** (8.1), CRO (7.9),
modest: < 5%	BUL (4.9), CYP (2.4), MLT (0.2)	

Notes: \* 2006; \*\* 2005;

Source: EUROSTAT, 2009b and Country Reports, 2009

When looking at the share of bio-energy to total RE, i.e. “traditional” (fire wood) plus “modern” forms (wood pellets and briquettes, biogas and biofuels), it becomes evident that in most countries of the region this source is the most dominant one (Table 2). Particularly, among the NMS this source is very important. Only the small states of Malta and Cyprus cannot rely on bio-energy significantly due to climatic reasons. In these two countries, solar power has become the major source of RE. In the CC and PCC the use of bio-energy is important, but not that dominant as in the NMS. In most of these countries the most important alternative source of RE is (large-scale) hydropower. With respect to the states of former Yugoslavia, there is no clear picture. While bio-energy makes up about one fifth of total RE in Montenegro and Serbia, it is almost the only source of RE in Kosovo. The major reason seems to be the availability of (large-scale) hydropower which in general forms the only alternative form of RE among these countries.

**Table 2. Share of bio-energy of total supply of renewable energy (%), 2007**

	NMS	CC/PCC
very important: > 90%	EST (98.6), POL (94.9), LTU (94.2), CZE (91.9), HUN (91.7)	KOS (95.4)
important: 50 - 90%	LVA (86.7), BUL (71.5), ROM (70.4), SVN (61.3), SVK (59.8)	BIH (66.3), MAC* (54.3), TUR (52.3)
modest: < 50%	MLT (34.5), CYP (16.9)	CRO (49.8), ALB (44.9), SER (22.5), MON** (20.9)

Notes: \* 2005; \*\* 2006 Bio-energy comprises traditionally wood and the modern forms are wood pellets and briquettes, municipal solid waste, biogas and biofuels.

Source: EUROSTAT, 2009b and Country Reports, 2009

As discussed above, the “traditional” forms of biomass have been used as a source of bio-energy since early mankind. At this stage, we want to deduce ‘what is the share of “modern” forms of bio-energy to the total supply of bio-energy, i.e. the share of biofuel, biogas and municipal solid waste?’ Here, a sharp differentiation between the countries of the region can be made (Table 3). In some countries it takes up a relatively high share while in others it plays no role at all, so far. In a few states of Central and Eastern Europe (CEE), the production of “modern” forms of bio-energy has increased during the last years and has become relatively important. While Malta is a special case (here most used cooking oil is refined to biodiesel), some Central European states show shares amounting to 10% or more. However, these states are focusing on different

<sup>1</sup> The NMS comprise Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Hungary, Slovenia, Malta, Cyprus, Bulgaria and Romania.

<sup>2</sup> The CC comprise Croatia, Macedonia and Turkey. The PCC comprise Serbia, Bosnia & Herzegovina, Montenegro, Kosovo and Albania.

sources. Slovakia is focusing on biofuel, while the Czech Republic is diversifying its sources relatively equally on biofuel, municipal solid wastes and biogas. Hungary is predominantly making use of municipal solid wastes and Poland is focusing on biofuel and biogas, so far. Among the other NMS, only in Lithuania (biofuel) and Slovenia (biogas) the modern forms of bio-energy are of some marginal relevance. With respect to CC/PCC the “modern” forms of bio-energy are of no or just of a very modest relevance, so far. Just Serbia (biofuel), Croatia (biofuel and biogas) and, to a very small extent, Turkey have just started in producing these “modern” forms of bio-energy. All other CC/PCC are still in the planning phase in taking up the production of “modern” forms of bio-energy.

**Table 3. Share of “modern” forms to total supply of bio-energy (%), 2007**

	NMS	CC/PCC
important: > 8%	MLT (100), SVK (17.7), CZE (11.9), HUN (11.0), POL (8.6)	-
modest: 2.1- 8.0	LTU (4.5), SVN (3.6)	SER (3.1)
marginal: 0.1 - 2.0%	LVA (1.5), EST (0.8), ROM (0.6), BUL (0.3)	CRO (1.6), TUR (0.6)
not at all	CYP	MAC*, BIH, MON**, KOS, ALB

Notes: \* 2005; \*\* 2006 The “modern” forms of bio-energy comprise wood pellets and briquettes, municipal solid waste, biogas and biofuels.

Source: EUROSTAT (2009b) and Country Reports 2009

In conclusion, it can be stated that, at this stage, the “modern” forms of bio-energy in total national energy demand are still marginal. In a few countries, i.e. Slovakia, Czech Republic, Hungary and Latvia, they just meet about half a percent of total demand. In another group of countries the share of “modern” forms of bio-energy is between 0.2% and 0.4%, i.e. Lithuania, Poland, Slovenia and Malta. In the remaining countries which have taken up “modern” forms of bio-energy production, the share just comes up maximally to 0.1%, i.e. Estonia, Romania, Bulgaria, Serbia, Croatia and Turkey.

### **Impact of bio-energy production of agricultural and rural development I: Statistical data**

While, for the time being, the modern forms of bio-energy are still in the start-up phase, almost all countries are optimistic that this form of energy production will have a positive impact on agriculture and rural areas. In general, all reports emphasise that the potential employment and income effects of biomass production could be enlarged. It is difficult to assess statistically the size of area cultivated by energy crops as, in general, they can mostly be used for human consumption and as animal feed as well. However, concerning the cropping patterns not many changes could be observed up to now. Hence, we will rely on two proxy indicators:

(1) In many countries the area under rape seed cultivation has expanded rapidly during the last years (Table 4). While rape seed is also used in human consumption, we understand this rapid expansion also as an (indirect) indicator for the growing importance of bio-energy among farmers. While other crops are also used for bio-energy production, e.g. cereals including maize and sunflower, the area under cultivation with respect to these crops did not change much during the last years. Hence, these crops seem not to influence bio-energy production substantially up to now. The expansion in the cultivation of rape seed is seen by most farmers as a new source of income. Among the NMS, rape seed production also seemed to have been encouraged by the subsidies for energy crops under the EU. Among CC/PCC the increase of rape seed cultivation is not that impressive as in NMS. If there is limited national demand, rape seeds are, in general, exported to neighbouring countries, e.g. by Estonia. Also among the states of former Yugoslavia, rape seed production is just starting to be enlarged. But the increase of the share of rape seeds in the crop rotation brings also a couple of repercussions to the farmers which have partly contradictory effects:

- improvement of crop rotation leading to an increase of the yields of cereals (Latvia, Slovenia),
- reduction of fertilizer applications (Latvia) while others claim an increase in fertilizer and pesticides needs (Slovenia),
- decrease by fixed machine costs due to better utilisation (Latvia). However, rape seed cultivation requires special technical know-how and special machines, hence specific additional investments, and
- reduction of soil erosion during winter season (Slovenia).

Table 4. Change of rape seed area under cultivation, 2000 - 2007 (ha)

	2000	2007
NMS		
Lithuania	0	124,800
Latvia	6,900	99,200
Estonia	28,800	73,600
Poland	437,000	797,000
Czech Republic	325,000	338,000
Slovakia	n.a.	153,831
Hungary	121,838	223,579
Slovenia	122	5,358
Bulgaria	9,500	54,000
Romania	68,000	87,700*
CC/PCC		
Croatia	10,000	13,000
Turkey	82	10,700
Serbia	6,300	12,900
Bosnia & Herzegovina	0	1,578

Note: n.a. = not available; \* 2005; MLT, CYP, MAC, MON, KOS, ALB: no energy crops

Source: Country Reports 2009

There are just a few figures about the share of area under energy crops. Four reports provide national figures; i.e. in Lithuania, Latvia and Czech Republic their share comes up to about 5% and in Slovakia to about 3.3%. In six countries no energy crops are grown at all yet; besides Malta and Cyprus these are Macedonia, Montenegro, Kosovo and Albania.

(2) The rising demand on bio-energy has not only first implications on agricultural production and cropping patterns, but also on the use of wood. However, when looking in more detail at modern forms of wood energy production and use, the information available is even more scarce. Some information about the production of wood pellets and briquettes as modern forms of wood energy is available. This is summarised in Table 5. A few countries reported that there is no pellet or briquette production from wood and wood waste. The major reasons seem to be that either there is no wood available (e.g. Malta), or no investments in this source of bio-energy had been made due to high initial costs, so far (e.g. Bulgaria, Romania, Montenegro, Kosovo and Albania). In a number of country reports no information has been given, hence it is not known whether there is any pellet/briquette production at all. Just Macedonia and Serbia report that pellet production had been taken up recently, but no figures had been given.

Only a few countries provided some figures. But they show that pellet and briquette production are rapidly increasing. Particularly, entrepreneurs in the Baltic States and some Central European countries are investing in this source of bio-energy. However, when producing wood pellets/briquettes, it does not necessarily mean that these “modern” forms of bio-energy are used in the respective countries. Particularly, the Baltic States as well as Croatia and Serbia report that almost the whole production is exported. Bosnia & Herzegovina exports about one third of the national production. In this way, it can be concluded that “modern” forms of wood energy start playing a more prominent role in the analysed countries, but this source of bio-energy is not predominantly used in domestic markets, but is seen as an attractive export product. Due to the limited data availability, it is impossible to estimate the share of this “modern” form of wood energy in total wood energy demand of the respective countries.

Although biomass production for bio-energy is still in its infant shoes, all NMS but also more and more CC and PCC are setting RE targets which require higher production volumes of biogas and biofuel. However, more or less all country reports emphasise a severe social repercussion: While in almost all countries of the region small scale farming predominates, rape seed production is, in general, taken up by larger farms (agricultural holdings) only. But also the reports on Bosnia & Herzegovina and Kosovo where no energy crops are grown for the time being, stress the fact that energy crop production might be a potential source of income for large farmers only. A certain minimum size for cultivating these crops (in terms of area and economic size) seems to be necessary. As small scale farmers in the region are reluctant to organise themselves in order to increase economies of scale and their bargaining power, they are also not acceptable as input providers by (potential) biogas and biofuel producers. The country reports just mention two cases that tried to overcome this disadvantage: (1) In Latvia one cooperative was established in 2000 promoting rape seed production. It is also investing in a biodiesel production plant which became operational in 2009. (2) In

Croatia, a rape seed producer association has been established, recently. However, in both cases no more information has been provided. Similarly, in many countries of the region large shares of forestry land is owned by farmers and other private individuals. Their plots, in general, are quite small. Hence, it is doubtful that many of them can provide enough wood for pellet and briquette production in an economically viable manner.

At this stage, it can be concluded that, although the data availability is quite limited, the expansion of bio-energy production had a very modest impact on the agricultural and forestry sectors. The only measurable change is the expansion of the cultivated area under rape seed and the expansion of wood pellet and briquette production. The area under other (potential) energy crops did not change much during the last years. Similarly, in many countries the area under fast growing trees has been expanded but from a very low level and statistical data had not been available.

**Table 5. Change in the production of wood pellets/briquettes in NMS and CC/PCC, 2000 - 2007 (tons)**

	2000	2007
NMS		
Lithuania	270,000	547,000
Latvia	287,000*	461,000
Estonia		377,000**
Poland	20,000***	350,000
Czech Republic	20,900*	102,000
Slovakia		68,000
CC/PCC		
Croatia	≤2,000	41,000
Bosnia & Herzegovina	3,200*	22,000
Macedonia		just started
Serbia		just started

Note: \* 2005, \*\* 2006, \*\*\* 2003; HUN, SVN, CYP, TUR: no information; MLT, BUL, ROM, MON, KOS, ALB: no production  
Source: Country Reports 2009

### **Impact of bio-energy production of agricultural and rural development II: Experts' assessment**

The major arguments for promoting the expansion of bio-energy can be summarised as follows: it provides new sources of employment and income not only for the agricultural sector but for the rural areas in general. Since the statistical evidence is not available, we relied on experts' assessments in the respective countries. In each country up to ten national experts on RE were asked to assess the employment and income effects of bio-energy in their respective countries. These experts were randomly selected among scientists and administrators. However, while there had been a rough common outline of key questions, their statements presented below just provide a glance and are not representative, statistically. In the following, we will focus on two major dimensions: First it is looked at the impact on the agricultural and forestry sectors in specific and, second, on rural development in general.

In a first round, the national experts had been asked whether they would see any employment and income effect in agriculture and forestry with the expansion of biomass production for bio-energy. Their answers were summarised in the national reports on a Likert scale between 0 (not at all) up to 5 (very high). The national findings are summarised in Table 6. In general, the experts only anticipated a modest employment effect or no effect at all if bio-energy production is expanded in their respective countries. Concerning bio-energy as a potential source of income the experts, in general, are a bit more optimistic, particularly in Latvia, Serbia, Bosnia & Herzegovina and Turkey but these effects seem to be small and mostly concentrated on larger farms and forestry owners.



**Table 6. Assessment of the impact of bio-energy on employment and income in the agricultural and forestry sectors by national experts**

		High (4-5)	Somewhat (2-3)	None (0-1)
Employment	NMS		EST (3), HUN (3), SVN (3), POL (2), CZE (2)	LVA (1), MLT (1), CYP (1), BUL (1), ROM (1)
	CC/PCC	TUR (4)	SER (3), BIH (3)	CRO (0), ALB (0)
Income	NMS	LVA (4)	EST (3), CZE (3), SVN (3), ROM (3), CYP (2)	POL (1), HUN (1), MLT (1), BUL (1)
	CC/PCC	BIH (5), TUR (4); SER (4)		ALB (1), CRO (0)

Note: LIT, SVK, MAC, MON, KOS: no data

Source: Country Reports 2009

Besides an impact on the agricultural and forestry sectors in particular, the promotion and expansion of bio-energy production might have also an impact on the rural economy in general. Most of the newly established biomass processing plants are already or will be located in the rural areas, with the exception of municipal solid waste plants which might have good prospects in mostly urban areas. The country reports mention that there might be employment and income effects in building and servicing bio-energy processing plants in the rural areas. Again, the national experts had been asked how they assess the role of bio-energy in rural development and whether they anticipate employment and income effects in the rural areas if biomass production will be expanded in their respective countries. The findings are summarised in Table 7.

**Table 7. Assessment of the impact of bio-energy on rural development by national experts**

		High (4-5)	Somewhat (2-3)	None (0-1)
Employment (non-farm)	NMS	EST (5)	LVA (3), CZE (3), HUN (3), POL (2), SVN (2), MLT (2), CYP (2), BUL (2), ROM (2)	
	CC/PCC	TUR (4), BIH (4)	ALB (3), SER (2)	CRO (0)
Income (non-farm)	NMS	EST (5), ROM (4)	LVA (3), CYP (3), CZE (2), HUN (2), SVN (2), MLT (2), BUL (2)	
	CC/PCC	BIH (5), TUR (4), SER (4)	ALB (2)	CRO (0)

Note: LIT, SVK, MAC, MON, KOS: no data

Source: Country Reports 2009

According to experts' opinion, bio-energy plays a limited role in rural development, so far. They just see a limited employment and income potential within the rural areas. While experts in Estonia, Turkey, Bosnia & Herzegovina and, to some extent, in Serbia and Romania are quite optimistic, Croatian experts are extremely pessimistic. However, national reports are short of providing any rationale for their opinions. If at all, it is referred to national programmes, including Rural Development Programmes 2007-2013 where some financial support for the establishment of bio-energy plants is available. In this way, it can be concluded that some modest impact with respect to employment and income will be expected due to an expansion of bio-energy production, but the impact is very vague. Just in Slovakia and Bosnia & Herzegovina a first estimation with respect to employment effects has been conducted. In Slovakia, it is assumed if the broader RE-targets will be met by 2020, about 5,000-6,000 additional jobs will be created. In Bosnia & Herzegovina it is estimated if the country can use just half of its natural potential, about 5,000 new jobs will be created. But, in total, it is doubtful whether bio-energy production in specific or RE production in general will stop the rural-urban migration pattern observed all over the region.

Finally, based on the modest statistical data and the expert' assessments, it can be concluded that the cultivation of energy crops in general and of rape seed in particular does not, in general, create any employment and income effects for most (small scale) farmers in the region. If any, they will be modest and will reduce the outmigration rate of farmers. Income effects seem to be observed among larger-scale farmers. This is reflected by the observation that, if farmers engage in biomass production, these are the bigger ones.

## Conclusions

The promotion of RE and bio-energy has become a political top priority among almost all over Europe. At this stage, the supply of "modern" forms of bio-energy is still at its infancy. All EU member states, including NMS, have adopted national targets aiming at expanding the shares of RE. Some CC/PCC have started to do the same. These targets have to be met by 2010 and 2020, respectively. Since RE, at this stage of development,

is economically not competitive with fossil fuels, EU and most national governments in the region are prepared to provide financial incentives in promoting RE. Bio-energy makes up a significant share of total RE and a further expansion is envisaged. The expansion of RE in general and bio-energy in specific seems to depend on three major factors:

The economic potential, or financial resources, of the respective country is almost a precondition in promoting the production of bio-energy (i.e. for electricity, heat and/or fuel production) since they are not economically competitive, so far. Without state subsidies, the production would be in a pilot stage only and would play no role at all in meeting total energy demand. Due to co-financing a large part of that burden is taken over by the EU with respect to the NMS, but nevertheless a certain share has to be financed by national budgets and/or consumers. So the expansion of bio-energy production is restricted by the available financial resources. Otherwise, interested entrepreneurs are frightened off by the high initial investment costs and the not cost-covering market prices.

The natural conditions of the respective country favour one source of bio-energy over another one. Countries in Northern and Central Europe are more favoured in producing biomass than countries in Southern Europe due to more favourable precipitation patterns. Besides annual crops they can make use wood and wood products on a larger scale than the dryer and hotter regions in Southern Europe. In this way, we conclude that while a mix of various sources of bio-energy production might be desirable, regions will ultimately specialise in those sources which are best adjusted to the respective natural conditions.

Finally, social repercussions of bio-energy production become evident in most countries of the region. Most of them are dominated by small-scale farming and small scale forestry ownership. In order to produce needed biomass for processing a certain minimum size seems to be a pre-requisite. Hence, most farmers and forestry owners cannot participate in this new type of farm and forestry activity. A way out might be a better organisation of interested small-scale producers in self-help groups or cooperatives, but most farmers of the region are still reluctant in joining these types of organisation. In this way, most country reports conclude that the employment and income effects of an expansion of bio-energy production among the agricultural and forestry sectors as well as in rural regions in general will be very modest.

### Recommendations

All country reports acknowledge the fact that RE and bio-energy production is and will remain an important political issue for the years to come. In general, the need of expanding RE is accepted by the respective societies. Concerning a future expansion of RE and bio-energy production, the following recommendations can be deduced.

It is no surprise that the call for more financial resources has been listed at first stage in most country reports. More financial support is needed for meeting the RE targets in time (adopted by almost all countries of the region), i.e. the construction of bio-energy processing plants and their integration into existing energy systems.

While some financial support seems to be available in most countries analysed, almost all country reports emphasise the need to “make more” out of it. On the one side, there is a lack of a consistent and long-term oriented policy which is supposed to give strong guidelines to potential investors. On the other side, many reports complain about the high administrative barriers and “red tape” that potential investors face if they want to go into energy production. Various ministries and administrative levels are involved when deciding on licences and financial support. This procedure should be streamlined and simplified for potential investors.

In general, the debate about RE in general and bio-energy in specific is restricted to experts and insiders. Public participation is weak. In many reports it is demanded that the general public should be better involved and public knowledge about energy and RE in general and bio-energy in specific should be increased.

A number of reports complain that there is no clear link between public support in expanding RE, including bio-energy, and the need to achieve competitiveness over time. In general, RE as such is already seen as a good development. What is missed is an exit strategy once RE pays for itself without public support anymore.

As discussed above small scale farmers and forestry owners have just a limited option in participating in bio-energy production. There is a need that a higher share of farmers and forestry owners will participate in bio-energy production in the future. This can only be accomplished if these groups are better organised.

There is a need in better and more reliable data about the use of the respective sources of RE. While at national level information is already sketchy, it is often missing at regional and household levels.

### **Note**

This paper is based on 20 country reports which have been prepared in 2009. They form part of the results of the project “Enlargement Network for Agricultural Policy Analysis” which was financially supported by the European Community under the 7th Framework Programme. All reports are available at [www.agripolicy.net](http://www.agripolicy.net). The views expressed in this paper are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission.

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sa2011\_0004

# The sugar beet: new uses as a energy crop

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## History

In 1747, the German chemist A. S. Marggraf (1709-1782) announced his discovery of sugar in fodder beets (*B. v. ssp. v. convar. vulgaris* var. *crassa*). His student Franz K. Achard (1753-1821) devised in 1801 an economical industrial method to extract the sugar in its pure form. At the same time the sugar beet was developed through selection of beets with higher sugar content. The sugar content was increased from 8% to 18 - 20% today.

## Taxonomy

The beet (*Beta vulgaris*) is a plant in the *Chenopodiaceae* family. It is best known in its numerous cultivated varieties. Two subspecies are typically recognised. All cultivated varieties fall into the subspecies *Beta vulgaris* subsp. *vulgaris*, while *Beta vulgaris* subsp. *maritima*, commonly known as the sea beet, is the wild ancestor of these, and is found throughout the Mediterranean, the Atlantic coast of Europe, the Near East and India.

Group *B. v. ssp. vulgaris* convar. *vulgaris* (roots beets) contains all beets grown for their thickened root rather than their leaves.

## Economic importance

### Sugar and energy

Today sugar beet is grown on approximately 5 million ha worldwide, it provides 30% of the world sugar production. In the last five years sugar beet was detected as a source for biofuel production: today in the EU 27 more than 110.000 ha are planted especially for the bioethanol industry, mainly in France and Germany.

### Biogas

In the last 10 years in Germany a decentralised network of biogasplants was installed. Today about 6.800 plants with an installed capacity of >2.6 MW are producing biogas, which is either converted in electricity or directly (after the removal of CO<sub>2</sub>) fed into the existing gas grid. Biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, plant material and energy crops. This type of biogas comprises primarily methane (60%) and carbon dioxide.

In Germany 600.000 ha (3% of arable land) is used for the production of energy crops, mainly silage maize. In Germany a premium for the produced electricity is granted only, if you plant crops only for the purpose of energy production. The forecasted further increase of the maize area started some political discussion in Germany, whether it is desirable to increase the acreage planted with biogas maize. A lot of owners and operators of biogas plants are also looking for other energy crops in order to spread the risk.

Lately, sugar beet is also used in biogas plants. The biggest advantage of sugar beet is its high content of the disaccharid saccharose, which ferments very fast in the biogas plant.

This table shows the advantages and disadvantages of different crops in regard to possibles use in biogas plants (table 1.).

Table 1. Advantages and disadvantages of different crops in regard to possible use in biogas plants

Energy crop (entire plant)	Mass formation potential	Energy output of entire plant	Conversion time and efficiency	Cost in whole fermentation process
Maize	+++	++	-+	+
Sorghum bicolor	+++	++	-+	+
Silaged cereals	+	++	+	+
Sugar beet	+++	+++	++++	++

(Source: own research, KWS 2008)

The biggest advantage of sugar beet is its optimal use of installed m<sup>3</sup> of biogas plants which is very intensive capital.

The main problem with sugar beet is the storage in order to secure the supply of biogas plants all around the year. Several systems like mixed silages (maize and beets in layers), whole beets ensilaged in vacuum plastic tubes or mashed beets in open lagoons are tested successfully. Removal of stones and clay is done satisfactorily with beet washers or beet mashers.

It is estimated, that in the EU 27 in five years up to 100.000 ha will be planted with sugarbeets to be used solely for biogas production.

After the beets have been proven to be a good substrate for fermenters of biogas plants, the question came up, whether the classical sugar beets are the right choice for this purpose.

### Breeding of bioenergy beets

Some five years ago the beet breeding department of KWS decided to start a breeding programme in order to breed beets especially designed for the use as a fermentation substrate in biogas plants. In the classical sugar beet breeding the quality of the juice is very important and thus a limiting factor. But in the fermenter of a biogas plant the beet quality is of no importance. The most important goal is the maximum production of dry matter/ha (table 2.).

Table 2. Comparison of breeding goal sugar beet and energy beet

Sugar beet	Energy beet
Breeding parameters	Breeding parameters
- White sugar yield	- Dry matter yield
- Sugar content	- Dry matter content
- Standard losses to molasses	- Methane and biogas yield
- Root yield	- Soil tare
Use	Use
- Sugar production	- Exclusively for the production of biogas
- Ethanol production	
- Industrial beet	
- (Biogas)	

Using different genetic resources from the *B. v. ssp. vulgaris* convar. *vulgaris* (root beet) family energy beets were developed and tested in official trials. Already in the first generation the energy beets could produce 1.4 t/ha or 6.5% more dry matter yield / ha than a sugar beet variety (figure 1.). They also showed a great advantage if compared to a fodder beet.

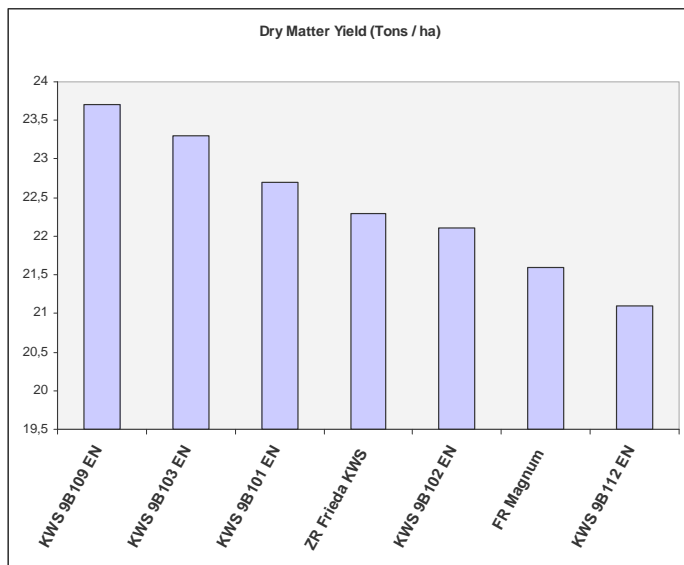


Figure 1. Dry matter yield (t/ha) of sugar beet variety

### Conclusions

The production of renewable energy in the world, based on biomass, will become more important in the future. Considering the needs to produce food and energy crops on a limited worldwide acreage, crops with a high output/ha will be more in the focus in the future. Sugar beet has already proven its suitability for the bioethanol industry and the last years it became even more important for the biogas production. Consequently, KWS has set up a breeding programme especially for energy beets which already showed the first generation of energy beets with a great yield increase regarding dry matter content compared to classical sugar beet.

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# Značajke međusobnog utjecaja kanala Dunav-Sava i poljoprivrede na agroekosustave

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## Sažetak

U radu su prikazani samo neki od dobivenih višegodišnjih (2002.-2006.) pokazatelja, koji ukazuju na mogući uzajamni utjecaj budućeg Višenamjenskog kanala Dunav-Sava (VKDS-a) i poljoprivredne proizvodnje na agroekosustave unutar istraživanog Pilot područja, koje zauzima ukupnu površinu od oko 7000 ha. Temeljem navedenog, za razdoblje istraživanja (2002.-2006.) data je sažeta analiza utjecaja klimatskih prilika, posebice oborina i srednjih temperatura zraka na bilancu vode zastupljenih poljoprivrednih tala.

Na temelju kontinuiranog praćenja dinamike podzemnih voda, dat je prikaz postojećeg vodnog režima poljoprivrednih tala unutar područja istraživanja u "nultom" stanju (stanje prije izgradnje VKDS-a) i njegove pogodnosti za uzgoj poljoprivrednih kultura.

Uporabom matematičkog modela, analiziran je mogući utjecaj VKDS-a na promjenu vodnog režima tala nakon njegove izgradnje. S aspekta mogućeg onečišćenja voda iz pravca poljoprivrede, analizirana je sadašnja poljoprivredna proizvodnja, u prvom redu ispiranje dušika i fosfora te kakvoća površinskih i podzemnih voda. U radu je sažeto prikazan i prijedlog mjera zaštite u pravcu sprječavanja mogućeg negativnog utjecaja VKDS-a i poljoprivrede na agroekosustave istraživanog područja.

Ključne riječi: utjecaj, Kanal Dunav-Sava, poljoprivreda, vodni režim tla, kakvoća voda

## Joint impact of the Danube-Sava canal and agriculture upon the existing agroecosystems

### Abstract

The paper presents only some of the multi-year (2002-2006) indicators that point to the potential joint impact of the future Multifunctional Danube-Sava Canal (MDSC) and agricultural production upon the agroecosystems within the studied pilot area of about 7000 ha. In this respect, a concise analysis is given for the investigation period (2002-2006) of the impact of weather conditions, particularly precipitation and mean air temperatures, upon the water balance of the present agricultural soils.

Based on permanent monitoring of groundwater dynamics, a survey is given of the current water regime of agricultural soils in the studied area in "zero" state (state prior to MDSC construction) and its suitability for field crop production.

Using a mathematical model, potential influence was analyzed of MDSC on changes in soil water regime after its construction. From the aspect of potential water contamination by agriculture, the current agricultural production was analyzed, primarily nitrogen and phosphorus leaching and the quality of surface and groundwater. The paper also provides suggestions for protective measures aimed at prevention of possible adverse impacts of MDSC and agriculture on the agroecosystems of the studied area.

Key words: impact, Danube-Sava Canal, agriculture, soil water regime, water quality

## Uvod

Od Rimskog carstva do današnjeg doba promišlja se i traži kraći put kojim bi se kanalom povezoao Dunav sa Savom. Od osamostaljenja Hrvatske osvježava se zamisao o Kanalu, da bi Vlada RH 1991. godine donijela "Odluku o pripremama za gradnju višenamjenskog kanala Dunav-Sava". Državna uprava za zaštitu okoliša 1999. godine donosi Rješenje u kojemu je ocijenjeno da su predviđeni zahvati vezani za izgradnju kanala prihvatljivi za okoliš, uz primjenu odgovarajućih mjera zaštite okoliša i provedbu programa praćenja stanja u okolišu. U okviru provedbe cjelovitog Programa, Agronomski fakultet Sveučilišta u Zagrebu (AFZ), zavod za melioracije je 2002. godine započeo sa stacionarnim istraživanjima u okviru Projekta: "Vodni režim i stanje tala na području (Pilot područje) donjeg toka Višenamjenskog kanala Dunav Sava - s monitoringom". U ovom radu su sažeto prikazani neki od dobivenih rezultata istraživanja za petogodišnje razdoblje 2002.-2006. godine. Ukupna površina šireg slivnog područja budućeg Višenamjenskog kanala Dunav-Sava (u daljnjem tekstu VKDS-a) iznosi oko 250.000 ha od čega poljoprivredno zemljište čini oko 174.000 ha. S obzirom na bogatstvo tala (zemljišta) kao glavnog prirodnog resursa i poljoprivreda je najznačajnija sastavnica gospodarstva na prostoru budućeg VKDS-a. Temeljna obilježja poljoprivrednih gospodarstava na ovom prostoru su da su ona miješana, dakle ratarsko-stočarska, s intenzivnim ratarenjem i intenzivnim uzgojem blaga (Petošić et al. 2006). Treba naglasiti da visoka razina gospodarenja na većem dijelu ovog područja povlači za sobom i veću potrošnju mineralnih i organskih gnojiva. Prema podacima Mesića i sur. (2002), Vukovarsko-srijemska županija, koja ujedno površinski i najviše participira u razmatranom slivnom području VKDS-a, po potrošnji mineralnih gnojiva po jedinici poljoprivredne površine sa 476 kg/ha vodeća je u Hrvatskoj. Neprijeporno je da će budući kanal Dunav-Sava imati snažan utjecaj na prirodne resurse i poljoprivredne ekološke sustave na cijeloj dužini trase. Razumljivo je stoga da moguće promjene agroekoloških uvjeta za uzgoj poljoprivrednog bilja zbog izgradnje kanala treba predviđati i, koliko god je to moguće, održavati pod nadzorom, kako bi se prije svega izbjegli negativni, a osnažili pozitivni utjecaji koji se tom izgradnjom ostvaruju.

## Materijali i metode istraživanja

Istraživanje u ovom radu je obavljeno na užem slivnom području (Pilot području) budućeg višenamjenskog kanala Dunav - Sava (VKDS-a), koje obuhvaća poljoprivrednu površinu od 6600 ha. U geografskom pogledu područje istraživanja se nalazi u Biđ polju na prijelazu između Brodsko-posavske i Vukovarsko-srijemske županije. Istraživano područje je smješteno uz neposrednu trasu budućeg kanala na dionici od 46+500 do 57+500 km, odnosno na potezu naselja Kladavac, B. Greda, Gundinci i Sikirevci. Analiza potrebnih klimatskih pokazatelja za 29 godišnje razdoblje, izvršena je za šire područje sliva VKDS-a. Za uže područje (oko 7000 ha) izvršena je analiza istih elemenata u razdoblju istraživanja od 2000. do 2006., odnosno 2009. godine. U oba slučaja analizirani su podaci s najbliže meteorološke postaje (Gradište kod Županje). Metodom po Thorntweitu izrađen je proračun bilanciranja vode. Napravljena su (2000. godine) i detaljna pedološka istraživanja s izradom pedološke karte u mjerilu 1:10000 za poljoprivredno područje u neposrednoj zoni kanala, na površini od 9 155 ha. Monitoring dinamike podzemnih voda na području od 6 600 ha s težištem na kolebanje njene razine u profilu do 4,0 m dubine vršen je kontinuiranim opažanjem putem hidropedoloških piezometara. Za tu svrhu ugrađeno je ukupno 80 hidropedoloških piezometara, 40 dubokih do 4,0 m dubine i 40 plitkih do 1,0 m dubine. Pored hidropedoloških piezometara, razina podzemne vode na tri lokacije praćena je i pomoću automatskih limnigrafa (tip Orphimedes). Praćenje je rađeno kontinuirano svaki dan u razdoblju od 1.1.2002. do 31.06. 2006. godine. Piezometri i limnigrafi su bili postavljeni u četiri trase (Profila), okomito na uzdužnu os VKDS-a. Raspored piezometara (udaljenost od uzdužne osi kanala) na svim trasama odnosno poprečnim Profilima postavljen je prema shemi: 200, 500, 1000, 1500 i 2500 m s obje strane kanala. Iz numeričkih podataka o razini podzemne vode u piezometrima formirani su za razdoblje od 01.06.2001. do 01.06.2006. godine osnovni i dekadni nizovi hidroloških veličina na kojima je napravljena matematičko-statistička obrada, koristeći statistički računalni program SPSS for Windows. Modeliranje toka podzemnih voda u neposrednoj blizini VKDS-a te njegov utjecaj na njihovu dinamiku izrađeno je uz pomoć programa VS2DTI Ver.1.2 koji je izrađen u *US Geological survey*. Kakvoća podzemnih voda u pokrovnom (talnom) dijelu profila do 4,0 m dubine praćena je na ukupno 40 lokacija, odnosno na svim dubokim hidropedološkim piezometrima. Uzorkovanje vode iz piezometara izvršeno je svakih 60 dana ili 6 puta godišnje, odnosno 30 puta tijekom razdoblja 2002-2006. godine. U svim uzorcima vode analizirani su slijedeći pokazatelji: nitrati, fosfati i teški metali: bakar (Cu), cink (Zn), kadmij (Cd), olovo (Pb), željezo (Fe), mangan (Mn) i nikal (Ni). Kakvoća procjednih voda vršena je posredstvom



lizimetara. Za potrebe ovih istraživanja ugrađeno je 10 lizimetara (tzv. Ebermayerovog tipa) na ukupno 5 lokacija. Uzorkovanje i analiza procjedne vode (perkolata) tijekom 2002-2006. godine, izvršena je za svako kišno razdoblje koje je polučio minimalnu količinu procijeđene vode. Ukupno je tijekom istraživnog razdoblja analizirano 592 uzorka perkolata. Praćenje poljoprivredne proizvodnje u petogodišnjem razdoblju od 2002-2006. godine vršeno je na ukupno pet lokacija. Proizvodnja je praćena na proizvodnim površinama obiteljskih gospodarstava (OPG) iz Gundinaca i Babine Grede. Sve laboratorijske analize (tla i vode) izvršene su na Agronomskom fakultetu Zagreb, prema standardnim analitičkim metodama.

## Rezultati istraživanja

### Utjecaj klimatskih prilika na bilancu vode

Prema višegodišnjem prosjeku (1981 - 2009) na ovom području padne 682 mm oborina, srednja godišnja temperatura zraka iznosi 11,6 °C, a relativna vlaga 74% (tablica 1).

U prosjeku najviše oborina padne u mjesecu lipnju 81,4 mm, a najmanje u veljači 34,4 mm. Srednja mjesečna temperatura zraka u prosjeku je najveća u srpnju 21,9 °C, a najmanja u siječnju 0,5 °C. U mjesecu prosincu srednja mjesečna relativna vlaga zraka je najveća 85%, a u travnju najmanja 66%. U analiziranom razdoblju, maksimalna mjesečna količina oborina pala je u lipnju 216,8 mm (2001), a najmanja u listopadu 0,2 mm (1995).

Vremenske prilike tijekom razdoblja istraživanja (2001-2009) vrlo zorno karakterizira klimadijagram prema Walteru (grafikon 1). Razvidno je da se sušna razdoblja u prosjeku javljaju tijekom ljetnih mjeseci (VI, VII, VIII), a humidna tijekom jesensko-zimsko-proljetnog dijela godine.

U tablici 2 prikazan je proračun bilance vode u prosječnom tlu (višak i manjak), za razdoblje 2000-2009 (prosjek), te 2003 (sušnu) i 2004 (humidnu) godinu.

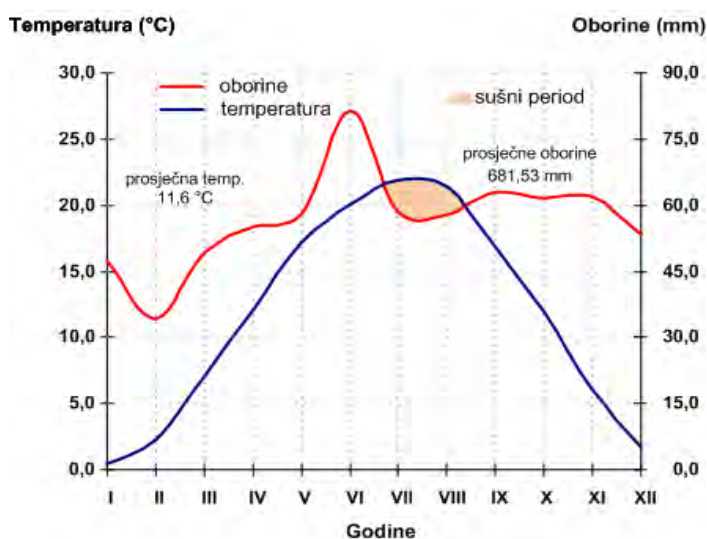
Tijekom prošlog desetgodišnjeg razdoblja (2000-2009) prosječna godišnja vrijednost viška vode u tlu na području istraživanja iznosila je 179,2 mm, a manjka 214,1 mm. Najveći višak vode u tlu valja u prosjeku očekivati u hladnijem dijelu godine. Tijekom humidnih godina (2004) valja računati sa znatno većim godišnjim vrijednostima viška vode 320,0 mm. Prosječna godišnja vrijednost manjka vode u navedenom razdoblju iznosila je 214,1 mm. U izrazito sušnoj 2003 godini, godišnja vrijednost je bila znatno veća i iznosila je 315,7 mm. Manjak vode u tlu kao što je razvidno u prosječnoj godini javlja se tijekom ljetnog razdoblja od mjeseca svibnja do rujna.

Tablica 1. Temeljni pokazatelji klimatskih prilika tijekom 29-godišnjeg prosjeka, (1981-2009)

Sred. mjes. i god. vrijednosti	Mjeseci												Godišnja vrijednost
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Oborine, mm	47,1	34,4	49,1	54,9	58,1	81,4	58,6	58,0	63,1	61,6	61,8	53,5	681,5
Temp. zraka, °C	0,5	2,3	7,0	12,0	17,2	20,1	21,9	21,4	16,8	11,9	6,1	1,8	11,6
Rel. vl. zraka,%	83	76	69	66	67	70	68	70	75	78	82	85	74

Tablica 2. Proračun viška i manjka vode u tlu prema metodi Thornthwaite-a

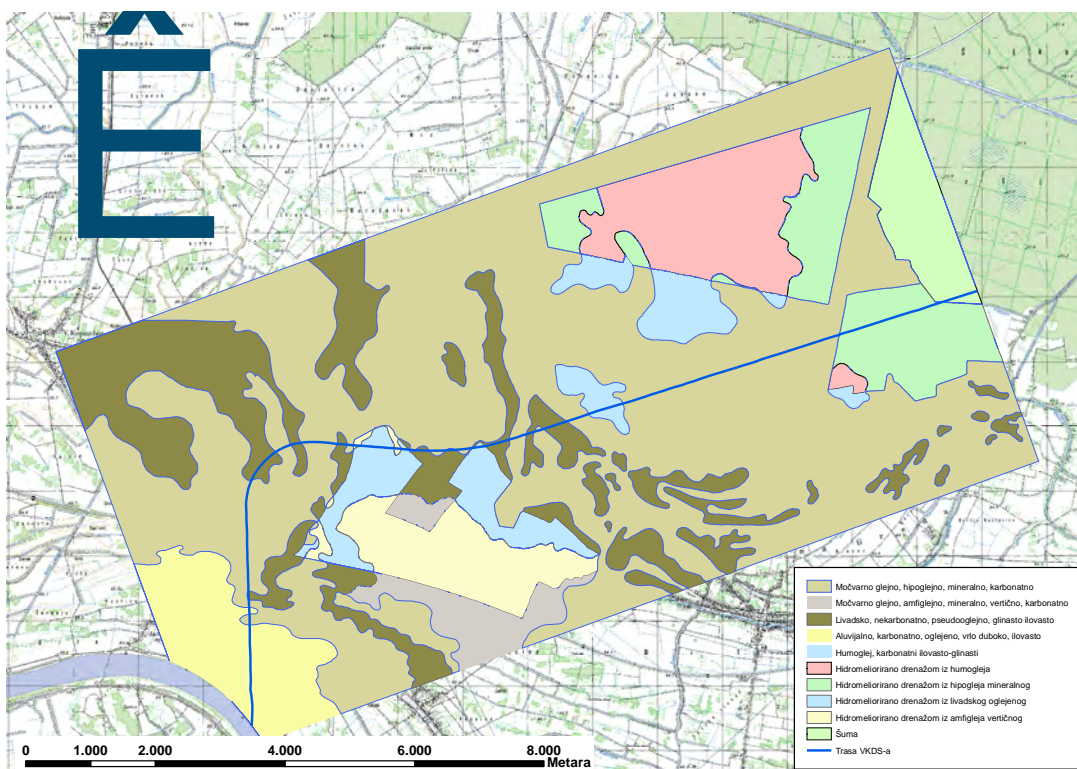
Balanca vode, mm	Razdo blje	Mjeseci												Godišnja vrijednost
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Višak vode	2000-09	48,3	27,3	25,2	18,3	2,4	4,3	0,0	0,0	3,2	3,1	21,4	25,7	179,2
	2003	58,2	7,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,8	12,3	87,0
	2004	75,6	55,3	9,6	95,8	23,6	0,0	0,0	0,0	0,0	0,0	19,2	40,9	320,0
Manjak vode	2000-09	0,0	0,0	0,0	0,0	2,7	31,5	76,7	71,3	22,8	8,6	0,5	0,0	214,1
	2003	0,0	0,0	0,0	0,0	18,9	78,5	97,4	89,2	31,7	0,0	0,0	0,0	315,7
	2004	0,0	0,0	0,0	0,0	0,0	0,0	14,3	19,0	30,6	0,0	0,0	0,0	63,9



Grafikon 1.  
Klimadijagram po Walteru za područje Gradišta (1981.-2009.)

### Pedološke značajke istraživanog Pilot područja

Na temelju detaljnih terenskih i laboratorijskih pedoloških istraživanja, a uvažavajući postojeću klasifikaciju tala (Škorić i sur., 1985), na širem istraživanom području od 9155 ha je determinirano ukupno devet pedosistematskih jedinica. Zastupljenost i Prostorni raspored izdvojenih pedosistematskih jedinica prikazan je na slici 1. Analize fizikalno - kemijskih značajki istraživanih tala prikazani su u prilogu studije “Vodni režim i stanje tala na području donjeg toka kanala Dunav - Sava, s monitoringom” (Petošić i sur., 2002). Valja naglasiti da je dominantno tlo hipoglej mineralni karbonatni, koji zauzima 4826 ha ili 52,6% od ukupno (9155 ha) istraživanog područja. Hidromeliorirano tlo otvorenim kanalima i cijevnom drenažom zauzima 1824 ha ili oko 20% istraživanog područja.



Slika 1. Pedološka karta Pilot područja istraživanja (9155 ha)

### Dinamika podzemnih voda

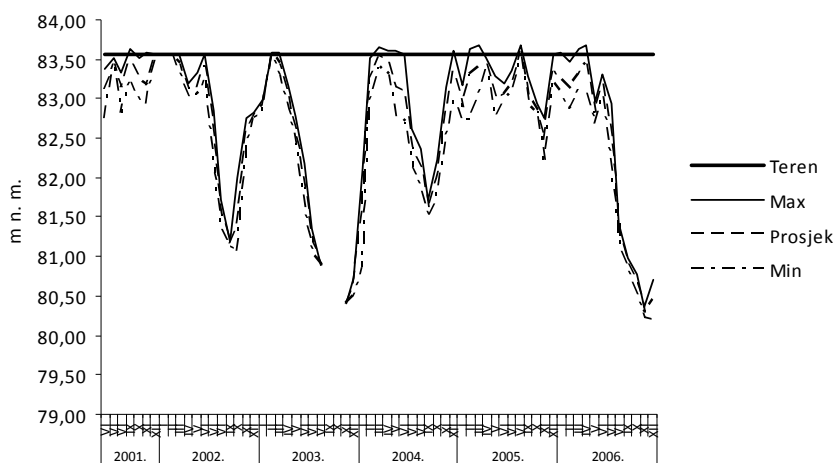
Temeljem višegodišnjeg monitoringa (2001-2006) razine podzemne vode na istraživanom području potvrđeni su sljedeći načini vlaženja poljoprivrednih tala: semiglejni, hipoglejni, humoglejni, amfoglejni i hidromeliorirani. Radi ilustracije na grafikonu 2 prikazan je nivogram hidropedološkog piezometra br. 24 koji potvrđuje hipoglejni način vlaženja tla.

Na osnovi relevantnih pokazatelja, dobivenih višegodišnjim monitoringom razine podzemne vode, izrađene su karte područja s prikazom njene dubine u odnosu na površinu terena (hidroizohipsama). Radi ilustracije na slici 2 daje se prikaz područja tijekom maksimalnih razina podzemne vode.

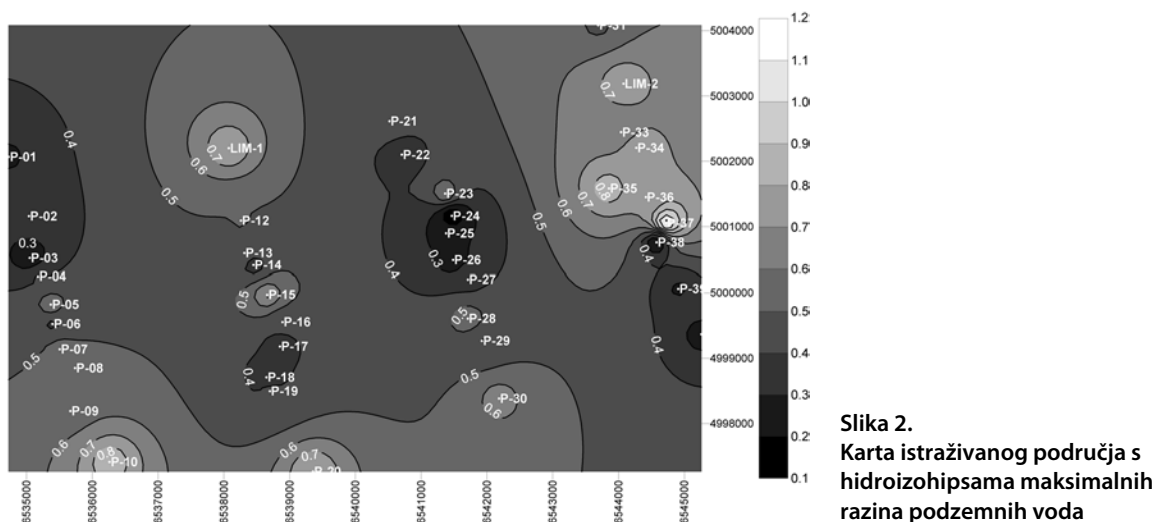
Valja naglasiti da je tijekom razdoblja istraživanja (2002-2006) utvrđeno godišnje kolebanje razine podzemne vode koje pokazuje izraženu pravilnost po sezonama. Slične rezultate u dolini Save, dobili su Pušić i Škorić (1965), te Dolanjski i sur. (1999).

### Pogodnost vodnog režima za uzgoj poljoprivrednih kultura ("nulto" stanje) prije izgradnje kanala

Poznavanje vodnog režima osmatranih poljoprivrednih tala na području istraživanja prije izgradnje kanala, vrlo je bitno s aspekta sadašnjeg, ali i budućeg razvoja biljne poljoprivredne proizvodnje, koja će se odvijati u uvjetima nakon njegove izgradnje. Temeljne značajke vodnog režima poljoprivrednih tala u "nultom" stanju s procjenom pogodnosti za uzgoj zastupljenih poljoprivrednih kultura prikazane su u tablici 3 i na slici 3.



Grafikon 2. Nivogram piezometra 24 - hipoglejni način vlaženja tla

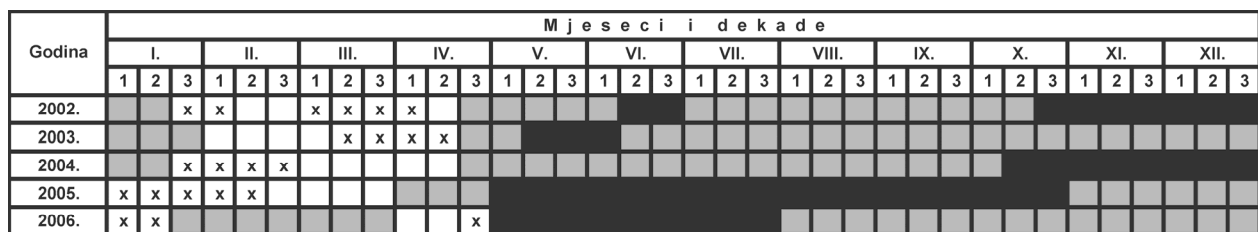


Slika 2. Karta istraživanog područja s hidroizohipsama maksimalnih razina podzemnih voda

Tablica 3. Osnovne značajke vodnog režima poljoprivrednih tala na osmatranom području VKDS-a tijekom razdoblja 2002.-2009. godine (prosječne vrijednosti)

Podjela (kategorija) podzemne vode	Dubina od pov. terena m	Duljina trajanja		Pov. područja		Stupanj pogodnosti za uzgoj kultura
		dan	vrem. razd.	ha	%	
vrlo plitka	< 0,2	30	15.02.-01.03. 25.03.-10.04.	737	10,2	vrlo nepogodan
plitka	0,2-0,5	50	21.01.-15.02. 01.03.-25.03.	4641	64,2	nepogodan
srednje duboka	0,5-1,0	65	01.01.-25.01. 10.04.-20.05.	1594	22,0	osrednje pogodan
duboka	1,0-2,0	105	20.05.-25.06. 20.10.-31.12.	3988	55,2	pogodan
vrlo duboka	> 2,0	120	25.06.-20.10.	6368	88,0	osrednje pogodan

Izdvojene kategorije vode, bile su u određenom razdoblju prisutne na dijelu površine osmatranog područja kako slijedi: vrlo nepogodan vodni režim na 737 ha ili 10,2% ukupne bruto površine (7.230 ha), nepogodan na 4.641 ha (64,2%), osrednje pogodan pod utjecajem srednje dubokih voda na 1.594 ha (22,0%) i vrlo dubokih voda na 6.368 ha (88,0%), te pogodan vodni režim na 3.488 ha ili 55,2% ukupnih površina.

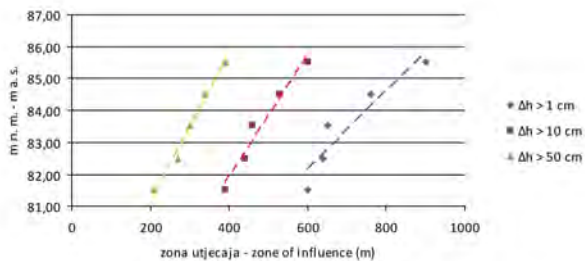


Legenda:  vrlo nepogodan     nepogodan     osrednje pogodan     pogodan

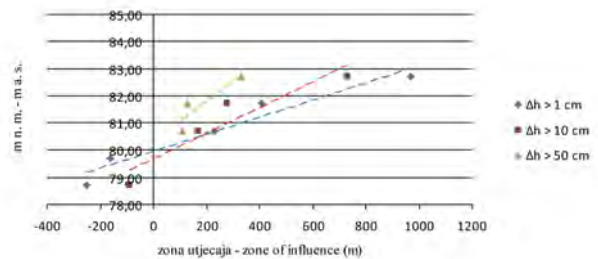
Slika 3. Pogodnost vodnog režima poljoprivrednih tala za uzgoj kultura na osmatranom području tijekom razdoblja 2002.-2006. godine

### Utjecaj budućeg Višenamjenskog kanala Dunav-Sava na vodni režim poljoprivrednih tala

Temeljni cilj istraživanja u ovom dijelu rada bila je procjena mogućeg utjecaja budućeg Višenamjenskog kanala Dunav-Sava (VKDS) na dinamiku podzemnih voda poljoprivrednih tala, koja se prostiru u njegovom neposrednom zaobalju. Procjena se temelji na matematičkom modelu, pri čemu je općenito usvojena hipoteza da će utjecaj budućeg kanala Dunav-Sava na dinamiku podzemne vode u tlu ovisiti prvenstveno o geološkoj strukturi slojeva u kojima će kanal biti usječen, razini vode u samom kanalu, kao i razini podzemne vode u navedenim slojevima. Potvrđeno je da bi budući VKDS na lokacijama promatranih presjeka-Profila, u prosječnim klimatskim godinama, prvenstveno drenirao okolno zaobalno područje. Na lokaciji profila IV, kanal bi pored drenirajuće, imao i ulogu prihranjivanja profila poljoprivrednih tala putem infiltracije vode iz njegovog korita (grafikoni 3 i 4).



Grafikon 3. Zona utjecaja VKDS-a na razinu podzemne vode u tlu na Profilu I



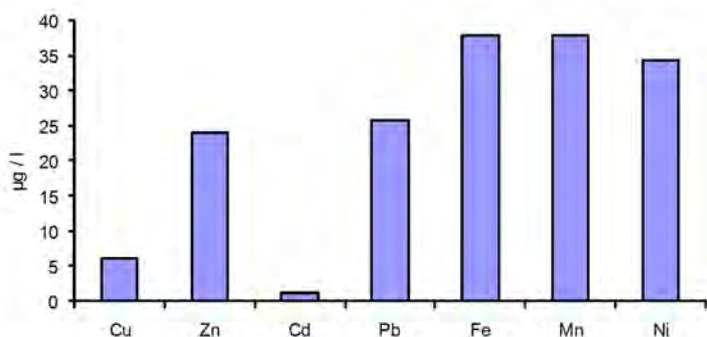
Grafikon 4. Zona utjecaja VKDS-a na razinu podzemne vode u tlu na Profilu IV

Značajke monitoringa kakvoće voda unutar područja kanala

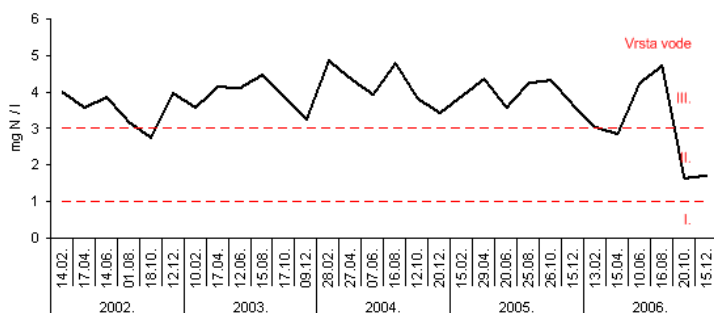
Zaštita tla a posebice voda (površinskih i podzemnih) aktualan je problem s poljoprivrednog i vodno-gospodarskog gledišta. Onečišćenje površinskih i podzemnih voda nitratima, fosfatima i teškim metalima sve je prisutnije i postaje problem lokalnog i nacionalnog značenja. Jedan od osnovnih ciljeva istraživanja je bio i praćenje kakvoće voda u neposrednoj zoni Kanala. Simboličan dio dobivenih rezultata koje prikazujemo u ovom radu su interpretirani u okviru postojećih propisa vezanih za kakvoću podzemnih i površinskih voda: Uredba o klasifikaciji voda, NN br. 77/98, Pravilnik o zdravstvenoj ispravnosti vode za piće, N.N. 182, 12. mjesec 2004. godine. Istraživanjima je utvrđeno da su srednje vrijednosti koncentracije teških metala u podzemnoj vodi na području donjeg toka VKDS-a u razdoblju 2001-2003. godine kod svih motrenih metala bile niže od maksimalno dozvoljenih koncentracija.

Valja naglasiti da je podzemna voda poljoprivrednih tala na području osmatranja prema utvrđenim srednjim vrijednostima ukupnog dušika tijekom razdoblja praćenja (2002.-2006.) odgovarala III vrsti (kategoriji) ekološke kakvoće vode (grafikon 6).

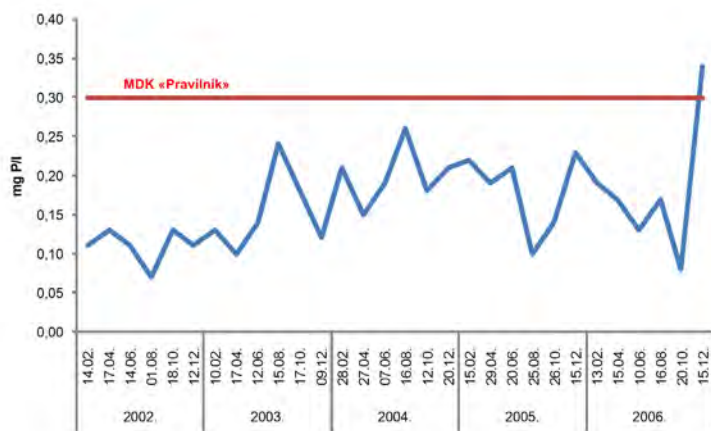
Utvrđeno je također da su srednje vrijednosti koncentracije fosfora (mg P/l) u podzemnoj vodi bile znatno niže od MDK, prema "Pravilniku" (0,30 mg P/l), grafikon 7.



Grafikon 5. Prosječne vrijednosti koncentracije teških metala u podzemnoj vodi na području donjeg toka VKDS-a, tijekom razdoblja 2001-2003 (piezometri 1-40)

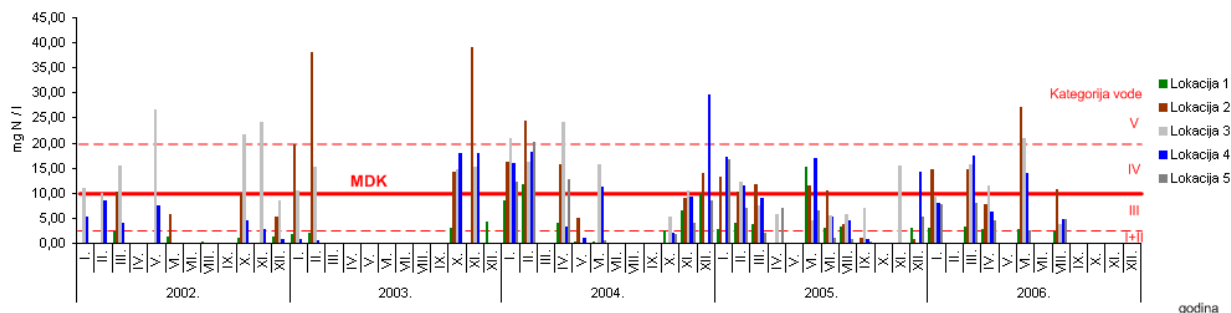


Grafikon 6. Srednje vrijednosti koncentracije ukupnog dušika (N) u podzemnoj vodi na području donjeg toka VKDS-a u osmatranom razdoblju 2002-2006 godine (piezometri 1-40)



Grafikon 7. Srednje vrijednosti koncentracije fosfora (P) u podzemnoj vodi na istraživanom području, razdoblje 2002.-2006. godine (piezometri 1-40)

Temeljem lizimetarskih istraživanja, utvrđeno je da su na svim osmatranim lokacijama tijekom razdoblja praćenja, srednje vrijednosti koncentracije  $\text{NH}_4\text{-N}$ ,  $\text{NO}_3\text{-N}$  i ukupnog dušika (N) u procjednoj vodi lizimetara (perkolatu) povremeno prelazile vrijednosti maksimalno dozvoljene koncentracije. Također je potvrđeno da je procjedna voda iz lizimetara (perkolat) na osmatranim lokacijama tijekom razdoblja praćenja (2002.-2006.) prema sadržaju i dinamici koncentracije ukupnog dušika kolebala u rasponu od I. do V. vrste (kategorije) ekološke kakvoće. Na većini lokacija voda je u najdužem razdoblju motrenja, kolebala u rasponu od II.-IV. vrste ekološke kakvoće (grafikon 8).



Grafikon 8. Srednje vrijednosti koncentracije ukupnog dušika (N) u procjednoj vodi lizimetara (perkolatu) po lokacijama motrenja u razdoblju 2002.-2006. godine

#### Utjecaj poljoprivredne proizvodnje na kakvoću voda

Poljoprivreda se svrstava prvenstveno u difuzne izvore onečišćenja voda. Posebice je osjetljivo pitanje o utjecaju poljoprivredne proizvodnje na onečišćenje voda u vodozaštitnim područjima crpilišta. Jedan od temeljnih ciljeva u ovom projektu je bio procijeniti utjecaj poljoprivredne proizvodnje na ispiranje dušika i fosfora, a time i na moguće onečišćenje površinskih i podzemnih voda, na području budućeg VKDS-a. Tako su godišnje količine dušika, koje su isprane procjednom vodom iz lizimetara (perkolatom) po lokacijama praćenja tijekom razdoblja 2002.-2006. kolebale od minimalnih 4,10 kg N/ha na lokaciji 1. pri uzgoju lucerne (2006. godine) do maksimalnih 38,30 kg N/ha na lokaciji 3., pri uzgoju kukuruza (2004. godine). Godišnje količine ispranog fosfora bile su u rasponu vrijednosti od minimalnih 0,16 kg P/ha na lokaciji 4. (2002. godine) do maksimalnih 2,28 kg P/ha na istoj lokaciji u 2006. godini, pri uzgoju kukuruza (tablica 4). Generalno se može zaključiti da su okopavinski usjevi (kukuruz) polučili znatno veća ispiranja kako dušika tako i fosfora, u odnosu na ostale uzgajane kulture, posebice krmne (lucerna i prirodna livada).

Tablica 4. Srednje godišnje vrijednosti ispiranja dušika i fosfora putem procjedne vode iz lizimetara (perkolata) po lokacijama tijekom osmatranog razdoblja (2001.-2006.)

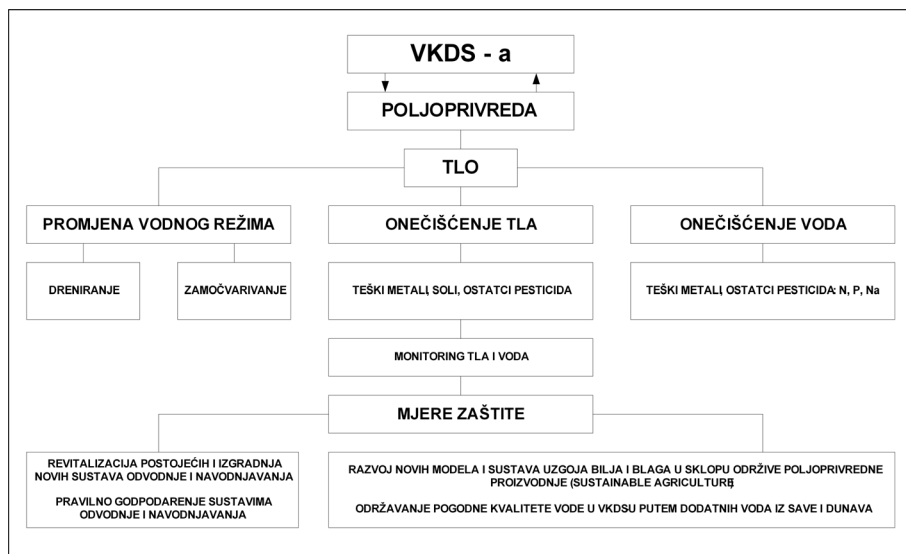
Oznaka lokacije	Uzgajane kulture	Gnojidba		Isprano iz tla (kg/ha)			
		kg/ha		N		P	
		N	P	kg	%	kg	%
1.	Lucerna	95	60	7,10	7,50	0,43	0,71
2.	Lucerna, kukuruz, pšenica, pšenica, kukuruz	170	80	22,20	13,00	0,76	0,95
3.	Kukuruz, stoč. ječam, kukuruz, ječam, kukuruz	195	95	24,70	12,70	0,69	0,72
4.	Prirodna livada, pšenica, pšenica, kukuruz	240	80	11,70	4,90	0,66	0,82
5.	Jari ječam, kukuruz, ozimi ječam	115	95	13,40	11,60	0,70	0,73
Srednjak		163	82	15,82	9,70	0,65	0,78

#### Mjere zaštite

U tablici 5. dat je shematski prikaz mogućeg obostranog (negativnog) utjecaja VKDS-a i poljoprivrede na tlo i vodni režim na istraživanom području, s potrebnim mjerama zaštite.

Vidljivo je da težište u mjerama zaštite valja usmjeriti u pravcu revitalizacije postojećih i izgradnje novih sustava odvodnje i navodnjavanja, kao i njihovom pravilnom (stručnom) gospodarenju te razvoju novih modela i sustava uzgoja bilja i blaga na poznatim principima održive poljoprivredne proizvodnje.

Tablica 5. Prikaz mogućeg obostranog (negativnog) utjecaja VKDS-a i poljoprivrede na tlo i vodni režim na istraživanom području s potrebnim mjerama zaštite



## Zaključci

Najveći dio istraživanog područja čini poljoprivredno zemljište s razvijenom tradicionalnom ratarsko-stočarskom proizvodnjom. Područje istraživanja nalazi se u prijelaznom klimatskom pojasu između semiaridne prema semihumidnoj klimi. Suma godišnjeg viška vode u tlu tijekom razdoblja istraživanja (2002.-2009.) iznosila je u rasponu vrijednosti od minimalnih 87 mm (2003.) do maksimalnih 320 mm (2004.), a manjka vode od 64 mm (2004.) do 316 mm (2003.). Na širem području istraživanja koje obuhvaća površinu od 9155 ha, zastupljeno je 9 pedosistematskih jedinica, a močvarno glejno hipoglejno tlo je dominiralo s 4826 ha ili 52,6%. Monitoringom vodnog režima poljoprivrednih tala potvrđeni su slijedeći osnovni načini (tipovi) vlaženja tla: semiglejno-pseudoglejni, hipoglejni, humoglejni, amfiglejni i hidromeliorirani.

Prema uzgoju zastupljenih kultura mogu se na području istraživanja izdvojiti četiri kategorije pogodnosti vodnog režima tla: vrlo nepogodan, nepogodan, osrednje pogodan i pogodan.

Utvrđena je drenirajuća zona utjecaja VKDS-a, u kojoj valja očekivati sniženje razine podzemne vode u tlu od minimalno 170 m do maksimalno 970 m (odnosno od 85 m do 485 m bočno na obje strane od uzdužne osi kanala). U uvjetima vrlo duboke razine podzemne vode u tlu (>3 m od površine terena), na Profilu IV (Babina Greda - Konjsko - Kladavac), VKDS bi prihranjivao vodom solum poljoprivrednih tala, putem infiltracije vode iz korita kanala.

Monitoringom kakvoće podzemne vode, utvrđeno je da su srednje vrijednosti koncentracije teških metala (Cu, Zn, Cd, Pb, Fe, Mn, i Ni) u podzemnoj vodi poljoprivrednih tala na području donjeg toka VKDS-a u razdoblju 2001-2003. godine kod svih metala bile niže od maksimalno dozvoljenih koncentracija. Potvrđeno je također, da su srednje vrijednosti koncentracije ukupnog dušika (mg N/l) u podzemnoj vodi tijekom razdoblja motrenja (2002-2006) bile znatno niže od MDK prema "Pravilniku" (11 mg N/l) i kolebale su u rasponu od 3,16 mg N/l (prosinac) do 4,27 mg N/l (kolovoz). Vrijednosti koncentracije fosfora u podzemnoj vodi na području istraživanog razdoblja 2002-2006 godine, bile su znatno niže od MDK (0,30 mg P/l). Na svim lokacijama praćenja tijekom osmatranog razdoblja, srednje vrijednosti koncentracije i ukupnog dušika (N), kao i fosfora u procjednoj vodi lizimetara (perkolatu) povremeno su bile veće od vrijednosti maksimalno dozvoljenih koncentracija (11 mg NO<sub>3</sub>-N/l i 0,30 mg P/l).

Prema dobivenim količinama ispranog dušika i fosfora općenito se može zaključiti da tradicionalna poljoprivredna proizvodnja na istraživanom području VKDS-a može predstavljati potencijalnu opasnost u pravcu jačeg onečišćenja podzemnih i površinskih voda s dušikom, a u znatno manjoj mjeri s fosforom.

Težište zaštite u cilju svođenja mogućeg obostranog negativnog utjecaja VKDS-a i poljoprivredne proizvodnje na vodni režim poljoprivrednih tala i kvalitetu površinskih i podzemnih voda, valja usmjeriti u

pravcu revitalizacije postojećih i izgradnju novih hidromelioracijskih sustava odvodnje i navodnjavanja, razvoju novih modela i sustava uzgoja bilja i blaga na načelima održive poljoprivredne proizvodnje te održavanju pogodne kvalitete vode u budućem Kanalu Dunav-Sava.

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# Evaluation of some tree species for heavy metal biomonitoring and pollution tolerance index in urban zone in Isfahan

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## Abstract

It is well established that trees help to reduce air pollution, and there is a growing impetus for green belt expansion in urban areas. For greenbelt development it is necessary to selected plants that tolerant to air pollution. In this study, the air pollution tolerance index (APTI) of plant species were evaluated with the help of analysis of some biochemical parameters.

Concentrations of Cu, Fe, Mn, Zn and biochemical parameters were determined in leaves. The results showed that *Morus alba*, *Fraxinus excesior*, *Cupressus sempervirens* and *Ligustrum ovalifolium* could be used as biomonitor species for these heavy metals especially for Fe, Zn and Cu .A comparison of the four plant species indicated that *M. alba* was the most tolerant plant to air pollution.

Key words: air pollution tolerance index (APTI), biomonitoring, heavy metals, biochemical parameters.

## Introduction

Currently, air pollution increased in the world. Manifold numbers of cars in urban areas, industrialization along with the expansion of cities, increasing demand of energy and rapid economic development have most effects in increasing air pollution (Oliva et al., 2007). Lack of enough knowledge about resistant and sensitive species to air pollution has caused the field studies to identify sensitive and resistant species to air pollution (Prajapati et al., 2008). Biomonitoring with plants is low-cost and valuable method to evaluating the effect of different air and environment pollutants (Oliva et al., 2007). Biological methods can replace with physical methods in the places that are limited to using to detect air pollution (Aksoy et al., 1997). Isfahan city in terms of establishment of air contaminant industrial units, special heavy traffic conditions, and geographical location is at air pollution risk. Thus, we aimed to (i) estimating concentration of heavy metals (Cu, Fe, Mn, Zn) in leaves of different plant species, (ii) identifying best species for absorbing heavy metals from the atmosphere, (iii) determining sensitive and tolerance of species to air pollution.

## Material and methods

In this study, four plant species were selected in Isfahan city. Leaves samples were collected in July 2009. Leaf samples were dried at 70°C to constant weight. Heavy metals were determined by dry ashing procedure (Peter et al., 2006). The APTI of different plant species were calculated by incorporating ascorbic acid content, leaf extract pH, total chlorophyll content and relative water content into the following mathematical expression((Joshi et al.,2007).

$$APTI = \frac{A(T + P) + R}{10}$$

Where, A = Ascorbic acid content of leaf (mgg<sup>-1</sup> of fresh weight)

T = Total chlorophyll of leaf (mgg<sup>-1</sup> of fresh weight);

P = pH of leaf extract

R = relative water content, in percentage.

With using amounts of APTI, plants were classified in three groups (Singh et al., 1983).

- APTI < 10 → sensitive
- 10 < APTI < 16 → mediocre
- APTI > 17 → resistant

All the data obtained were further analyzed by using one-way ANOVA

## Results and discussion

### a -Physiological characteristics of plants

Different plant species showed considerable variation in their response to air pollutants. The level of studied parameter in plants reduced to various extents depending on the pollution load and its impact on the sites (Tables 1 and 2). However, plants maintained a certain level of a parameter due to a balance between the injury caused by the pollutants and the homeostatic processes governing repair. The results of the physiological characteristics of the plant species are represented in table 1 and 2. There was not a significant difference between four site and four plant species in contents of the acid ascorbic, total chlorophyll, pH, relative water content and air pollution tolerance index. The acidity and relative water content in plant species had different significant at p<0.01. Based on the results, pH of leaf samples was between 5.4 to 6.8. The lowest and highest content was measured for cypress and mulberry, respectively. Higher pH is known to improve tolerance to air pollution, while lower pH showed good correlation with sensitivity to air pollution (Yan and Hui., 2007). Relative water content was between 67.7 to 83.8 percent. The highest content of relative water content in the mulberry and the lowest was measured in Cypress. The range of total chlorophyll content was between 7.8 to 9.23 mg g<sup>-1</sup>. The highest and lowest content of chlorophyll was measured in the leaves of mulberry and ash, respectively. Reduction of chlorophyll in plants could unfavorably affect the photosynthesis, growth and Productivity of plants (Yan and Hui., 2007). The range of acid ascorbic content was between 0.75 to 1.59 mgg<sup>-1</sup> and the highest was in Cypress and the lowest was in ash. Ascorbic acid, a natural antioxidant in plants has been shown to play an important role in pollution tolerance (Joshi et al .2007) .The range of the air pollution tolerance was between 8.3 to 9.91 whereas the highest and lowest was in mulberry and ash, respectively. Plants which have higher index value are tolerant to air pollution and can be used as sink to mitigate pollution, while plants having low index value show less tolerance and can be used to indicate levels of air pollution (Singh et al., 1983).

Table 1. Comparison of the means of physiological parameters in plant species and four different sites

Treatments	Mean				
	pH	Relative water content	Total chlorophyll	Ascorbic acid	Air pollution tolerance index
Azadi Square	5.368A	74.43A	8.91A	1.932A	10.29A
Bozorgmehr Square	5.097A	80.20A	8.55A	0.787A	9.13A
Laleh Square	5.069A	78.30A	8.23A	0.741	8.88A
Mellat Ave.	5.318A	73.97A	7.97A	0.854	8.56A
Morus alba	6.038A	83.85A	9.23A	0.952A	9.91A
Fraxinus excesior	5.628 B	72.98B	7.80A	0.757A	8.30A
Cupressus sempervirens	5.430 B	67.74B	7.94A	1.590A	8.89A
Ligustrum ovalifolium	5.536 B	82.32A	8.69A	1.015A	9.66A

Means in each Column having common Alphabets are not significant At 1% Level.

Table 2. Analysis of variance of physiological characteristics in plants species

S.O.V.	df	Mean				
		Ascorbic acid	Total chlorophyll	pH	Relative water content	Air pollution tolerance index
Site	3	1.305	.0681	0.023	36.567	0.654
species	3	0.513	0.899	1.712**	235.4**	1.805
Error	9	0.926	0.804	0.114	11.466	0.755
Total	15					

\*, \*\*, n.s : Significant at 5%, 1% levels of probability and no significant, respectively

#### b- Plant analysis

The average concentrations of heavy metals are represented in table 3 and 4. There were significant differences between four sites and four plant species in concentrations of Fe, Cu, Mn and Zn at  $p < 0.05$ . The maximum and minimum heavy metal concentrations were observed in the leaves of Cypress ( $340.8 \text{ mg kg}^{-1}$ ) and Prim ( $216.6 \text{ mg kg}^{-1}$ ), respectively. The Fe concentration in the leaves of studied species was higher than standard level ( $150 \text{ mg kg}^{-1}$ ) that has been reported by Markert (1993). Czarnowska and Milewska (2000) measured leaf Fe amounts between  $121\text{-}1056 \text{ } \mu\text{g g}^{-1} \text{Dw}$  using *Taraxacum officinale* in Warsaw Polonia related with the distance to the motorways. The range of Mn was measured in leaves of plant species  $52.1$  to  $95.3 \text{ mg kg}^{-1}$ . In the present study, the concentration of Mn was very low in comparison with standard level. Copper is a minor trace metal for the plants. As a result of measurements, a change of Cu was between  $7.8$  to  $14.5 \text{ mg kg}^{-1}$  which the highest concentration was in Prim and the lowest was measured in mulberry leaves. It is accepted that the normal limits of Cu concentrations in plants are in the range of  $4\text{-}15 \text{ } \mu\text{g g}^{-1} \text{Dw}$  (Allaway, 1968) and between  $20\text{-}100 \text{ } \mu\text{g g}^{-1} \text{Dw}$  are accepted as toxic values (Kabata-Pendias and Pendias, 2001). According to these values, the Cu concentrations in this study were within normal limits. Aksoy and Ozturk (1997) used *Nerium oleander* as a biomonitor in Antalya and found minimum and maximum limits as  $3.2\text{-}6.18 \text{ } \mu\text{g g}^{-1} \text{Dw}$  in unwashed and  $3\text{-}4.45 \text{ } \mu\text{g g}^{-1} \text{Dw}$  in washed leaves. Zinc is also one of the essential elements for plants. Plant limitation of this element in the tissue is  $20\text{-}100 \text{ mg kg}^{-1}$  (Kabata-Pendias and Pendias, 2001). In this study, the range of Zn in leaves of plant species was between  $26.1$  to  $59.2$ . Maximum and minimum concentration was measured in cypress and ash, respectively. The normal limits of Zn concentrations in plants are  $15 \text{ mg kg}^{-1}$  (Markert, 1993). High levels of Zn in plants may cause a loss of production, and the low levels may cause deformation of leaves. Zinc is not at harmful levels as a major threat to the environment in our study. This study supports the view ash, mulberry, Cyprus and Prim could be used as biomonitor for Fe, Zn and Cu metals, especially with its branches and leaves.

Table 3. Comparison of the means of metal concentrations in plant species and four different sites ( $\text{mg kg}^{-1}$ )

Treatments Zone	Mean			
	Fe	Zn	Cu	
Azadi Square	270.5 AB	50.74 A	11.86 AB	63.680A
Bozorgmehr Square	325.3 A	54.03 A	12.86 A	72.962A
Laleh Square	301.4 A	46.40 AB	13.78 A	85.575A
Mellat Ave.	223.5 B	24.68 B	7.65 B	51.605A
Morus alba	280.8 A	45.60 AB	7.80 B	52.190A
Fraxinus excesior	282.5 A	26.13 B	12.86 A	58.240A
Cupressus sempervirens	340.8 A	59.29 A	10.94 AB	95.317A
Ligustrum ovalifolium	216.6 B	44.81 AB	14.55 A	95.075A

Means in each Column having common Alphabets are not significant At 1% Level.

Table 4. Analysis of variation of metal concentrations in plant species

S.O.V.	df	Mean			
		Fe	Zn	Cu	Mn
Site	3	7731.103*	699.546*	29.293*	2788.442
species	3	10288.579*	741.585*	33.440*	2155.775
Error	9	1523.441	192.508	7.326	1316.432
Total	15				

\*, \*\*, n.s : Significant at 5%, 1% levels of probability and no significant, respectively

## Conclusions

The plant species collected at studied area exhibited different concentrations of metals and the Fe and Cu concentrations in studied plants exceeds the permissible limit, whereas, Zn and Mn concentrations were below the permissible limit. The plants with higher APTI value were found to be tolerant and also act as a biomonitor for air pollutants.

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# Impact of different cropping system and fertilization on water regime of agricultural soil

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## Abstract

Žitný Ostrov (the Rye Island) region is the largest reservoir of high-quality drinking water in Slovak Republic. The region is characterized by the intensive crop production, as well. Therefore, it is necessary to consider all possible ways of the water resources protection from the pollution with fertilizers, especially with nitrates.

One of the possible way how to reduce penetration of fertilizers to groundwater is also the systematic exploitation of different agriculture system of soil use in concrete area on regulate water regime of soil (cover-protection layer of groundwater).

A research which has been made from year 1991 to 2000) in the water protection zone in Borovce, district Piešťany, deals with influence of different factors on distribution of soil moisture in soil profile up to the depth 3 m. The factors are: two different crop rotations, biological (A1) and cereal (A2), two different fertilization variants, manure fertilization (B1) and straw fertilization +NPK (B2) and two different ways of soil cultivation, conventional cultivation (C1) and protective cultivation (C2).

Results of these experiments inter alia showed that the crop rotation had the highest influence on the soil profile moisture. On the other hand, the influence of examined fertilization variants on the change of moisture was the smallest.

From the point of view of groundwater protection on this specific area, the best combination of variants was A1B1C2 i.e. biological crop rotation fertilized by manure with using protective cultivation.

Key words: pollution, water resources, soil moisture, soil cultivation, fertilizers

## Introduction

The largest reservoirs of high-quality drinking ground water in Slovak republic are situated in the Žitný Ostrov (The Rye Island) region. In this paper are presented results for the period from 1991-2000. This region belongs to the Danubian lowland where the Quaternary deposit with thickness up to 350 m creates ideal conditions for water accumulation. Considering that this area is also the area with the most intensive crop production in our republic it is necessary to look for all available ways of protection of these water resources from the agricultural pollution (especially with nitrates) as well (e.g. restriction or limitation of same agricultural activities in this area .

We can say that if there is no water movement, there is no movement of water soluble substances and there is no water percolation to the ground water level and therefore there is no pollution of groundwater. The root zone of soil profile is the eligible zone of fertilizers movement. The lower zone which is situated under the root zone of soil profile is the zone of ineligible fertilizers movement which we can review forms the economical point of view and from the environmental point of view. We usually want that the amount of infiltration will be the same as the amount of precipitation, than the amount of deep percolation will be equal to zero etc. Under the irrigated conditions we can reach this relatively easy f.e. increasing or decreasing of watering, change the depth of irrigation or change application term etc. But in the natural conditions it is not possible to change some factors as precipitation therefore we cannot affect value of hydrolimit field capacity.

But in natural conditions we can affect intensity of infiltration, evapotranspiration and the depth of root zone. These characteristics are partly affect by f.e. selection of crops, way of cultivation and by amount and form of fertilizers. Because of these facts was made the following experiment.

### Material and methods

The experimental area on which was field experiment made is situated in water protection zone Borovce, district Piešťany (Antal, 2010). Experiment was established in 1990 and it has lasted for nowadays. In this paper are presented results for the period from 1991-2000. In mentioned experiments were examined also the influence of different factors and their combinations on allocation of soil moisture in soil profile deep trough 3,0 m. Between these factors belong different crops rotation i.e. biological crop rotation (A1) and cereal crop rotation (A2). The second group of factors is different way of fertilization. To this group belong manure fertilization (B1) and straw fertilization with addition NPK (B2). The last group of examined factors is different ways of soil cultivation i.e. conventional cultivation (C1) and protective cultivation (C2).

Table 1 showed changing of 6-years crop rotation on examined area in biological and cereal crop rotation as well.

Table1. Changing of crops in analyzed crop rotation (Antal, 2010)

Year	Crop rotation	
	Biological (A1)	Cereal (A2)
1	Winter wheat	Winter wheat
2	Sugar-beet	Spring barley
3	Spring barley	Pea
4	Corn silage	Winter wheat
5	Lucerne	Corn silage
6	Lucerne	Spring barley

From the figure 1 we can see the experiment variants on examined area.

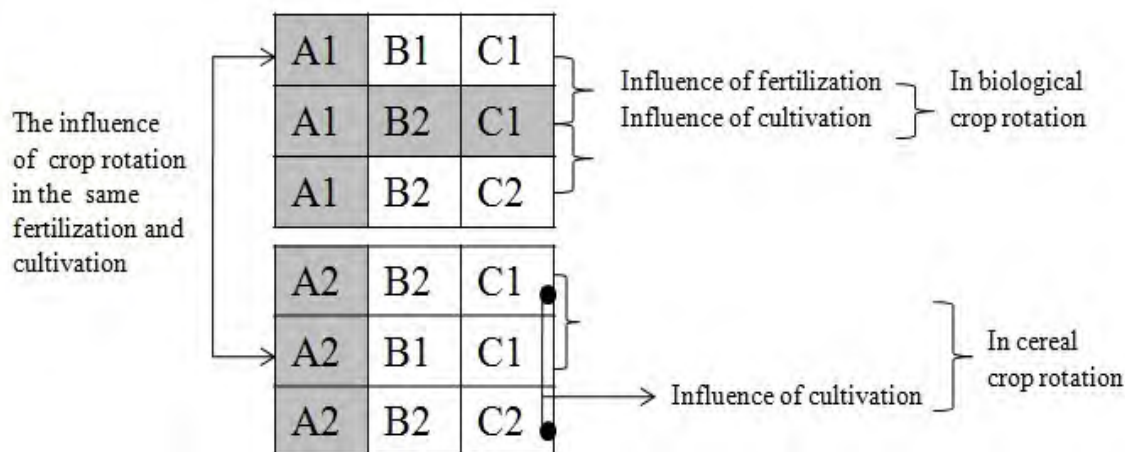


Figure 1. Variants of experiments (Antal, 2010)

The terms, when samples were collected are spring, summer and autumn and the concrete term of sample collection depended on the weather condition in each season. The soil samples were collected from soil profile in different depths namely in 5cm, 30cm, 60 cm, 100cm, 150 cm, 220cm and 300cm depth.

For further hydrological characteristics of the experimental area, we calculated the so-called CN-values and the average evapotranspiration for both analyzed crop rotation and precipitation as well, for the period 1991-2000.



## Result and discussion

The field experiments showed significant influence of mentioned factors and their variants on soil moisture in different depths of soil profile. The highest influence had the crop rotation on the experimental area. The second highest influence had the soil cultivation i.e. conventional and conservation tillage. The lowest influence on the allocation of soil moisture had the fertilization. The other detected influence was influence of different variants combination on soil moisture and also from the point of view of groundwater protection in soil profile in depth from 0,0m to 3,0m. The first reviewed variants group is crop rotation (biological (A1) and cereal (A2) crop rotation), where the influence of A2 variant was higher than A1 variant. From the figures 2 and 3 we can see the example of distribution of soil moisture in soil profile in spring and summer season for A1 and A2 variant.

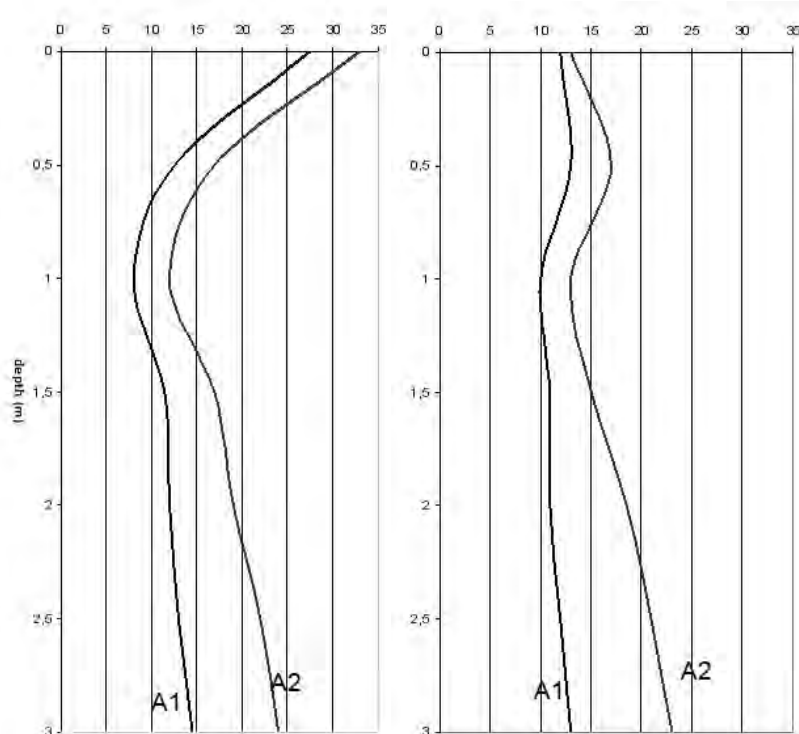


Figure 2 and 3.  
Distribution of soil moisture in soil profile for A1 and A2 variants in spring and summer

The ratio of these two different variants is vary in variable seasons i.e. in the spring time was the ratio 1,12 :1,0; in the summer time was the ration 1,27 :1,0 and in the autumn time was the ration 1,33 :1,0, so as we can see from these results the highest ratio was in the autumn time. In the case of C2 (protective cultivation) and C1 (conventional cultivation) variants higher influence had the C2 variant than the C1 variant. And the last group of examined factor was fertilization. In the case of biological crop rotation (A1) was the influence of both types of fertilization (manure fertilization and straw fertilization + NPK) same (B1=B2). But in the cereal crop rotation (A2) had higher influence B2 variant than B1 variant. From the figure 4 we can see the distribution of soil moisture for all examined combinations of factors.

Calculated CN values for both analyzed crop rotations ( $CN_{A1} = 69,3$  and  $CN_{A2} = 74,0$ ) indicate that the effect of crop rotations on the amount of infiltrated rainwater is small.

Another situation is the influence of crop rotations on the value of evapotranspiration. Biological crop rotation for the whole vegetation period has higher evapotranspiration in comparison with cereal crop rotation for about 12%. This was reflected in the second half of the year when evapotranspiration in biological crop rotation was 2,5 times higher than in cereal crop rotation.

In regard of that precipitation, temperature, wind, soil, etc. were the same in both crop rotations; they probably had no significant effect on soil water and soil moisture.

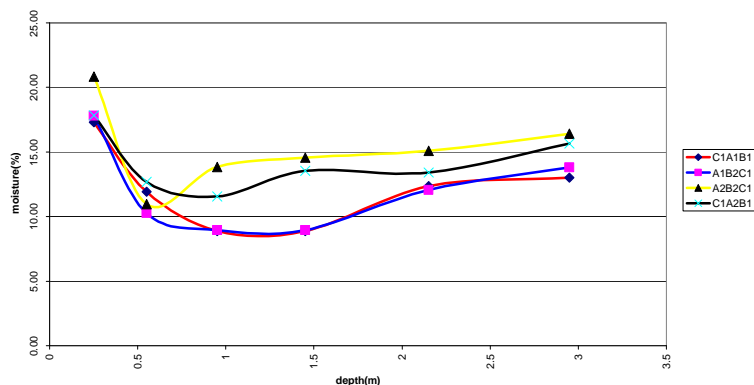


Figure 4. Distribution of soil moisture for all examined combinations of factors

### Conclusion

The field experiments on the water protection zone Borovce, district Piešťany showed that the different ways of crop rotation and soil cultivation are very significant and maybe the only one real way how to regulate the soil moisture in unregulated conditions, it means in areas without irrigation or without soil drainage.

The other important fact which resulted from this experiment is that the protective (conservative) cultivation significantly reduced and increased the infiltration especially in dry period and in pre-vegetation period of cultivated crop.

The crop rotation significantly affected the evapotranspiration i.e. the ratio between the evapotranspiration of biological crop rotation (A1) and cereal crop rotation (A2) is changing in different part of vegetation period. During the whole vegetation period has the ratio  $ET_{A1} : ET_{A2}$  the value 1,12. In the first half of vegetation period is the value of ratio 1,20 and in the second half of vegetation period is the value highest i.e. 2,50, so we can state the highest influence of the biological crop on evapotranspiration is significant especially in the 2<sup>nd</sup> half of vegetation period.

### Acknowledgements

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# Influence of different production systems on body mass and number of earthworms

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## Abstract

The present study examines how different production systems (i.e. control, organic, integrated, biodynamic and conventional) influence the body mass and number of earthworms in soil after harvesting cabbage, wheat and pumpkins. Experiments were conducted in October 2009 at the experiment fields of the Faculty of Agriculture and Life Sciences (FKBV) in Pivola. A mixture of 1/3 white mustard and 2/3 water, which is not harmful for earthworms, was used. Earthworms were divided by appearance into three groups (i.e. small, middle and large) and weighed (wet). The average population of earthworms was higher in the biodynamic (24.00) and organic (22.41) production systems than in the control, conventional and integrated systems. The average body mass of earthworms was the largest in the organic (22.25 g/0.25 m<sup>2</sup>) and biodynamic (18.83 g/0.25 m<sup>2</sup>) production systems. Earthworms reached the highest average body mass (1,440 kg/ha) after the growth of pumpkins.

Key words: earthworms, white mustard, production systems, body mass, number

## Introduction

Earthworms are a major component of soil fauna communities in most ecosystems and comprise a large proportion of macrofauna biomass. Numerous investigators, reviewed recently by Bhadauria and Gopal Saxena (2010), have pointed out the beneficial effects of earthworms on soil properties. As earthworms pass through the soil they eat, decompose and deposit the castings. Their activity is beneficial because it can enhance soil nutrient cycling through the rapid incorporation of detritus into mineral soils. In addition to this mixing effect, mucus production associated with water excretion in earthworm guts also enhances the activity of other beneficial soil microorganisms. Earthworms accelerate the mineralization as well as the turnover of soil organic matter. The increased transfer of organic C and N into soil aggregates indicates the potential for earthworms to facilitate soil organic matter stabilization and accumulation in agricultural systems. In addition to the significant enhancement of nutrients concentration (N, P, K and Ca, which are easily assimilable by plants in fresh cast depositions), the earthworm activity positively influences soil structure, gas dynamics and water flow in the soil (VandenBygaart et al., 2000). The population of earthworms in an agricultural field is influenced by the intensity and number of soil disturbance events (i.e. tillage and traffic), the abundance and quality of food sources (i.e. organic manure, crop rotation and cover crops), the chemical environment of the soil (i.e. pH, salinity and agrochemical inputs) and the soil microclimate. Agrochemical inputs such as heavy metals and many commonly applied pesticides are shown to have detrimental effects on earthworm communities and their activity (Lee, 1985; Edwards and Bohlen, 1992; Greigh-Smith et al., 1992).

The aim of the present study was to evaluate the influence of the examined production systems on earthworm population and its body mass, and to determine how the earthworm population varies across different crops in crop rotation.

## Materials and methods

The experiment was conducted in the frame of a long-term field trial at the University Agricultural Centre of the University of Maribor in Pivola near Hoče (46°28'N, 15°38'E, 282 m a.s.l), where four production systems (i.e. conventional (CON), integrated (INT), organic (ORG) and bio-dynamic (BD)) were arranged in a randomized complete block split-plot design with four replications (i.e. control plot, cabbage, wheat and pumpkins). The production systems differed mostly in plant protection and fertilization strategies and were defined by the valid legislation and standards, including a control plot (managed without fertilizers and plant protection application) and four production systems. Systems were managed in accordance with the following national and European rules and legislation: Good Agriculture Practice, Rules (MKGP, 2002; MKGP, 2004), Guidelines for integrated field crops (Džuban et al., 2009a) and vegetable production (Džuban et al., 2009b), EU regulation on organic farming (EC, 2007) and standards for biodynamic certification (Demeter International, 2009). Earthworm population and body mass were evaluated in October 2009 on plots where white cabbage, oil pumpkins and wheat were grown in crop rotation. Earthworms were collected using mustard aqueous solution, which was prepared by mixing 50 g of powdered white mustard and 100 g of water and then dissolving it in 13 L of water. The soil surface was cleared of weeds and litter, and a rectangular metal frame (50 x 50 cm) was pressed down into the soil (5 cm deep). Mustard solution was poured inside the frame, 20 minutes later the soil was dug to a depth of 10 cm and earthworms that emerged were collected. The mustard solution served as a non-toxic irritant that drove deep burrowing earthworm species to the surface (Lawrence and Bowers, 2002). Earthworms (ERW) were counted, divided into three groups (i.e. small, middle and large) and weighed. After measurements, earthworms were returned back to the soil. Differences in earthworm population and biomass among production systems and investigated crops were analysed using a two factor (system, crop) ANOVA for a randomized complete block design, followed by a Duncan test ( $\alpha = 0.05$ ). Analyses were carried out using the Statgraphic Centurion XV statistical program (Statgraphic®, 2005). Results are presented as mean of four replications  $\pm$  standard error of mean ( $\pm$ SEM).

## Results and discussion

Total earthworm population, total earthworm body mass and the populations of different earthworm groups as affected by production systems (PS) and crop species (C) are presented in Table 1. Studied production systems significantly influenced the population of small earthworms and thus the total earthworm population (Table 1). Both were demonstrated to be higher in the biodynamic and organic production systems than in control, conventional and integrated production systems. When compared to control plots, managed without fertilizers and plant protection agents, there were roughly 2.7 and 2.5 times more small earthworms in biodynamic (13.25/0.25 m<sup>2</sup>) and organic (12.30/0.25 m<sup>2</sup>) production systems, respectively. In the same manner the total earthworm population in the biodynamic production system was 207% and in the organic production system 193% of that counted in control treatments (11.58/0.25 m<sup>2</sup>). Similarly, the beneficial effect of organic farming on earthworms was emphasised by other investigations (Hansen et al., 2001; Vazquez et al., 2003; Riley et al., 2008; Irmeler, 2010). The abundance of earthworms as well as their total body mass was affected by plant species occurred in crop rotation (Table 1). The oil pumpkins revealed to have a beneficial effect on earthworms.

In comparison to white cabbage and wheat, the cropping of oil pumpkins favoured the populations of middle (6.26/0.25 m<sup>2</sup>) and large (6.73/0.25 m<sup>2</sup>) earthworms, and therefore the total earthworm population (21.95/0.25 m<sup>2</sup>) and their total body mass (26.78 g/0.25 m<sup>2</sup>). Lower earthworm population and especially lower abundance of earthworms in the large earthworm population, which were observed in wheat plots, might be attributed to tillage intensity. In the period between wheat harvest and soil sampling in October, the harrowing was performed on these plots. Small earthworms were favoured by white cabbage. Results are supported by Curry et al. (2002), who found a drastic decline of earthworm abundance by intensive cultivation. The abundance of 11.25/0.25 m<sup>2</sup> was higher, but statistically the same as in plots cropped by oil pumpkins (8.90/0.25 m<sup>2</sup>).

**Table 1. The influence of production systems (PS) and plant species in crop rotation (C) on total earthworm (ERW) population, total body mass of earthworms and the populations of different earthworm groups**

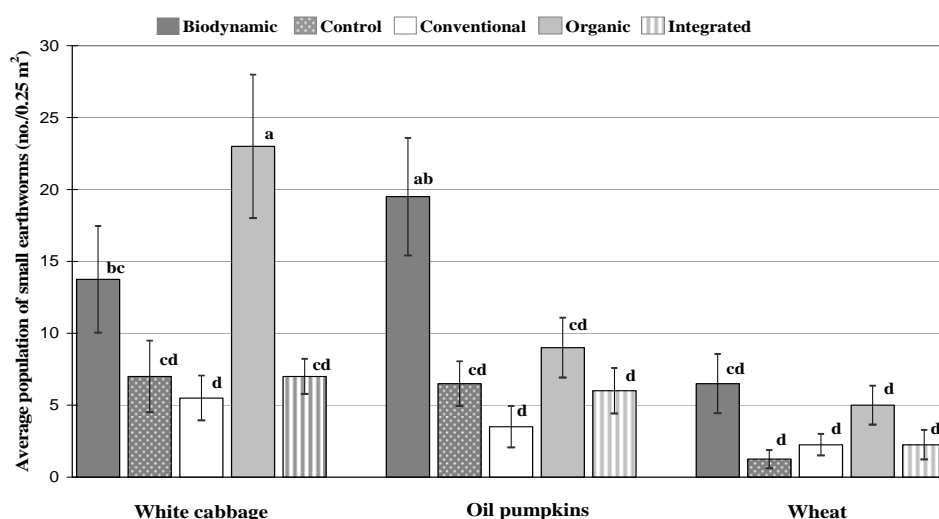
Treatment	Total ERW population (no./0.25m <sup>2</sup> )	Total ERW body mass (g/0.25m <sup>2</sup> )	Small ERW (no./0.25m <sup>2</sup> )	Middle ERW (no./0.25m <sup>2</sup> )	Large ERW (no./0.25m <sup>2</sup> )
PS	**	ns	**	ns	ns
C	**	*	**	**	*
PSxC	ns	ns	**	ns	ns
PS					
Biodynamic	24.00±3.63a	18.83±4.12	13.25±2.39a	6.00±1.07	5.00±1.13
Control	11.58±1.72b	14.00±2.50	4.92±1.20b	3.17±0.85	3.50±0.58
Conventional	11.25±1.24b	15.17±3.91	3.75±0.79b	3.67±0.70	3.83±0.96
Organic	22.41±3.01a	22.25±4.23	12.30±2.87a	4.58±0.95	5.50±1.23
Integrated	13.00±2.35b	13.17±5.00	5.08±0.92b	4.83±0.93	3.08±1.08
C					
Cabbage	15.50±2.22b	7.20±1.27c	11.25±1.95a	3.35±0.53b	0.90±0.23c
Oil pumpkins	21.95±2.65a	28.15±3.35a	8.90±1.60a	6.35±0.87a	6.70±0.76a
Wheat	12.05±1.26b	14.70±2.31b	3.45±0.68b	3.65±0.50b	4.95±0.61b

\*\* , \* significant at the 0.01 and 0.05 probability levels, respectively; ns - non significant

<sup>a-c</sup> mean values (± SEM) followed by different letters within a column and particular factor are significantly different (Duncan,  $\alpha=0.05$ )

There was also a significant production system and plant species interaction concerning the population of small earthworms (Table 1). Therefore, all pairwise comparisons of production systems are presented for the three plant species occurred in crop rotation (Figure 1). The beneficial effect of the organic production system was mainly attributed to the highest abundance of earthworms in plots where white cabbage was grown (23.0/0.25 m<sup>2</sup>) and the beneficial effect of biodynamic production to numerous small earthworms, identified in plots cropped by oil pumpkins (19.5/0.25 m<sup>2</sup>) and white cabbage (13.8/0.25 m<sup>2</sup>). Different production systems had no effect on the population of small earthworms, identified in plots where wheat was grown in 2009 (Figure 1).

To form a picture of how large is the mass proportion of earthworms in soil, the results obtained on sampled area were converted into values expressing the earthworm body mass per hectare (Table 2). On average, the earthworm mass achieved in soil after oil pumpkins was 1,126 kg/ha and the values derived from different production systems ranked as follows: integrated (527 kg/ha), control (560 kg/ha), conventional (606 kg/ha), biodynamic (753 kg/ha) and organic (890 kg/ha).


**Figure 1. Population of small earthworms (no./0.25 m<sup>2</sup>) as influenced by production system and plant species interaction.**

Mean values (± SEM) followed by different letters are significantly different (Duncan,  $\alpha=0.05$ )

**Table 2. Earthworm body mass (in kg ha<sup>-1</sup>) after cropping white cabbage, oil pumpkins and wheat produced in different systems**

Production system	Cabbage (kg ha <sup>-1</sup> )	Oil pumpkins (kg ha <sup>-1</sup> )	Wheat (kg ha <sup>-1</sup> )	Average (kg ha <sup>-1</sup> )	Index (%)
Biodynamic	240	1,440	580	753	134
Control	370	900	410	560	100
Conventional	110	800	910	606	108
Organic	550	1,380	740	890	159
Integrated	170	1,110	300	527	94
Average	288	1,126	588	667	
Index (%)	49	191	100		

## Conclusions

Although production systems investigated in a long-term study are a complex set of management factors applied over a range of years, it was found that the number of earthworms and their body mass were consistently varied by different production systems and by plant species occurred in crop rotation. Differences obtained by earthworm sampling in 2009 could mainly refer to the use of livestock manure (higher abundance in organic and biodynamic treatments) and less to applied pesticides (no differences between control, conventional and integrated production systems). The oil pumpkins in crop rotation seem to have a beneficial effect on earthworms, and small earthworms were favoured by white cabbage. Lower earthworm population and especially lower abundance of large earthworms revealed on plots after wheat may be attributed to tillage intensity.

## Acknowledgement

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# Yield and nutrient uptake of white cabbage affected by different intercrops

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## Abstract

Intercropping represents an important production method in organic farming, contributing to its sustainability and productivity. The present trial was conducted to determine the effects of different intercropping systems on yield and mineral content of cabbage (*Brassica oleracea* L. var. *capitata* f. *alba* DC) in organic farming. It was performed under the field conditions in 2008 and 2009. Cos lettuce, bush bean, celery, tomatoes, red beet and leek were used as intercrops. Results showed that significant effects of intercropping systems on yield, dry matter and the nutrition uptake of cabbage were present, although, the cabbage in pure stand in general demonstrated better results.

Key words: mixed cropping, organic farming, mineral content

## Introduction

Organic vegetable production is recognized as environmentally friendly production and is becoming more important also due to increasing demand among consumers. Good and quality yield performance often includes production systems providing stable agricultural conditions. Intercropping has been reported as the most suitable approach to provide the sustainability of vegetable production (Coolman and Hoyt, 1993), enhance yield and yield stability (Willey, 1979), increase resource use efficiency, especially of nitrogen (Jensen, 1996), reduce weed infestation (Hauggaard-Nielsen et al., 2001) and the occurrence of plant diseases and pests (Altieri, 1999). Cabbage is not a space efficient crop; however, it is a relatively long season crop, growing slowly at early growth stages, which opens an opportunity for other vegetables to be grown between the rows (Fukai and Trenbath, 1993). The advantages of vegetable intercropping, which could lead to better land use efficiency as an important component of organic farming, have been demonstrated by Guvenc and Yildirim (1999). Many other studies indicate that intercropping with different vegetables is more productive and profitable than sole cropping (Yildirim and Guvenc, 2005; Žuljan et al., 2008; Bavec et al., 2010). In addition, mixed stands have often more efficient mineral uptake and utilization compared to sole cropping (Wooley and Davis, 1991; Morris and Garrity, 1993). Despite literature cited in the present study, there is a lack of data on yield performance and nutrient uptake of mentioned vegetable mixtures in organic agriculture. The aim of this study is to investigate organic cabbage production in intercropping based on yields and nutrient uptake.

## Materials and methods

The present study was conducted under the field conditions at the University Agricultural Centre Pohorski Dvor in Pivola near Maribor, Slovenia, and managed according to organic farming rules (EC 834, 2007 and EC 889, 2008), in 2008 and 2009. The mean air temperature of the area in the growing period (May-September) was 18.6 °C in 2008 and 19.8 °C in 2009, while total rainfall in the same period amounted to 436 mm in 2008 and 809 in 2009. Soil chemical characteristics were in 2008 and 2009 as following: pH<sub>KCl</sub> 6.0 and 6.1, AL P<sub>2</sub>O<sub>5</sub> 23.1 and 29.5 mg 100 g<sup>-1</sup>soil, AL K<sub>2</sub>O 16.5 and 12.7 mg 100 g<sup>-1</sup>soil and N<sub>min</sub> 25.3 and 27.6 kg ha<sup>-1</sup>.

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The experiment was performed in thirteen treatments as randomized block design with four replications on district cambisol, each with basic plot size 4.5 x 3.6 m. Cabbage (*Brassica oleracea* L. var. *capitata* f. *alba* DC) as the main crop was intercropped with cos lettuce (*Lactuca sativa* L. var. *capitata* DC), bush bean (*Phaseolus vulgaris* L. var. *communis*), celery (*Apium graveolens* L.), tomatoes (*Lycopersicon esculentum* Mill.), red beet (*Beta vulgaris* L. ssp. *rubra* L.) and leek (*Allium porrum* L.). All crops were also grown in pure stands (not presented in this paper). Cabbage spacing in sole cropping as well as in intercropping was 75 x 60 cm. In intercropping treatments, plants were planted between cabbage rows with usually plant density. Cabbage, cos lettuce, tomatoes, leek and celery were transplanted on May 7 and 8, 2008 and May 12 and 13, 2009. Red beet and bush bean were field-seeded on the same time. Fertilisation was preformed equally for all treatments in both years, according to the recommendations for integrated cabbage production ( $N_{\min}$  target value 240 kg N ha<sup>-1</sup>, 65 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 280 kg K<sub>2</sub>O ha<sup>-1</sup>). The applied fertilizers were oil pumpkin cakes (9.6% N, 0.21% CaO, 0.5% P<sub>2</sub>O<sub>5</sub> and 0.82% MgO), potassium salt (40% K<sub>2</sub>O) and crude phosphate (32% P<sub>2</sub>O<sub>5</sub>). Weeds were controlled manually in both years. The tested crops were harvested when they reached marketable size and quality and cabbage heads were placed in nylon mesh bags and stored in optimal conditions until analyses took place. After harvest, cabbage head weight and yield were measured, with all the measurements made by taking 10 plants from the centre of each plot. Nitrate was extracted from the fresh cabbage sample with H<sub>2</sub>O and determined spectrophotometrically according to EN 12014-7 (1998). Chemical analyses were performed for fresh (not presented here) and dried samples. Total nitrogen was determined by the micro-Kjeldahl method. Plant samples were dried at 60 °C, crushed and wet-fired with nitric-perchloric acid. Macro- and micro- nutrients (N, P, K, Ca, Mg and Fe) were determined according to ISO 6491 (1998) and ISO 6869 (2000). Data were evaluated by analysis of variance using the Statgraphics Centurion XV statistical program (Statgraphic<sup>®</sup>, 2005) with the significance level set at  $P \leq 0.05$ . The comparison of means was done by the Duncan test ( $\alpha=0.05$ ).

### Results and discussion

The highest cabbage yield (66.04 t ha<sup>-1</sup>) was achieved in pure stand (Table 1); however, it was not significantly different from the yields achieved in treatments with cos lettuce and red beet. Results confirm the findings of Bavec et al., (2010) in the same intercropping system and Gliessman (1998) in the broccoli:lettuce intercropping system. In comparison to pure cabbage stands, the yields of cabbage intercropped with bush bean and tomatoes were significantly lower. Results were in contrast to Guvenc and Yildirim (2006), who reported no significant differences among the cropping systems in terms of cabbage yield, where cabbage was intercropped with bean, but results confirm findings of Bavec et al., (2010). The obtained results also differ to Poniedzialek and Kunicki (1995) in the case of the cabbage:bean treatment and Subhan (1991) in the case of the tomato:bean treatment. The cabbage yield response was also lower at treatments with celery and leek. Compared to sole crop, (relative yield = 1.00), lower relative yields were obtained when cabbage was intercropped, which proves that a competitive mechanism acted between the cabbage and other intercrops. Years had no effect on cabbage yield and the year x treatment interaction was significantly, contrary to DM (dry matter) content. The average DM content of cabbage leaves was higher in 2009 than 2008. The DM contents of cabbage intercropped with bush bean, celery, tomatoes and leek were significantly lower compared to the pure cabbage treatment; however, the obtained value on pure cabbage treatment was similar to treatments where cabbage was intercropped with red beet and cos lettuce. The highest N uptake was analysed in the cabbage pure stand treatment, in contrast to Varghese (2000) and Santos et al. (2002), who reported no significant response of N uptake in cabbage to various intercropping systems.

The results of N uptake obtained in the pure cabbage treatment were similar to the cabbage:cos lettuce treatment, but higher than in treatments with other intercrops. The influence of a specific year was very significant looking at NO<sub>3</sub><sup>-</sup> concentration. In 2009, the concentration of NO<sub>3</sub><sup>-</sup> was almost three times lower than in 2008. This was most likely the result of the high amount of rainfall in the growing period of 2009 (809 mm), which caused NO<sub>3</sub><sup>-</sup> leaching. Pure cabbage and the cabbage:cos lettuce intercrops had the highest NO<sub>3</sub><sup>-</sup> concentration. The treatments with celery, tomatoes and leek had lower NO<sub>3</sub><sup>-</sup> concentration compared to those mentioned above. The lowest NO<sub>3</sub><sup>-</sup> concentration was measured on cabbage:red beet treatment. The uptakes of Ca, Mg, K, P and Fe in leaves from the pure cabbage treatment were different compared to intercropped cabbage, resulting in higher uptake of all minerals (Table 2). This is contrary to Varghese report (2000), who indicated that intercropping with six different vegetables did not affect the N, P and K

uptakes of intercropped cabbage compared to pure cabbage. In addition, Santos et al. (2002) reported that the uptakes of N, P, K and Ca in leaves of intercropped vegetables were similar to those from sole cropping. In the present study, the lowest uptakes of Ca, K and P were detected in treatments where cabbage was intercropped with bush bean, celery and tomatoes. These uptakes were significantly different compared to pure cabbage cropping, but without differences among them. The Mg uptake measured in leaves of cabbage as a pure stand was higher than in intercropped cabbage, while the same was not affected by intercrops. The highest Fe uptake was obtained on pure stand cabbage, but not statistically different compared with cabbage:red beet treatment whereas other intercropped treatments recorded statistically different and lower results compared to those mentioned above. Year significantly influenced Ca, Mg and Fe uptakes, but not K and P.

**Table 1. Yield (t ha<sup>-1</sup>), relative yield (RY) and dry matter (DM, t ha<sup>-1</sup>) content; nitrogen (N, kg ha<sup>-1</sup>) uptake and nitrate (NO<sub>3</sub><sup>-</sup>, mg kg<sup>-1</sup>) concentration of cabbage in relation to year and various cabbage-based intercropping systems**

		Yield	RY	DM	N	NO <sub>3</sub> <sup>-</sup>
Year (Y)		ns		*	***	
Treatment (T)		***		***	***	
Y x T		***		ns	***	
Year	2008	55.78 a		3.93 b	116.85 a	788
	2009	51.87 a		4.50 a	97.22 b	339
<b>Treatment</b>						
cabbage:cos lettuce		61.08 a	0.92	4.40 ab	119.50 ab	908
cabbage:bush bean		44.12 c	0.66	3.36 c	85.86 c	707
cabbage:celery		47.48 bc	0.71	3.51 c	105.49 bc	448
cabbage:tomatoes		39.59 c	0.59	3.46 c	88.70 c	433
cabbage:red beet		61.19 a	0.92	5.17 a	106.91 bc	298
cabbage:leek		57.28 ab	0.86	4.09 bc	105.24 bc	337
cabbage		66.04 a	1.00	5.30 a	137.71 a	814

\*\*\*, \* significant at 0.001, and 0.05 probability levels; ns - non significant

<sup>a-c</sup> Mean values followed by different letters are significantly different (Duncan,  $\alpha=0.05$ )

**Table 2. Nutrient uptake by cabbage (kg ha<sup>-1</sup>) in relation to year and various cabbage-based intercropping systems**

		Ca	Mg	K	P	Fe
Year (Y)		**	*	ns	ns	*
Treatment (T)		***	***	***	***	***
Y x T		***	*	*	ns	***
Year	2008	28.70 a	5.60 b	124.56 a	16.71 a	0.20 a
	2009	24.89 b	6.35 a	130.61 a	16.78 a	0.17 b
<b>Treatment</b>						
cabbage:cos lettuce		26.51 bc	6.32 b	140.30 ab	18.73 ab	0.19 bc
cabbage:bush bean		22.54 c	5.06 b	104.01 c	14.17 c	0.22 bc
cabbage:celery		23.88 c	5.09 b	108.64 c	14.72 c	0.16 c
cabbage:tomatoes		23.91 c	5.51 b	108.05 c	13.63 c	0.17 bc
cabbage:red beet		30.33 ab	6.07 b	144.62 ab	18.96 ab	0.21 ab
cabbage:leek		25.60 bc	5.87 b	125.61 bc	15.86 bc	0.18 bc
cabbage		34.76 a	7.92 a	161.85 a	21.16 a	0.23 a

\*\*\*, \* significant at 0.001, and 0.05 probability levels; ns - non significant

<sup>a-c</sup> Mean values followed by different letters are significantly different (Duncan,  $\alpha=0.05$ )

## Conclusions

The present study showed that cabbage sown in pure stand had the highest yield, relative yield, dry matter and nutrient uptake compared to other treatments. Intercropping systems resulted with similar but still lower results of all measured parameters with the exception of the cabbage:cos lettuce treatment. The lowest and statistically different results for all measured parameters, compared to the pure stand cabbage, were obtained in the intercropping systems with bush bean, celery and tomatoes. The obtained differences

regarding yield, DM and N, P and K uptakes in relation to the pure stand cabbage and the cabbage intercropped with cos lettuce were not statistically proven. The decrease of nutrient uptake in intercropped cabbage indicated that competition for macronutrients and Fe between species existed. Year did not affect yield and K and P uptakes in cabbage; however, the year treatment interaction was present, including yield and nutrients with the exception of P and DM. Climatic conditions in 2008 resulted in the higher average results of observed parameters, while DM and Mg uptake were higher in 2009.

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# The greenhouse protection by ecological pest control strategies

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## Abstract

The researches carried out between 2008-2010 at Cluj-Napoca (Romania), in laboratory and 2 greenhouses, in six experiments. Our aim was to study and use some ecological pest control methods based on indirect and direct strategies: 1) the pest monitoring and the useful fauna identification in a greenhouse with medicinal plants (hop, rosemary, lemon balm) and a greenhouse with vegetable crops (tomato and pepper) by visual control, collecting manually, striking method on a tarpaulin; 2) the use of some physical and biotechnical methods (use of attractant traps - visual, alimentary and repellents) to control the pests. The fauna in studied protected ecosystems is by represented by 5 pests and 4 useful species. All the methods recorded a good efficacy against the pests.

Key words: pest, greenhouse, control, ecological strategies

## Introduction

The pests remains in specialists permanent focus, because of their great annual damages in agroecosystems (Seastedt and Crossley Jr., 1984). The pollution in agroecosystems, as consequence of an irrational chemotherapy using an excessive practice of some pesticides against the pests, produced grave environmental unbalanced effects, difficult to eliminate, even using modern knowledge and methods. The consequence was the redirect of plant protection towards the ecological approach, unpollutant, applying some alternative methods and using some modern pesticides (Debach, 1974; Glass, 1979; Horn, 1988; Cavalloro, 1989). In Romania, the chemotherapy is widely used by integrated pest management, at a high level. Besides the negative impact on the environment, the high price of modern pesticides settle the direction to unpollutant methods, cheaper, like the non-chemical methods to control the pests.

We proposed to study and use some ecological pest control methods based on the non-chemical control (Land, 1997; Albajes et al., 2002, Bunescu et al., 2003).

## Materials and methods

The methods are based on indirect and direct strategies: 1) the pest monitoring and the useful fauna identification in protected ecosystems (by visual control, collecting manually - direct with pincers, striking method on a tarpaulin); 2) the use of some physico-mechanical and biotechnical methods (use of barriers - attractant traps - visual, alimentary and repellents) to control the pests from studied ecosystems. The experiments were carried out between 2008-2010, according to experimental technics, in laboratory (Discipline of Entomology-Zoology at USAMV Cluj-Napoca) and 2 greenhouses (The Greenhouse of Medicinal Plants of USAMV Cluj-Napoca and a private greenhouse with vegetable crops at Cluj-Napoca - District of Cluj - Romania). The host-plants has been chosed according to their economic importance and the relationship with the specific pests, respectively hop, rosemary, lemon balm, tomato and pepper.

1) The indirect strategies by monitoring of harmful fauna and identification of useful species, carried out from January 2008 to September 2010. The biological material has been collected straight by hand or with the

aid of fine brushes and pincers, from different vegetal organs (sprouts, stems, leaves, flowers and inflorescences) by shaking down the plant on a tarpaulin, by random collecting from plants for a better objectiveness. The collected material has been introduced in small bottles (with 70% ethanol or 4% formalin), boxes or plastic bags which has been labeled. The identification of the material has been made with the binocular microscope in the Laboratory of Zoology-Entomology. After the species identification, the collected material has been prepared and conserved. The species identification was made according to identification keys (Ghizdavu et al, 1987; Perju et al, 1989).

2) The direct strategies to control the pests, meant the use of some ecological, unpollutant methods, in studied protected ecosystems: physical and biotechnical (use of barriers -attractant traps - visual, alimentary and repellents).

a) colored sticky traps - The 1<sup>st</sup> experiment with attractant materials was carried out in May at the Greenhouse with medicinal plants of USAMV Cluj-Napoca, using visual or colored traps (panels) - 7 variants (white, silver, light-green, emerald-green, light-blue, dark-blue, red) + control (yellow). The visual traps (panels) has been made by plastic and aluminium, measuring 25/25 cm and covered with a special adhesive not siccative, being fixed with wire at 75 cm high over the plants on 30 m<sup>2</sup> area. The data were recorded after 1 week.

The 2<sup>nd</sup> experiment was carried out at the greenhouse with vegetable crops (tomato and pepper), using the same 8 variants with colored traps. The data were recorded after 1 month.

b) repellents - The experiment organised in August meant the use of vegetal materials, selective for useful fauna. It has been used: absinth decoction (*Artemisia absinthium* Linné) against aphids; nut-tree decoction (*Juglans regia* Linné) against aphids; nettle extract (*Urtica dioica* Linné) against aphids; tansy infusion (*Tanacetum vulgare* Linné) against whiteflies and thrips; rhubarb infusion (*Rheum rhabarbarum* Linné) against aphids. For the absinth decoction there were used 300 g fresh plants with flowers/10 l water; for the nut-tree decoction there were used 100 g dry leaves/10 l water; for the nettle extract there were used 1 kg fresh plants/10 l water, extraction time 10-12 h; for the tansy infusion and 3% bentonite, there were used 300 g dry flowers/10 l water; for the rhubarb infusion there were used 2 kg fresh leaves/10 l water, concentration use of 50%.

At hop infected with *Phorodon humuli* Schrank (the damson-hop aphid) the average numerical density was about 100 aphids/plant, at medicinal plants (rosemary and lemon balm) infected with *Trialeurodes vaporariorum* Westwood (the greenhouse whitefly) the average numerical density was about 250 insects/plant and at vegetable crops (tomato and pepper) infected with *Myzodes persicae* Sulzer (the green peach aphid) the average numerical density was about 300 aphids/plant.

c) attractant traps with alimentary baits

The experience has been organized in August at the Greenhouse of medicinal plants of USAMV Cluj-Napoca against the slugs, using attractant traps with alimentary baits. There were used 10 plastic vases of 500 ml, fixed in the ground until their top. The vases were filled with beer until 1 cm from their top and were placed between the plants. The results has been noted daily, counting the slug captures.

## Results and discussion

### 1) THE HARMFUL FAUNA

Results concerning the morphology on the harmful fauna from the 2 studied greenhouses (medicinal plants and vegetable crops) showed the following 5 pest species (Table 1):

- Phyll. MOLLUSCA - Cls. GASTRPODA - Ord. STYLLOMATOPHORA - Fam. AGRILIMACIDAE
  - *Deroceras agreste* Linné
- Phyll. ARTHROPODA - Cls. ARACHNIDA - Ord. ACARI - Fam. TETRANYCHIDAE
  - *Tetranychus urticae* Koch
- Phyll. ARTHROPODA - Cls. INSECTA - Ord. HOMOPTERA - Fam. APHIDIDAE
  - *Phorodon humuli* Schrank
- Fam. ALEURODIDAE - *Trialeurodes vaporariorum* Westwood
- Ord. THYSANOPTERA - Fam. THRIPIDAE - Thrips tabaci Linné

**Table 1. The harmful fauna from greenhouse studied ecosystems (Cluj-Napoca, 2008-2010)**

Phylum	Class	Order	Family	Species
MOLLUSCA	GASTROPODA	STYLOMATO-PHORA	AGRIOLIMACIDAE	<i>Deroceras agreste</i> Linné
ARTHROPODA	ARACHNIDA	ACARI	TETRANYCHIDAE	<i>Tetranychus urticae</i> Koch
		INSECTA	APHIDIDAE	<i>Phorodon humuli</i> Schrank
	ALEURODIDAE		<i>Trialeurodes vaporariorum</i> Westwood	
	THYSANOPTERA	THRIPIDAE	<i>Thrips tabaci</i> Linné	

## 2) THE USEFUL FAUNA

After the analysis of collected material from greenhouses, the following 4 predator species has been identified (Table 2):

- Phyll. ARTHROPODA - Cls. INSECTA - Ord. DERMAPTERA - Fam. FORFICULIDAE  
- *Forficula auricularia* Linné
- Ord. PLANIPENNIA - Fam. CHRYSOPIDAE - *Chrysopa carnea* Stephens
- Ord. COLEOPTERA - Fam. COCCINELLIDAE - *Coccinella 7-punctata* Linné; *Adalia 2-punctata* Linné

**Table 2. The useful fauna from greenhouse studied ecosystems (Cluj-Napoca, 2008-2010)**

Phylum	Class	Order	Family	Species
ARTHROPODA	INSECTA	DERMAPTERA	FORFICULIDAE	<i>Forficula auricularia</i> Linné
		PLANIPENNIA	CHRYSOPIDAE	<i>Chrysopa carnea</i> Stephens
		COLEOPTERA	COCCINELLIDAE	<i>Coccinella septempunctata</i> Linné <i>Adalia bipunctata</i> Linné

2) The direct strategies to control the pests meant the use of some ecological, unpollutant control methods in protected studied ecosystems:

a) colored sticky traps - At the first experiment with colored sticky panels installed in the Greenhouse with medicinal plants of USAMV Cluj-Napoca, it has been recorded a very good efficacy at all variants. The most captures has recorded the yellow trap (variant 8-control) with 1500 insects, the white one with 1250 captures (variant 1), followed by the silver trap (variant 2) with 860 captures, the light-green trap (variant 3) with 650 captures, the light-blue trap (variant 5) with 500 captures, the emerald-green trap (variant 4) with 430 captures, the dark-blue trap (variant 6) with 300 captures and the red one (variant 7) with 150 captures. It has been captured aphids, whiteflies, thrips (Table 3).

**Table 3. The direct strategies to control the pests in the greenhouse with medicinal plants (Cluj-Napoca, 2008-2010)**

Method	Variant	Nr. of captures
1. Colored sticky traps	1 - white	1250
	2- silver	860
	3- light-green	650
	4 - light-blue	500
	5 - emerald-green	430
	6 - dark-blue	300
	7 - red	150
	8 - yellow (control)	1500

Concerning the second experiment using visual sticky panels in the greenhouse with vegetable crops, the most efficacy were variant 9-control (yellow) with 1300 captures, 1 (white) with 1000 captures and 2 (silver) with 850 captures, followed by variant 6 (blue-ultramarine) with 700 captures, 5 (blue-light) with 680 captures, 3 (light-green) with 540 captures, 7 (dark-blue) with 450 captures, 4 (emerald-green) with 380 captures and 8 (red) with 90 captures (Table 4).

**Table 4. The direct strategies to control the pests in the greenhouse with vegetable crops (Cluj-Napoca, 2008-2010)**

Method	Variant	Nr. of captures
1.Colored sticky traps	1 - white	1000
	2- silver	850
	6- blue-ultramarine	700
	5 - light-blue	680
	3 - light-green	540
	7 - dark-blue	450
	4 - emerald-green	380
	8 - red	90
	9 - yellow (control)	1300

b) repellents - The use of repellents had a good efficacy at all variants, removing successfully all the pests.

c) attractant traps with alimentary baits - Regarding the experiment with attractant traps based on alimentary baits (beer) it had a good efficacy by continuous capture of slugs.

### Conclusions

After the developed experiments in 2008-2010, from the experimental data analysis recorded after the use of both strategies in controlling the pests from greenhouse ecosystems the following conclusions are evident: the use of some indirect strategies meant the identifying and monitoring of harmful fauna with 5 identified pests and useful fauna with 4 identified species; the direct strategies by use of colored sticky traps in 2 experiments recorded a very good efficacy at all variants; the best results recorded the control - yellow, followed by variant 1 (white); in the experiment with repellents all the variants recorded good results removing the pests; the use of attractant traps based on alimentary bait (beer), showed a good efficacy, continuous capturing slugs.

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# Travni busen, zeleni izazov za budućnost - smjernice za gnojidbu

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## Sažetak

Zbog mogućnosti busanja određene vrste trava koriste se za uzgoj travnog busena (tepiha) te uređenje hortikulturnih i športskih površina. Busanje se odvija tijekom cijele vegetacijske sezone pa okolišni uvjeti i optimalna količina hraniva imaju ključnu ulogu u rastu trava. Cilj ovih istraživanja bio je istražiti tržište potencijalnih korisnika travnog busena te dati smjernice za gnojidbu. U tu svrhu, provedena je anketa na 200 ispitanika i postavljen poljski gnojidbeni pokus metodom latinskog kvadrata s 5 tretmana: kontrola - negnojeno; 100 g m<sup>-2</sup> NPK 15-15-15 predsjetveno; 100 g m<sup>-2</sup> NPK 15-15-15 uz 15 g m<sup>-2</sup> KAN-a predsjetveno, te tri prihrane s po 15 g m<sup>-2</sup> KAN-a; 100 g m<sup>-2</sup> NPK 15-15-15 uz 15 g m<sup>-2</sup> amonijevog sulfata predsjetveno, te tri prihrane s po 15 g m<sup>-2</sup> amonijevog sulfata; 100 g m<sup>-2</sup> NPK 15-15-15 uz 10 L m<sup>-2</sup> kiselog litvanskog treseta predsjetveno. U pokusu je korištena smjesa trava: *Lolium* sp., *Poa* sp. i *Festuca* sp. Anketom je utvrđeno da 74% ispitanika zna što je travni busen, no, samo ga 2% koristi, a njih 67% smatra da je kvalitetan busen na nogometnim terenima bitan čimbenik. Iako Hrvatska ima potencijale za njegovu uspješnu proizvodnju, što smatra i 89% ispitanika, u najvećoj mjeri se uvozi. Uspješna proizvodnja moguća je na tlu gdje je pH<sub>H2O</sub> od 5,5-7,2, humus od 2,7-3,0%, fosfor oko 10 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> tla, te kalij oko 20 mg K<sub>2</sub>O 100 g<sup>-1</sup> tla.

Ključne riječi: travni busen, zelene površine, športski tereni, gnojidba, ishrana, anketa

## Turfgrass, a green challenge for the future - guidelines for fertilization

### Abstract

Because of grass sodding ability certain species of grass are used for turf grass production and the management of the horticultural areas and sport courts. Sodding takes place throughout the growing season, so environmental conditions and the optimal amount of nutrients play a key role in its grass growth. The aim of this study was to investigate the market of potential turf grass users and provide guidelines for fertilization.

For this purpose, the survey on 200 participants was made and field fertilization trial was conducted according to Latin square method with 5 treatments: control-unfertilized; 100 g NPK 15-15-15 m<sup>-2</sup> pre-sowing; 100 g NPK 15-15-15 m<sup>-2</sup> with 15 g KAN m<sup>-2</sup> pre-sowing, and monthly topdressing with 15 g KAN m<sup>-2</sup>; 100 g NPK 15-15-15 m<sup>-2</sup> with 15 g amon sulphate m<sup>-2</sup> pre-sowing, and monthly topdressing with 15 g amon sulphate m<sup>-2</sup>; 100 g NPK 15-15-15 m<sup>-2</sup> with 10 L acid Lithuanian peat m<sup>-2</sup> pre-sowing. Grass mixture of *Lolium* sp., *Poa* sp. and *Festuca* sp. was used in trial. The survey found that 74% participants know what turf grass is, but use it only 2%, and 67% of them considered that the high-quality turf grass on the football field is important factor. Although Croatia has the potential for successful production, which is considered by

89% participants it is mostly imported. A successful production is possible on the soil where is  $pH_{H_2O}$  from 5.5 to 7.2, humus from 2.7 to 3.0%, around 10 mg  $P_2O_5$  100  $g^{-1}$  soil, and around 20 mg  $K_2O$  100  $g^{-1}$  soil.

Key words: turfgrass, green areas, sports court, fertilization, nutrition, survey

## Uvod

Trave (porodica *Poaceae*) jedna su od najvećih, a za poljoprivredu jedna od najznačajnijih porodica biljaka. Prema broju vrsta i podvrsta, porodica *Poaceae* je treća u Hrvatskoj s 341 svojtom (Nikolić i Topić, 2005). Trave koje se koriste za uzgoj busena dobro su prilagođene svojoj podlozi i omogućuju dobar uzgoj travnjaka kao tepiha. No, za njihovu proizvodnju najznačajnije biološko svojstvo je stvaranje busena. On se dalje po potrebi lako i brzo presađuje i ozelenjava različite ukrasne površine od okućnica, dječjih igrališta, parkova do sportskih terena, osobito nogometnih i golf igrališta. Busanje trava je različito kod različitih vrsta, ali na njega utječu i mjere redovitog održavanja, a to su prihrana, nisko i često košenje, prozračivanje i natapanje. Za zdrav i zeleni travnjak potrebna je adekvatna gnojidba. Redovita prihrana dušikom i pravilan odnos ostalih hranivih elemenata značajni su za gustoću i kvalitetu travnatog tepiha (Finck, 1982). Pored mineralnih dušičnih gnojiva mogu se koristiti i organska gnojiva osobito kiseli treset. Naime, dušik i fosfor utječu na rast korijena i vlati, na zelenu boju, a kalij utječe na sintezu ugljikohidrata i translokaciju asimilata, sintezu aminokiselina i proteina (Pessaraki, 2008). Reakcija tla jedan je od ključnih čimbenika u uspostavljanju i održavanju travnog busena-tepiha u mnogim regijama svijeta. Kako navodi Finck (1982), optimalni pH tla za uzgoj trava iznosi 5,0-6,0, Samardžija (1998) i Herak Čustić i sur. (2006) navode 5,5-6,5. Patton (2010) sugerira da je odgovarajući pH tla (5,8-7,0) potreban za proizvodnju zdrave, visokokvalitetne i atraktivne trave, te da analiza tla osigurava uspjeh.

Liu i sur. (cit. prema Pessaraki, 2008) navode da ovisno o vrsti trave pH ispod 5,0 može uzrokovati toksičnost mobilnog aluminijskog na travama, ali navodi i iznimke nekih vrsta trava, pa tako *Poa pratensis* i *Festuca arundinacea* mogu podnijeti i pH 4,0. S druge strane, postoje vrste koje se koriste u tropskim i subtropskim regijama, poput *Cynodon dactylon* (Bermudagrass) i *Stenotaphrum secundatum* (St. Augustinegrass) koje podnose širok raspon pH od 5,0 do 8,5. Tipični predstavnici busenastih oblika su *Lolium perenne* i *Poa pratensis* (Čížek, 2007; Samardžija, 1998). Procvat uzgoja travnog busena započeo je zbog sve većih potreba za postizanjem brzog pokrivanja površina travom dobre kakvoće. Isprva tek na sportskim igralištima, a kasnije i radi golemog povećanja broja individualnih i obiteljskih građevinskih stambenih objekata (Waddington i sur., 1992).

Kako bi dobili što više kvalitetnih spoznaja o tomu što prosječan građanin zna o prednostima travnog busena i mogućnostima njegova korištenja, a istovremeno dali smjernice za gnojidbu kao jednom od ključnih čimbenika za proizvodnju kvalitetnog travnog tepiha-busena, cilj ovog istraživanja bio je provesti anketu te postaviti gnojidbeni pokus.

## Materijal i metode

Anketa, koja je sadržavala metodički postavljena pitanja, napravljena je na reprezentativnom uzorku od 200 ispitanika (100 muških i 100 ženskih, te isti omjer ispitanika dobne granice ispod i iznad 30 godina). Tijekom 2009. i 2010. godine poljski gnojidbeni pokus s travnim busenom proveden je na proizvodnom objektu za proizvodnju travnog busena u Botincu, Novi Zagreb, u tvrtki "Hortikultura Čustić". Tlo na kojem je provedeno istraživanje prema mehaničkom sastavu pripada u praškasto glinastu ilovaču, čiji  $pH_{H_2O}$  iznosi 6,7, a sadrži 2,7% humusa, 8,5 mg  $P_2O_5$  100  $g^{-1}$  tla i 17,5 mg  $K_2O$  100  $g^{-1}$ . Zrakosuh, samljeveni i homogenizirani uzorci tla analizirani su u Analitičkom laboratoriju Zavoda za ishranu bilja Agronomskog fakulteta u Zagrebu. Reakcija tla (pH) određena je elektrometrijski, kombiniranom elektrodom u suspenziji tla i vode (aktivna kiselost) u omjeru 1:2,5 (Škorić, 1982), humus metodom po Tjurinu (JDPZ, 1966), a fiziološki aktivni fosfor i kalij metodom po Egner-Riehm-Domingo (Egner i sur., 1960). Mehanički sastav tla određen je metodom prosijavanja i sedimentacije u Na-pirofosfatu (Škorić, 1982). Gnojidbeni pokus postavljen je metodom latinskog kvadrata s 5 tretmana: a) kontrola - negnojeno [kont]; b) 100  $g m^{-2}$  NPK 15-15-15 predstjetveno [NPK]; c) 100  $g m^{-2}$  NPK 15-15-15 uz 15  $g m^{-2}$  KAN-a predstjetveno, te tri prihrane s po 15  $g m^{-2}$  KAN-a [NPK+KAN]; d) 100  $g m^{-2}$  NPK 15-15-15 uz 15  $g m^{-2}$  amonijevog sulfata predstjetveno, te tri prihrane s po 15  $g m^{-2}$  amonijevog sulfata [NPK+AS]; e) 100  $g m^{-2}$  NPK 15-15-15 uz 10 L  $m^{-2}$  kiselog

litvanskog treseta predsjetveno [NPK+tres]. Sjeme trave izravno je sijano na tlo, te se valjkom utisnulo u tlo. Sjetva je obavljena 11.09.2009., a prihrane 26.03.2010., 26.04.2010. i 21.05.2010. Pokusna parcela veličine 4,0 m x 2,5 m imala je izolaciju od 0,3 m. Po potrebi je obavljeno navodnjavanje te zaštita od korova i štetnika. U pokusu je korištena smjesa trava: *Lolium perennae* "Esquire" 15%, *Lolium perennae* "Margarita" 10%, *Poa pratensis* "Balin" 15%, *Festuca rubra* "Maxima1" 15%, *Festuca rubra* "Aniset" 15%, *Festuca rubra* "Calliope" 10% i *Festuca arundinacea* "Starlett" 20%. Podaci su obrađeni uz pomoć statističkog programskog paketa SAS System for Win Ver. 9.1 (SAS Institute Inc., 2002-2003).

### Rezultati i rasprava

Provedenom anketom utvrđeno je da 74% ispitanika zna što je travni busen, no, samo ga 2% koristi, a njih 67% smatra da je kvalitetan busen na nogometnim terenima bitan čimbenik. Iako, 89% ispitanika smatra da Hrvatska ima potencijale za uspješnu proizvodnju kvalitetnog busena, u najvećoj mjeri ga se uvozi, a 57% ispitanika smatra da je tomu kriva loša promocija hrvatskih proizvoda (loša agrarna politika). Unatoč ovakvoj percepciji ispitanika i povoljnim resursima za proizvodnju u Hrvatsku se više uvozi travnog busena (tepiha), nego što ga se proizvodi. Rezultati istraživanja tržišta ukazuju na to da je većina ispitanika upoznata s upotrebom i proizvodnjom travnatog busena (tepiha), no i dalje smatra da je cijena glavni kriterij prilikom kupnje određenog proizvoda.

Sve vrijednosti reakcije tla tijekom istraživanja (2009-2010) variraju od 6,5 do 7,2 u H<sub>2</sub>O (tablica 1). Iako literaturni navodi prethodnih istraživanja (Herak Čustić i sur., 2005; Patton, 2010) navode pH u optimalnom rasponu od 5,5-6,5, naša istraživanja nisu pokazala štetan utjecaj pH<sub>H<sub>2</sub>O</sub> 7,2 na vizualni dojam travnog busena. Općenito su najviše vrijednosti (7,1 do 7,2) utvrđene u drugom uzorkovanju (7.4.2010.) i nije bilo statistički značajnih razlika između gnojidbenih tretmana. Najniže vrijednosti reakcije tla utvrđene su u prvom uzorkovanju od 6,6 do 6,9. Pretpostavka da će primjena kiselog treseta i/ili amonijevog sulfata dovesti do značajnijeg zakiseljavanja medija (tla) u ovim istraživanjima nije se potvrdila, jer je samo u prvom uzorkovanju utvrđeno općenito blago smanjenje reakcije tla njegovom primjenom. Bitno je naglasiti da su vrijednosti reakcije tla u odnosu na preliminarnu rezultate (6,7) općenito sve blago porasle, osobito tijekom travnja i svibnja (2010) što je vjerojatno posljedica metabolizma korijena, kemijskih reakcija u tlu, kao i intenzivnog zalijevanja vodom s dosta karbonata.

Tablica 1. Vrijednosti reakcije tla (pH<sub>H<sub>2</sub>O</sub>) u tlu

Tretman	Dubina (cm)	pH <sub>H<sub>2</sub>O</sub>			
		29.10.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	0-30	6,89 a	7,10	6,98	6,86 b
NPK	0-30	6,78 ab	7,18	7,05	6,97 ab
NPK+KAN	0-30	6,67 bc	7,21	7,11	7,03 a
NPK+AS	0-30	6,66 bc	7,11	6,97	6,86 b
NPK+tres	0-30	6,59 c	7,10	7,06	6,98 ab
Prosjeck		6,72	7,14	7,03	6,94

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p<0,05. Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

Tablica 2. Vrijednosti% humusa u tlu

Tretman	Dubina (cm)	% humusa			
		29.10.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	0-30	2,73	3,00	2,64	2,91
NPK	0-30	2,66	3,03	2,68	2,94
NPK+KAN	0-30	2,89	2,98	2,68	2,88
NPK+AS	0-30	2,86	2,97	2,64	2,88
NPK+tres	0-30	2,65	3,04	2,73	2,94
Prosjeck		2,76	3,00	2,67	2,91

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p<0,05. Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

Količina humusa (tablica 2) tijekom istraživanja kretala se od 2,64 do 3,04%. Općenito najviše vrijednosti, neovisno o gnojidbi, utvrđene su u proljeće (travanj 2010), što bi moglo biti posljedica intenzivnije

mikrobiološke razgradnje. Fosfor u tlu se tijekom cijelog perioda istraživanja kretao od 6,9 do 17,1 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> tla (tablica 3). Neovisno o vremenu uzorkovanja, najviše vrijednosti utvrđene su u tretmanu s kiselim litvanskim tresetom, a najniže u kontroli bez gnojidbe. Kalij u tlu varira od 16,4 do 28,1 mg K<sub>2</sub>O 100 g<sup>-1</sup> tla tijekom istraživanja (tablica 4), a općenito najviše vrijednosti neovisno o gnojidbenim tretmanima utvrđene su u prvom uzorkovanju (listopad 2009.). Slično kao i s fosforom, najveća količina kalija u tlu utvrđena je u tretmanu s kiselim litvanskim tresetom neovisno o vremenu uzorkovanja. To bi moglo biti posljedica boljih fizikalnih i bioloških uvjeta u tlu koje sadrži puno čestica sitnog praha i gline. Bitno je napomenuti da se količina fosfora i kalija u tlu neovisno o gnojidbenom tretmanu prema kraju vegetacije smanjuje, što je i za očekivati obzirom na rast trave i obilno iznošenje hraniva čestom košnjom travnog tepiha.

**Tablica 3. Vrijednosti fiziološki aktivnog fosfora u tlu (mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup>)**

Tretman	Dubina (cm)	mg P <sub>2</sub> O <sub>5</sub> 100 g <sup>-1</sup>			
		29.10.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	0-30	7,4 c	9,3 b	7,5 b	6,9 c
NPK	0-30	11,4 bc	11,3 ab	11,9 a	9,7 ab
NPK+KAN	0-30	12,2 b	9,8 b	10,5 ab	7,8 bc
NPK+AS	0-30	11,2 bc	12,2 ab	9,6 ab	8,7 bc
NPK+tres	0-30	17,1 a	15,1 a	13,1 a	11,4 a
Prosjek		11,9	11,5	10,5	8,9

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05. Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

**Tablica 4. Vrijednosti fiziološki aktivnog kalija u tlu (mg K<sub>2</sub>O 100 g<sup>-1</sup>)**

Tretman	Dubina (cm)	mg K <sub>2</sub> O 100 g <sup>-1</sup>			
		29.10.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	0-30	16,4 b	20,3	17,5 b	16,5 b
NPK	0-30	19,2 ab	19,9	18,3 b	17,2 ab
NPK+KAN	0-30	21,1 ab	19,9	19,2 ab	17,4 ab
NPK+AS	0-30	18,6 ab	19,0	18,7 b	16,7 ab
NPK+tres	0-30	28,1 a	20,9	22,5 a	20,4 a
Prosjek		20,7	20,0	19,2	17,6

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05. Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

## Zaključak

Hrvatska ima potencijal za uspješnu proizvodnju travnog busena, što smatra 89% ispitanika, a 57% ispitanika smatra da je loša promocija hrvatskih proizvoda glavni krivac velikog uvoza travnog busena.

Travni se busen može uzgajati na tlu reakcije tla u H<sub>2</sub>O u rasponu od 5,5 do 7,2, količine humusa od najmanje 2,7%, fosfora od oko 10 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> tla, te kalija od oko 20 mg K<sub>2</sub>O 100 g<sup>-1</sup> tla. Sugerira se upotreba mineralnih gnojiva: 100 g NPK 15-15-15 m<sup>-2</sup> u osnovnoj gnojidbi uz 15 g KAN-a m<sup>-2</sup>, te svaki mjesec prihrana KAN-om s istom količinom, osobito na siromašnijim tlima. Isto tako, u ovim agroekološkim uvjetima na tlu s velikim udjelom čestica praha i gline, učinak primijenjenog kiselog litvanskog treseta pokazao se vrlo dobrim, te se preporuča i njegovo korištenje u minimalnoj količini od 10 L m<sup>-2</sup> presdsjetveno.

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# Grain yields of alternative small grains in organic field production

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## Abstract

The aim of this paper is to outline the potential interests for alternative wheat species for organic crop production. This paper deals with result of the effects organic field production on grain yield of different alternative small grains in investigated period (2007/08 - 2008/09) on the chernozem luvic soil type in "Radmilovac"- Experimental field trial Faculty of Agriculture Belgrade-Zemun, Republic Serbia. The results shows that yield of small grains were higher in first year study with better meteorological conditions. Alternative small grains wheat species (*Tr. Spelta*, *Tr. aestivum* ssp. *compactum* and *Tr. durum*), barley and oats gives lower grain yield compared with commercial cultivar *Triticum aestivum* ssp. *vulgare* NS-40S. Combination with organic and microbiological fertilizer has better effect on the grain yield of different alternative small grains compared with only organic fertilizers.

Key words: grain yield, organic field production, wheat, naked barley, naked oat

## Introduction

Currently, organic production is gaining attention due to its important role in natural resources protection and soil conservation in the framework of sustainable agriculture. The transformation from conventional to sustainable organic field crop technology production requires changes and adaptation of many cultural practices. Organic production is very specific in this respect must be for alternative small grains crops to develop appropriate supporting technology based on respect for ecological principles (Pearson et al., 2004). Republic Serbia has significant heterogeneous natural resources and favorable conditions for agricultural production that can meet the basic requirements for the establishment of organic agricultural production, due to lower land and water pollution due to less application of pesticides and other chemicals. This production, under our conditions in Serbia, is still modest due to the existing market restrictions. However, when it comes to organic production of cultivated and it is necessary to choose the type of field crops that do not have normal use (alternative) that would be suitable for such production (Kovacevic et al., 2007). Each of these crops has the botanical characteristics, needs for different growing factors and more like any other commercial crop. Some of these crops can be with local significance or in limited markets, and some may be of interest and on farms that are so oriented.

This paper aims at finding a growing technology by modifying the basic cultural practices in alternative small grains production that are of particular interest for organic producers. All this is inseparable from each type of grain is therefore necessary to choose those that are adaptable to our agroecological conditions.

## Materials and methods

Investigation of the effect of organic production technology on grain yield different alternative small grains was measured in "Radmilovac" - Experimental field trial Faculty of Agriculture, Belgrade-Zemun, Republic Serbia the field experiment was set up on leached chernozem soil type. The study was conducted during 2007/08. and 2008/09. vegetation season. The experiment was conducted under 4-yr rotations (maize - winter wheat - barley + red clover - red clover) where legumes red clover was nitrogen source. The previous crop every year to winter wheat were maize.

The following factors were included in investigations:

Factor A - Years;

Factor B in examining the different alternative small grains types. The basic characteristics of these different types alternative small grains of NS cultivars are as follows: *Triticum spelta* - cultivar Nirvana - This type of wheat used for making special bread that is digested much faster than the regular wheat. *Triticum durum* - cultivar named Durumko - intended exclusively for making pasta, spaghetti, macaroni and the like. *Triticum aestivum* ssp. *compactum* - cultivar Bambi is solely intended for preparing tea and hard biscuits. *Triticum aestivum* ssp. *vulgare* - cultivar NS 40S baking cultivar of ordinary soft wheat has been selected primarily for conventional intensive production leading cultivar for conventional production in Serbia NS 40S - good resistance to winter frost, drought tolerant, high yield potential, high-quality Class B<sub>1</sub>-B<sub>2</sub>. *Hordeum vulgare* - cultivar named Golijat suitable for human consumption - baking industry, cereal and the like. Naked barley important in human nutrition in addition to higher content of beta glucan, a range of other advantages over the hull forms of barley. *Avena sativa* L. NS naked oat. Due to the high nutritional value and fiber content is high quality food for humans, animals and birds.

The experiment tested two variants of fertilization (factor C): control C<sub>0</sub> without fertilization; C<sub>1</sub>- fertilization with Bio-Humus (30 t/ha) and C<sub>2</sub>-fertilization Bio-Humus and microbial fertilizers "Slavol" (30 t / ha + 5l/ha). This organic fertilizer under the trade name "Royal Bio-Humus offert" was applied just before basic tillage. Characterized by high pH 8 and the average content of N 2.1%; 3.6% P<sub>2</sub>O<sub>5</sub> and 2.2% K<sub>2</sub>O. In full tillering of small grains we applied 5 l/ha microbial fertilizer "Slavol". Fertilization system is complete with this treatment because it is a natural microbial inoculant that contains two groups of bacteria and nitrogen fixers, as well as some biostimulators. The essence of this preparation consists in the fact that in addition to the supply of plants in nitrogen and phosphorus, and allows production entomotoxins that protect plants from insects. After harvest, the yield was measured by elemental plots immediately after threshing and reduced to a moisture level of 14%. All data were subjected to analysis of variance. For individual comparisons, we used the LSD test.

### Meteorological conditions during the period of investigation

Meteorological data on the experimental field "Radmilovac" during vegetation period small grains 2007/08-2008/09. are shown in figure1.

The data shows better meteorological conditions for winter wheat in initial year of this investigation. In the first year is characterized by large amounts of rainfall in autumn and winter months. Good distribution of rainfall in spring and early summer followed the same time a relatively high average monthly air temperature at all growth stages of winter wheat, which was consistent with the studied cultivated species of winter wheat. The second year of investigation had a bad rainfall distribution in spring period compared with first year.

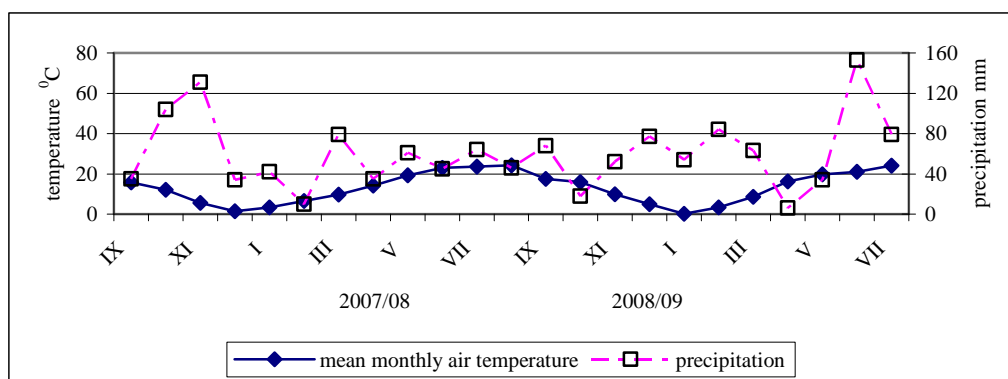


Figure 1. Climate diagram for meteorological conditions in Belgrade according to Walter

## Results and discussion

The results of the effect of organic technology on grain yield different alternative small grains shown in table 1. Based on these results show that grain yield of wheat was higher (3.97 t/ha) in first year (factor A) with better meteorological conditions compared with yield in the second year (1.78 t/ha).

When comparing grain yields between small grains as a distinct factor (B) we can see that the bread making cultivar for intensive production NS-40S - *Triticum aestivum* ssp. *vulgare*, had average a significantly higher yield than any other alternative types of wheat (3.73 t/ha). This is quite expected, because due to these advantages and used in conventional breeding technology but alternative small grains and their cultivars have the other advantages, first of all, quality (Kovacevic et al., 2009). Alternative types of wheat yield the highest return given the species of *Triticum durum* (3.34 t/ha) which was significantly higher yield of the species *Triticum spelta* and *Triticum compactum*. Statistically significantly lowest grain yield given with naked barley (2.67 t/ha) and naked oat (1.45 t/ha).

Fertilizers are important factor of organic field production technology alternative small grains as indicated by our results. The combination of organic and microbiological fertilizers gave a significantly higher yield (3.54 t/ha) compared with control and variants with only organic fertilizers (2.79 t/ha). Interestingly, the differences between the two type of fertilization more pronounced in favorable years for winter wheat. In the less favorable meteorological conditions due to lack of moisture is missing the full effect of both type fertilizing. If we compare the interaction between of two AB factors (years x types of alternative small grains) can be seen that all interactions in the first year of study had a significantly higher yields than the same interaction in the second years. Yield results in the interaction AC (years x fertilization) shows the same tendency as in the previous case. The greater effect of fertilization was achieved in years with favorable meteorological conditions.

**Table 1. The effect of technology based on organic principles on grain yield different alternative small grain species (t/ha)**

Years (A)	Alternative small grains (B)	Fertilizers (C)			Average			
		Control (C <sub>0</sub> )	Bio humus - (C <sub>1</sub> )	Bio humus +Slavol (C <sub>2</sub> )	AB	A		
2007/08.	<i>Triticum spelta</i> - Nirvana	3.75	4.51	4.84	4.37	3.97		
	<i>Triticum durum</i> - Durumko	3.83	4.84	6.10	4.92			
	<i>Triticum aestivum</i> ssp. <i>compactum</i> - Bambi	3.49	3.97	5.22	4.23			
	<i>Triticum aestivum</i> ssp. <i>vulgare</i> - NS 40S	4.63	4.44	5.40	4.82			
	<i>Hordeum vulgare</i> L. - naked barley	2.92	3.93	4.41	3.75			
	<i>Avena sativa</i> L. - naked oat	1.27	1.51	2.35	1.71			
	AC	3.31	3.87	4.72				
2008/09.	<i>Triticum spelta</i> - Nirvana	1.43	1.84	2.11	1.79	1.78		
	<i>Triticum durum</i> - Durumko	0.85	1.66	2.79	1.77			
	<i>Triticum aestivum</i> ssp. <i>compactum</i> - Bambi	1.33	1.85	1.88	1.69			
	<i>Triticum aestivum</i> ssp. <i>vulgare</i> - NS-40S	1.99	2.26	3.69	2.65			
	<i>Hordeum vulgare</i> L. naked barley	0.98	1.52	2.30	1.60			
	<i>Avena sativa</i> L. naked oat	0.97	1.15	1.44	1.19			
	AC	1.26	1.71	2.37				
Average		2.59	3.17	3.47	3.08	B		
	BC	2.34	3.25	4.44	3.34			
		2.41	2.91	3.55	2.96			
		3.31	3.35	4.54	3.73			
		1.95	2.72	3.35	2.67			
		1.12	1.33	1.89	1.45			
	C	2.29	2.79	3.54				
LSD	0.05	0.01	0.05	0.01	0.05	0.01		
A	0.047	0.063	AB	0.116	0.154	ABC	0.217	0.268
B	0.082	0.109	AC	0.082	0.109			
C	0.058	0.077	BC	0.142	0.268			

Good yields were obtained in the interactions of the combined fertilization with all three alternative species of winter wheat (4.44 t/ha; 3.55 t/ha; 3.47 t/ha).



In BC interaction (type of alternative small grains x fertilization), in general a significantly higher yields were obtained in combinations studied species of wheat x combined fertilization Bio-Humus + microbial fertilizer in relation to the interaction of small grain species x only Bio-Humus fertilization. Individually observed the highest yield was achieved in the interaction bread commercial cultivar NS-40S x Bio-Humus + microbiological fertilizer (4.54 t/ha). This is as expected, so the interesting results because it suggests that commercial varieties can produce good yields and modest conditions, cultural practices such as present in organic farming.

### Conclusion

According to the obtained results during investigations of effects 3rd fertilization (2 and control) and different species of cereales under organic farming practice, the following conclusions can be made:

The results of our investigation show that yield grain of wheat was higher in first year with better meteorological conditions. With different alternative wheat species, naked barley and naked oat were obtained lower yields compared with *Triticum aestivum* ssp. *vulgare* - commercial cultivar NS 40S. However, it is expected, but we emphasize that the good yields obtained and tested with alternative small grains that have other advantages when it comes to their specific purpose and quality. In particular it highlights the winter wheat *Triticum durum* - cultivar Durumko. Organic field crop technology that includes a combination of basic fertilization with Bio-Humus and microbial fertilizer in recharge gives the highest yield. This results it could be usefull for organic growers.

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# Researches regarding the links between microclimate conditions and the main irrigated parameters of the plants in unirrigated and irrigated maize from Crişurilor Plain

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## Abstract

The researches were carried out during 2007-2009 on the preluvosoil from Agricultural Research and Development Station Oradea. The microclimate is characterized by de Martonne aridity index (IdM) and Domuța climate index (IcD). The irrigation determined the improve of the climate index values. There are a better quatification of the link between microclimate conditions and water consumption, yield and protein content of the maize grains using the climate index Domuța (IcD) in comparison with de Martonne aridity index, the explanation is more vegetation factors used by Domuța climate index (water, air humidity, air temperature, light) in comparison with de Martonne aridity index (water, air temperature).

Key words: de Martonne aridity index, Domuța climate index, water consumption, yield, protein content, irrigation

## Introduction

The Crişurilor Plain is situated in the Western part of Romania and the climate is characterized like "moderate wet" (Borza I., 2007). To characterize the climate using one climate element (rainfall, temperature etc.) is not enough for a so complexe probleme. The climate indicators use offers a better opportunity. The climate indexes use one climate element (rainfall - Topor index), two climate elements (rainfall and temperature - de Martonne aridity index, Seleaninov hydrothermic coefficient, Palfai aridity index, Teaci index, Mirkin coefficient etc.), three climate elements (rainfall, temperature, sun brilliance - hydroheliothermic index) or four climate elements (rainfall, temperature, air humidity, sun brilliance - Domuța climate index) (Grumeza N. et al., 1989, Domuța C., 1995, 2003, 2005, 2009). The climate indexes is better if the coefficients for regression functions with the plant parameters (yield, water consumption, etc.) are better. (Domuța C., 1995). For quantification the relationship between climate and maize yield, Domuța C., 1995, obtained better results using the hydroheliothermic index in comparison with de Martonne aridity index, Selianinov hydrothermic coefficient. Ciobanu Gh., 2003, Domuța C., 2003, Pălcuț N., 2003, obtained better results using Domuța climate index in comparison with de Martonne aridity index for characterization the relationship climate - yield for research data obtained in a long term trial with different doses and combinations of the fertilizers and for behavior characterization of different maize hybrids (Domuța C., 2005, 2009).

The paper used the most known climate index from Romania (de Martonne aridity index) and Domuța climate index for maize microclimate characterization and for quantification the link between microclimate conditions and water consumption, yield and protein content of the grains.

## Material and methods

The paper based on the researches carried out in Agricultural Research and Development Station Oradea during 2007-2009 on the preluvosoil. The watering depth (0-75 cm) was a fixed one (Grumeza N. et al., 1989) and field capacity (FC = 24.2% = 2782 m<sup>3</sup>/ha) and wilting point (WP = 10.1 = 1158 m<sup>3</sup>/ha) have median values. Easily available water content (Wea) was established in function of texture: Wea = WP + 2/3 (FC - WP).

A drill is the water source for irrigation and their quality for irrigation is very good: pH = 7.2; Na<sup>+</sup> = 12.9%; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

In comparison with multiannual average (1931-2005) of 621.1 mm during the studied period the annual rainfall were of 684.7 mm in 2006; of 556.1 mm in 2007 and of 585.7 mm in 2008.

Soil moisture of 0 - 75 cm depth was determined ten to ten days. In the variant without irrigation suspending the moment of the irrigation use was when the soil water reserve on 0 - 75 cm depth decreased to easily available water content.

De Martonne aridity index (IdM) was determined using the formula

$$IdM = \frac{12p}{t + 10} \text{ in wich:}$$

p= monthly rainfall (mm); t= average temperature on the month (°C)

Domuța climate index was determined using the formula:

$$IcD = \frac{100W + 12.9A}{\sum t + Sb} \text{ in wich:}$$

W= water (mm); A= air humidity (%);  $\sum t$  = sum of the monthly average temperature (oC); Sb= sun brilliance.

Both de Martonne aridity index and Domuța climate index for irrigated vriant included the irrigation rate in the calculation formula (Domuța C., 2009)

Water consumption was determined using the soil water balance method and water use efficiency was determined like report between field and water consumption.

Results research was processed by variance analysis and with the regression functions (Domuța C., 2009)

## Results and discussions

### Optimum irrigation regime in maize

For maintaining the soil water reserve on 0-75 cm between easily available water content and field capacity the following irrigation rates were used: 2950 m<sup>3</sup>/ha in 2007, 3320 m<sup>3</sup>/ha in 2008 and 4200 m<sup>3</sup>/ha in 2009. (table 1)

**Table 1. Optimum irrigation regime used in maize, Oradea 2007-2009**

Year	April		May		June		July		August		April-August	
	$\Sigma m$	n	$\Sigma m$	n	$\Sigma m$	n	$\Sigma m$	n	$\Sigma m$	n	$\Sigma m$	n
2007	300	1	400	1	500	1	1200	4	550	4	2950	8
2008	-	-	500	1	1020	2	1100	3	700	2	3320	8
2009	500	1	900	2	500	1	1300	3	1000	2	4200	9

$\Sigma m$ = irrigation regime; n= number of rates

### Irrigation influence on maize microclimate

The irrigation determined the improve of the microclimate conditions. The use of the de Martonne aridity index shows that the report between water and temperature improved every month with irrigation; in average on the period April-August the values of the de Martonne aridity index increased with 105% in 2007, with 115% in 2008 and with 161% in 2009. (table 2).

Using the Domuța climate index the report between water+air humidita and temperature+ sun brilliance increased in average on the period April-August with 90% in 2007, with 92% in 2008 and with 144% in 2009. (table 3)

**Table 2. Irrigation influence on microclimate (de Martonne aridity index, IdM) in maize, Oradea 2007-2009**

Variant	April		May		June		July		August		April-August	
	de Martonne aridity index, IdM											
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
2007												
Unirrigated	1.7	100	34.3	100	18.8	100	24.1	100	30.6	100	21.9	100
Irrigated	17.9	1006	51.3	150	37.5	199	67.0	278	51.0	167	44.9	205
2008												
Unirrigated	24.0	100	17.4	100	35.7	100	26.9	100	10,2	100	22.8	100
Irrigated	24.0	100	39.7	228	75.1	211	69.6	259	36,5	358	48.9	215
2009												
Unirrigated	6.5	100	11.9	100	39.3	100	11.4	100	33.3	100	20.5	100
Irrigated	31.1	478	51.5	433	59.4	151	55.1	483	70.6	212	53.5	261

**Table 3. Irrigation influence on microclimate (DomuȚa climate index, IcD) in maize, Oradea, 2007-2009**

Variant	April		May		June		July		August		April-August	
	de Martonne aridity index, IdM											
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
2007												
Unirrigated	1.4	100	10.8	100	6.0	100	6.9	100	9.4	100	6.9	100
Irrigated	5.8	414	15.7	145	11.1	185	18.0	261	15.0	160	13.1	190
2008												
Unirrigated	9.8	100	5.8	100	11.2	100	8.1	100	3.5	100	7.7	100
Irrigated	9.8	100	12.0	207	22.3	199	19.6	242	10.3	295	14.8	192
2009												
Unirrigated	2.7	100	4.1	100	12.1	100	2.7	100	10.4	100	6.4	100
Irrigated	9.5	352	15.1	368	17.8	147	14.8	548	20.8	200	15.6	244

#### Irrigation influence on maize total water consumption

The values of the total water consumption increased in the irrigated variant with 56% in 2007, 58% in 2008 and 61% in 2009. In the covering sources of the optimum water consumption, the irrigation participated with 44% in 2007, with 48% in 2008 and with 54% in 2009 (table 4).

**Table 4. Irrigation influence on total water consumption in maize, Oradea 2007-2009**

Variant	Total water consumption			Covering sources			
	m <sup>3</sup> /ha	%	Soil water reserve m <sup>3</sup> /ha	Rainfall m <sup>3</sup> /ha	Irrigation		
					m <sup>3</sup> /ha	%	
2007							
Unirrigated	4302	100	490	3812	-	-	-
Irrigated	6719	156	143	3812	2950	44	
2008							
Unirrigated	4410	100	1300	3110	-	-	-
Irrigated	6942	158	512	3110	3320	48	
2009							
Unirrigated	4820	100	2280	2540	-	-	-
Irrigated	7767	161	1027	2540	4200	54	

#### Irrigation influence on yield and protein content

The irrigation determined the yield gains very significant statistically every year; the relative difference in comparison with unirrigated variant were of 56% in 2007, of 58% in 2008 and of 61% in 2009. (table 5)

The protein content of the maize grains increased very significant statistically, too every year. The relative differences in comparison with unirrigated variant were of 59% in 2007, of 80% in 2008 and of 69% in 2009 (table 5).

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Table 5. Irrigation influence on yield and protein content of the maize grains, Oradea 2007-2009

Variant	Yield			Protein content		
	kg/ha	%	Statistically significant	%	%	Statistically significant
2007						
Unirrigated	6470	100	Mt	7.0	100	Mt
Irrigated	13120	203	xxx	11.12	159	xxx
LSD 5%=240; LSD 1%= 410; LSD 0.1% =790      LSD 5%= 0.81; LSD 1%= 1.56; LSD 0.1%= 2.63						
2008						
Unirrigated	5910	100	Mt	6.30	100	Mt
Irrigated	12500	212	xxx	11.36	180	xxx
LSD 5%=190; LSD 1%= 310; LSD 0.1% =570      LSD 5%= 0.50; LSD 1%= 1.06; LSD 0.1%= 2.00						
2009						
Unirrigated	5300	100	Mt	6.68	100	Mt
Irrigated	11800	223	xxx	11.29	169	xxx
LSD 5%=210; LSD 1%= 330; LSD 0.1% =640      LSD 5%= 0.59; LSD 1%= 1.15; LSD 0.1%= 1.96						

The link between microclimate conditions and water consumption

Both de Martonne aridity index and Domuța climate index were used for quantification the link between microclimate conditions and maize water consumption. Five regression functions was tested: linear, logarithmic, polynomial, power, exponential. Using the Domuța climate index a correlation coefficient of 0.96 was obtained in comparison with 0.69, the coefficient obtained using the de Martonne aridity index for the quantification and yield. (fig.1)

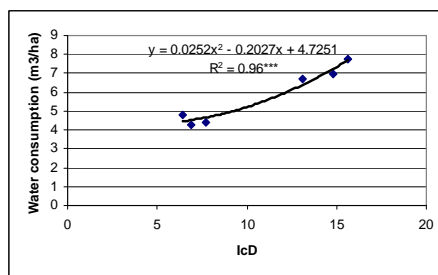
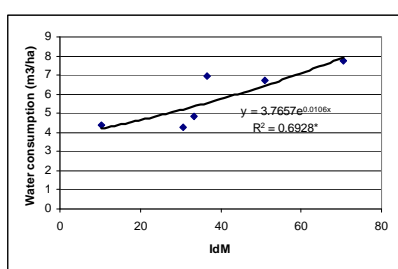


Fig. 1  
The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and maize water consumption, Oradea 2007-2009

The link between microclimate conditions and yields

The link between microclimate conditions and yield is a direct too. The use of the Domuța climate index determined a better quantification of the link microclimate-yield than the use of the de Martonne aridity index: R²= 0.9541 vs R²=0.5072 (figure 2)

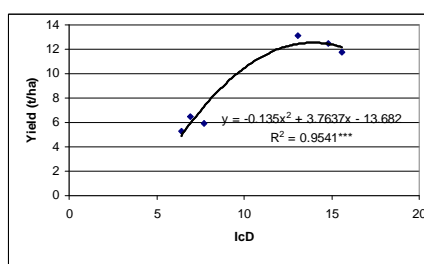
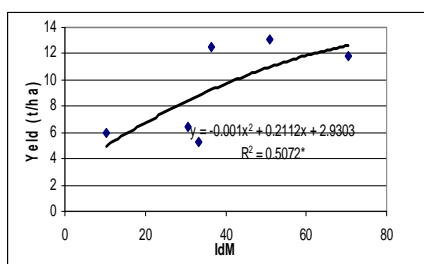
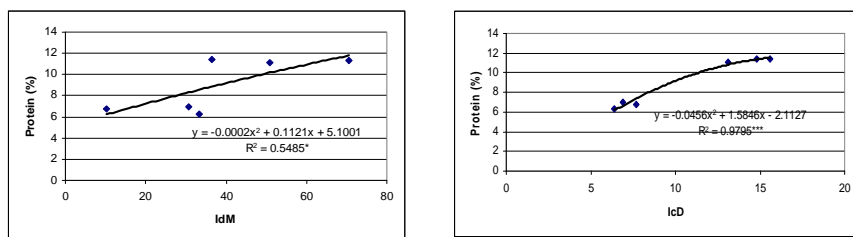


Fig. 2  
The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and maize yield, Oradea 2007-2009

The link between microclimate conditions and protein content

The protein content is influenced by microclimate conditions, too. Using the Domuța climate index for quantification the link between the microclimate conditions and protein content of the maize a bigger regression function (R²= 0.96) was obtained in comparison with the use of the Martonne index (R²= 0.6928)



**Fig. 3**  
The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and protein content, Oradea 2007-2009

## Conclusions

The researches carried out during 2007-2009 determined the following conclusions:

Using the irrigation for maintaining the soil water reserve between easily available water content and field capacity determined the increase of the water/ temperature report (de Martonne aridity index, IdM) with 105% in 2007, with 115% in 2008 and with 161% in 2009. The report water+air humidity/temperature+ sun brilliance (Domuța climate index, IcD) increased with 90% in 2007, with 92% in 2008 and with 144% in 2009.

The irrigation determined the increase of the maize water consumption with 56% in 2007, with 58% in 2008 and with 61% in 2009. The yields increased very significant statistically every year, the relative differences were of 103% in 2007, f 112% in 2008 and of 123% in 2009. The protein content of the grains increased very significant statistically, too; the relative differences in comparison with unirrigated variant were of 59% in 2007, of 80% in 2008 and of 69% in 2009.

The direct links, statistically assured, were registered between microclimate conditions and water consumption, yields and protein content of the grains. The microclimate quantification by de Martonne aridity index detrmined a link significant statistically and microclimate quantification by Domuța climate index determined a link very significant statistically.

## Acknowledgments

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# Optimalna ishranjenost travnog busena - preduvjet za korištenje u krajobraznoj arhitekturi

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## Sažetak

Travnjak u vrtu, parku ili na športskom terenu okosnica je uređenog okoliša i utječe na osjećaj slobode i prostornosti. Mogućnost trave da na jednom mjestu stvaraju busen koji se može brzo i jednostavno premjestiti, daje niz mogućnosti korištenja travnog busena-tepiha na krajobraznim projektom predviđeno mjesto. Preduvjet je dobra kvaliteta i boja travnog tepiha te dobro prožet i razgranat korijen za što između ostalog treba osigurati i dovoljnu količinu lako dostupnih hraniva, što je i bio cilj istraživanja. Poljski gnojidbeni pokus (2009 i 2010) za proizvodnju travnog busena proveden je u tvrtki 'Hortikultura Ćustić' metodom latinskog kvadrata s 5 tretmana: kontrola - negnojeno; 100 g m<sup>-2</sup> NPK 15-15-15 predstetveno; 100 g m<sup>-2</sup> NPK 15-15-15 uz 15 g m<sup>-2</sup> KAN-a predstetveno, te tri prihrane s po 15 g m<sup>-2</sup> KAN-a; 100 g m<sup>-2</sup> NPK 15-15-15 uz 15 g m<sup>-2</sup> amonijevog sulfata predstetveno, te tri prihrane s po 15 g m<sup>-2</sup> amonijevog sulfata; 100 g m<sup>-2</sup> NPK 15-15-15 uz 10 L m<sup>-2</sup> kiselog litvanskog treseta predstetveno. U pokusu je korištena smjesa trave: *Lolium* sp., *Poa* sp. i *Festuca* sp. Rezultati pokazuju da su najveće količine N, P, K, Mg i NO<sub>3</sub><sup>-</sup> u biljci te najbolji vizualni dojam ostvareni u gnojidbenom tretmanu sa 100 g NPK 15-15-15 m<sup>-2</sup> uz 15 g KAN-a m<sup>-2</sup> predstetveno i prihranom s po 15 g KAN-a m<sup>-2</sup> mjesečno te se ovaj tretman predlaže za zahtjevne projekte krajobraznog uređenja i športske terene.

Ključne riječi: uređenje okoliša, hranivo, gnojidba, športski teren, travni busen

## Optimal turfgrass nutrition - a precondition for landscape architecture use

### Abstract

Well arranged lawn in garden, park or at sport court is outline of landscape design and gives sense of freedom and spatiality. Grass sodding ability to generate turf on one place and quickly and easily turf establishment on other, provides a number of possibilities of using turf grass carpets on the landscape project provided space. A precondition for it, is a good turf grass quality and colour as well as infused and outspreaded root to which, among other things, should provide a sufficient amount of easily available nutrients, which was the aim of research. A filed fertilization trial (2009 and 2010) for turf grass production was carried out in firm 'Hortikultura Ćustić' according to Latin square method with 5 treatments: control-unfertilized; 100 g NPK 15-15-15 m<sup>-2</sup> pre-sowing; 100 g NPK 15-15-15 m<sup>-2</sup> with 15 g KAN m<sup>-2</sup> pre-sowing, and monthly topdressing with 15 g KAN m<sup>-2</sup>; 100 g NPK 15-15-15 m<sup>-2</sup> with 15 g amon sulphate m<sup>-2</sup> pre-sowing, and monthly topdressing with 15 g amon sulphate m<sup>-2</sup>; 100 g NPK 15-15-15 m<sup>-2</sup>

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with 10 L acid Lithuanian peat  $m^{-2}$  pre-sowing. Grass mixture of *Lolium* sp., *Poa* sp. and *Festuca* sp. was used in trial. Results show that the highest amounts of N, P, K, Mg and  $NO_3^-$  in the plant and the best visual impression were achieved in fertilizer treatment with 100 g NPK 15-15-15  $m^{-2}$  with 15 g KAN  $m^{-2}$  pre-sowing and monthly fertilization with 15 g KAN  $m^{-2}$ . In addition, for required landscape architecture projects as well as sport courts we suggest referred treatment.

Key words: landscape design, nutrient, fertilization, sport court, turfgrass

## Uvod

Biološko svojstvo trava stvaranja busena omogućava im lako i brzo presađivanje na drugo mjesto. Brzo ozelenjavanje golih ukrasnih i sportskih površina, posebice nogometnih i golf terena, značajno je s aspekta krajobrazne arhitekture i okoliša u cjelini. Naime, pored toga što travnjak-tepih služi kao podloga za rekreacijske i sportske aktivnosti, zaštita je kuće od blata, mulja i prašine te smanjuje efekt sunčevog zračenja i vrućine. Također filtrira nečisti zrak i proizvodi kisik, a 250  $m^2$  travnog tepiha osigurava dovoljno kisika za četveročlanu obitelj, čime generalno utječe na kvalitetu i ljepotu življenja. Ishranjenost travnjaka lako dostupnim hranivima pored ostalih čimbenika ima važnu ulogu, a kemijska analiza tla preduvjet je za kvalitetnu gnojidbu. Tako Finck (1982) navodi da za povećanje nivoa lako dostupnih hraniva u tlu treba obilnija gnojidba mineralnim gnojivima u osnovnoj gnojidbi i sugerira cca 10 kg NPK 10-20-30 100  $m^{-2}$  ili slične formulacije, te prihranu jednom mjesečno s 1,5-2,0 kg 100  $m^{-2}$  Uree ili 3-4 kg KAN-a 100  $m^{-2}$ . Autor istovremeno sugerira primjenu 2-5 bala kiselog treseta 100  $m^{-2}$  koje će povećati količinu organske tvari u tlu te popraviti reakciju tla i vodozračne odnose. Poznato je da povećana gnojidba, osobito dušikom, može dovesti do ljepšeg izgleda travnjaka-busena, no, Pessarakli (2008) te Heydari i Balestra (cit. prema Pessarakli, 2008) navode da povećana gnojidba dušikom u početku dovodi do povećanja korijena i vlasi, a kasnije do depresije u rastu korijena.

U literaturi se također napominje kao važna činjenica da gnojidba dušikom u najvećoj mjeri ovisi o namjeni travnjaka. Tako Snyder i sur. (cit. prema Pessarakli, 2008) navode da je za golf i druge sportske terene u tropskom klimatu za trave poput *Cynodon dactylon* i sl. uobičajena prihrana s 5-10 g N  $m^{-2}$  a za vrtove i okućnice 2,5 g N  $m^{-2}$  mjesečno. Autori predlažu i mogućnost folijarne gnojidbe dušikom kad je korijen oštećen zbog napada štetnika (osobito nematoda) ili kad je trava zasijana pregusto. Isti autori predlažu da kada je tlo slabo opskrbljeno fosforom treba inkorporirati u tlo prije sjetve 10 g  $P_2O_5$   $m^{-2}$ , te još rano u proljeće prihraniti s 1 g  $P_2O_5$   $m^{-2}$ . Da fosfor utječe na boju travnjaka te da je rano proljetna kloroza indikator nedostatka fosfora u travi navode Heydari i Balestra (cit. prema Pessarakli, 2008), koji su utvrdili da nedostatak fosfora uzrokuje blijedo zelenu boju kod ljulja (*Lolium* sp.), crvene vlasulje (*Festuca rubra*) i livadne vlasnjače (*Poa pratensis*). Pored toga navode i da fosfor pospješuje otpornost na stres od suše i hladnoće te povećava otpornost na bolesti. Snyder i sur. (cit. prema Pessarakli, 2008) sugeriraju upola manju gnojidbu kalijem od dušične gnojidbe jer trave ne zahtijevaju puno kalija. No, napominju da se na travi može pojaviti nedostatak magnezija koji se manifestira klorozom na starijim listovima i bordo crvenim opržotinama uzduž ruba lista. Kako bi se to izbjeglo i/ili saniralo, autori predlažu primjenu 0,5 g  $MgSO_4$   $m^{-2}$ .

Zbog niza različitih literaturnih navoda cilj istraživanja bio je utvrditi kako stanje ishranjenosti trave utječe na kvalitetu travnjaka-busena, osobito boju i gustoću, te preporučiti optimalnu gnojidbu. U tu svrhu postavljen je gnojidbeni pokus s različitim količinama i dozama gnojiva.

## Materijal i metode

Poljski gnojidbeni pokus (2009 i 2010) s travnim busenom proveden je u tvrtki "Hortikultura Ćustić" metodom latinskog kvadrata s 5 tretiranja kako slijedi: a) kontrola - negnojeno [kont]; b) 100 g NPK 15-15-15  $m^{-2}$  predsjetveno [NPK]; c) 100 g NPK 15-15-15  $m^{-2}$  uz 15 g KAN-a  $m^{-2}$  predsjetveno, te tri prihrane s po 15 g KAN-a  $m^{-2}$  [NPK+KAN]; d) 100 g NPK 15-15-15  $m^{-2}$  uz 15 g amonijevog sulfata  $m^{-2}$  predsjetveno, te tri prihrane s po 15 g amonijevog sulfata  $m^{-2}$  [NPK+AS]; e) 100 g NPK 15-15-15  $m^{-2}$  uz 10 L kiselog litvanskog treseta  $m^{-2}$  predsjetveno [NPK+tres]. Sjeme trave izravno je sijano na tlo, te se valjkom utisnulo u tlo. Sjetva je obavljena 11.09.2009., a prihrane 26.03.2010., 26.04.2010. i 21.05.2010. Pokusna parcela veličine 4,0 m x 2,5 m imala je izolaciju od 0,3 m. Po potrebi je obavljeno navodnjavanje te zaštita od korova i štetnika. U pokusu je korištena sljedeća smjesa trava: *Lolium perenne* "Esquire" 15%, *Lolium perenne* "Margarita" 10%, *Poa pratensis* "Balin" 15%, *Festuca rubra* "Maxima1" 15%, *Festuca rubra* "Aniset" 15%, *Festuca rubra* "Calliope"



10% i *Festuca arundinacea* "Starlett" 20%. Uzorkovanje biljnog materijala provedeno je u četiri navrata: 30.11.2009., 15.04.2010., 14.05.2010. i 17.06.2010. Istraživanje je provedeno na praškasto glinastoj ilovači, čiji  $pH_{H_2O}$  iznosi 6,7, a sadrži 2,7% humusa, 8,5 mg  $P_2O_5$  100 g tla<sup>-1</sup> i 17,5 mg  $K_2O$  100 g<sup>-1</sup>. Reakcija tla (pH) određena je elektrometrijski, kombiniranom elektrodom u suspenziji tla i vode (aktivna kiselost) u omjeru 1:2,5 (Škorić, 1982), humus metodom po Tjurinu (JDPZ, 1966), fosfor i kalij metodom po Egner-Riehm-Domingo (Egner i sur., 1960). Mehanički sastav tla određen je metodom prosijavanja i sedimentacije u Napirofosfatu (Škorić, 1982). Osušeni na 105 °C, samljeveni i homogenizirani uzorci biljnog materijala analizirani su u Laboratoriju zavoda za ishranu bilja Agronomskog fakulteta u Zagrebu. Nakon digestije s koncentriranom  $HNO_3$  fosfor je određen spektrofotometrijski, kalij plamenfotometrijski, a magnezij AAS-om. Ukupni dušik određen je metodom po Kjeldahlu. Nitrati su određeni u svježem uzorku ksilenol metodom (AOAC, 1995).

Podaci su obrađeni uz pomoć statističkog programskog paketa SAS System for Win Ver. 9.1 (SAS Institute Inc., 2002-2003).

### Rezultati i rasprava

Vrijednosti dušika (tablica 1) u travnom busenu kretale su se od 2,3 do 4,9% N suhe tvari (ST) i općenito su se smanjivale prema kraju istraživanja u svim tretmanima, što je i uobičajeno za dinamiku dušika u biljci. Uspoređujući gnojdbene tretmane bez obzira na termin uzorkovanja, u tretmanu NPK+KAN utvrđene su najveće vrijednosti dušika, a najniža količina utvrđena je u kontrolnom negnojnom tretmanu, osim u prvom uzorkovanju. Prema Bergmann (1992) optimalne vrijednosti dušika za *Festuca pratensis* kreću se od 2,8-4,0% N, za *Lolium* sp. od 3,0-4,2% N, te za *Poa pratensis* od 2,6-3,2% N. Kako se u našem istraživanju u travnom busenu nalazi smjesa navedenih trava, vidljivo je da su početkom vegetacije sve vrijednosti nešto više od literaturnih navoda, dok vrijednosti dušika krajem istraživanja ulaze u optimalni rang, osim u kontroli i NPK tretmanu. Nitrati u biljci kreću se od 167 do 947 mg  $NO_3^-$  kg<sup>-1</sup> svježe tvari (tablica 2). Općenito više vrijednosti nitrata neovisno o gnojidbi utvrđene su u prvom i drugom uzorkovanju (studeni 2009. i travanj 2010.) u odnosu na treće i četvrto uzorkovanje (svibanj i lipanj 2010.). Gledajući gnojdbene tretmane u prvom uzorkovanju, najveća količina nitrata utvrđena je primjenom treseta, a u svim ostalim uzorkovanjima primjenom NPK+KAN. Kako je u provedenim istraživanjima primjenom mineralnih gnojiva korišten i  $NO_3^-$  i/ili  $NH_4^+$  oblik dušika, vrijednosti nitrata u biljci nužno ne prikazuju njegov nedostatak. To potvrđuju vrijednosti ukupnog dušika koje su u granicama optimalnog pa čak i više, te osobito dobar vizualni dojam trave u pokusu.

Tablica 1. Vrijednosti ukupnog dušika u lišću trava (% N ST)

Tretman	% N ST			
	30.11.2009.	15.04.2010.	14.05.2010.	17.06.2010.
Kontrola	4,91 a	3,96 c	3,36 c	2,30 b
NPK	4,90 a	4,42 b	3,72 bc	2,49 b
NPK+KAN	4,78 a	4,95 a	4,92 a	3,27 a
NPK+AS	4,79 a	4,83 a	4,58 a	3,16 a
NPK+tres	4,23 b	4,56 b	4,09 b	2,92 a

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ . Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

Tablica 2. Vrijednosti nitrata u lišću trava (mg  $NO_3^-$  kg<sup>-1</sup> svježe tvari)

Tretman	mg $NO_3^-$ kg <sup>-1</sup> svježe tvari			
	30.11.2009.	15.04.2010.	14.05.2010.	17.06.2010.
Kontrola	618,5 b	523,0	166,5 b	349,5
NPK	616,0 b	768,5	175,5 b	315,0
NPK+KAN	619,5 b	947,0	609,0 a	375,5
NPK+AS	426,5 c	757,0	212,4 b	170,0
NPK+tres	756,6 a	598,0	235,1 b	304,0

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ . Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

Vrijednosti fosfora (tablica 3) u biljnom materijalu kreću se od 0,38 do 0,65% P ST tijekom perioda istraživanja i u granicama su optimalnog (0,3-0,6% P) prema Bergmann (1992). To upućuje na općenito dobru ishranjenost travnog busena fosforom koji zasigurno ima ključnu ulogu jer utječe na nicanje i rast korijena te boju i ukupnu kvalitetu busena kako navode Snyder i sur. (cit. prema Pessarakli, 2008). Utvrđene vrijednosti kalija (tablica 4) tijekom istraživanja variraju od 1,71 do 3,05% K ST, što je nešto niže od navoda Bergmann (1992) (2,0-3,5% K) i neovisno o gnojidbi i vremenu uzorkovanja nisu značajno varirale. Tretmani NPK+KAN i NPK+AS ostvarili su nešto veće vrijednosti kalija. Utvrđene vrijednosti magnezija (tablica 5) kretale su se od 0,22 do 0,42% Mg ST i u granicama su optimalnog od 0,15-0,50% Mg za ispitivane trave kako navodi Bergmann (1992). Općenito veće vrijednosti utvrđene su na početku istraživanja (jesen 2009.) u odnosu na ostala uzorkovanja a tijekom proljeća 2010. u tretmanu NPK+KAN.

**Tablica 3. Vrijednosti fosfora u lišću trave (% P ST)**

Tretman	% P ST			
	30.11.2009.	15.04.2010.	14.05.2010.	17.06.2010.
Kontrola	0,47	0,59 b	0,39 c	0,38 d
NPK	0,46	0,65 a	0,38 c	0,40 cd
NPK+KAN	0,48	0,58 b	0,47 a	0,44 a
NPK+AS	0,49	0,55 c	0,45 a	0,41 bc
NPK+tres	0,49	0,48 d	0,41 b	0,43 ab

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ . Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

**Tablica 4. Vrijednosti kalija u lišću trave (% K ST)**

Tretman	% K ST			
	30.11.2009.	15.04.2010.	14.05.2010.	17.06.2010.
Kontrola	2,89 a	2,20 d	2,58 c	1,71 b
NPK	2,76 a	2,44 c	2,46 d	2,13 ab
NPK+KAN	2,75 a	3,05 a	2,95 a	2,47 a
NPK+AS	2,50 b	2,98 a	2,82 b	2,50 a
NPK+tres	2,48 b	2,69 b	2,39 d	2,09 ab

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ . Vrijednosti, kojima nije pridruženo slovo, nisu značajno različite.

**Tablica 5. Vrijednosti magnezija u lišću trave (% Mg ST)**

Tretman	% Mg ST			
	30.11.2009.	15.04.2010.	14.05.2010.	17.06.2010.
Kontrola	0,29 b	0,23 ab	0,25 c	0,27 a
NPK	0,26 b	0,24 a	0,27 bc	0,26 ab
NPK+KAN	0,29 b	0,24 a	0,32 a	0,27 a
NPK+AS	0,31 b	0,22 b	0,31 a	0,24 b
NPK+tres	0,42 a	0,23 a	0,28 b	0,27 a

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ . Vrijednosti kojima nije pridruženo slovo, nisu značajno različite.

## Zaključak

Uspoređujući dobivene količine hraniva (N, P, K, Mg, te  $\text{NO}_3^-$ ) u lišću trave kao i njezinom vizualnom dojmu na terenu (boja i gustoća) utvrđeno je da je najbolji gnojidbeni tretman (I klasa busena) za potrebe osobito zahtjevnih projekata krajobraznog uređenja te sportskih terena ostvaren primjenom 100 g NPK-15-15-15  $\text{m}^{-2}$  uz 15 g KAN-a  $\text{m}^{-2}$  predstjetveno uz prihranu s po 15 g KAN-a  $\text{m}^{-2}$  mjesečno. Kako je kiseli treset u startu utjecao na bolje vodozračne odnose u tlu i potakao bolje nicanje i rast, predlažemo uz navedenu mineralnu gnojidbu korištenje minimalno 10 L kiselog treseta  $\text{m}^{-2}$  prije sjetve. Za manje zahtjevne projekte krajobraznog uređenja (busen II klase), kao i primjenu busena za sprječavanje erozije i ispiranje hraniva na pokosima uz autoceste, te na kosim terenima u vinogradarstvu i voćarstvu moguće je koristiti i ostale istraživane gnojidbene tretmane, osim kontrole.

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# Utjecaj folijarnih gnojiva na prinos i sadržaj suhe tvari gomolja krumpira (*Solanum tuberosum* L.)

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## Sažetak

Cilj ovog istraživanja bio je utvrditi utjecaj folijarnih gnojiva na prinos i sadržaj suhe tvari gomolja krumpira. Dvogodišnji poljski pokusi s tri tretmana folijarne gnojidbe (Epsa Salt, Drin i Stopit) te kontrolom provedeni su u četiri ponavljanja po shemi slučajno-bloknog rasporeda na sorti *Courage*. Značajno veći prinos gomolja, masa gomolja veličine 0-35 i 35-55 mm i sadržaj suhe tvari gomolja utvrđeni su u vegetacijskoj sezoni 2004. Sadržaj suhe tvari gomolja nije bio pod utjecajem folijarnih tretmana kao ni masa gomolja veličine od 0-35 i 35-55 mm. U tretmana Stopit utvrđen je značajno manji prinos i masa gomolja veličine >55 mm u vegetacijskoj sezoni 2004. u odnosu na 2005. godinu.

Ključne riječi: krumpir, folijarna gnojiva, prinos, sadržaj suhe tvari

## Effect of foliar fertilizers on yield and dry matter content of potato tubers (*Solanum tuberosum* L.)

### Abstract

The aim of this study was to determine the effect of foliar fertilizers on yield and dry matter content of potato tubers. A two-year field experiment with three foliar treatments (Epsa Salt, Drin and Stopit) and control were arranged in a randomized complete block design with four replications on potato variety *Courage*. Significantly higher yield of tubers, tuber weight size 0-35 and 35-55 mm and dry matter content were found in 2004. Dry matter content of tubers and tuber weight size 0-35 and 35-55 mm were not affected by foliar treatments. Foliar treatment of Stopit brought about significantly lower tuber yield and weight tuber size >55 mm in the growing season of 2004. compared to 2005.

Key words: potato, foliar fertilizers, tuber yield, dry matter content

### Uvod

Gnojidba krumpira (*Solanum tuberosum* L.) predstavlja važan čimbenik u tehnologiji proizvodnje krumpira za postizanje optimalnih prinosa i kvalitete gomolja (Kleinkopf i sur., 1981; Horvat i sur., 2006). Visoki prinosi mogu se ostvariti aplikacijom optimalnih doza hranjiva u balansiranim količinama (Poljak i sur., 2007). Sadržaj suhe tvari gomolja ovisi o sorti, trajanju vegetacije, prosječnoj temperaturi tijekom vegetacije i pristupačnosti vode naročito na kraju vegetacijske sezone (Kleinkopf i sur., 1981, Vreugdenhil i sur., 2008). Sadržaj suhe tvari se povećava tijekom vegetacije i u gomolju krumpira se kreće od 10% u fazi inicijacije gomolja do 15-25% u fiziološkoj zriobi (Vreugdenhil i sur., 2008). Općenito sorta *Courage* akumulira visoki sadržaj suhe tvari, približno oko 23,9% i prvenstveno je namijenjena za industrijsku preradu u čips (Buturac,

2003). Tijekom faze nalijevanja gomolja potrebe za hranjivima su izrazito visoke što može uzrokovati translokaciju hranjiva iz vrha nadzemnih organa u gomolje rezultirajući ranijom senescencijom nadzemnih organa (Harris, 1978). Pri povećanim potrebama hranjiva u određenim fazama razvoja preporučuje se folijarna gnojidba putem listova i stabljike. Folijarna gnojidba predstavlja dopunsku ishranu makro i mikro elementima. Primjenjuje se višekratno tijekom vegetacije zbog nižih koncentracija hranjiva koje podnosi list. Zamijećeni efekti folijarne gnojidbe uključuju povećanje prinosa i kvalitete (Bolíglowa i Dzienia, 1999.; Horvat i sur., 2010). Međutim, postoje istraživanja u kojima folijarna gnojidba nije polučila pozitivne rezultate. Fiziološka reakcija krumpira na primjenu folijarnih gnojiva nedovoljno je poznata. Stoga je cilj ovog istraživanja utvrditi utjecaj folijarnih gnojiva na prinos, strukturu prinosa i sadržaj suhe tvari gomolja krumpira.

### Materijal i metode

Poljski pokusi na krumpiru provedeni su na obiteljskom gospodarstvu u Belici blizu Čakovca tijekom vegetacijske sezone 2004. i 2005. Provedena je strojna sadnja naklijalog gomolja krumpira sorte *Courage* 28. travnja 2004. te 29. travnja 2005. s razmacima između redova od 75 cm, a u redu 33 cm. Osnovna gnojidba tla provedena je s 700 kg ha<sup>-1</sup> NPK 7:20:30 i 200 kg ha<sup>-1</sup> KAN-a prije sadnje te prihrana s 150 kg ha<sup>-1</sup> KAN-a. Poljski pokusi s tri tretmana folijarne gnojidbe (Epsa Salt, Drin i Stopit) te kontrolom (bez primjene folijarnih gnojiva) provedeni su u četiri ponavljanja po shemi slučajno-bloknog rasporeda. Svaka osnovna parcela sastojala se od 8 redova krumpira, površine 60 m<sup>2</sup>. Epsa Salt predstavlja magnezij-sulfatno gnojivo (16% MgO, 13% SO<sub>4</sub>) sa 1% B i 1% Mn. Drin je fiziološki biostimulator koji sadrži L-alfa aminokiseline 39% (alanin, arginin, asparginska kiselina, cistein, glutaminska kiselina, metionin, fenilalanin, prolin, serin, treonin, triptofan). Stopit predstavlja 16,8%-tni CaO. Gnojidba folijarnim tretmanima provedena je u pet navrata, u intervalima od desetak dana, u periodu od početka formiranja gomolja do faze fiziološke zrelosti prema uputama proizvođača (Epsa Salt u dozi od 25 kg ha<sup>-1</sup>, Drin 0,5 L ha<sup>-1</sup> te Stopit u dozi od 10 L ha<sup>-1</sup>) uz utrošak vode od 300 L ha<sup>-1</sup>. U pokusima su provedene standardne mjere kontrole korova, štetočinja i bolesti. Podaci o temperaturama i oborinama tijekom dvogodišnjeg istraživanja dani su u tablici 1. Iz podataka je vidljivo da su prosječne minimalne i maksimalne temperature tijekom vegetacijskih sezona 2004. i 2005. bile vrlo slične i iznosile 10,5 °C i 22,4 °C. Tijekom vegetacijske sezone 2004. ukupna količina oborina u razdoblju od 01. travnja do 30. rujna iznosila je 428 mm. Najmanja količina oborina zabilježena je tijekom svibnja (39,9 mm), a najveća u lipnju (114,1 mm). U vegetacijskoj sezoni 2005. količina oborina bila je veća za 16% i iznosila je 509,1 mm. Tijekom lipnja zabilježeno je svega 43,5 mm oborina, a najveća količina zabilježena je u srpnju i iznosila je 124,0 mm.

Tablica 1. Srednja minimalna i maksimalna temperatura i količina oborina u Belici tijekom vegetacijskih sezona 2004. i 2005.

	2004			2005		
	Min. T (°C)	Max. T (°C)	Oborine (mm)	Min. T (°C)	Max. T (°C)	Oborine (mm)
Travanj	5,8	15,8	93,8	4,8	16,7	95,6
Svibanj	7,2	19,8	39,9	8,6	21,8	50,2
Lipanj	12,4	23,8	114,1	12,2	25,3	43,5
Srpanj	13,5	26,0	50,8	14,7	26,1	124,0
Kolovoz	14,0	27,0	63,3	13,0	23,6	112,3
Rujan	14,0	27,0	63,3	10,7	22,0	83,5
Prosjeak/Suma	10,4	22,3	428	10,7	22,6	509,1

Nakon 100 dana vegetacije uslijedila je berba usjeva. Za određivanje prinosa, strukture prinosa gomolja po veličini te sadržaja suhe tvari uzimani su uzorci s dvadeset sadnih mjesta u dva srednja reda u svakoj osnovnoj parceli. Podaci su statistički bili obrađeni analizom varijance. Za usporedbu prosječnih vrijednosti korišten je LSD test kada je F test bio signifikantan na razini P = 0.05.

### Rezultati i rasprava

Rezultati analize varijance pokazuju da je vegetacijska sezona signifikantno utjecala na prinos, sadržaj suhe tvari i strukturu prinosa gomolja (tablica 2). U 2004. utvrđen je značajno veći prinos gomolja od 46,5 t ha<sup>-1</sup> u

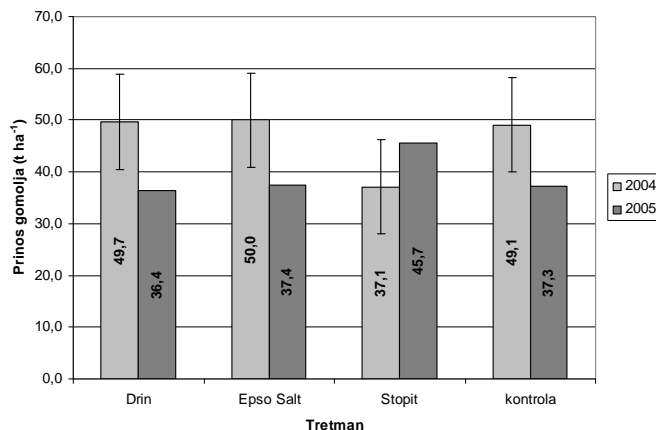
odnosu na 39,2 t ha<sup>-1</sup> utvrđene 2005. Veći prinos gomolja u 2004. rezultat je većeg broja formiranih gomolja, ali sitnije frakcije. Rezultati pokazuju da je u 2004. utvrđena značajno veća masa gomolja veličine 0-35 mm i prosječno je iznosila 5,54 t ha<sup>-1</sup> u odnosu na 2005. u kojoj je utvrđeno 1,63 t ha<sup>-1</sup>. Također je u 2004. utvrđena veća masa gomolja veličine 35-55 mm i prosječno je iznosila 19,93 t ha<sup>-1</sup> u odnosu na 5,93 t ha<sup>-1</sup> utvrđenih u 2005. Naime, u 2004. tijekom faze inicijacije gomolja palo je više od 60 mm kiše što je pogodovalo većim brojem zametnutih gomolja. Shock i sur. (1992) navode da je broj gomolja reduciran ako se stres uslijed nedostatka vode pojavi rano u vegetaciji, u vrijeme ili prije inicijacije gomolja. Nadalje, u istoj 2004. faza nalijevanja gomolja tijekom srpnja i do sredine kolovoza popraćena je s vrlo malo padalina, u odnosu na 2005., što je spriječilo translokaciju asimilata u gomolje te njihovo daljnje zadebljanje što potvrđuju i rezultati istraživanja. Tako je u 2004. dobivena značajno manja masa gomolja veličine >55 mm i iznosila je 19,9 t ha<sup>-1</sup> u odnosu na 31,6 t ha<sup>-1</sup> utvrđenih 2005. Nadalje, King i sur. (2003) utvrdili su da vodni stres tijekom nalijevanja gomolja rezultira u smanjenom postotku krupnijih gomolja. U vegetacijskoj sezoni 2004. utvrđen je značajno veći sadržaj suhe tvari u gomolju krumpira i prosječno je iznosio 27,97% u odnosu na vegetacijsku sezonu 2005. godine u kojoj je zabilježeno 23,04% suhe tvari. Razlog povećanom postotku suhe tvari u gomolju krumpira u 2004. vjerojatno je period suše na kraju vegetacije (palo je svega 5,8 mm kiše). Naime umjereni vodni stres na kraju vegetacije obično dovodi do povećanja postotka suhe tvari (Haverkort i sur., 1992; DeBlonde i sur., 1999).

Tablica 2. Rezultati analize varijance za prinos, sadržaj suhe tvari i strukturu prinosa gomolja

Izvori varijabiliteta	Prinos	Sadržaj suhe tvari	Masa gomolja		
			0-35 mm	35-55 mm	>55 mm
Vegetacijska sezona (VS)	**	**	**	**	**
Tretman (T)	NS	NS	NS	NS	NS
VS × T	**	NS	NS	NS	*

\* signifikantno na razini 0,05; \*\* signifikantno na razini 0,01; NS nije signifikantno

Prinos gomolja krumpira značajno je varirao pod utjecajem tretmana u obje vegetacijske sezone na što ukazuje signifikantna interakcija vegetacijska sezona × tretman (tablica 2). U 2004. tretman Stopit ostvario je značajno manji prinos gomolja krumpira od 37,1 t ha<sup>-1</sup> u odnosu na kontrolu (49,1 t ha<sup>-1</sup>) (grafikon 1). U istoj vegetacijskoj sezoni između tretmana Drin i Epso Salt i kontrole nije utvrđena značajna razlika u prinosu gomolja. U 2005. nije utvrđena signifikantna razlika u prinosu gomolja između folijarnih tretmana i kontrole.

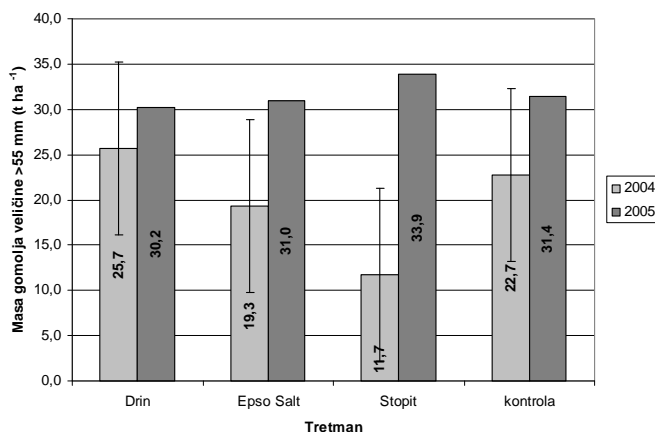


Grafikon 1. Prinos gomolja krumpira folijarnih tretmana u usporedbi s kontrolom u vegetacijskim sezonama 2004. i 2005. LSD (0,05) = 9,16 t ha<sup>-1</sup>.

Masa gomolja krupne frakcije (>55 mm) varirala je pod utjecajem tretmana tijekom dvije vegetacijske sezone (tablica 2). U 2004. značajno manju masu gomolja krupne frakcije u odnosu na kontrolu ostvario je tretman Stopit (grafikon 2). Između tretmana Drin i Epso Salt i kontrole nije utvrđena signifikantna razlika u masi gomolja krupne frakcije. U 2005. nije utvrđena signifikantna razlika između folijarnih tretmana i kontrole za navedeno svojstvo.

Nije utvrđen značajan utjecaj tretmana na sadržaj suhe tvari gomolja krumpira. Svi tretmani su imali slične međusobne odnose u postignutom sadržaju suhe tvari u gomolju u obje vegetacijske sezone na što je i ukazala nesignifikantna interakcija vegetacijska sezona × tretman (tablica 2).

## Utjecaj folijarnih gnojiva na prinos i sadržaj suhe tvari gomolja krumpira (*Solanum tuberosum* L.)



Grafikon 2. Masa gomolja krumpira veličine >55 mm nakon primjene folijarnih tretmana u usporedbi s kontrolom u vegetacijskim sezonama 2004. i 2005. LSD (0,05) = 9,55 t ha<sup>-1</sup>.

### Zaključci

Prinos, sadržaj suhe tvari i struktura prinosa gomolja značajno su varirali ovisno o vegetacijskoj sezoni. Primjena folijarnih gnojiva nije utjecala na sadržaj suhe tvari gomolja krumpira. Prinos gomolja i masa gomolja veličine >55 mm značajno su varirali pod utjecajem tretmana u obje vegetacijske sezone. Smatramo da istraživanja treba nastaviti i utvrditi utjecaj folijarnih gnojiva na fotosintetsku aktivnost biljaka krumpira.

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# Amelioration of pseudogley soil using different ameliorants and fertilizers

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## Abstract

This study evaluates the effect of different ameliorants (phosphorus fertilisers, Njival Ca lime fertiliser and manure) on pseudogley fertility and yield of small grains. The largest positive effect on major agrochemical properties of acid pseudogley was produced by Njival Ca lime fertiliser and manure. The combined use of lime fertiliser, manure and NPK led to a reduction in soil acidity, a substantial increase in available phosphorus levels (6.9 to 10.4 mg 100<sup>-1</sup>g) and, partly, potassium levels, and a decrease in mobile Al (down to 0.4 mg 100<sup>-1</sup>g) and available forms of Fe and Mn. Grain yield of small grains, particularly wheat and barley, considerably increased with the use of Njival Ca lime fertiliser and manure.

Key words: amelioration, fertiliser, “Njival Ca”, pseudogley, soil

## Introduction

Acid soils limit crop production in 30-40% of the total world's arable land and 70% of potentially arable land (Eswaran et al., 1997). Acid soils in the Republic of Serbia account for more than 60% of total arable land (Stevanović et al., 1995).

The low pH of these soils and a deficiency of major biogenic nutrients, primarily P and Ca, are factors constraining high stable yields of cultivated plants. Apart from the acid reaction, these soils are often characterised by an increased content of toxic forms of Al, Fe and Mn, and a deficiency or reduced availability of P, Ca, Mg and certain micronutrients, Mo, Zn and B in particular (Sumner, 2004).

Different ameliorants are used to improve soil properties and increase yields of cultivated plants (Vakalis et al., 2005; Caires et al., 2008). Acid soil neutralisation leads to an increase in soil pH and exchangeable Ca level, as well as to a decrease in mobile Al level down to a soil depth of 60 cm (Caires et al., 2008).

Pseudogley and other types of acid soils occupy large land area in Central Serbia. Therefore, it was deemed important to evaluate the effect of certain ameliorants in improving major agrochemical properties of acid pseudogley and increasing yield of winter small grains.

## Material and methods

A field trial was conducted over a period of three years (2008-2010) to study fertilisation on pseudogley soil. The trial included an untreated control and three ameliorative fertilisation treatments: NPK+1 (120 kgNha<sup>-1</sup>; 160 kgP<sub>2</sub>O<sub>5</sub>ha<sup>-1</sup>; 53 kgK<sub>2</sub>Oha<sup>-1</sup>), NPK+2 (120 kgNha<sup>-1</sup>; 80 kgP<sub>2</sub>O<sub>5</sub>ha<sup>-1</sup>; 53 kgK<sub>2</sub>Oha<sup>-1</sup>+5 t “Njival Ca”ha<sup>-1</sup>) and NPK+3 (120 kgNha<sup>-1</sup>; 80 kgP<sub>2</sub>O<sub>5</sub>ha<sup>-1</sup>; 53 kgK<sub>2</sub>Oha<sup>-1</sup>+5 t “Njival Ca” ha<sup>-1</sup>+20 t manure ha<sup>-1</sup>). Fertilisation treatments were set up in a randomised block design with three replications. The experimental plot was 50 m<sup>2</sup>. The fertilisers applied included complex NPK fertiliser (8:24:16), superphosphate (17% P<sub>2</sub>O<sub>5</sub>) and ammonium nitrate (AN=17% N) applied as a nitrogen fertiliser towards the end of winter. Maize was used as the preceding crop. Four different genotypes of winter small grains (wheat, barley, triticale and rye) were



cultivated on the trial field. Following harvest in the second year of the study, soil samples were collected from the soil depth of 0-20 cm from different ameliorative fertilisation treatments. Upon preparation of soil samples, chemical analysis was performed using standard methods: the Koltzman method for humus content, the Kjeldahl method for nitrogen, the Egner-Riehm Al method for readily available phosphorus and potassium, atomic absorption spectrophotometry for available forms of micronutrients and iron upon extraction from soil: for Fe and Zn = 1M CH<sub>3</sub>COONH<sub>4</sub> (pH = 4.8), for Mn = 0.1 M H<sub>2</sub>SO<sub>4</sub>, for Cu = 1M HCl, and the calorimetric method using aluminon acetate buffer for mobile Al.

## Results and discussions

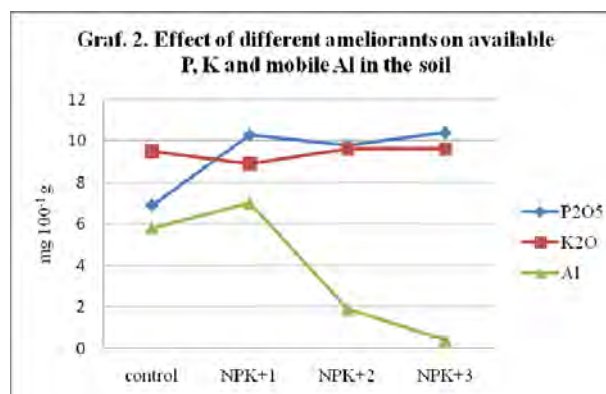
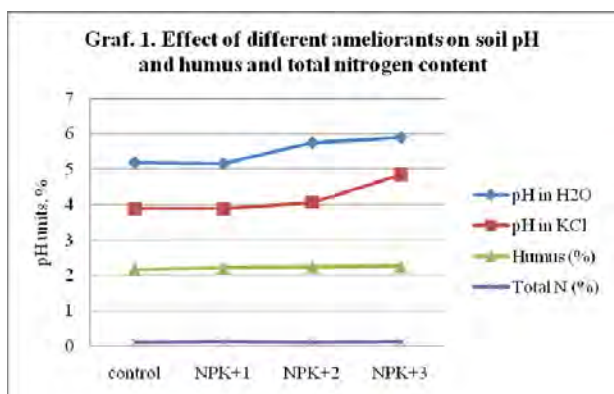
The soil used in the study was an extremely acid soil having a poor supply of readily available phosphorus, nitrogen and humus, a moderate supply of readily available potassium and a high supply of mobile aluminium (Tab. 1).

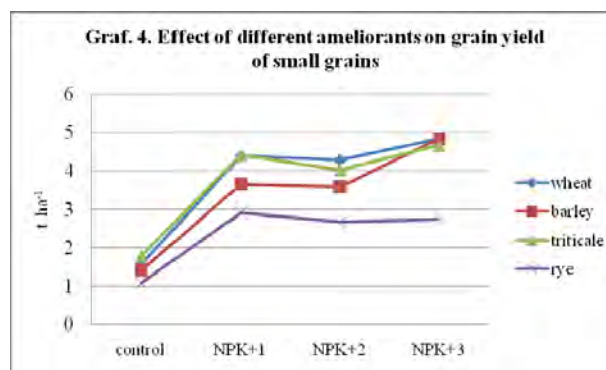
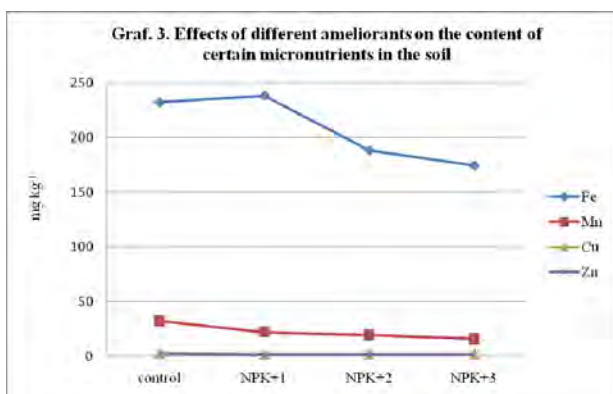
Table 1. Major soil agrochemical properties

Depth (cm)	pH		Humus (%)	Total N (%)	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O mg 100 <sup>-1</sup> g	Al mobile
	H <sub>2</sub> O	KCl					
0-20	5.42	4.46	2.19	0.148	8.0	13.8	11.86
20-40	5.52	4.62	1.74	0.132	7.0	18.8	13.61
40-60	5.60	4.78	1.06	0.098	1.3	24.6	8.50

The combined use of different ameliorants and regular fertilisation showed a positive effect on certain agrochemical properties of the soil. Namely, soil pH in H<sub>2</sub>O and KCl exhibited an increasing tendency as induced by the use of the Njival Ca lime fertiliser, particularly when combined with manure (Graph 1). Similar results were reported by previous studies (Jelić et al., 2003; Caires et al., 2008).

The humus and total nitrogen contents were not substantially affected by the different ameliorants used in the study (Graph 1). Humus is known as a highly stable soil constituent, its content being invariable over a short period of time. Similar observations have been made on the content of total nitrogen, which is directly correlated with the soil humus content. The content of available phosphorus in the soil considerably increased with the use of different ameliorants (Graph 2). As compared to the control, a substantial increase in P<sub>2</sub>O<sub>5</sub> resulted from the use of ameliorative phosphorus fertiliser (NPK+1). An almost identical soil level of P<sub>2</sub>O<sub>5</sub> was obtained with the ameliorative application of the Njival Ca lime fertiliser, as well as with the combined use of lime fertiliser and manure. An increase in the content of available phosphorus due to the ameliorative use of phosphorus fertilisers was also previously reported by other authors (Jelić et al., 2003; Haynes, 2010). The availability of potassium in pseudogley soil was not significantly affected by the ameliorants employed (Graph 2). A slight decrease in soil K<sub>2</sub>O was induced by the ameliorative use of phosphorus fertiliser. Given the fact that an identical amount of potassium was used in the NPK fertiliser, minimum changes in K<sub>2</sub>O in the soil were expected.





The use of different ameliorants had a strong effect on Al mobility in the soil (Graph 2). The ameliorative use of phosphorus fertiliser (NPK+1) resulted in increasing the content of mobile Al in the soil, whereas that of the Njival Ca lime fertiliser (NPK+2) led to a substantial decrease in its mobility. The highest reduction in the content of mobile Al was induced by the combined use of lime fertiliser, manure and regular NPK fertilisation (NPK+3). The ameliorative use of fertilisers had an indirect effect on mobile Al content, the effect being exhibited through the effect on soil pH. Namely, the ameliorated treatments having the highest pH value had the lowest content of mobile Al ( $0.4 \text{ mg } 100^{-1} \text{ g}$ ). Similar results were obtained by other authors (Caires et al., 2008; Haynes, 2010).

Ameliorative fertilisation had quite different effects on the availability of certain micronutrients in the soil (Graph 3). The decrease in available Fe was highest with the use of Njival Ca lime fertiliser as well as with the combined application of lime fertiliser and manure. The same ameliorants also caused a decrease in active Mn content but no substantial effect on Cu and Zn availability.

Grain yield of small grains tested in this study showed a substantial increase as induced by the use of different ameliorants (Graph 4). The highest average yield was obtained with the Njival Ca limer fertiliser and manure.

A number of previous studies showed susceptibility of winter wheat and, particularly, winter barley to low soil pH. Therefore, lime and manure fertilisation coupled with NPK have a strong effect on grain yield of these crops (Jelić et al., 2004). A highly positive effect on grain yield, as compared to the control, was produced by the ameliorative use of phosphorus fertiliser (NPK+1). The application of NPK and ameliorative rates of P had a high effect on grain yield of all crops tested. The highest effect was manifested in the increased production of winter wheat and barley. The effect resulted from both a reduction in soil acidity and an increase in the content of available phosphorus in the soil. The positive effect of the ameliorative use of phosphorus fertilisers on grain yield of winter wheat and barley and other small grains was reported previously by other authors (Jovanović et al., 2006; Kovačević et al., 2006).

## Conclusions

The results obtained in this study on the positive effect of different ameliorants on the chemical properties of pseudogley soil and grain yield of small grains grown on the ameliorated soil suggest the following: The highest positive effect on major chemical properties of acid pseudogley was produced with the use of Njival Ca lime fertiliser and manure. Lime and manure fertilisation along with the regular application of NPK induced an increase in soil pH (about 1.0 pH unit), a substantial increase in available forms of phosphorus (from 6.9 to 10.4 mg 100<sup>-1</sup>g) and, partly, potassium, a decrease in mobile Al content (to 0.4 mg 100<sup>-1</sup>g) and available forms of Fe and Mn, and no significant effect on the humus and total nitrogen content. The use of 5 t ha<sup>-1</sup> lime and 20 t ha<sup>-1</sup> manure, along with the regular NPK fertilisation, led to a considerable increase in grain yield of small grains, particularly barley and wheat.

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# Land use system analysis approach

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## Abstract

Land use system analysis data are presented to highlight risk areas and vulnerability of Hungarian agriculture in accordance with recent studies. The analysis approach has been based on government statistical data, land use technology characteristics as well as geographic information databases. Over the past century (from 1938 to 2010) profound changes have been introduced regarding the cropping structure of the country. Major grain crops like winter wheat, kernel maize and other cereals proved to be stable crops with some crop year variations. Oil seed crops, - sunflower and oilseed rape started a boom in the nineties, while root and tuber crops have almost been eliminated from the cropping structure. Other crops including fodder species have been exposed to decrement in accordance with the decline of animal husbandry. The results obtained support a conclusion, that land use changes have induced increment of risk factors in agricultural area. Major territories of Hungary are exposed to wind erosion, and some one third of the country is exposed to water erosion as well. Subsurface water bodies (water table, ground water, karst etc) are available in most parts of the country, however the magnitude and utility of them is rather diverse. Some two thirds of the country is exposed to potential nitrate pollution susceptibility. Less favourable agricultural areas are scattered all over the country including large homogeneous areas in the Northern and Eastern parts as well as the Danube-Tisza interfluvial areas. Location of the endangered areas can be correlated with the presence of employment failures like increment of jobless population.

Key words: land use, cropping structure, risk assessment

## Introduction

Hungary is well-endowed for agricultural production. The country has fertile soils and a high number of sunshine hours. Almost two-thirds of the country's total area is under agricultural cultivation (Várallyay 2006). Among other EU members states, only Denmark and the United Kingdom have higher proportions. The agricultural area of the old EU member states has tended to decrease in the past few years, while the proportion of cultivated areas in the new EU member states has not changed. Although Hungary accounts for only 3% of the total agricultural area of the 27 EU member states, we play a major role in the production of a number of agricultural products (Jolánkai-Birkás 2009). In the EU-27, an average of one third of the agricultural area is devoted to cereal production. Cereal-production land accounts for 30% of the available area in the old member states, while the share is much higher (44%) in the new member states. Hungary produces cereals on half of its agricultural area. This proportion is only exceeded in a few member states. Oilseed crop production as well as fodder cropping is of high importance in recent years.

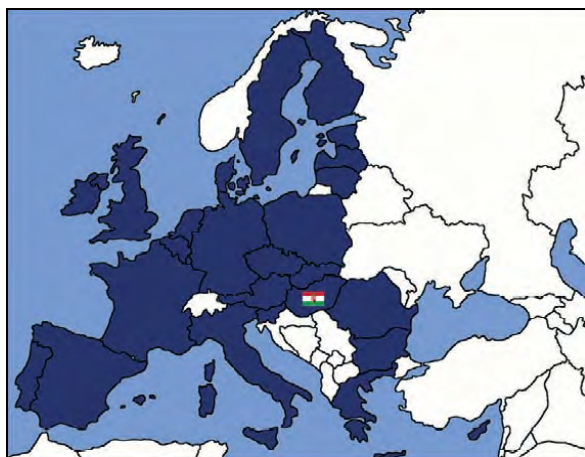


Figure 1.  
Hungary within the European Union

### Materials and methods

Land use system analysis data have been processed to formulate risk assessment of areas and vulnerability of Hungarian agriculture (Láng et al 2004). The analysis approach has been based on government statistical data, land use technology characteristics as well as geographic information databases.

Table 1. Agricultural statistical data of Hungary

Area of Hungary (km <sup>2</sup> )	93.030
Agricultural area (without forests) (million ha)	6,58
Number of inhabitants	10 005 000
Agricultural area per capita (ha)	0,65
Arable land (million ha)	4,76
Grassland (million ha)	1,43
Others; orchards, vinyards (million ha)	0,39
Proportion of arable land per country's area(%)	51,2
Proportion of arable land per agricultural area(%)	72,3
Proportion of less favoured areas (LFA) (%)	38,2
Vulnerable areas according to Nitrate Directive (% of agric area)	33,5
Proportion of land under organic management (% of agric area)	2,3
of which:	
- arable land (%)	48,3
- grassland (%)	51,7
Area under minimum soil tillage (% of arable land)	na
Area under precision farming (% of arable land)	na

Source FVM 2009

Profound changes have been introduced regarding the cropping structure of the country in the period from 1938 to 2010. Major grain crops like winter wheat, kernel maize and other cereals proved to be stable crops with some crop year variations. Oil seed crops, - sunflower and oilseed rape increased in the nineties, while root and tuber crops have almost been eliminated. Other crops including fodder species have been exposed to decrement in accordance with the decline of animal husbandry.

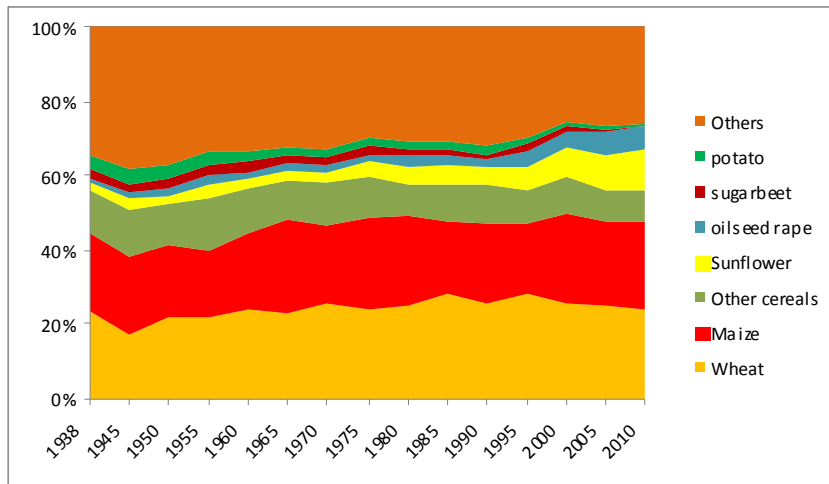


Figure 2. Changes in crop structure in Hungary 1938-2010. Source: FVM 2010

For estimating risk factors and potential vulnerability, statistical data downscaled to the community territories have been used.

### Results

It can be concluded upon the results obtained, that land use changes have induced increment of risk factors in agricultural area, summarized by the following charts. Major territories of Hungary are exposed to wind erosion, and some one third of the country is exposed to water erosion as well.



#### Risk areas of potential wind erosion.

The coloured patches represent community territories.

Source: Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences

## Land use system analysis approach



### Risk areas of potential water erosion.

The coloured patches represent community territories.

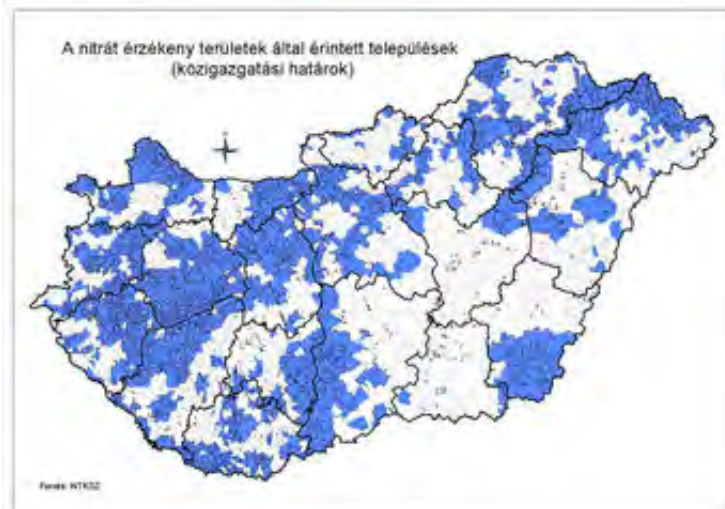
Source: Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences



### Available water bodies in Hungary

The coloured patches represent community territories.

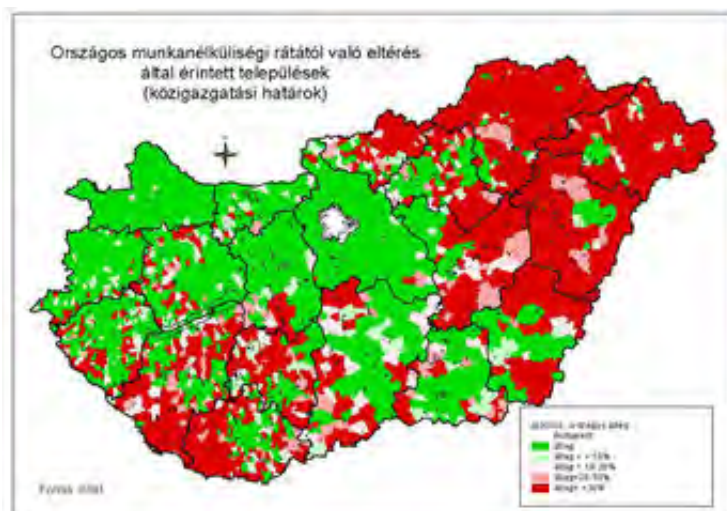
Source: Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences



### Potential nitrate vulnerability

The coloured patches represent community territories.

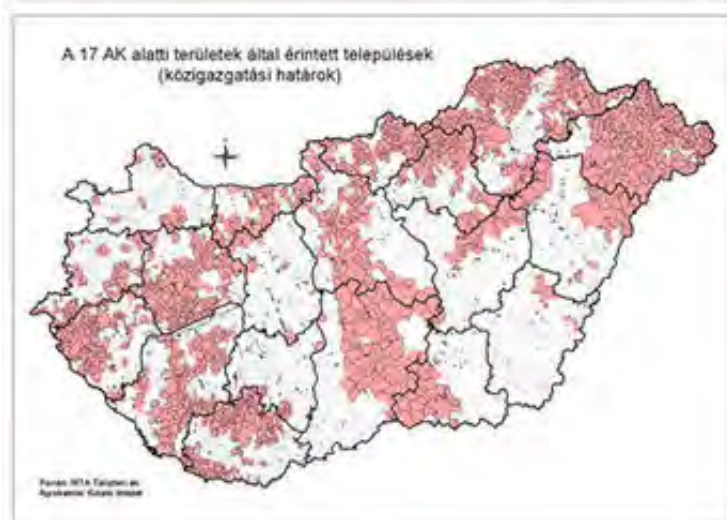
Source: Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences



#### Unemployment rate deviations in Hungary

Red colour patches indicate increment, while that of green is for decrement.

Source: Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences



#### Less favourable agricultural land in Hungary

The coloured patches represent community territories with >17AK value

Source: Research Institute of Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences

Availability of subsurface water bodies (water table, ground water, karst etc) is given in most parts of Hungary, however the magnitude and utility of them is rather diverse. A considerably big part of the country is endangered by potential nitrate pollution susceptibility. Less favourable agricultural areas are scattered all over the country including large homogeneous tracts in the Northern and Eastern parts as well as the Danube-Tisza interfluvial areas. Location of the endangered areas can be correlated with the presence of unemployment.

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# Effect of aerial deposition on an experimental station near to Budapest, Hungary

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## Abstract

The composition of precipitation and element loads originating from rainwater were examined at an experimental station (Órbottyán) in Hungary, in order to identify the aerial input of elements and define their effects on agriculture and environment. Twenty-five characteristics were analysed: pH, EC, NO<sub>3</sub>-N, NH<sub>4</sub>-N, and concentrations of the main macro- and microelements. The observation represents the dry and wet depositions together.

Generally, the lower amount of monthly precipitations resulted in higher EC, pH, NH<sub>4</sub>-N, Ca, Na, K concentrations. The highest element yields however, were typical for the wet months. Acidic precipitation under pH 5 was rich in nitric acid forming NO<sub>3</sub>-N, but poor in NH<sub>4</sub>-N at the Experimental Station. Emission of the nearby cement plant in February and March 2006 caused an increase of Ca, Mg, Na, Sr elements with an order of magnitude compared to the other months and the concentrations of NH<sub>4</sub>-N, S, Zn, As, Cr, Pb also lifted considerably in the precipitation. The pH reached 7.0 at this site.

Aerial input has considerable agronomical and environmental significance. According to this study the aerial deposition could substitute for 10% K, 15% Mg, 20% P, 30% Ca and N, 40% S element demand of an average 5 t/ha cereal grain yield with its 5 t/ha straw. The deposition of Zn, Mn, Fe, Cu, B elements in this site were similar to previous Hungarian and Austrian data, however Pb, Ni, Cd, Co depositions were lower with an order of magnitude, which demonstrates the result of the successful heavy metal pollution control in Europe since 1990.

Key words: aerial deposition, macro- and microelements, agricultural importance, environmental consequences, nutrient balances

## Introduction

In Hungary, Kazay (1904) analysed the ammonium and nitrate content of the rainfall at Ó-Gallya Station between 1902 and 1904. Concentration of NH<sub>4</sub>-N was 12 kg/ha and NO<sub>3</sub>-N was 5 kg/ha in 1902, so he found a 17 kg/ha/year N deposition. Data from the literature also supports that content of NH<sub>4</sub>-N can be 2-3-fold compared to NO<sub>3</sub>-N. NH<sub>4</sub>-N can be enriched in lower strata clouds, since it is mostly emitted by the soil surface. Maximum values are typical for January, minimum values for July, because water can absorb less gas at higher temperature. The first raindrops and the hail in summer are also rich in ammonia. N deposition of an abundant rainfall with available nitrate and ammonia could be equal to 30 kg/ha N fertilization, according to Kazay (1904).

Based on data from the 1980's Nriagu and Pacyna (1988) and Nriagu (1989) estimated, that human activity is responsible for 96% of Pb, 85% Cd, 75% V, 66% Zn, 65% Ni, 61% As, 59% Hg and Sb, 56% Cu, 52% Mo, 42% Se, 41% Cr of the total aerial amount of these elements on a global scale. It was also established, that toxic elements accumulate fast in air, waters, soils and in the whole food chain, which is an unknown risk for the future generations.

Sager (2009) in Austria calculated the atmospheric deposition in 1999-2000 from own and literature data as follows: Zn 308, Cu 110, Ni 30, Pb 24, Cr 12, Cd 2 g/ha/year. The Cr and V pollution was made mainly by

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fertilizers, while Pb and Zn pollution came mainly from aerial deposition. In the case of As, Cd, Ni elements the two mentioned sources had similar effects.

Ammonia emission was reduced by 60% in Hungary between 1980 and 2000. About 94-98% of this emission originates from agriculture. The main sources are manuring, N-fertilization, animal farms, communal sewage and garbage production (CSOH 2003). Since 1990, the decreasing trend in N-fertilization, animal husbandries and manuring are responsible for most of the emission reduction in Hungary. In Northwestern Europe efforts were also successful for the reduction of air pollution (SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>) since 1990 (Boxman et al. 2008).

Table 1 presents an estimated microelement-balance in the 1980's in Hungary. According to our analytical data, phosphorous fertilizers had the highest content of microelement pollutants. Fertilization caused about 30 g As, 8 g Zn and Cu, 4-5 g Pb, 1-2 g Se, 0.8 g Cd and 0.4 g Ni per hectare load yearly as an estimation in the 1980's due to the practice of large-scale fertilizer application. Fertilization made only 5-10% of the total pollution, so generally its role was almost negligible, but this source was responsible for the 2/3 of the total As load. Manure application is a considerable source of Zn, Pb, Cu, Ni, As elements. However, greatest pollution of Zn, Pb, Cd and partly Ni came from atmospheric precipitation.

According to Table 1 the balances of the observed microelements were positive. Inputs of Pb and As were 5-fold, Cd 4-fold, Se 2.5-fold, Zn and Ni 1.5-fold compared to outputs of these elements. The situation has changed by nowadays. After the 1990's Pb load decreased to 1/5 with the introduction of unleaded fuel, and As decrement was similar due to the reduction of superphosphate application. Income of Pb, Cd and Zn from the Silesian "Black triangle" also declined as the former industrial area has been collapsed.

**Table 1. Estimated microelement-balance in agricultural cultivated soils in Hungary in the 1980's, g/ha (In: Kádár et al. 2009)**

Balance items	Zn	Pb	Cu	Ni	As	Cd	Se
<b>Input</b>							
Mineral fertilizers	8	5	8	<1	30	0.8	1.5
Organic fertilizers	180	30	60	15	15	1.5	1.5
Sewage sludge	50	17	17	3	2	0.3	1.7
Liming materials	2	<1	1	<1	<1	<0.1	<0.1
By-products	80	8	60	7	<1	0.8	0.5
Precipitation	200	70	24	15	1	5.0	*1.0
<b>Total</b>	<b>520</b>	<b>130</b>	<b>170</b>	<b>40</b>	<b>47</b>	<b>8.4</b>	<b>6.2</b>
<b>Output</b>							
Plant uptake	200	10	100	10	1	1.0	1.0
Leaching	20	10	5	5	4	1.0	0.5
Volatilisation	-	5	-	-	5	-	1.0
<b>Total</b>	<b>220</b>	<b>25</b>	<b>105</b>	<b>15</b>	<b>10</b>	<b>2.0</b>	<b>2.5</b>
<b>Balance</b>	<b>+300</b>	<b>+105</b>	<b>+65</b>	<b>+25</b>	<b>+38</b>	<b>+6.4</b>	<b>+3.7</b>
<b>Input% compared to output</b>	<b>236</b>	<b>520</b>	<b>162</b>	<b>267</b>	<b>480</b>	<b>420</b>	<b>248</b>

\*Verbal information from Ágnes Molnár, Atmospheric chemistry group, University of Veszprém

Earlier, a comprehensive research was done at two Experimental Stations of the Research Institute for Soil Sciences and Agricultural Chemistry in order to estimate the amount of the aerial element input and its effects on agriculture and environment (Kádár et al. 2009, Kádár and Ragályi 2010).

### Material and methods

Samplings were conducted at one of the Experimental Sites of the Research Institute for Soil Sciences and Agricultural Chemistry in Órbottyán city (Danube-Tisza mid region), where amount of monthly precipitations were measured for almost 50 years. The measuring equipment was installed 1 m high above the ground and emptied every day at 7 a.m. according to the general meteorological practice. The accuracy of the measurement is 0.1 mm. The solid snow, sleet, freezing rain and hail are measured after melting. The dew, frost and hoar are not considered to be precipitation.

The precipitation samples were stored in glass bottles at 7°C and analysed monthly for 26 attributes. Measuring of mineral elements were conducted by ICP technique. Electrical conductivity, pH as well as As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Se, Sr, Zn, S, B, NH<sub>4</sub>-N and NO<sub>3</sub>-N

contents were determined. Element yield or atmospheric deposition was calculated by multiplying the rainfall amount with element concentrations. The measuring equipments collected not only rain but also aerosol particles of dry fall-out so wet and dry inputs were sampled together. However according literature data the proportion of dry deposition is diverse depending on elements, but makes only 5-10% of the total aerial input. The incidental pollution from the measuring equipment was additionally observed. Measurements of macro- and microelements were made by ICP-OES device excluding nitrogen.

### Results and discussion

The monthly data of amount, conductivity, pH as well as element concentrations and yields of rainfall are shown in *Table 2* between January and July 2007.

**Table 2. Characteristics of the monthly precipitation as well as element yield in 2007 (Danube-Tisza mid region, calcareous sandy soil, Órbottyán)**

Months in 2007	Precipitation mm	Conductivity $\mu\text{S}/\text{cm}$	pH	Ca	NH <sub>4</sub> -N	NO <sub>3</sub> -N	S	Na	K
				Concentration, mg/l					
I.	31	62	4.5	3.6	0.7	4.0	n.d.	1.1	1.1
II.	46	54	4.8	3.4	1.1	3.6	n.d.	1.1	0.9
III.	39	78	4.2	4.4	0.8	4.0	n.d.	0.7	0.7
IV.	4	140	7.2	4.7	11.6	0.0	n.d.	1.2	3.1
V.	58	71	6.9	1.9	5.5	1.7	n.d.	1.2	1.2
VI.	61	86	4.5	7.7	0.7	5.8	n.d.	0.9	2.0

Months in 2007	Precipitation mm	Conductivity $\mu\text{S}/\text{cm}$	pH	Ca	NH <sub>4</sub> -N	NO <sub>3</sub> -N	S	Na	K
				Element yield, kg/ha					
I.	31	62	4.5	1.1	0.2	1.2	n.d.	0.3	0.3
II.	46	54	4.8	1.5	0.5	1.6	n.d.	0.5	0.4
III.	39	78	4.2	1.7	0.3	1.6	n.d.	0.3	0.3
IV.	4	140	7.2	0.2	0.5	0.0	n.d.	0.0	0.1
V.	58	71	6.9	1.1	3.2	1.0	n.d.	0.7	0.7
VI.	61	86	4.5	4.7	0.4	3.6	n.d.	0.5	1.2

Total:	239	-	-	10.3	5.2	9.0	-	2.4	3.1
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n.d. - not detectable

The maximal electrical conductivity, pH, NH<sub>4</sub>-N, Na and K concentrations, as well as the lack of NO<sub>3</sub>-N connected to the lowest 4 mm amount of rainfall in April. The highest element yield resulted however in the rainiest May and June. The precipitation in March was strongly acidic with pH 4.2. Generally, when the nitric acid forming NO<sub>3</sub>-N concentration is 3-5-fold more than the pH increasing NH<sub>4</sub>-N concentration, the pH value goes under 5. The NO<sub>3</sub>-N excess is also related to the high atmospheric N yields.

During the examined half year total aerial deposition was 14 kg N, 10 kg Ca, 2-3 kg Na and K per hectare. S could be detected only in traces. During the second half-year the amount and composition of the rain did not undergo such dramatic changes so it will not be presented in details.

Table 3 gives an overview about the amount and observed characteristics of measured aerial deposition between 2005 and 2008. The Ca, Mg, Na and Sr concentrations in rainwater raised an order of magnitude in February and March 2006. NH<sub>4</sub>-N, S and Zn depositions were also high.

**Table 3. Atmospheric deposition to soil at the Órbottyán Experimental Station (Danube-Tisza mid region, 2005-2008)**

Soil characteristics	Unit	2005	2006	2007	2008
		July-Dec.	Total	Total	January-June
NO <sub>3</sub> -N	kg/ha	10.7	10.0	19.9	4.3
NH <sub>4</sub> -N	kg/ha	5.7	38.0	9.5	9.2
Total N	kg/ha	16.4	48.0	29.4	13.5
Ca	kg/ha	8.0	60.1	13.3	8.6
K	kg/ha	6.0	16.5	6.3	3.1
S	kg/ha	5.8	21.1	2.2	0.0
Na	kg/ha	3.0	13.3	4.1	0.8
Mg	kg/ha	2.8	15.8	2.4	1.3
P	kg/ha	1.2	5.6	2.5	1.5
Zn	g/ha	430	1 391	264	67
Ba	g/ha	60	79	40	15
Sr	g/ha	27	202	35	24
Cu	g/ha	33	153	21	10
Precipitation	mm	406	523	466	273
pH					
minimum		5.2	4.7	4.2	5.0
maximum		6.8	7.0	7.2	5.9
Mean		6.1	6.0	5.5	5.4
EC					
minimum	μS/cm	30	47	25	26
maximum	μS/cm	179	1 996	140	149
Mean	μS/cm	71	320	68	61

These emissions originated mainly from the cement works in city Vác, which is about 14 km far away north-westward from where usually the wind blows. The pH reached 7.0 and conductivity was near to 2000 μS/cm. Yearly element yields were outstanding: 60 kg/ha Ca; 48 kg/ha N; 21 kg/ha S; 16 kg/ha K and Mg; 13 kg Na; 5-6 kg/ha P. The yields of the notable microelements were as follows: Zn 1391 g/ha; Sr 202 g/ha; Cu 153 g/ha; Pb 7 g/ha; As 4 g/ha; Cr 3 g/ha.

### Conclusions

Aerial deposition varied widely. The deposition of Zn, Mn, Fe, Cu, B elements were similar to previous Hungarian and Austrian data. However, Pb, Ni, Cd, Co depositions were lower with an order of magnitude compared to the earlier data from Mészáros et al. (1993), which demonstrates the result of the successful heavy metal pollution control in Europe since 1990.

The site was poor in N, P and K elements. The yearly 25-50 kg/ha N, 6-10 kg/ha K and 2-4 kg/ha P aerial depositions have agronomical importance. Yields are increasing year by year in PK treatments of a rye monoculture experiment since 1960 at this site, probably due to aerial N input (Kádár et al. 1984). In dry and unfavourable years the cereal yields remain below 2 t/ha, no N-effects observed. N supply could be covered by atmospheric N deposition because of the low crop yields. The Zn and Cu inputs are important among the microelements. This site is poor in Zn and Cu so the aerial deposition can totally cover the supply of these elements for the average yields. The adverse effect of the occasional acid rains can be compensated by the aerial deposition of Ca, Mg and Na.

### Acknowledgement

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# Utjecaj organske gnojidbe na količinu i dinamiku kalija u listu vinove loze (*Vitis vinifera* L.) na karbonatnom tlu

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## Sažetak

Cilj ovog istraživanja bio je utvrditi utjecaj različitih doza organskih gnojiva na količinu i dinamiku kalija u listu vinove loze na karbonatnom tlu tijekom jedne vegetacije.

Statistički značajno najveća količina kalija u prvom uzorkovanju (cvatnja) utvrđena je na tretmanu gnojidbe s 40 t ha<sup>-1</sup> stajskog gnoja (1,22% u suhoj tvari) a statistički značajno najmanja vrijednost na tretmanu kontrole (0,80% u suhoj tvari). U drugom i trećem uzorkovanju (2 tjedna poslije cvatnje i šara) statistički značajno najveća količina kalija također je utvrđena na tretmanu gnojidbe s 40 t ha<sup>-1</sup> stajskog gnoja, dok je statistički značajno najmanja količina kalija u oba uzorkovanja utvrđena na tretmanu gnojidbe s 20 t ha<sup>-1</sup> kiselog treseta.

S obzirom na vrijeme uzorkovanja na tretmanima: kontrola, stajski gnoj 20 t ha<sup>-1</sup> te NPK + URE-a količina kalija u listu je rasla od prvog (cvatnja) do drugog (2 tjedna poslije cvatnje) uzorkovanja te padala od drugog do trećeg uzorkovanja. Na tretmanima gnojidbe: treset 20 t ha<sup>-1</sup>, treset 40 t ha<sup>-1</sup> te stajski gnoj 40 t ha<sup>-1</sup> količina kalija u listu je imala padajući trend od prvog do trećeg uzorkovanja.

Ključne riječi: gnojidba, kalij, stajski gnoj, treset, vinova loza

## Effects of organic fertilization on potassium content and dynamics in grapevine leaf (*Vitis vinifera* L.) on calcareous soil

### Abstract

The aim of this study was to determine the effect of different amount of organic fertilizers on potassium content and dynamics in grapevine leaf during one growing season. In the first sampling time the statistically significant highest potassium leaf content (flowering) was determined in the treatment with 40 t ha<sup>-1</sup> farmyard manure (1.22% K in dry matter) and the statistically significant lowest value was determined in the control treatment.

In the second and the third sampling time (2 weeks after flowering and veraison) the significantly highest potassium leaf content (0,96% and 0,78% in dry matter, respectively) was determined in the treatment with 40 t ha<sup>-1</sup> of farmyard manure too, while the lowest content of potassium in each sampling was determined in the treatment with 20 t ha<sup>-1</sup> peat.

Considering to sampling time in the treatments: control, farmyard manure 20 t ha<sup>-1</sup> and NPK+UREA potassium leaf content has increased from the first (flowering) to the second sampling time (2 weeks after flowering), and has decreased from the second to the third sampling time. In the treatments: peat 20 t ha<sup>-1</sup>, peat 40 t ha<sup>-1</sup> and farmyard manure 40 t ha<sup>-1</sup> potassium leaf content had a decreasing trend from the first to the third sampling time.

Key words: farmyard manure, fertilization, grapevine, peat, potassium

## Uvod

Kalij je jedini jednovalentni kation koji je nužan za biljke. To je dominantan anorganski kation u biljnoj stanici, a čini 0,5 do 6% težine suhe tvari biljaka (Pavalek-Kozlina, 2003). Za razliku od dušika i fosfora, kalij ne ulazi u sastav organske tvari. Njegova važnost proizlazi iz aktivnosti u ionskoj formi i velikoj pokretljivosti u biljci (Bergman, 1992).

Neophodan je za regulaciju osmotskog tlaka i ravnotežu iona u stanici, neutralizaciju organskih kiselina, regulaciju gibanja puči, diobu stanica, za aktivaciju enzima, te ima važnu ulogu pri sintezi i translokaciji šećera (Fregoni, 1998). Conradie i Saayman (1989) navode da kalij povećava količinu suhe tvari u mladima, lišću i vinu dok Smolarz i Marcik (1997) navode da manjak kalija utječe na smanjenje priroda.

Vinova loza je veliki potrošač kalija a najviše ga usvaja od početka vegetacije do cvatnje i to 5/8, a ostatak od šare do dozrijevanja (Mirošević i Karlogan Kotić, 2008). Kod vinove loze na apsorpciju kalija značajan utjecaj ima i podloga. Tako je prema Brancadoro i sur., (1994) najveća količina kalija u lišću i moštu utvrđena na podlogama 44-53 M i SO<sub>4</sub>, a najmanja količina kalija na podlogama 140 Ru, 420 A i 1202 C. Taj utjecaj posebno je izražen u sušnim godinama.

Do nedostatka kalija najčešće dolazi na lakim, pjeskovitim tlima, teškim glinovitim tlima gdje se kalij fiksira, na karbonatnim tlima s obiljem fiziološki aktivnog vapna te pri višku Mg koji mu je antagonist. Biljke ga iznose u velikoj količini pa je gnojidba kalijem redovita agrotehnička mjera jer je manjak kalija vrlo česta pojava (Vukadinović i Lončarić, 1998).

Kako navodi Herencia i sur. (2008) aplikacijom organskih materijala utječe se na distribuciju biogenih elemenata kao i na bolju pristupačnost mikroelemenata biljci. Morlat i Symoneaux (2008) navode da organska tvar dodana tlu utječe na karakteristike tla kao što su gustoća tla i vododržnost, no, i na količinu dušika i kalija. Mineralizacija hraniva iz primjenjenih organskih gnojiva ovisi o temperaturi, vlažnosti tla, karakteristikama tla i gnojiva, te mikrobiološkoj aktivnosti. Butorac (1999) navodi da stajski gnoj prvenstveno popravljiva fizikalna svojstva tla, povećava njegovu adsorpcijsku sposobnost i pufernost te da sadrži dušik, fosfor, kalij, kalcij i magnezij. Da je pristupačnost kalija iz organskih gnojiva gotovo 100-postotna navode Eghball i sur., (2002).

## Materijali i metode rada

Pokus je postavljen 2009. godine na lokaciji Borička (Plešivičko vinogorje) po metodi slučajnog blokno rasporeda u četiri ponavljanja. Istraživanje je provedeno na sorti Sauvignon Blanc na podlozi SO<sub>4</sub>. Pokus je postavljen na rendzini, čiji pH<sub>H2O</sub> iznosi 8,02 te prosječno sadrži 2,75 mg P<sub>2</sub>O<sub>5</sub> na 100 g<sup>-1</sup> tla i 17 mg K<sub>2</sub>O na 100 g<sup>-1</sup> tla. U istraživanje je uključeno šest tretmana gnojidbe (kontrola-bez gnojidbe, 20 t ha<sup>-1</sup> zrelog stajskog gnoja, 40 t ha<sup>-1</sup> zrelog stajskog gnoja, 20 000 l ha<sup>-1</sup> kiselog treseta, 40 000 l ha<sup>-1</sup> kiselog treseta i 500 kg NPK 5:20:30 ha<sup>-1</sup> s dvije prihrane URE-om sa po 100 kg ha<sup>-1</sup>. Osnovna parcelica je veličine 22 m<sup>2</sup> uz razmak sadnje 2,20 x 1,00 m. Između svake varijante nalazi se izolacija 10 m, dok je izolacija između repeticija 1 red.

Reakcija tla (pH) određena je elektrometrijski, kombiniranom elektrodom na pH-metru MA5730 u suspenziji tla i vode u omjeru 1:2,5 (aktivna kiselost) (Škorić, 1982), humus metodom po Tjurinu (JDPZ, 1966), a fiziološki aktivni fosfor i kalij metodom po Egner-Riehm-Domingo (Egner i sur., 1960).

Uzorkovanje lišća provedeno je tri puta tijekom vegetacije (cvatnja, dva tjedna nakon cvatnje i šara). Prosječni uzorak lišća formiran je od 120 zdravih, potpuno razvijenih i neoštećenih listova uzetih nasuprot najnižeg grozda sa svakog trsa na pokusnoj parceli.

Prosječni uzorci lišća sušeni su na 105 °C. Količina kalija u listu određena je nakon digestije s koncentriranom HNO<sub>3</sub> (MILESTONE 1200 Mega Microwave Digester) očitanjem na plamenfotometru (AOAC, 1995).

Podaci su obrađeni uz pomoć statističkog programskog paketa SAS System for Win Ver. 9.1 (SAS Institute Inc., 2002-2003).

## Rezultati i rasprava

Prema provedenoj analizi varijance (tablica 1) statistički značajno najveća količina kalija u prvom uzorkovanju (cvatnja) utvrđena je na varijanti gnojidbe s 40 t ha<sup>-1</sup> stajskog gnoja (1,22% u suhoj tvari) kao i u drugom (1,2%) i trećem (0,95%) uzorkovanju (2 tjedna poslije cvatnje i šara). Utvrđene vrijednosti kalija u

ovom tretmanu u sorti Souvignon Blanc, cijepjenoj na podlozi SO4 u skladu su s navodima Herak Ćustić i sur. (2008), za karbonatna tla (1,15-1,19% K). Dobiveni rezultati također su i u skladu s istraživanjima (Morlat i Saymoneaux, 2008) koji navode da je najveća količina kalija u višegodišnjem gnojidbenom pokusu redovito utvrđivna na tretmanu gnojidbe s najvećom količinom organskog gnojiva (20 t ha<sup>-1</sup> stajskog gnoja).

Pretpostavlja se da je utjecaj kiselog treseta izostao prvenstveno zbog relativno dobre pristupačnosti kalija u širokom pH spektru, što navodi i Čoga i sur. (2009).

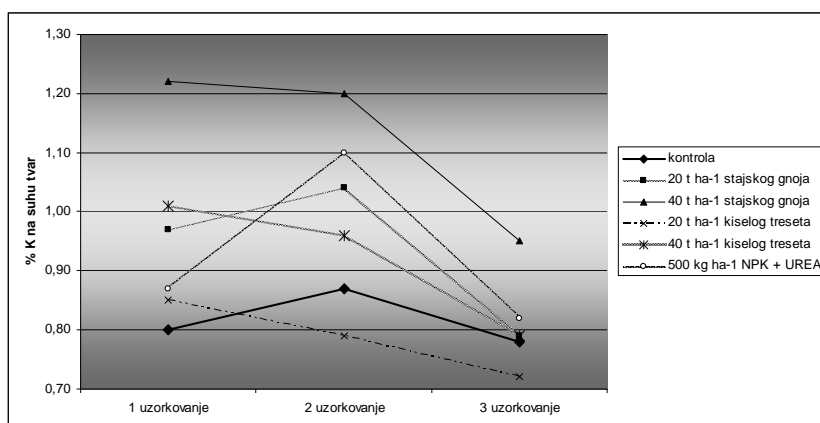
Tablica 1. Rezultati analize varijance na količinu kalija u listu vinove loze

Tretmani	% K u suhoj tvari		
kontrola	0,80 c	0,87 bc	0,78 ab
20 t ha <sup>-1</sup> stajskog gnoja	0,97 bc	1,04 abc	0,79 ab
40 t ha <sup>-1</sup> stajskog gnoja	1,22 a	1,20 a	0,95 a
20 t ha <sup>-1</sup> kiselog treseta	0,85 bc	0,79 c	0,72 b
40 t ha <sup>-1</sup> kiselog treseta	1,01 b	0,96 abc	0,78 ab
500 kg ha <sup>-1</sup> NPK + UREA	0,87 bc	1,10 ab	0,82 ab
	1 uzorkovanje	2 uzorkovanje	3 uzorkovanje

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05. Vrijednosti, kojima nije pridruženo slovo, nisu značajno različite.

S obzirom na vrijeme uzorkovanja na tretmanima: kontrola, stajski gnoj 20 t ha<sup>-1</sup> te NPK količina kalija u listu je rasla od prvog (cvatnja) do drugog (2 tjedna poslije cvatnje) uzorkovanja te padala od drugog do trećeg uzorkovanja.

Na tretmanima gnojidbe: treset 20 t ha<sup>-1</sup>, treset 40 t ha<sup>-1</sup> te stajski gnoj 40 t ha<sup>-1</sup> količina kalija u listu je imala padajući trend od prvog do trećeg uzorkovanja (grafikon 1), što je u skladu s literaturnim navodima (Bergmann, 1992)



Grafikon 1. Dinamika kalija u listu vinove loze

## Zaključak

Primjena organskih gnojiva (osobito stajskog gnoja) ima značajan utjecaj na količinu i dinamiku kalija u listu vinove loze na karbonatnom tlu. Temeljem ovih rezultata u gnojidbu vinograda uputno je primjenjivati zreli stajski gnoj u količini od 40 t ha<sup>-1</sup> svake 3-4 godine. Primjena treseta daje slabije rezultate, naročito ako je treset primijenjen u manjoj dozi (20 t ha<sup>-1</sup>).

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# Organic farming in Bela krajina and some future perspectives

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## Abstract

Since 1998 legal foundations of organic farming in Slovenia have been regulated. Although the supply of organic crops and products has been enlarged, it is not sufficient due to the rising demand. The article presents activities in organic farming, their distribution and productivity. The studied organic farms are situated in Bela Krajina (the southern part of southeastern Slovenia), which lies along the border with Croatia and is also the least polluted landscape in Slovenia. Organic farmers from this area are faced with low income per family member, the lack of manpower, the labour shortage and over-distance market locations. To improve mentioned situation the arrangement of inheritance question, the increased creative enthusiasm for processing and marketing as well as the expansion of local tourism with traditional organic food and products made by organic materials, namely organic textiles and biocomposed products, must be taken into account.

Key words: organic farming, questionnaire for organic farmers, Slovenia, autochthon varieties and breeds, integration of tourism

## Introduction

The attitude towards organic farming, organic food and non-food products made by organic materials has been changed in last decade among Slovenian consumers (Bavec M., 2004; MAFF, 2010). As the domestic supply is insufficient and seasonable, the majority of organic crops and products are imported. The international transport causes further pollution of environment, what is contradictory to organic farming guidelines. The quality of transported organic products, especially fresh fruit, vegetables and meat, does not equal the quality of local supplied organic products. The purpose of investigation is to present the weaknesses, advantages, opportunities and possibilities for further development of organic farming in Slovenia in case of Bela Krajina. The aim of research is to define some future perspectives that will contribute to greater market supply of organic food and organic non-food products, consequently Slovenian consumers could be self-sufficient in indigenous organic products.

## Material and methods

The development, scope and productivity of individual activities of organic farming in Slovenia were presented by using online statistical indicators and by analysis of questionnaire of 51 owners of organic farms in Bela krajina. The farms were visited in person, by prior telephone arrangement, in the first half of December 2009. Respondents completed the questionnaire with 29 questions enthusiastically, exemplary and independently; further explanations or assistance with the questions from providers of questionnaire were not given. The questionnaire included information about farm size and farm structure, about production specialization and the use of organic farming technologies as well as about the possibilities of supplementary activities and the way of marketing. Answers were grouped and explained by means of descriptive statistics.

## Results and discussion

After 1998 in Slovenia the legal aspect of organic farming was arranged by adopting a number of regulations on organic production and by appointing control organizations (Kocjan Ačko, 2000; Bavec et al., 2009). With Slovenia's entry into the European Union in 2004, all regulations comply with EEC Regulations 2092/91 and 1804/99. In 2007 the EU adopted new legislation which was enacted on 1 January 2009. Canceled earlier regulation was replaced by Council Regulation (EC) 834/2007, namely Organic production and labelling of foodstuffs, while specific areas of organic farming have been regulated by Community Regulations (EC) 889/2008 and 1235/2008 (Mikkelsen and Schlueter, 2009). Because innovations in regulations have been changing a lot constant renewal and updating of experts knowledge is necessary. At the end of 2009 there was 2096 organic farms included in organic farming inspection, only 1853 of them have obtained organic certification (MAFF, 2010; Statistical Office of ..., 2009). The percentage of organic farms is 2.7%, compared to all farms' number. The area cultivated by organic farming sized 30000 ha, which represent 6.1% of all agriculture land. More than 90% of organic cultivated land represents grassland therefore it is understandable that organic production with 10% can not be self-sufficient in producing organic vegetables, crops and fruits for Slovenian market. The average size of organic farms is 15 ha, which is about 2.5 times more than the size of the average Slovenian farm (6.4 ha). As organic farming in Slovenia is most common in areas where the conditions for intensive agriculture are less favourable, the conversion into organic farms seemed to be unsophisticated. There are notable differences among areas in Slovenia due to the geographical location, soil fertility and climatic, economic and social conditions. In all regions, except in Pomurje where at least organic farms are presented, dominates grassland (Statistical Office, 2009). Grassland is the main importance for organic animal breeding. Processing and marketing of organic meat and milk due to lack of domestic processing facilities (dairies, slaughterhouse, portable cooling devices) are more difficult than the processing and marketing of cereals, vegetables and fruits. The majority of organic milk is sold as the conventional milk. In Bela Krajina, which is one of the unpolluted natural areas in Slovenia, organic farming with dominant grassland is the main production activity.

### Bela krajina

Bela krajina is the southern part of south-eastern Slovenia, which lies along the border with Croatia. In the north it borders on Gorjanci, in the east and south is restricted by river Kolpa, which represents the state border with Croatia, on the west Bela krajina borders on Kočevsko-Roško hills and Poljanska mountain (Gerkšič, 2004). The area covers 580 km<sup>2</sup>, which presents approximately 2.5% of the total national territory. Bela krajina is represented by municipalities, namely Črnomelj, Metlika, and Semič with total population by 26920 with corresponding index of population growth under 96 (Statistical Office of ..., 2009a). In times of economic crisis employment opportunities are minor, therefore the retardation of Bela krajina is noticed, compared to Dolenjska as a well-developed industrial northern part of south-eastern Slovenia (Gerkšič, 2004). Due to karst terrain (rocked soil surface) area of qualitative arable land ranges less than one fifth of approximately 11000 ha grassland and arable fields. Almost half of the Bela krajina area is covered by forests, meadows and pastures present 6000 ha; land abandonment is increasing with 10-percent annually (Gerkšič, 2004). Agri-environmental program (MAFF, 2010) is the only possibility of preserving the agricultural landscape before changing it into the wooded area. In the late nineties, when the first conversion of Bela krajina farmers was registered, Organic Farmers Association of Dolenjska, Bela krajina and Posavje was established. Excursions and education at home and abroad enabled them to learn about technologies of organic farming and marketing from more experienced countries. In 2010 there were more than 80 farms, all from Bela Krajina, included in the inspection of organic farming (Judnič, 2010).

### The result of questionnaire for organic farmers in Bela krajina

The results showed that the first farmers began with organic farming in years 1998-1999 (11 farms); in following periods 8 farms (2000-2001) and 5 farms (2002-2003) joined them. In 2004-2005 there were 14 newly included farms, to which higher government subsidies were offered (APOF, 2006). A decision for organic farming in first six years was based on choice for healthier food and unpolluted environment, while in further six years it based on possibility for getting subsidies and because of unfavourable cultivation conditions. Over past four years a decrease of newly registered organic farms was noticed due to emigration of educated young people of Bela krajina, moving to more developed part of the country. During time for obtaining the certificate of organic farm, a third of all respondents (31%) had no difficulties to cope with

organic farming standards as they had cultivated organically in the past. Since nearly half of farmer owners aged over 50 years, it resulted that one third (29%) had difficulties because of deficiently kept records. A smaller percentage of farmers had problems with the unregulated discharge of domestic animals (18%), outdated and unregulated midden and stables (14%); the minor difficulties were presented by inadequate crop rotation and purchasing conventionally produced feed (5 to 8%). According the geographical and growing conditions, the 19 questionnaire farms are classified as karst farms, 14 as lowland farms, 11 as mountain farms, 4 high-mountain farms and 3 as hilly-mountain farms. We calculated that respondents dispose with 789 ha of agricultural land in relatively unfavourable natural conditions (on average 15.8ha per farm). Dominated by grassland and pastures (580ha), agriculture is less developed and covers only 185 hectares (on average 3.7ha per farm) due to the karst terrain. In organic farming inspection there is also 17 ha of orchards (0.3 ha per farm), 4.5 ha of vineyards (0.1 ha per farm), 2 ha of gardens (0.04 ha per farm; altogether they own 399 ha of forest. On 185 ha of fields the most commonly used is four-year crop rotation, the most common sown crops are corn (on 27 farms), barley (on 25 farms), oats (on 15 farms) and wheat (on 14 farms). There are too little legumes included in the crop rotation, especially perennial roughages legumes and grass-clover mixtures, which can contribute to producing a larger amount of quality feed for winter. Farmers should be encouraged for sowing annual and perennial forage crops, namely lucerne, red clover, crimson clover, Persian and Egyptian clover, Italian ryegrass and catch crops ("Ovsiga = oats + rye", "Ječmiga = barley + vetch", Landsberger mixture), which have been already sown in the past (Kocjan Ačko and Šantavec, 2009). The importance of including legumes in crop rotation is their impact on improvement of the structure and soil fertility, legumes also represent a supply of protein feed from indigenous fields. As fertilizer the farmyard manure is used more often (in 94%), compared to fertilizing with manure and slurry (32%) or composted waste (10%). Only few farmers buy fertilizers and preparations for weed control, pathogens and pests, which are listed in the publication "Preparations and guidelines for organic farming" (Bavec et al., 2009), as the price of mentioned preparations is too high. More than half of interviewed farmers produce herbal products for pest protection by themselves. Three of them are producing and using bio-dynamics preparations. Farmers are increasingly aware the importance for better adjustment of the autochthon varieties of crops and breeds of domestic animals, unfortunately, there are only few preserved. A strong ethnographic and tourist importance is in a production of autochthon flax, which runs on three farms near Adlešiči (area about 0.3 ha). From flax steams the fibbers for fabrics are produced by traditional method, meanwhile seeds, necessary for sowing, human food (Bela Krajina cake sprinkled with flax seeds, flax oil) or drugs, are produced (Judnič, 2010). Expanding production, craft and industrial processing of stems and fibres could be successfully implemented only by setting up pilot technologically well-equipped facilities for traditional and modern textile products (organic textile) and biocomposed products; the consumer demand for such products has been increased lately (Wulfhorst et al., 2006). Buckwheat with total production of a few dozen tons and with average yield of 0.8 t/ha, is used as a porridge or flour for cooking the traditional dishes, namely "Ajdova potica - Buckwheat cake", "Ajdovi žganci z ocvirki - Buckwheat porridge with cracklings". Production of buckwheat should be extended not only because of its direct use in human food chain also because of its high nectar production and its impact on organic beekeeping. Extraction of buckwheat honey (ajdovca) is possible only if there is enough available buckwheat fields (Kreft, 1995). The whole area is characterized by meadow orchards, which have unique cultural and natural heritage (Gačnik, 2010). Old trees have been encouraged to have greater fertility with so-called a revival cut. Fruit processing into apple juice, vinegar, brandy, cider and dried fruit contribute to the tourist offer, which could be associated with products from herbs and honey. Due to difficult access, fragmentation and karst terrain it is better for farmers to decide for livestock production. At the end of 2009 there was 1523 heads of sheep, 347 head of cattle, 59 horses, 53 pigs, 22 donkeys and 1304 heads of poultry with the average load of 1.34 livestock units per hectare. Impoverished grassland type Mezobrometum and Xerobrometum with low quality feed does not allow increasing the load per hectares. The main production activity in Bela krajina is livestock production, dominated by sheep breeding as in the past (Kompan, 2010). In recent years the Slovenian autochthon breed "Pramenka", sheep of Bela krajina, is again integrated. Excellent disease resistance and adaptability to poor and humble conditions are reasons for integration of

"Pramenka" into organic farming at this area; "Pramenka" is breded at 13 interviewed farms. Importance of sheep husbandry is greater as it prevents land abandonment. Moreover, according to researches about rural areas made by Angerer (2005), reintroducing of sheep breeding has maintained rural population, especially in the mountainous areas. Great adaptability and undemanding sheep breeding allow the bond between farming and tourism, such as hiking and other types of relaxation in nature. Despite the apparent optimism

of farmers from Bela krajina, the major concerns are current situation in agriculture and low purchase price as well as the increasing employment and hence decreased purchasing power. Farmers are convinced that selling organic crops and products at higher price is difficult, in comparison to other better-developed parts of the country. As farmers are individually too small providers of organic crops and products for large shopping centres there are almost no selling bond between them. Ljubljana, with a high concentration of consumers, is only occasional target market, because the costs, caused by transportation and consumption of working time due to long distance to Ljubljana, are greater. Supplementary activities (particularly mechanical services and tourism) represent additional earnings for 19 farms as meanwhile organic products are easier to be sold. Regional agricultural experts are increasingly aware of the importance of maintaining the rural areas therefore they promote a self-employment of young people on farms and tourist activities. Respondents attach great importance to ecological awareness of young people; an increased number of Bela Krajina primary schools are detected in the project "Eco-school as a way of life" (Eco-school as ..., 2010).

### Conclusions

Organic farming in the Bela Krajina can be described as a specific, but organic farmers are faced with typical problems in the field of organic farming; therefore indicated guidelines could be applied elsewhere. The interviewed farmers from Bela krajina deal with agricultural to a lesser extend, most common sown field crops are corn and barley. There is a lack of legumes included into crop rotation. Legumes increase soil fertility and provide satisfactory protein meal during winter time. Furthermore the increased yield due to *Rhizobium* bacteria that fix nitrogen could ensure also a higher quality of meat. Most agriculture land covers meadows and pastures, suggesting the greater development of organic livestock production and processing of food by animal origin. For processing (slaughterhouse) and marketing of organic meat a new or renewed local facilities must be built. In addition to organic food, organic farmers can market organic textiles and biocomposed products of flax, which is their traditional textile plant. Organic flax grown without synthetic chemical agents is the basis for fabrics and materials that do not harm human health and pollute environment in process of degradation. More attention should be paid to the traditional processing of sheep wool from "Pramenka sheep" and wool mixture with other sheep breeds, such as "Solčava sheep", which is also breed by organic farmers in Bela krajina. In order to realize new challenges (one of them could be successful sales of wool products as the most attractive and useful products for tourist) the development of processing facilities as well as expertise knowledge in organic processing and marketing should be enlarged. It has been noticed that among farmers there are no practical cooperation and also no direct transfer of knowledge; without processing of crops into products organic farming could not survive. The progress and development of organic farming could be limited by discouragement and negative thinking. If the development of organic farming is in accordance with organic guidelines, Bela krajina could present an important role as a supplying area of organic crops and organic products for Slovenian consumers. According to the future development plan of the EU, the opportunity of Bela krajina for cross-border cooperation with Croatia should be taken into consideration.

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# Changes of some physiological parameters in rapeseed, mustard and turnip grown in the presence of Ni and Cd

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## Abstract

Rapeseed (*Brassica napus* L.), white mustard (*Brassica alba* L.), black mustard (*Brassica nigra* L.) and turnip (*Brassica rapa* L.) were grown in the continuous presence of  $10^{-6}$  M Cd or  $10^{-5}$  M Ni, since sowing, with the aim to assess effects of Ni and Cd on plant growth, water regime and photosynthesis.

Dry matter content increased, whereas leaf area, shoot/root dry weight and concentrations of chloroplast pigments and their ratios declined in the presence of Ni and especially Cd. An increase in transpiration intensity in the presence of Ni, concomitantly with the reduction in biomass production, suggests that the transpiration coefficient in those plants increased, which is highly undesirable.

Key words: Cd, Ni, *Brassica*, photosynthetic pigments, transpiration

## Introduction

The main sources of contamination of agricultural soils with Cd and Ni are fertilizer impurities (Cd) and the use of contaminated compost and sewage sludge (Cd and Ni). Inadequate disposal of waste from households, municipalities and industries may increase even more concentrations of Cd and Ni the soil (Alloway, 1995). These two metals are very toxic for humans and animals and they enter food chain mainly through the food of plant origin (Guo and Marschner, 1995). Therefore, it is important to reduce uptake and accumulation of Cd and Ni in edible plants/plant parts, and also to define plant genotypes that are suitable for phytoremediation as this is the most appropriate way to reduce Cd and Ni concentration in mildly contaminated soils (Salt et al., 1995). The ability of plants to tolerate excessive concentrations of heavy metals, including Ni, and Cd, depends, among the other features, on their ability to synthesize sulfur containing compounds. Plants from the genus *Brassica* are among them. Moreover, they are important agricultural crops. Rapeseed and turnip are important oil crops and often are the first spring and the last autumn green feed (Erić et al., 2006). They are also very important for the production of honey (Blažytė-Čereškienė et al., 2010). Black and white mustard are grown for seeds that are used as spices. Oil of black mustard has strong antibacterial activity and white mustard is also used as feed and green manure. Contamination with heavy metals in the field is the most often present during the entire vegetation. With this respect, we studied the effect of continuous presence of Cd and Ni on growth, dry weight, leaf area, transpiration and concentrations of chloroplast pigments in winter and spring variety of rapeseed (*Brassica napus* L.), white mustard (*Brassica alba* L.), black mustard (*Brassica nigra* L.) and turnip (*Brassica rapa* L.).

## Materials and methods

Five genotypes from the genus *Brassica* were used in the experiments: 1) cultivar Jovana, spring variety of rapeseed (*Brassica napus* L.) 2) cultivar Slavica, winter variety of rapeseed (*Brassica napus* L.) 3) white mustard (*Sinapis alba* L. ssp. *alba*, syn. *Brassica hirta*) 4) black mustard (*Brassica nigra* L.) and 5) turnip (*Brassica rapa* L.). Before sowing, seeds were kept for 24 h in deionized water (control),  $10^{-6}$  M CdCl<sub>2</sub> or  $10^{-5}$  M NiSO<sub>4</sub> dissolved in deionized water. Seeds were germinated in the quartz sand, in an incubator, at 26°C. Seedlings were planted in pots containing ½ strength Hoagland nutrient solution (Hoagland i Arnon, 1950) (control) to which was added either CdCl<sub>2</sub> or NiSO<sub>4</sub> to final concentration of  $10^{-6}$  or  $10^{-5}$  M, respectively. Each treatment was set in 5 replications with 8 plants per replication. Nutrient solution was changed every other day and aerated regularly. Plants were grown for 30 days.

Transpiration intensity was determined gravimetrically, in three replications with 2 h intervals. Fresh matter was measured immediately after harvest and dry matter after drying the samples at 70 °C to constant mass. Total leaf area was measured by an automatic area meter (*LI-3000*, *Li-Cor*, Lincoln, USA). Concentrations of chlorophylls *a* and *b* and carotenoids were determined spectrophotometrically, in the acetone extract of freshly harvested leaves, using molar extinction coefficients of Holm (1954) and von Wettstein (1957).

Statistical analysis was performed using STATISTICA 9.0 (StatSoft, University Licence, University of Novi Sad, 2010) and Excell (Microsoft Inc.) software packages. Means of replicates and evaluation of significance of differences between analysed parameters were determined with descriptive statistics and one-way ANOVA analysis, followed by LSD *post hoc* test ( $\alpha=0.05$ ).

## Results and discussion

Continuous presence of Ni and Cd reduced plant dry weight (DW), shoot/root DW ratio and total leaf area (Table 1). Leaf, stem and root DW significantly declined both in the presence of Ni and Cd. DW was significantly lower in the presence of Cd as compared to Ni, with exceptions of root DW in white mustard and turnip. Reduction of shoot/root DW was significant both in the presence of Ni and Cd, with exception to Ni treatment in black mustard. The overall reduction of shoot/root DW indicates that Ni and Cd had stronger effect on the growth of leaves and stems than on roots. Total leaf area also significantly declined in the presence of Ni and Cd and differences were significant between Ni and Cd treatments as well. The reduced growth is typical response of plants to excess Ni and Cd (Sanita di Topi and Gabbrielli 1999, Maksimovic et al. 2007). The effect of Cd was much stronger than Ni in all plant genotypes.

In the presence of Ni, transpiration intensity increased significantly in all genotypes except for turnip (Figure 1). The highest increase in transpiration intensity was recorded in white mustard, 101%, and the lowest in turnip, 9%, with respect to corresponding controls. Plants treated with Cd had so small total leaf area, that measurement of transpiration intensity was not possible. Reduction of transpiration intensity in the presence of heavy metals is common plant reaction (Barceló and Poschenrieder, 1990).

Concentration of photosynthetic pigments declined significantly in the presence of both Ni and Cd (Table 2). The effect of Cd was more pronounced in comparison to Ni, similarly to DW, % of DW, leaf area and shoot/root DW. The Chl.*a/b* ratio also significantly declined, suggesting that both heavy metals reduced more the concentration of Chl.*a* than Chl.*b*. The decline of Chl.*a+b*/Car. ratio in the presence of Ni and Cd was statistically significant as well, meaning that concentrations of chlorophylls declined more severely in comparison to the concentrations of carotenoids. Negative effect of heavy metals on photosynthetic apparatus was shown also in the other dicots (Krupa et al., 1993; Panković et al., 2000).



Changes of some physiological parameters in rapeseed, mustard and turnip grown in the presence of Ni and Cd

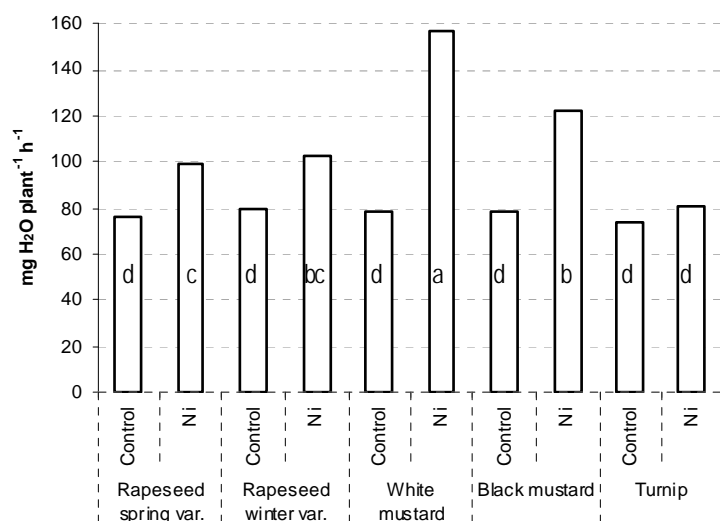


Figure 1. Transpiration intensity in rapeseed, mustard and turnip in the presence of Ni. The same letters inside bars indicate the absence of the statistically significant differences between the treatments at  $\alpha=0.05$

Table 1. Dry weight, shoot/root dry weight,% of dry matter and total leaf area of rapeseed, mustard and turnip in the continuous presence of Ni and Cd. Numbers in brackets represent% with respect to the corresponding control

Geno-type	Treatment	Dry weight (mg plant <sup>-1</sup> )			Shoot/Root DW	% of dry matter			Leaf area (cm <sup>2</sup> plant <sup>-1</sup> )
		Leaves	Stem	Root		Leaves	Stem	Root	
Rapeseed spring variety	Contr.	93.31 (100)	60.53 (100)	8.10 (100)	18.99 (100)	5.40 (100)	6.80 (100)	6.61 (100)	76.29 (100)
	Ni	35.47 (38)	22.49 (37)	5.44 (67)	10.65 (56)	6.78 (126)	8.38 (123)	11.05 (167)	20.98 (28)
	Cd	5.98 (6)	4.97 (8)	3.53 (44)	3.10 (16)	7.43 (138)	13.83 (203)	12.36 (187)	2.24 (3)
Rapeseed winter variety	Contr.	78.07 (100)	63.46 (100)	6.84 (100)	20.69 (100)	4.88 (100)	6.55 (100)	8.01 (100)	65.04 (100)
	Ni	52.48 (67)	41.38 (65)	7.06 (103)	13.29 (64)	5.80 (119)	8.30 (127)	10.53 (131)	32.84 (50)
	Cd	12.75 (16)	10.98 (17)	4.76 (70)	4.99 (24)	6.48 (133)	12.44 (190)	16.13 (201)	5.18 (8)
White mustard	K	103.76 (100)	103.13 (100)	19.60 (100)	10.56 (100)	4.45 (100)	7.74 (100)	9.53 (100)	79.75 (100)
	Ni	35.14 (34)	25.35 (25)	12.22 (62)	4.95 (47)	6.78 (152)	10.76 (139)	11.69 (123)	14.93 (19)
	Cd	25.58 (25)	14.01 (14)	14.11 (72)	2.81 (27)	12.41 (279)	13.86 (179)	11.43 (120)	8.95 (11)
Black mustard	Contr.	92.60 (100)	51.16 (100)	15.21 (100)	9.45 (100)	5.24 (100)	6.99 (100)	11.69 (100)	83.59 (100)
	Ni	38.66 (42)	23.48 (46)	7.08 (47)	8.78 (93)	5.73 (109)	8.96 (128)	11.55 (99)	22.05 (26)
	Cd	11.44 (12)	3.96 (8)	2.81 (18)	5.48 (58)	13.31 (254)	34.17 (489)	14.96 (128)	3.00 (4)
Turnip	Contr.	116.08 (100)	45.45 (100)	9.55 (100)	16.91 (100)	4.09 (100)	6.54 (100)	9.34 (100)	90.05 (100)
	Ni	40.98 (35)	15.54 (34)	4.56 (48)	12.39 (73)	5.27 (129)	9.83 (150)	13.09 (140)	19.04 (21)
	Cd	14.62 (13)	4.83 (11)	4.36 (46)	4.46 (26)	8.40 (205)	15.54 (238)	11.00 (118)	4.29 (5)

Reduced uptake of water and nutrients, reduced photosynthetic and transpiration surfaces as well as concentration of photosynthetic pigments resulted in severely reduced growth and biomass production of rapeseed, mustard and turnip in the continuous presence of  $10^{-5}$  M Ni and  $10^{-6}$  M Cd. It is possible that Ni and Cd changed morphology and anatomy of young plant roots. This might, at least in part, explain the impairment in plant water and nutrient uptake. However, this remains to be analysed, in addition to the effect of those heavy metals on plant nutritional status. In addition, important issue for further investigations are differences in tolerance to the presence of Ni and Cd of different genotypes belonging to the genus *Brassica*.

**Table 2. Concentrations of chloroplast pigments and their ratios in rapeseed, mustard and turnip in the continuous presence of Ni and Cd. Numbers in brackets represent% with respect to the corresponding control**

Genotype	Treatment	Chl.a	Chl.b	Car	Chl.a+b	Chl. a/b	Chl. a+b/Car.
Rapeseed spring var.	Control	14.69 (100)	4.90 (100)	3.23 (100)	19.58 (100)	55.56 (100)	112.28 (100)
	Ni	6.69 (46)	2.32 (47)	1.64 (51)	9.02 (46)	42.77 (77)	81.66 (73)
	Cd	1.77 (12)	0.67 (14)	0.53 (16)	2.44 (12)	36.51 (66)	63.63 (57)
Rapeseed winter var.	Control	15.30 (100)	5.11 (100)	3.29 (100)	20.42 (100)	63.40 (100)	131.62 (100)
	Ni	11.86 (78)	4.11 (80)	2.94 (89)	15.97 (78)	49.14 (78)	92.68 (70)
	Cd	1.69 (11)	0.78 (15)	0.51 (16)	2.47 (12)	33.39 (53)	74.52 (57)
White mustard	K	17.02 (100)	8.61 (100)	4.32 (100)	25.62 (100)	43.94 (100)	131.74 (100)
	Ni	6.95 (41)	3.02 (35)	1.63 (38)	9.97 (39)	32.80 (75)	87.01 (66)
	Cd	2.14 (13)	0.88 (10)	0.59 (14)	3.03 (12)	20.39 (46)	42.88 (33)
Black mustard	Control	17.75 (100)	5.74 (100)	3.91 (100)	23.49 (100)	59.35 (100)	115.35 (100)
	Ni	9.80 (55)	3.50 (61)	2.46 (63)	13.30 (57)	50.00 (84)	96.41 (84)
	Cd	0.84 (5)	0.30 (5)	0.25 (6)	1.14 (5)	22.36 (38)	37.03 (32)
Turnip	Control	17.50 (100)	5.58 (100)	3.85 (100)	23.07 (100)	77.48 (100)	148.01 (100)
	Ni	9.30 (53)	3.19 (57)	2.32 (60)	12.48 (54)	55.12 (71)	101.85 (69)
	Cd	2.85 (16)	1.04 (19)	0.78 (20)	3.89 (17)	31.57 (41)	57.50 (39)

## Conclusion

Continuous presence of  $10^{-5}$  M Ni reduced plant dry weight to 50% in average whereas  $10^{-6}$  M Cd reduced it to only 25% with respect to corresponding controls. At the same time,% of dry matter in plants increased, to 131% in the presence of Ni and to 204% in the presence of Cd, in comparison with respective controls, suggesting disturbances of water regime. However, there were significant differences between the genotypes. Total leaf area significantly dropped in the presence of Ni and especially Cd. Shoot/root DW ratio declined as well, with exception of black mustard which did not differ significantly with respect to the control. The increase in transpiration intensity in the presence of Ni, together with the reduction of biomass production, suggests that Ni increased transpiration coefficient which is very undesirable. Concentration of chloroplast pigments as well as Chl.a/b and Chl.a+b/Car significantly declined in the presence of Ni and particularly Cd, signifying stronger effect of Ni and Cd on Chl.a than Chl.b and on chlorophylls than on carotenoids. The effect of Ni and Cd on plant anatomical properties and elemental composition remain to be studied further.

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# Evaluation effect of wetting and drying on soil strength

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## Abstract

Soil penetration resistance is generally regarded as one of the best tools to assess soil strength. It measure by cone penetrometer. However, effects of relative humidity (RH) on measured cone index (CI) can confound interpretations of treatment effects on soil strength. Depending on the top and subsoil textures, semi-arid soils exhibit cohesive and frictional properties that are associated with the relatively high soil strength, bulk density and penetration resistance. The objective of this study was to determine the penetration resistance of the compacting soil and investigate the effects of temperature and relative humidity on penetration resistance. Tests were carried out in two temperature (30°C and 45°C) and two relative humidities of (10% and 30%). The cone index for higher temperature (45°C) is higher than the other temperature at the same penetration and relative humidity. Drying soil in low temperature decreases the CI. Increasing in the relative humidity was decreased the cone index at the same penetration and temperature. Drying soil in high environmental humidity decreases the CI.

Key words: wetting and drying the soil, soil penetration resistance, cone Index, soil properties

## Introduction

The working part of a machine receiving energy from the tractor or other source works the soil and changes its state and properties. To understand the physical significance of the processes occurring in the soil due to the action of the tools of the soil-working machines, we must study the engineering properties of soils. It is interesting to note that the prime incentive for studying the correlation between the cone index and the fundamental engineering properties of terrain is to enable investigators to derive the fundamental engineering properties of terrain from a large cone index data base already in existence.

Since the penetration resistance of soils is highly dependent on the water tension, penetration resistance was measured for the entire water tension range. Stock and Downes (2008) determined the effect of the addition of organic matter on the penetration resistance of glacial till in the first stages of reclamation. Lapen *et al.* (2004) studied was to use a portable combination penetration resistance/water content instrument to evaluate and quantify growing season changes in penetration resistance versus water content relationships for different tillage, trafficked, and corn cropping systems. Unger and Jones (1998) determined effects of tillage methods and cropping systems used for dryland winter wheat and grain sorghum production on soil bulk density and penetration resistance. They also determined soil water content to aid interpretation of the penetration resistance data. Brye *et al.* (2005) characterized the effects of shallow-cut land leveling and cropping on penetration resistance in a soil commonly used for rice and soybean production. They hypothesized that shallow-cut land leveling significantly affects cone index profiles, the depth to the root-limiting hard pan, and the spatial distribution of cone index values. Kılıç *et al.* (2004) determined the relationships between soil penetration resistance and some physical soil properties (water content, bulk density, clay content, silt content and sand content) affecting soil penetration resistance, with classical statistical and geostatistical methods, and to observe the formation of a plow pan and its variability in the study area, which was conventionally tilled for a long period of time. Pachepskya *et al.* (1998) considered whether penetration resistance can improve the accuracy of estimating water retention from soil composition and bulk density for soils with widely differing properties. Gitau *et al.* (2006) considered gain

the knowledge of mechanical properties of the compacting chromic luvisols in order to improve the design of tillage tools. They applied critical state soil mechanics to study the stress-strain behaviour of the luvisols using triaxial tests under laboratory conditions. Rajarama and Erbachb (1999) determined the effect of drying stress, induced by a single cycle of wetting and drying, on soil bulk density, cone penetration resistance, shear strength, adhesion, and aggregate size and stability of a clay-loam soil. Dexter *et al.* (1984) considered the mechanical properties of aggregates created by wetting and drying of remolded soil. They reported that tensile strength increased with soil clay content and decreased with soil porosity. Mellis *et al.* (1996) determined the effect of wetting and drying on soil physical properties and found that the soil was degraded by rainfall as indicated by aggregate size distribution and crusting.

The literature reviewed showed that there is a need for understanding what soil penetration resistance changes take place in a loam soil as a result of wetting and drying. Soil penetration resistance was studied via measuring cone index. Our objective was to determine effects of wetting and drying on loam soil penetration resistance with four treatments.

### Materials and methods

The soil type according to USA soil classification was a loam soil with 24.6% clay, 40.8% silt and 34.6% sand and bulk density was 1.3 g.cm<sup>-3</sup>. The PH of this soil was 7.5. The percent of organic carbon (OC%) and organic matter (OM%) of the soil was 0.007% and 0.01%, respectively.

Twelve circular plastic containers with diameter 180 mm and height 250 mm were used to experiments. These containers were used for preparing sample soil with uniform bulk density and moisture content across its profile. Experimental soil was screened by riddle No. 4. After filling, the soil was compacted by using a weight with weighing 98 N and fall height 70 mm. All of the containers had drainage. The volumetric moisture content before and after drying for all of the treatments was 80% which measured with using an oven-dry technique.

The soil treatments included of four groups:

Group A: In this treatment the soil have been moisturized up to 80% then they were kept in an environment of 30°C temperature and 10% moisturized environment for 2.5 hours until it's moisture reaches 40%.

Group B: In this treatment the soil have been moisturized up to 80% then they were kept in an environment with fan air flow of 30°C temperature and 30% moisturized environment for 20 hours until it's moisture reaches 40%.

Group C: In this treatment the soil have been moisturized up to 80% then they were kept in an environment of 45°C temperature and 10% moisturized environment for 2 hours until it's moisture reaches 40%.

Group D: In this treatment the soil have been moisturized up to 80% then they were kept in an environment with fan air flow of 45°C temperature and 30% moisturized environment for 20 hours until it's moisture reaches 40%.

Tests were carried out with the cone penetrometer with cone angle of 30°, base area of 323mm<sup>2</sup> and diameter shaft of 15.8 mm. Cone index is defined by the insertion force divided by the cross-sectional area of the base of the cone. The cone penetrometer was constructed based on the ASAE EP542 FEB99 Standard. The rate of penetration during tests was 25mm.s<sup>-1</sup>. The cone index was measured with a digital cone penetrometer originally built at College of Abouraihan of the University of Tehran, Iran. The overall construction of the complete digital cone penetrometer unit was made up of the following main components: the double acting hydraulic cylinder (AHE01350A-3A-3, Taiyo, Japan) with piston diameter 40 mm, stroke 240 mm to apply the vertical force on the cone penetrometer; the pressure, flow and directional control valves; An interface (CAWL2RG, Camos, Iran) was used to show the values of force and displacement, to send output load cell and position transducer linear to computer, and to stop the hydraulic cylinder displacement in consequence of overload force; the laptop computer with the controlling software; the S-beam load cell (DBBP, Bongshin, Korea) with capacity 1.96 KN, to measure the applied vertical load; the position transducer linear (KTC 375, Hystar, Taiwan) with resistance 4 kΩ and mechanical travel 378 mm to measure vertical displacement. The resolutions of the load cell and position transducer linear were 1.96 N and 0.01 mm, respectively. Cone penetrometer was connected directly into the load cell. The double acting hydraulic cylinder applied the vertical force on the cone penetrometer and moved it into the terrain. The load cell analogue signals were

also converted to digital signals by an A/D interface and were sent to the laptop computer. The rate of penetration during tests was 25mm.s-1. Tests were replicated three times in each of the treatments.

### Results and discussion

A representative record of the penetration resistance in two temperatures 30°C and 45°C and two RH%10 and%30 of the cone per unit base area versus the penetration depth are shown in Figs. 1 and 2. The penetration depth shown in the figures is calculated from the original surface of the soil. As shown in the figures, initially, the CI increases with an increase in the penetration depth. However, when the applied pressure reached a critical pressure, the surface layer was broken. Since the sub layer is often weaker than the surface layer and has lower resistance, the CI decreased with an increase of the penetration depth.

Based on the results of the experiments drying soil in high environmental humidity decreases the CI more than drying soil in low environmental humidity. Since drying soil in the high humidity gets long time (Table 1), the soil loses its moisture gently. Therefore, the CI does not increase suddenly. With the same RH and penetration depth, the soil treatments that were located in temperature 45°C have the higher CI than the soil treatments that were located in temperature 30°C. Since in the high temperature soil loses its moisture simply. Therefore, drying soil in high temperature increases the CI more than low temperature.

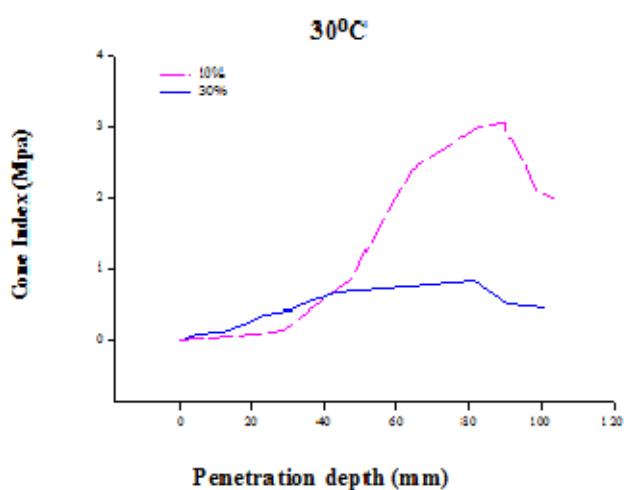


Figure 1. Cone index versus the penetration depth for drying of treatments in an environment of 30°C temperature

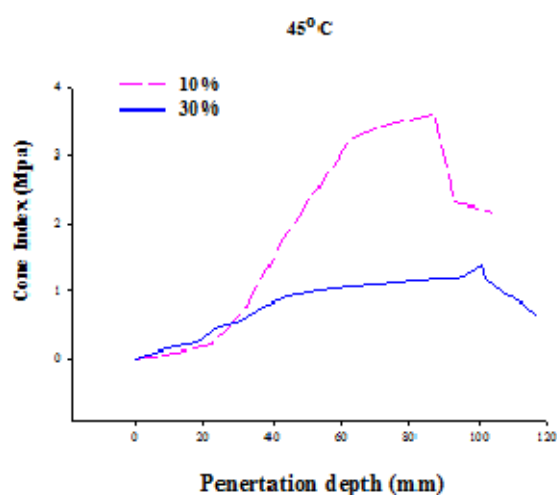


Figure 2. Cone index versus the penetration depth for drying of treatments in an environment of 45°C temperature.

Table 1. Cone index of four soil treatments

Depth (mm)	T=30°C				T=45°C			
	RH=%10		RH=%30		RH=%10		RH=%30	
	Mean Values of CI (Mpa)	S.D	Mean Values of CI (Mpa)	S.D	Mean Values of CI (Mpa)	S.D	Mean Values of CI (Mpa)	S.D
25.4	0.092	0.27	0.37	0.05	0.34	0.03	0.49	0.005
50.8	1.17	0.13	0.70	0.15	2.39	0.52	0.97	0.02
76.2	2.75	0.34	0.80	0.005	3.5	0.6	1.15	0.08
101.6	2.03	0.05	0.43	0.07	2.19	0.02	1.18	0.145

In fig. 3 graph of the cone index versus drying time were drawn. As shown in fig. 3 by increasing drying time, the cone index was decreasing. B and D are treatments that process decreasing moisture from 80% to 40% take long time consequence, the values max of cone index were decreased as well as environment moisture for those were 30%.

Data obtained from our tests can be helpful to determine time of irrigation, entry of instrument agriculture to the field. Based on a large number of measurements, the mean values of the CI per unit base area and the associated standard deviations at various depths for each of soil treatments are summarized in Table 1.

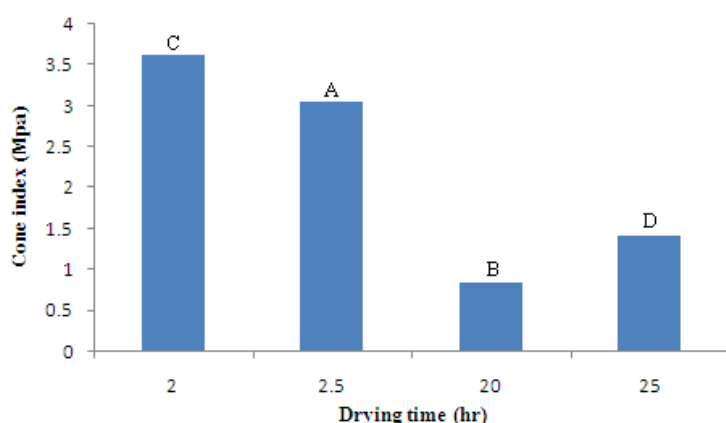


Figure 3. Cone index versus drying time for each of the treatments

### Conclusions

The following conclusion can be drawn from this study: The CI increases with an increase in the penetration depth. The cone index for higher temperature (45°C) is higher than the other temperature at the same penetration and relative humidity. Drying soil in low temperature decreases the CI. Increasing in the relative humidity was decreased the cone index at the same penetration and temperature. Drying soil in high environmental humidity decreases the CI.

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# Plant productivity parameters under conditions of deficit irrigation

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## Abstract

The aim of this study was to determine the effects of deficit irrigation techniques on plant productivity parameters of potato growth in field conditions and to compare these effects with the conventional method of irrigation. Deficit irrigation methods were: Partial Root Drying (PRD) and Regulated Deficit Irrigation (RDI), methods where irrigation was performed with 70% water compared to plants that are optimally irrigated. In the last 3 weeks of the irrigation period, 70% PRD and RDI was replaced by 50% (PRD, RDI plants received 50% of Full irrigation - FI treatment). During experimental period the following parameters were measured: plant height, leaf area, plant biomass of leaf and stem and calculated of plant productivity parameters: relative growth rate (RGR), net assimilation rate (NAR), leaf area ratio (LAR) and her components - specific leaf area (SLA) and leaf weight ratio (LWR). In investigation year maximum value of plant productivity parameters was in phase of potato flowering period and than increased. The results point out that the tested irrigation regimes affected the process of the assimilates synthesis, but most of the assimilates partitioning from leaf and stem into tuber and root. This may be important for understanding impact of different irrigation technique on plant growth.

Key words: partial root drying, regulated deficit irrigation, potatoes, productivity parameters

## Introduction

The study parameters of productivity of cultivated plants is based on observations of photosynthesis, growth and water regime of plants as a basic physiological processes that determine the productivity of plants. However, in many areas as a consequence of global climate changes and environmental pollution, water use for agriculture is reduced (FAO, 2003). In the last decades, one of the management options to overcome the agricultural drought is the use of partial root-zone drying (PRD) and regulated deficit irrigation (RDI) and they are called deficit irrigation methods whose application started on many crops in many countries in the world (Kang and Zhang, 2004). Partial root-zone drying is a deficit irrigation strategy designed to maintain half of the root system in a dry or drying state, while the other half is irrigated, in order to keep the leaves hydrated. The treatment is then reversed, allowing the previously well-watered side of the root system to dry down while fully irrigating the previously dry side. RDI is a method where the entire root zone irrigated with the amount of water less than the maximum crop evapotranspiration. PRD technique developed at the knowledge of chemical signaling at the level of root-shoot in terms of lack of water. Part of the roots in contact with dry land becomes a source of chemical signals ABA primarily as inhibitors of growth. The increased content of ABA leads to partial closure of stomata, which causes the reduction of transpiration and leaf growth, but also increase water use efficiency by plants (Davies et al., 2002). The aim of this study was to determine the effects of deficit irrigation methods on productivity parameters in potato grown in field conditions and to compare these effects with the conventional method of irrigation.

## Materials and methods

Potato (*Solanum tuberosum* L.) cultivar Liseta was used for investigation. The experiment were carried out during the growing season of 2008. in a vegetable commercial farm (Salate Centre) located 10 km north of Serbian capital, Belgrade. The irrigation method used was a drip-subsurface method. The subsurface irrigation system was supplied by Netafim (A.C.S. Ltd. Netafim, Israel). For the FI and RDI treatments, one drip line was placed 10cm below the top of the ridge although in PRD treatment two drip lines were operated separately and were placed in parallel. The distance between emitters in FI and RDI treatments was 30 cm and these were place exactly in the middle between two plants. PRD treatments the drip line consisted of two bundled lines each with 60cm distance. In partial root drying sealing one side takes until the amount of water in the second half is reduced by 20-30% of the total irrigation and the shifting time interval varied between 3 and 7 days depending on evaporative demand and soil water content. With the RDI and the PRD treatment is started after the phase of tuber initiation (when 80% of tubers more than 20 mm long). In the last 3 weeks of the irrigation period, 70% PRD and RDI was replaced by 50% (PRD and RDI plants received 50% of FI treatment). Measurement of soil water content was done with a time domain reflectometer (TDR, TRASE, Soil Moisture Equipment Corp., USA). During the experimental period was carried out measurements: plant height, leaf area, fresh and dry weight of leaves and stem, and determine the productivity of plants through the following parameters: relative growth rate (RGR) as the most important indicators of growth, measurement of the productivity of a plant, defined as the increase in dry mass per unit of plant mass over a specified period of time, it is the product of the net assimilation rate (NAR) and leaf area ratio (LAR). NAR represents the mean rate of dry matter production per unit of leaf area while LAR is the size of photosynthetic area in relation to plant mass and depends on parameters such as specific leaf area (SLA) and leaf weight ratio (LWR). SLA is leaf area per unit dry mass leaf while LWR defines the translocation of dry matter in plant leaves.

Leaf area was determinate destructively by sampling leaves from plants and than scanned by scanner (Mustec Scan Express A3 USB), digital images stored on the hard disc of PC and than the leaf area was calculated by using Adobe Photoshop 9 programme. Plant biomass (leaf and stem dry weight) was measured after oven drying to constant weigh at 80°C. The measured traits have been analyzed for statistically significant differences by Students unpaired t - tests (Sigma Plot 6.0 for Windows - SPW 6.0, Jandel Scientific, Erckhart, Germany).

## Results and discussion

The analysis of productivity parameters based on the measurement of biomass and the assimilation of the surface. Our results show that the maximum values of the parameters of productivity were at the stage of flowering plants and they were caused by the maximum values of leaf area and dry mass of leaves during this period and it indicates that the plants had a higher intensity of photosynthesis and dry mass production during the period of flowering. Measurements of relative growth rate (RGR) and net assimilation rate (NAR) (Fig. 1) showed that in all of the irrigation regime, the highest value recorded in the early stages of development of plants which corresponds phenological flowering stage, then the values decreased until the end of the season . The results showed that there was no statistically significant differences in RGR and NAR values between different irrigation regimes. This decline in RGR during plant development was found in other plant species (Delgado and Medrano, 1991, Jovanovic et al., 2001). Growth rate depends on the capacity of leaves for photosynthesis, so in our experiment due to the higher value of leaf area during blooms, have increased the value of the relative growth rate. Our results are consistent with studies Poorter et al., (2002), to drought stress, high or low salt concentration, low temperature, leads to a reduction in productivity parameters

The reduction of NAR in conditions of drought stress is caused of stomatal closure and reduced assimilation of CO<sub>2</sub>, and therefore the intensity of photosynthesis (Chaves, 1991, 2002). Measurement results for LAR (Fig. 2) showed that the OPN plants identified higher levels of early-season test in both seasons compared to PRD irrigation regimes and the RDI. In all investigated regimes of irrigation there was a decrease in LAR by the end of the test season. Reduction of LAR under the influence of PRD and RDI irrigation regimes caused the reduction of specific leaf area since the LWR is not significantly different between RDI and PRD compared to control. Results of Greco et al., (2005) and Baraloto et al., (2006) show that in stress conditions increasing translocation of dry matter in the root plays a critical role in reducing LAR, as well as reduction of

leaf area. It is known that the efficiency of accumulation assimilates in potato depends on the rate of photosynthesis and assimilates partitioning to tubers (Tekalign and Hammes, 2005). Reduction of biomass can be a good indicator of water stress of potato plants (Yuan et al., 2003). The reduction occurred because of greater translocation of dry matter in roots and tubers. Our results indicate that low values of specific leaf area reduced adoption of light and CO<sub>2</sub>, which then leads to the reduction of relative growth rate. The cause of decline in SLA in our experiment with the PRD and the RDI regime likely amount of irrigation water applied for irrigation, because its value depends on the amount of water per unit dry weight (Poorter, 1989).

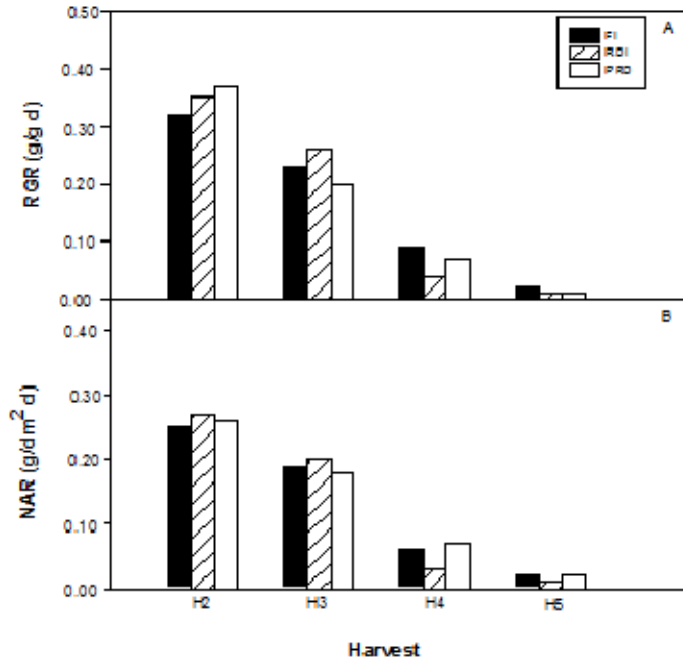


Figure 1. The effects of applied irrigation treatments (FI, RDI, PRD) on relative growth rate - RGR (A) and net assimilation rate - NAR (B) in 2008 year

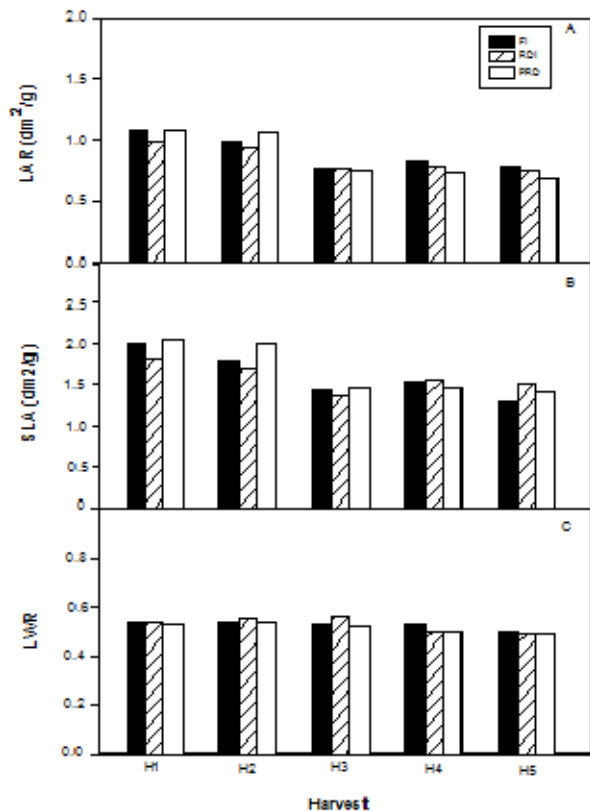


Figure 2. The effects of applied irrigation treatments (FI, RDI, PRD) on leaf area ratio - LAR (A), specific leaf area - SLA (B) and leaf weight ratio - LWR (C) in 2008 year

## Conclusion

Maximum value of plant productivity parameters was in phase of potato flowering period and then increased. The results showed that there were no significant differences in the values of RGR and NAR between tested irrigation regimes. Decreased value of LAR under the influence of RDI and PRD irrigation regime is caused by the reduction of SLA since the LWR is not significantly different between the RDI and PRD regime compared to control. The results point out that the tested irrigation regimes affected the process of the assimilates synthesis, but most of the assimilates partitioning from leaf and stem into tuber and root. This may be important for understanding impact of different irrigation technique on plant growth.

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# Sezonska dinamika proteolitičke aktivnosti u degradiranim šumskim tlima

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## Sažetak

Cilj ovog rada je utvrđivanje sezonske dinamike i promjene proteolitičke aktivnosti u degradiranim šumskim tlima. Uzorci tla sakupljeni su u prvom, trećem, petom i sedmom mjesecu 2008. godine sa područja Gorskog Kotara sa dva različita tipa tla. Uzorkovani su uzorci sa smeđeg vapnenačko-dolomitnog tla (O1) te sa kiselog smeđeg tla (O2). Tijekom ovog istraživanja utvrđena je sezonska dinamika proteolitičke aktivnosti. Najmanje vrijednosti zabilježene su u prvom mjesecu na obje plohe. Sezonske promjene proteolitičke aktivnosti povezane su sa sezonskim fluktuacijama abiotičkih faktora kao što su dostupnost hranjiva, temperatura te količina dostupne vode. Veća proteolitička aktivnost zabilježena je kroz sve mjesece i uzorke na vapnenačko-dolomitnom tlu u odnosu na kiselo smeđe tlo što se može povezati sa razlikama u količini organske tvari i pH vrijednosti istraživanih tala.

Ključne riječi: dušik, proteini, proteolitička aktivnost, šumsko tlo

## Proteolytic activity in degraded forest soils

### Abstract

The aim of this study was to evaluate the changes and seasonal dynamic of proteolytic activity in degraded forest soils. The experimental sites were located in Gorski Kotar (Croatia). The soils were sampled in January, March, May and July of 2008 from two different soil types, carbonate-dolomite soil (O1) and acid brown soil (O2). We found the high seasonal dynamic of proteolytic activity among all analyzed samples. The lowest values were noticed in January at both soil types. Seasonal changes can be related to the seasonal variability of soil abiotic factors as e. g. nutrient availability, temperature and water availability. Higher proteolytic activity was measured at O1 in comparison to O2 during the whole season which can be related to the differences in organic matter and pH values of the respective soils.

Key words: nitrogen, proteins, proteolytic activity, forest soil

### Uvod

Dušik je ključan element za plodnost tla i ishranu biljaka. Ograničen je resurs u tlima, a njegova dostupnost jedan je od najvažnijih faktora koji reguliraju rast organizama (Paul i Clark, 1996). Proteini predstavljaju najvažniji izvor organskog dušika u tlu (Lipson i Nasholm, 2001), a njihova razgradnja do manjih molekula koje stanice mogu apsorbirati, od primarnog je značaja unutar procesa kruženja dušika (Loll i Bollag, 1983). U tlima bez dodatka mineralnih gnojiva taj proces je, uz biološku fiksaciju dušika, jedini način na koji biljke i mikroorganizmi dolaze do dušika (Murphy i sur., 2000; Jones i sur., 2002). Proteoliza u tlu prvenstveno je

vezana uz aktivnost ekstracelularnih mikrobnih proteaza (Watanabe i sur., 1994) čija aktivnost ovisi o mnogobrojnim fizikalno-kemijskim parametrima tla budući da jednom izlučene, proteaze više nisu pod kontrolom stanice (Mrkonjić Fuka i sur., 2008). Proteolitička aktivnost važan je pokazatelj biološke aktivnosti i usko se povezuje s plodnošću tla pa je stoga od primarnog značaja istražiti proteolitičku aktivnost mikrobnih zajednica u različitim terestričkim ekosustavima. Iako postoje sporadična istraživanja proteolitičke aktivnosti u poljoprivrednim tlima na području RH (Sikora, 1990), gotovo ništa ne znamo o proteolitičkoj dinamici u šumskim tlima. Zbog toga je cilj ovog rada utvrđivanje sezonske dinamike i promjene proteolitičke aktivnosti u degradiranim šumskim ekosustavima. Nadalje, željeli smo utvrditi razlike u proteolitičkoj aktivnosti s obzirom na različite tipove tla. Kako bi postigli taj cilj uzorci tla uzorkovani su sa područja Gorskog Kotara sa dva različita tipa tla. Svi uzorci podvrgnuti su osnovnim kemijskim analizama tla i mjerenju potencijalne proteolitičke aktivnosti.

### Materijali i metode

Uzroci tla sakupljeni su sa velikih šumskih otvora nastalih intenzivnim odumiranjem stabala na području Gospodarske jedinice Bitoraj (O1) sa velikog otvora na smeđem tlu na vapnencu i dolomitu te sa Gospodarske jedinice Brloško (O2) sa velikog otvora na kiselom smeđem tlu (Ugarković, 2009). Uzorkovanje tla vršeno je pedološkom sondom na dubini od 10 cm u prvom, trećem, petom i sedmom mjesecu 2008. godine. Četiri uzroka sakupljena su sa jedne plohe kao četiri neovisna replikata. Svi uzroci su spremljeni na 4° C za mjerenje proteolitičke aktivnosti prema metodi opisanoj u radu Ladd i Butler (1972). Od kemijskih karakteristika tla utvrđeni su slijedeći parametri: pH tla (u H<sub>2</sub>O i 1M KCl-u na HACH EC 30 pH-metru), ukupni dušik (mjeren je elementarnim analizatorom Leco CNS 2000), humus (određen je metodom po Tjurinu), organski ugljik i organska tvar (određeni su metodom po Scheibleru).

### Rezultati i rasprava

Osnovni kemijski parametri tla korištenih u ovom istraživanju prikazani su u Tablici 1.

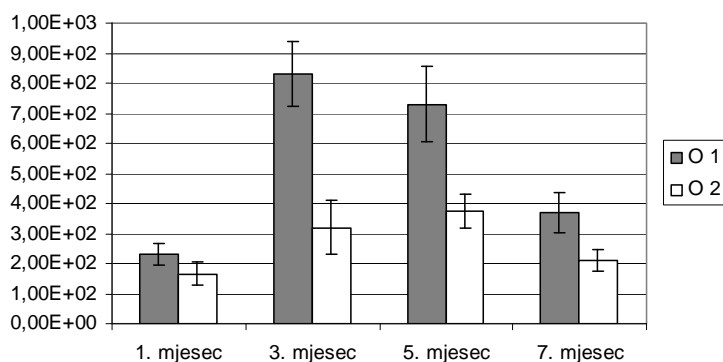
Tablica 1. Osnovni kemijski parametri tla

Uzorak	pH H <sub>2</sub> O	pH 1M KCl	Organska tvar %	N uk (g kg <sup>-1</sup> )	Humus %	C org (g kg <sup>-1</sup> )	C uk (g kg <sup>-1</sup> )	C:N
O1	4,66	3,82	28,60	5,87	13,81	80,30	88,73	15,11
O2	3,76	2,96	16,20	3,35	10,63	58,90	52,60	15,03

O1= vapnenačko- dolomitno tlo (Gospodarska jedinica Brloško Šumarije Fužine)

O2=kiselo smeđe tlo (Gospodarska jedinica Bitoraj)

Prema pH vrijednostima zaključujemo da su oba tla vrlo kisele reakcije. Nešto niže vrijednosti zabilježene su na kiselom smeđem tlu (O2). Količina organske tvari i ukupnog dušika na pokusnoj plohi O1 veća je nego na plohi O2, no obje imaju obilježja tla vrlo bogatog dušikom (Ugarković, 2009). Prema količini humusa u tlu O1 sadrži više humusa, no prema Muckenhausenu (1975) oba spadaju u jako humozna tla. Organskog ugljika, te ukupnog ugljika nalazimo više u pokusnoj plohi O1, što je obilježje tla bogatog humusom. Odnos ukupnog ugljika i ukupnog dušika (C:N) pokazuje da su oba otvora povoljna za više biljke. Naime, C/N odnos odnosi se na model imobilizacije i mineralizacije dušika tijekom mikrobiološke razgradnje organske tvari u tlu (Yamakura i Sahunalu, 1990) i indikator je kvalitete svježe organske tvari u šumskom tlu i postotka humifikacije (Callesen i sur., 2007). Potencijalna proteolitička aktivnost prikazana je na Slici 1. Prikazane su srednje vrijednosti sa standardnim devijacijama.



Graf 1. Potencijalna proteolitička aktivnost izmjerena u šumskim tlima u 1., 3., 5. i 7. mjesecu 2008. godine na dvije istraživane plohe (O1 i O2). Stupci pogreške označavaju standardnu devijaciju.

U uzorcima prikupljenima na pokusnim ploham O1 i O2 najveća proteolitička aktivnost zabilježena je u 3. mjesecu (O1) i u 5. mjesecu (O2) dok je najmanja zabilježena u 1. mjesecu. U 7. mjesecu zabilježen je pad proteolitičke aktivnosti na obje plohe u odnosu na prethodno razdoblje. Veća proteolitička aktivnost zabilježena je kroz sve mjesece i uzorke na pokusnoj plohi O1 u odnosu na plohu O2. Najveće razlike zabilježene su u 3. i 5. mjesecu. Pad proteolitičke aktivnosti u 7. mjesecu vjerojatno je posljedica smanjenja vlažnosti tla što je također zabilježeno tijekom ovog istraživanja (rezultati nisu prikazani). Dokazano je da se pri smanjenju vlage u tlu smanjuje i proteolitička aktivnost i to od 15 do 66% ovisno o godišnjem dobu i dubini tla (Sardans i Penuelas, 2005). U 1. mjesecu zabilježena je slabija proteolitička aktivnost uzrokovana najvjerojatnije niskim temperaturama. Čak i u tlu u kojem je količina dušika relativno visoka njegova dostupnost je slaba zbog niskih temperatura koje utječu na usporavanje razgradnje organske tvari. Dokazano je da porast temperature prema optimalnim vrijednostima povećava stopu razgradnje organske tvari u tlu i dostupnost dušika te potiče intenzivniji rasta biljaka (Shaver i Chapin, 1986). Budući da je optimum aktivnosti za proteaze 60°C (Ladd i Butler, 1972) zasigurno je proteolitička aktivnost zanemariva tijekom hladnijih zimskih mjeseci. To je također povezano sa nedostupnošću hranjiva i vode koji su tijekom zime blokirani uslijed zaleđivanja. Ponovnim povećanjem temperature i odleđivanjem hranjivo postaje dostupno organizmima tla (Sharma i sur., 2006) čime je stimulirana aktivnost mikroorganizama i potiče se rast mikrobnih zajednica. To može i objasniti višu proteolitičku aktivnost u 3. i 5. mjesecu zabilježenu u našem istraživanju. Sharma i sur. (2006) također bilježe višu aktivnost mikroorganizama nakon odmrzavanja što se povezuje sa nekoliko događaja u tlu: disrupcijom agregata u tlu, oslobađanjem organskog ugljika i lizom mikroorganizama nakon stresa, što sve povećava dostupnost supstrata i mikrobiološku aktivnost u tlu. Osim sezonske varijabilnosti proteolitičke aktivnosti, također smo zabilježili i značajne razlike s obzirom na tip tla s kojeg su uzorci sakupljeni. Višu proteolitičku aktivnost zamijetili smo na vapnenačko- dolomitnom tlu (O1) u odnosu na kiselo smeđe tlo (O2). Te razlike mogu se povezati sa većom količinom humusa, organskog ugljika i dušika na plohi O1 (Tablica 1) tj. sa većom količinom supstrata koji stimulira rast i aktivnost mikrobnih zajednica (Brosius i sur., 1981; Marx i sur., 2005). Nadalje, niža reakcija tla izmjerena na kiselom smeđem tlu nepovoljnije utječe na proteolitičku aktivnost. Ladd i Butler (1972) istraživali su proteolitičku aktivnosti tala različitih pH vrijednosti i dokazali da tla u laboratorijskim uvjetima pokazuju optimalnu proteolitičku aktivnost pri pH 8,0 i da smanjenje pH u tlu značajno utječe na potencijalnu proteolitičku aktivnost.

### Zaključci

Proteolitička aktivnost u tlu jedan je od najvažnijih pokazatelja biološke aktivnosti tla i usko se povezuje s kvalitetom i plodnošću tla. Svaka promjena proteolitičke aktivnosti rani je indikator promjena mikrobne aktivnosti i efektivne plodnosti tla. Tijekom ovog istraživanja utvrđena je sezonska dinamika proteolitičke aktivnosti u degradiranim šumskim tlima kao i značajne razlike obzirom na različite tipove tala. Sezonske promjene proteolitičke aktivnosti povezane su sa sezonskim fluktuacijama abiotičkih faktora kao što su nedostupnost hranjiva tijekom zimskih mjeseci, odleđivanje supstrata povećanjem temperature u proljeće, a također se sezonska varijabilnost proteolitičke aktivnosti može povezati i s količinom dostupne vode tijekom sezone. Veća proteolitička aktivnost zabilježena je kroz sve mjesece i uzorke na vapnenačko-dolomitnom tlu (O1) u odnosu na kisela smeđa tla (O2). Te razlike mogu se povezati sa kemijskim razlikama istraživanih

tala. Naime, značajno veća količina humusa, organskog C i N te viša reakcija tla zabilježena je na pokusnoj plohi O1 u odnosu na plohu O2.

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# Optimalna gnojidba i dubina korijena utječu na kvalitetu travnog busena

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## Sažetak

Trave se koriste kao izvor hrane (žitarice), ali i za formiranje uporabnih travnjaka. Najbrže formiranje travnjaka jest putem uzgoja i postavljanja travnog busena. Zbog važnosti korjenovog sustava u proizvodnji travnog busena (tepiha), u ovom je radu prikazano istraživanje utjecaja gnojidbe različitim gnojivima na njegov rast i razvoj. Temeljem rezultata istraživanja o duljini korijena sugerira se gnojidba sa  $100 \text{ g m}^{-2}$  NPK 15-15-15 u kombinaciji s  $15 \text{ g m}^{-2}$  KANa predsetvno i s mjesečnim prihranama s po  $15 \text{ g m}^{-2}$  KANa. Ujedno, utvrđeno je i da se 53-59% korijena nalazi na dubini od 0-5 cm.

Ključne riječi: duljina korijena, gnojidba, travni busen, WinRhizo

## Optimal fertilization and root depth influence turfgrass quality

### Abstract

Grasses are used as a source of food (cereals), but also for the formation of usable lawns. The fastest lawn forming is through growing and setting of turfgrasses. Because of the importance of root system in the production of turfgrasses, in this paper is shown how fertilization with different fertilizers affects on its growth and development. Based on the research results of the root length suggests fertilization with  $100 \text{ g m}^{-2}$  NPK 15-15-15 in combination with  $15 \text{ g m}^{-2}$  KAN presowing with monthly top dressing of  $15 \text{ g m}^{-2}$  KAN. It was also determined that 53-59% of root is located at a depth of 0-5 cm.

Key words: fertilization, root length, turfgrass, WinRhizo

### Uvod

Trave se ubrajaju u razred monokotiledona ili jednosupnica, a pripadaju porodici *Poaceae* (*Gramineae*) koja se smatra najvažnijom porodicom na svijetu zato što se veliki broj biljaka iz te porodice koristi za prehranu ljudi i životinja, ali se također određeni broj koristi i za ukrasne svrhe. Unatoč velikom broju travnih vrsta, za ukrasne svrhe koristi se tek 12-14 vrsta s oko 100 sorata koje su stvorene križanjem i selekcijom (Campbell, 2010; Dubravec, 1996; Čížek i sur., 2007).

Upotreba trava je raznolika. Prvenstveno se koriste za stvaranje bogatih i kvalitetnih travnjaka koji se mogu uzgajati u okućnicama, parkovima, športskim terenima i slično. Uzgoj kvalitetnog travnjaka zahtijeva dosta znanja, truda i vremena. Osim pravilne pripreme tla, potrebno je odabrati odgovarajuću smjesu travnih vrsta, pravilnu gnojidbu te osigurati navodnjavanje. U današnjem užurbanom svijetu zahtijeva se brzo ozelenjavanje golih površina i upravo je to razlog za potražnju za tzv. "instant travnjacima", koji omogućuju da se u jednom danu ogoljena površina transformira u zelenu oazu. Takvi su zahvati mogući zahvaljujući proizvodnji travnog busena (travnog tepiha). Travni busen (tepih) je uzgojena trava koja se reže na trake

određene dimenzije te polaže na drugu, prethodno pripremljenu lokaciju.

Kod proizvodnje travnog busena (tepiha) važan faktor je dobro razvijen korijen koji služi za opskrbu biljke vodom i hranivim elementima, ali i zato što, kad je dobro razvijen i rasprostranjen na dubini 3-5 cm, omogućava lakše rezanje traka jer onemogućava rasipanje tla te time olakšava pakiranje, transport i postavljanje samih traka. Nakon postavljanja travnog tepiha, dobro razvijen korijen olakšava ukorjenjavanje travnog busena (tepiha) na novoj površini, te time osigurava lijep izgled novog travnjaka.

Kako navodi Huang (2010), glavna korijena trave se nalazi 3-10 cm ispod površine tla. Trave razvijaju čupavo korijenje čiji rast uključuje razvoj novog korijenja, elongaciju i grananje. Čupavo se korijenje sastoji od nekoliko primarnih korijena koji rastu direktno iz sjemena. Čimbenik koji značajno utječe na razvoj i distribuciju korijena je tlo. Nejednaka raspodjela vode i hraniva u tlu uzrokuje promjene u morfologiji i distribuciji korijenovog sustava (Huang, 2010).

Malo je istraživanja provedeno na temu utjecaja gnojiva na razvoj korijena travnog busena, posebno u poljskim uvjetima. Većina se provodi u zaštićenim prostorima, u kontroliranim uvjetima i hidroponskom uzgoju.

Jedno od takvih istraživanja proveo je Pessaraki (2008) u hidroponskom uzgoju u plasteniku u hranivoj otopini različite koncentracije: puna koncentracija Hoaglandove hranive otopine, 1/2, 1/4, 1/8, i 1/16 koncentracije Hoaglandove otopine. Rezultati istraživanja pokazali su da je rast korijena stimuliran pri nižim razinama hraniva (1/4, 1/8, i 1/16 koncentracije Hoaglandove hranive otopine) između kojih nisu uočene razlike u veličini korijena. Takvi rezultati podudaraju se sa tvrdnjama Sagi i sur. (1997) da korijen jače raste u stresnim uvjetima, kao što je niska koncentracija hraniva. Budući da je istraživanje provedeno u hidroponskom uzgoju, rezultate bi trebalo provjeriti i u poljskim pokusima zbog različitih agroekoloških uvjeta. Istraživanje u tlu proveli su Su i sur. (2008) na hibridima *Poa pratensis*, te navode da se 90-96% cijelog korijena (0-80 cm dubine) nalazi u prvih 30 cm.

Zbog važnosti korijenovog sustava u proizvodnji travnog busena (tepiha), u ovom radu prikazano je istraživanje kako gnojidba različitim gnojivima utječe na njegov rast i razvoj.

## Materijal i metode

Poljski gnojidbeni pokus s travnim busenom proveden je tijekom 2009. i 2010. godine na proizvodnom objektu za proizvodnju travnog busena u Botincu, Novi Zagreb, u tvrtki "Hortikultura Ćustić".

Istraživanje je provedeno na praškasto glinastoj ilovači, čiji  $\text{pH}_{\text{H}_2\text{O}}$  iznosi 6,7, a sadrži 2,7% humusa, 8,5 mg  $\text{P}_2\text{O}_5$  100 g tla<sup>-1</sup> i 17,5 mg  $\text{K}_2\text{O}$  100 g<sup>-1</sup>. Zrakosuhi, samljeveni i homogenizirani uzorci tla analizirani su u Analitičkom laboratoriju Zavoda za ishranu bilja Agronomskog fakulteta u Zagrebu. Reakcija tla (pH) određena je elektrometrijski, kombiniranom elektrodom na pH-metru MA5730 u suspenziji tla i vode u omjeru 1:2,5 (aktivna kiselost) (Škorić, 1982), humus metodom po Tjurinu (JDPZ, 1966), a fiziološki aktivni fosfor i kalij metodom po Egner-Riehm-Domingo (Egner i sur., 1960). Mehanički sastav tla određen je metodom prosijavanja i sedimentacije u Na-pirofosfatu (Škorić, 1982).

Gnojidbeni pokus postavljen je metodom latinskog kvadrata s 5 tretiranja kako slijedi: a) kontrola - negnojeno [kont]; b) 100 g m<sup>-2</sup> NPK 15-15-15 predstetveno [NPK]; c) 100 g m<sup>-2</sup> NPK 15-15-15 uz 15 g m<sup>-2</sup> KAN-a predstetveno, te tri prihrane s po 15 g m<sup>-2</sup> KAN-a [NPK+KAN]; d) 100 g m<sup>-2</sup> NPK 15-15-15 uz 15 g m<sup>-2</sup> amonijevog sulfata predstetveno, te tri prihrane s po 15 g m<sup>-2</sup> amonijevog sulfata [NPK+AS]; e) 100 g m<sup>-2</sup> NPK 15-15-15 uz 10 L m<sup>-2</sup> kiselog litvanijskog treseta predstetveno [NPK+tres]. Sjeme trave izravno je sijano na tlo, te se valjkom utisnulo u tlo. Sjetva je obavljena 11.09.2009., a prihrane 26.03.2010., 26.04.2010. i 21.05.2010.

Pokusna parcela veličine 4,0 m x 2,5 m imala je izolaciju od 0,3 m. Po potrebi je obavljeno navodnjavanje te zaštita od korova i štetnika.

U pokusu je korištena sljedeća smjesa trava: *Lolium perennae* "Esquire" 15%, *Lolium perennae* "Margarita" 10%, *Poa pratensis* "Balin" 15%, *Festuca rubra* "Maximal" 15%, *Festuca rubra* "Aniset" 15%, *Festuca rubra* "Calliope" 10% i *Festuca arundinacea* "Starlett" 20%.

Uzorkovanje korijena provedeno je u četiri navrata 02.11.2009., 07.04.2010., 03.05.2010. i 07.06.2010. valjkastom sondom promjera 5 cm od nehrđajućeg inoksa, kreiranoj upravo za tu namjenu, na tri dubine: 0-5, 5-10 i 10-15 cm. Korijen je odvojen od čestica tla, skeniran na Epson perfection V700 skeneru upravljanim WinRhizo softverom (Regent Instruments INC., Quebec, Canada).

Podaci su obrađeni uz pomoć statističkog programskog paketa SAS System for Win Ver. 9.1 (SAS Institute Inc., 2002-2003).

### Rezultati i rasprava

U ovom je istraživanju određivana duljina korijena travnog busena po dubinama (0-15, 0-5, 5-10 i 10-15 cm) u četiri termina uzorkovanja (02.11.2009., 07.04.2010., 03.05.2010. i 07.06.2010.).

Tablica 1 prikazuje duljinu korijena travnog busena od 0-15 cm dubine. Prilikom prvog uzorkovanja statistički značajno najveća duljina korijena izmjerena je u kontrolnom tretmanu (2242 cm 300 cm<sup>-3</sup>). U drugom uzorkovanju između duljina korijena nije utvrđena statistički značajna razlika, ali je utvrđeno znantno povećanje u odnosu na prethodno uzorkovanje. Niti u trećem uzorkovanju nije utvrđena statistički značajna razlika u duljini korijena iako je relativno najveća duljina opet utvrđena pri kontrolnom tretmanu od 3617 cm 300 cm<sup>-3</sup>. U četvrtom uzorkovanju najveće vrijednosti duljine korijena od 0-15 cm dubine utvrđene su u kontroli i tretmanu NPK+KAN (4863 i 4325 cm 300 cm<sup>-3</sup>). Moguće je zapaziti da je najznačajnije povećanje duljine korijena na dubini od 0-15 cm bilo u proljeće, prilikom drugoga uzorkovanja (07.04.2010.), što odgovara činjenici da korijen u najvećoj mjeri raste u jesen i rano proljeće. Nakon toga porast korijena stagnira, te ponovo raste.

U tablici 2 prikazana je duljina korijena na 0-5 cm dubine koja je ujedno i najbitnija za praksu zbog premještanja travnog busena na drugu lokaciju, moguće već u lipnju. Početkom vegetacije (prvo uzorkovanje, studeni 2009.) uočen je najveći porast korijena u kontrolnom tretmanu, što je u suglasnosti sa Sagi i sur. (1997) koji navode da korijen jače raste u stresnim uvjetima (nedostatak hraniva). U drugom i trećem uzorkovanju nisu uočene statistički značajne razlike među gnojidbenim tretmanima. Pored dubine od 0-5 cm, važno je naglasiti, da je za praksu, uzorkovanje u lipnju značajnije od ostalih uzorkovanja, te da se vrijednosti duljine korijena kreću od 1918 do 2587 cm 100 cm<sup>-3</sup> što, relativno na ukupno mjerenu duljinu na dubini 0-15 cm, iznosi 53-59%. To je izuzetno bitno za proizvođače kako se traka travnog busena ne bi razdvojila pri rezanju, transportu i postavljanju, te kako bi se brzo ukorijenila na novoj lokaciji, a također u suglasnosti je s Huangom (2010) koji tvrdi da se glavina korijena nalazi na dubini od 3-10 cm.

U tablicama 3 i 4 prikazane su vrijednosti duljine korijena travnog busena na dubinama 5-10 i 10-15 cm. Vidljivo je da je trend duljine korijena isti kao i kod dubine 0-5 cm.

Rezultati ovog istraživanja o duljini korijena travnog busena u suglasnosti su s navodima literature, iako se uglavnom odnose na hidroponski uzgoj, a naše je istraživanje provedeno u tlu u poljskim uvjetima. Ovo je istraživanje pokazalo da je duljina korijena relativno najveća pri kontrolnom tretmanu bez gnojidbe što je u suglasnosti i s Pesarakli (2008) koji navodi da korijen bolje raste pri manjim količinama hraniva, kao i već spomenuti Sagi i sur. (1997).

Tablica 1. Duljina korijena travnog busena na dubini od 0-15 cm (cm 300 cm<sup>-3</sup>)

Tretman	Dubina (cm)	DULJINA (cm 300 cm <sup>-3</sup> )			
		02.11.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	0-15	2242 a	3631	3617	4863 a
NPK	0-15	1748 b	3726	3376	4145 b
NPK+KAN	0-15	1277 c	3356	3154	4325 ab
NPK+AS	0-15	1565 bc	3893	3010	4183 b
NPK+tres	0-15	1919 ab	3579	3064	3265 c

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05.

Vrijednosti, kojima nije pridruženo slovo, nisu značajno različite.

Tablica 2. Duljina korijena travnog busena na dubini od 0-5 cm (cm 100 cm<sup>-3</sup>)

Tretman	Dubina (cm)	DULJINA (cm 100 cm <sup>-3</sup> )			
		02.11.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	0-5	1545 a	2048	1844	2587 a
NPK	0-5	1247 abc	2306	1729	2307 ab
NPK+KAN	0-5	898 c	2013	1712	2378 ab
NPK+AS	0-5	1126 b	2181	1696	2389 ab
NPK+tres	0-5	1472 ab	2026	1635	1918 b

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05.

Vrijednosti, kojima nije pridruženo slovo, nisu značajno različite.

Tablica 3. Duljina korijena travnog busena na dubini od 5-10 cm (cm 100 cm<sup>-3</sup>)

Tretman	Dubina (cm)	DULJINA (cm 100 cm <sup>-3</sup> )			
		02.11.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	5-10	491 a	1046 a	1174 a	1353 a
NPK	5-10	365 ab	889 ab	1020 ab	1198 ab
NPK+KAN	5-10	265 b	848 ab	876 b	928 cd
NPK+AS	5-10	305 b	1048 a	762 b	1117 bc
NPK+tres	5-10	318 b	710 b	828 b	815 d

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05.

Vrijednosti, kojima nije pridruženo slovo, nisu značajno različite.

Tablica 4. Duljina korijena travnog busena na dubini od 10-15 cm (cm 100 cm<sup>-3</sup>)

Tretman	Dubina (cm)	DULJINA (cm 100 cm <sup>-3</sup> )			
		02.11.2009.	07.04.2010.	03.05.2010.	07.06.2010.
Kontrola	10-15	207 a	537 b	599	922
NPK	10-15	136 ab	532 b	628	640
NPK+KAN	10-15	115 b	496 b	566	1019
NPK+AS	10-15	134 ab	664 ab	552	676
NPK+tres	10-15	130 b	843 a	600	532

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu, p≤0,05.

Vrijednosti, kojima nije pridruženo slovo, nisu značajno različite.

### Zaključak

Zbog premještanja travnog busena na novu lokaciju, najbitnije je mjerenje u lipnju, kao i dubina prokorjenjivanja 0-5 cm. Temeljem rezultata istraživanja o duljini korijena sugerira se gnojidba sa 100 g m<sup>-2</sup> NPK 15-15-15 u kombinaciji s 15 g m<sup>-2</sup> KAN-a predstjetno i s mjesečnim prihranama s po 15 g m<sup>-2</sup> KAN-a jer je takva gnojidba rezultirala povoljnom duljinom korijena koja može osigurati i dovoljno hraniva za kvalitetan i lijep izgled nadzemnog dijela što je pokazala i vizualna dijagnostika na terenu, ali i neka naša druga istraživanja. Ujedno, utvrđeno je i da se 53-59% korijena nalazi na dubini od 0-5 cm (uzorkovanje u lipnju 2009.) što je osobito bitno za čvrstoću trake travnog busena zbog rezanja, transporta i postavljanja na novu lokaciju.

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# Designing an experimental model of sustainable agriculture performant for the hill mountain area

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## Abstract

In our country as well as worldwide processes of degraded soil fertility features are registered as result of irrational agricultural system practices. In order to be able to protect both the biological resources of agriculture and the environment it is important to turn to operating durable agricultural systems requiring the design and implementation of experimental models that include activities and technologies close to natural processes and tendencies. The present paper promotes the fact that a durable agriculture must be economically sustainable, ecologically “healthy” and fair from a social point of view (Vilain, 2003). Agricultural exploitations need to address these three objectives as well as possible taking into account their territorial context and their own agricultural system (Lazăr I and co., 2007).

Key words: resources, agriculture, durable (sustainable), experimental model, system.

## Introduction

The beginning of the millennium highlights the preoccupation of humanity for agricultural the development using a series of means as: financing research activities, supplying services and other forms of support, stimulating production by subsidies, etc. All these had both positive and negative effects in the sense of growing agricultural production and higher contribution of the agricultural sector to the development of society in general but also higher agricultural pollution and degradation of quality in some microzones (RĂDULESCU C., V., 2003). In essence, changes have been registered in agricultural exploitations' behavior and in the use of technologies with great impact upon the environment thus determining a series of problems confronting agriculture as for example:

1. Effects upon human health (pesticides residues, chemical fertilizers, heavy metals, additives for animal feeding and other polluting substances present in the soil, the water, the entire food chain).
2. Surface- and underground -waters contamination because of nitrates and phosphates.
3. Agricultural pollution related to the development of intensive animal breeding.
1. 4. Atmospheric pollution due to crop and field sprinkling with liquid and semi-liquid waste.
2. 5.. Hardening, erosion and pollution of soil.
3. 6. Degradation of landscape and habitat for wildlife species.

As an answer to this situation researchers in the field of agriculture look for an “ideal” change for a less pollutant and energy consuming ecosystem.

In the E.U. and in our country there are concerns regarding systems of sustainable agriculture materialized in financing numerous studies on this issue. (Comisia Europeană, 2001; Esty ș.a., 2005; McRae, Smith și Gregorich, 2000; Piorr, 2003).

The aim of a durable (sustainable) agriculture is to raise its productivity, to obtain constant profit with minimum negativ effects on the environment ensuring food security for the population, biological stability for plants and cultivated varieties, conservation and protection of natural resources, but also introducing and

generalizing the use of modern, more productive technologies. In order to reach the goal a determinant role is played by the social - economical framework which can determine the durability of the agricultural production systems. In this sense, the perenity of the system depends on social justice, on ensurance of not only a temporary income but a constant financial support in order to avoid soil degradation and producers' poverty, and in order to consolidate the rural community.

We also underline the role of practiced technologies within the system of durable agriculture for the protection of soil functions as starting point for a durable agriculture " with a certain sort of agro-technical invention based on understanding the laws of soil fertility evolution by subordinating the way of doing agriculture to the main criterion of biodynamic agriculture synetically expressed as - What is biologically correct is of economical advantage" (Ștefanic Gh. 1999).

### Material and methods

The design of a durable agriculture system for the mountain - hill area needs special attention that must be paid to both eco-pedoecological conditions, biological resources (plant varieties and quality seeds) and use of organic materials as insufficiently valorized resources (Iagăru P., 2010) beeing totally concordant with the affirmations of Cornel Răuță (1997) who shows that" the implementation of the durable agriculture concept has to be done according to Romania's specific circumstances".

The design of the experimental model of durable agriculture as object of the present paper is characterized by the fact that it is based both on promotion into crop of new varieties with multiple uses and on raising the quality of agricultural production due to high disease and pest rezistance of the used biological resource (the variety and the quality of seed). The results follow a careful selection and application of adequate technologies in order to favor nutrient adsorbtion by crop-plants and the genetic capacity of competition against weeds.

In order to design the experimental model of durable agriculture we started from establishing the crop structure and rotation and we concluded with the plan of the crop and the sketch of the placement.

Within the crop technologies proposed to be applied special attention has been granted to durable agriculture techniques. From among these techniques we mention the role of resources applied to the soil according to the impact they have upon the phytosanitary and the physiological aspect, upon the plants' productive potential, as well as upon the physical chemical and microbiological characteristics of the soil. The action of some non regenerable materials (mineral fertilizers, pesticides, stimulators, etc.) will be carefully watched, but especially actions of allotting recyclable materials will be followed under the influence of microorganisms up to soluble mineral substances and organic substances with structural role (using stable manure and other composted vegetal material, using asolement which includes the amelioration jumping sole cultivated with a perennial vegetable, etc). Attention will be given to plants' and soil characteristics in order to indicate optimal doze or moments for application. It is such we expect to maintain more or less renewable resources: soil, quantity and especially quality of soil water, as well as avoiding alteration of the biodiversity of agro ecosystems.

### Results and discussion

Although agriculture, through its biological nature, should contribute to the protection and the improvement of the environment quality it lead to the deterioration of the natural environment through irrational agricultural system practices. It is therefore that preoccupations exist in order to change the existing situation to the better and one such preoccupation is the object of the present paper referring to the fact that in order to be able to protect the environment we need to pass on to implement durable agricultural systems where the first step is the design of model of sustainable agriculture.

The designed experimental model of sustainable agriculture is based on the fact that " the implementation of the durable agricultural concept must be done according to Romania's specific circumstances (Cornel Răuță, 1997) and comprises a structure based on biological criteria (productiv potential, precocity, natural resistance to disease attack), ecological criteria and requirements of pedological factors (acidity, clay and calcium content, etc.) and climatic factors (resistance to freezing and high temperatures), technical factors (compatibility with durable crop systems) and economical factors (harvesting period, consumer preferences, the degree of complexity of the domestic market) observing zoning and micro-zoning criteria.

The structure of the 5 crops- phacelia, potato, triticale, red clover și maize for 2011, as well as the crop rotation until 2014 is presented in table 1.

**Table 1. The crop structure and rotation within the designed experimental model**

2010	2011	2012	2013	2014
Maize	Phacelia	Potato	Triticale	Maize
Plant mixture	Potato	Triticale	Maize	Phacelia
Potato	Triticale	Maize	Phacelia	Potato
Rye	Red Clover	Red Clover	Red Clover	Red Clover
Beet	Maize	Phacelia	Potato	Triticale

Within the designed structure conditions will be created in order to observe the impact of resources applied to the soil upon the physiological, phytosanitary estate and the productiv potential of plants as well as upon the physical - chemical and micro-biological characteristics of the soil. In this way will be established the performance indexes of plants and soil characteristics under the influence of some non-regenerable materials (mineral fertilizers, pesticides, stimulators, etc.), but especially under the action of some reciclable materials influenced by micro-organisms up to soluble mineral substances and organic substances with structural role (the use of manure and other composted vegetal materials, the use of asolement which is to include the amelioration jumping sole cultivated with a perennial vegetable, etc.) in order to make recommendations for optimal dozes and application moments respectively. All these culminate in maintaining more or less regenerable resources as: soil, quantity and especially quality of water in the soil, as well as avoiding the alteration of agro-systems' biodiversity.

In order to complete the things proposed the finalization is needed of durable agriculture crop technologies adopted within the durable agricultural system integrated economically and sustainably.

The technological variants proposed for application within the designed model as base for the technological packages (seed with specific characteristics concerning adaptability to superior category durable agriculture, varieties corresponding the 5 promoted crops) represent defining elements (table 2):

**Table 2. Technological variants with elements of durable agriculture**

Phacelia	Potato	Triticale	Red Clover	Maize
autumn ploughing;	organic fertilization with manure	organic fertilization with manure	autumn ploughing;	organic fertilization with manure
soil break up;	autumn ploughing;	autumn ploughing;	soil break up	autumn ploughing;
GPGS soil preparation;	spring soil break up	soil break up	GPGS soil preparation;	soil break up
soil preparation for seeding;	soil preparation for planting;	soil preparation for seeding;	soil preparation for seeding;	soil preparation for seeding;
seeding	potato planting	seeding	seeding	seeding
hardening after seeding;	biological material characterized by high manna resistance and less technological input requirements	Spring fertilization;	hardening after seeding;	manual weeding;
manual weeding;	remodeling the row;	harvesting	field toileting and vegetal residue removal	mechanical weeding;
offshoot cleaning;	manual weeding with	mow l + 2;	harvesting	
elimination of vegetal residues and remodeling the row				
harvesting	phytosanitary treatments;		hay rummage	
	destroying stalks;		packing	
	harvesting			
	sorting potatoes			

Within the experimental model red clover will be cultivated as secondary jumping sole, support for the other main crops (phacelia, potato, triticale, maize) because of its properties to naturally redo soil property and enrich the soil with natural fertilizing substances, especially nitrogen.

### Conclusions

The durable (sustainable) agriculture may constitute a guarantee of stability if success is reached in the durability of consolidation of food safety and security so much needed for the peace and prosperity of our nation.

The durable agriculture may be successfully promoted only if certain conditions are observed by the agricultural producers referring mostly to crop rotation, fertilization, weed control, disease control and reduction of energy consuming. Energy consuming reduction is done through “the SLCS system of soil conservation works”.

The design of the durable agriculture experimental model contributes to the realization of a model of sustainable agriculture at the level of the farm in order to obtain healthy vegetal products applying innovative crop technologies specific for each species, thus contributing to the maintenance and improvement of soil characteristics.

The presentation of scientific and technical information (obtained through applicative research) mediates the transfer towards interested operators (farmers, students) of modern techniques and ideas concerning durable agriculture.

### Acknowledgments

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# New technologies of heavy soils tillage

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## Abstract

The goal of the researches was to define the needed parameters for the construction of machines for tillage of all kinds of soils with heavy mechanical composition and, within a three year period, to develop new solutions for tillage of heavily composed soil. For example, increase of the penetration resistance, during disking, in the right wheel's trail is the greatest at a depth of 0 to 5 cm and it reached 476.19%.

The research includes the development and verification of the effects that the new machines have on physical and water properties of the heavily composed soils, the consumption of energy and resources, the amount of returns and the development of new technologies of tillage.

With new technologies of heavy soils tillage achieved biological returns of wheat, corn and sugar beet, during conditions of dry cropping, is 12 to 21% larger in favor of the heavy mechanical class soil type (according to heavy mechanical content), for operation of subsoiling depth of 0.6 m,

Key words: heavy soils, soil compaction, tillage, arrangement of the soil's surface and depth, new machinery.

## Introduction

According to data (Vučić, 1992), in Serbia there are over 400,000 hectares of heavy soil, and nearly 1,000,000 hectares of diversely damaged soil.

The development and application of the new agriculture machinery assets (Raičević at al., 2003, 2005), requires previously defining of the technologies used for the preservation of the soil's fertility, with taking into consideration the regional designations, intensity of the production with the prospect of greater working speeds.

The basic conventional tillage by a plough, once or twice a year, assumes that it is done through the full depth of the ploughed land (20-35 cm). This leads to a problem with the soil compaction beneath the working depth of the plough, when the two wheels of a tractor move over the furrow's bottom (Oljača, 1993, 1994). This matter can be removed by occasional subsoiling, which improves the macrostructure of the soil, but it rarely can improve its microstructure. The tractor's movement in the next stage of the cultivation compacts the soil further, to a certain degree. The soil compaction (Nikolić, at al., 1996), (Oljača, 1993), (Radojević at al., 2006), can effect the plant production by changing the soil's properties, especially its cubical mass, distribution of the soil's aggregates and the continuity of its pores.

## Material and methods

Experimental researches of a tillage of one type of soil with heavy mechanical composition were carried out on the grounds of the "PKB Corporation - Belgrade", on the "Padinska Skela" farms, on a parcel marked T-18, a 40 hectare area, type of Marsh soil.

The influence that soil tillage has on compaction, that is penetration resistance, was examined on a Marsh soil type, and Alluvium. The examined variety of the Marsh soil is with a deep humus accumulative surface, 80 cm deep. The alluvium surface with CaCO<sub>3</sub> at the initial process of the experiment is 100 cm deep.

The quantitative indicator of the physical, chemical, and water properties points that the examined soil falls under the heavy mechanical class soil type (heavy clay, in Ah horizon Clay content is 41.90-39.30%), meaning heavy mechanical composition.

In the aforementioned technological operations of the autumn soil cultivation, an MF-8160 tractor was used, aggregated with an MF-715 plough and an OLT Tara-36 disc harrow.

The measurement procedure, using a hand penetrometer, (*Ejkelkamp* Hand Penetrometer, Set A, measuring amplitude of 10 MPa), determined the penetrometric characteristics of the uncompacted and the compacted soil surfaces. These measurements were conducted in series of ten repetitions, at depths of 5 - 10 - 15 - 20 - 30 - 40 cm, on the prepared measurement sites. The penetration resistance was measured by a penetrometer on the trails of the tractor's wheels, when they moved along the furrow or out of it, as well as beside the trails on the uncompacted soil.

## Results and discussion

### Penetration resistance values during the ploughing operation

The examination of the compaction of Marsh soil type, during ploughing, has been done up to a depth of 40 cm. The effects of the soil compaction were gained by comparison of the compacted and uncompacted soil, with water content up to 40 cm deep, with a water content of 24 to 20.65%. The soil compaction has stipulated changes in the values of the penetration resistance and other parameters. The uncompacted soil had average values of penetration resistance (Cone index) within an interval from 0.91 to 5.55 MPa, whereas the compacted portion of the soil is from 1.35 to 6.52, and in the trail from 1.57 to 7.33 MPa.

Table 1 shows the increase (%) of the penetration resistance behind the wheel on the field, behind the wheel in a trail and behind the wheel in a trail compared to the condition of the soil before ploughing.

**Table 1. The increase (%) of the penetration resistance (Cone Index) during ploughing**

Depth (cm)	Water content (%)	Increase Cone Index behind wheel on grass-plot (%)	Increase Cone Index behind wheel in furrow (%)	Increase Cone Index behind wheel in furrow end before tillage (%)
0-5	24.00	148.35	142.73	172.53
5-10	23.00	130.56	124.55	190.28
10-15	21.63	126.00	117.33	206.50
15-20	23.44	149.47	110.17	212.10
20-30	21.80	129.72	100.93	120.83
30-40	20.65	117.48	105.32	132.07

The greatest increase of the penetration resistance (Cone index), during ploughing, behind the wheels on the field was at a depth of 0-5 cm, it came to 148.35%, and at a depth of 15-20 cm, where it came up to 149.47%. The increase of the penetration resistance (%) behind the wheel in a trail was the largest at a depth of 0-5 cm, amounting 142.73%. The increase of the penetration resistance behind the wheel in a trail and before ploughing at a depth of 15-20 cm was 212.10%.

### The values of penetration resistance during the disking process

Examining the changes of compaction values of the Marsh soil during disking was done to a depth of 40 cm. The effects of the soil compaction were gained by comparing the parameters of the compacted and uncompacted soil, with the water content from 24.54 to 21.44% up to a depth of 40 cm. The soil compaction has stipulated changes of the penetration resistance and other parameters. On the uncompacted soil, the average values of the penetration resistance were from 0.42 to 5.13 MPa, behind the left wheel the interval is from 1.70 to 5.75 MPa, and behind the right wheel from 2.00 to 5.85 MPa.

Table 2. shows the change of penetration resistance (%) during disking, behind the left and the right wheel, in relation to the soil's condition before disking.

**Table 2. The penetration resistance increase (%), during disking**

Depth (cm)	Water Content (%)	Cone Index before disking (MPa)	Cone Index in trail left wheel (MPa)	Increase of Cone Index left wheel (%)	Cone Index in trail right wheel (MPa)	Increase of Cone index right wheel (%)
0-5	24.54	0.42	1.70	404.76	2.00	476.19
5-10	24.22	0.83	2.64	318.07	2.68	322.89
10-15	23.05	1.61	3.00	186.34	3.03	188.20
15-20	23.00	1.82	4.00	219.78	4.00	219.78
20-30	23.00	3.14	4.40	140.13	4.40	140.13
30-40	21.44	5.13	5.75	112.09	5.85	114.04

The largest penetration resistance (Cone Index, Table 2), during disking behind the left wheel was at a depth of 5 cm and it reached 404.76%, and at a depth from 5 to 10 cm it was 318.07%. The increase of the penetration resistance in the right wheel's trail is the greatest at a depth of 0 to 5 cm and it reached 476.19%. If the increases behind the wheel and before ploughing are analyzed at a depth from 5 to 10 cm, that increase was 322.89%.

#### New solutions of agricultural machinery for the heavy soils tillage

The development of agricultural machinery that applies new technologies for the processes of heavy mechanical soil exploitation is given a special meaning nowadays.

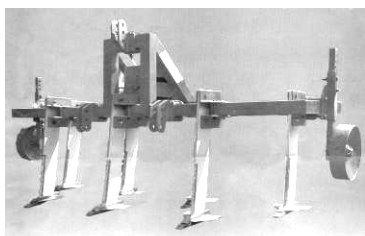
For the regions with annual rainfall less than 600 mm per m<sup>2</sup>, deep subsoiling tillage, with optimal agriculture machinery, can provide economically sustainable yields of basic agricultural crops: wheat, sugar beet, corn, soy and sunflower. Harmful effects of droughts in the last few years, especially in 2003, (Raičević at al., 1997, 2003), are also an effect of an inadequate soil cultivation

The goal of the research conducted by the Institute for Agriculture Engineering of the Agriculture Faculty in Belgrade (Raičević at al., 1997, 2005), was to define the required parameters for the construction of all types of heavy soil arrangement and tillage machines and within a period of three years, to develop new solutions for a rational tillage of heavy soils.

According to data collected under production and experimental conditions at the parcels of the sugar refinery "Crvenka" from Crvenka, and researches (Raičević at al., 1994, 2005), with a complete usage of agricultural machinery and deep subsoiling, the gained results show that the sugar beet plants advance quicker and resist the drought better. Therefore an increase in yield was noted, and an increase in gains by 14 to 20% per hectare.

A broad range of technical solutions are applied world wide for soil surface leveling, (Chen at al., 2005), (Derdack, 1989), (Nikolić at al., 1996, 2002), (Raper, 2005), subsoiling and deep soil tillage: scrape boards, special ploughs, chisel ploughs, subsoilers with stiff and vibratory working bodies, subsoilers with various add-ons, rotational machines, etc.

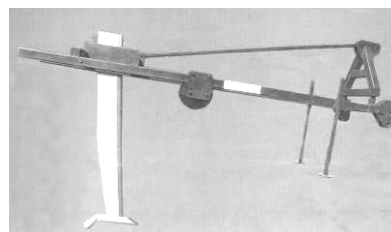
The Institute for Agriculture Engineering of the Agriculture Faculty in Belgrade has for a number of years worked on the development of the machines for the soil's surface and depth arrangement: carried vibratory subsoiler VR-5 (7), (Fig.1); universal self-propelled soil arrangement machine USM-5 (Fig. 2) and drainage plough DP-4 (Fig. 3).



**Fig.1 Carried vibratory subsoiler VR-5 (7)**



**Fig.2. Universal self-propelled soil arrangement machine USM-5**



**Fig.3. Drainage plough DP-4**

According to data gained during experimental measurements of the energy parameters in the course of the machines model and type testings (Fig. 1, 2, 3), it could be concluded that:

During the testing of the subsoiling tools (Raičević at al., 1995, 1997), an average decrease of the tractor's tractive power was accomplished through vibrations, of 0.80 to 0.85%,

During a working speed of 7 km/h, the tractive power was from 250 to 300 kW for a static version of the tool. Thus, for the given depth of subsoiling with the tractor usage coefficient of 80% during these working operations, a 60 kN tractive power tractor was needed.

The displayed machinery solutions are tested during conditions of different types of tillage and especially for soils with heavy mechanical composition.

Based on the test results presented in this text, it could be concluded that:

The cubic weight of the soil reaches: for plough tillage 1.40 [g/cm<sup>3</sup>], and for subsoiling (Subsoiler machine, Fig.1.) it was 1.43, at a working depth of 0.6 m,

Water permeability (the K-coefficient, by Darcy, [cm/s]), for plough tillage was (1.00 to 1.05) 10<sup>-3</sup>, and for subsoiling the value is (1.10 to 1.30) 10<sup>-3</sup>,

The penetration resistance of the soil (in MPa) was from 11 to 13% of the lesser values at subsoiling soils,

The achieved biological returns of wheat, corn and sugar beet, during conditions of dry cropping, is 12 to 21% larger in favor of the heavy mechanical class soil type (according to heavy mechanical content), for operation of subsoiling depth of 0.6 m,

Soil deformation, during working speeds of 0.9 to 1.33 m/s and tillage depth of 0.4 m, is significantly increased with the increment of working body's width and increased movement speed,

Measurements have established that the lateral sides of the working body have a greater effect on soil (Fig.1.) with the vibration of the subsoiler body, compared to a stationary working body,

Testing has shown that the work with a vibratory body subsoiler (Fig.1.) have accomplished a lower traction resistance for approximately 4%, compared to a subsoiler with a stationary body,

Appliance of the vibratory subsoilers (Fig.1.) for soil tillage has saved fuel consumption compared to classic plough tillage: 16% for sugar beet, 19% for corn and 29% for soy.

## Conclusion

By testing the changes of the more important properties of the heavy soils, it has been established that the penetration resistance has increased during all working operations and it has been especially increased during disking. Greater changes in soil compaction have been noticed in lateral areas up to 20 cm deep, which is specifically exposed to intense machine and tractor movement over the surface of the heavy soils.

Tractive resistances, during the same conditions, decrease at vibratory working bodies up to 4%, with an increase of working depth up to 6%. Application of the vibratory subsoilers in systems of a rational tillage of soils with heavy mechanical composition has led to formidable fuel savings, from 16 to 29%, depending on plant crops.

Based on new findings and new solutions of these machines world wide, it is necessary to work on perfecting the decrypted machinery solutions in this work, as well as construction of the machines that the market of agricultural and soil melioration machines in Serbia does not have and offer such improved machines to agricultural producers.

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# Comparison of municipal and tannery sludge effect on soil Cr mobility and barley bio accumulation

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## Abstract

A pot experiment was set up to investigate the effect of municipal and tannery sewage sludge loads on four soils (acid and calcareous sandy soils as well as acid and calcareous loamy more heavy soils with different basic soil properties) and plants. The examined soil element fractions were: mobilisable: 0.5 M NH<sub>4</sub>-acetate + 0.02 M EDTA extractable and the mobile: 1 M NH<sub>4</sub>NO<sub>3</sub> extractable. Applied sewage sludge loads were: 0, 5, 10, 20 g sludge D.M. kg/air-dry soil. Number of treatments was: 4 soil x 2 sludge x 4 load level = 32, in 4 replications. The test plant was barley. Our results showed that the relative amount of soluble Cr content in soil does not increase by the amount of sludge loads. Thus the risk of contamination of food chain and groundwater by Cr after sludge application does not increase linearly by the volume of sludge applied.

Based on the result of this experiment one can state that Cr accumulates more in the barley straw than in the grain. In function of sludge loads the BCF values for Cr lessened.

Key words: sewage sludge, bio-concentration, Cr

## Introduction

The sewage sludge volume is supposed to be grown with increasing sewage system and capacity of wastewater treatment. In Hungary, the amount of sewage sludge dry matter is 150-160 thousand tons per year at present. This value is supposed to be increasing to 350-400 thousand tons by 2015 (Ötvös, 2006).

The most cost effective treatment of sludge is agricultural utilisation (Csathó, 1994). The benefits of sewage sludge application to the agricultural soils as a source of nutrients and soil ameliorant have been widely acknowledged. The most positive effect of sewage sludge or compost application on field is organic matter increment, which improves also the soil physical and chemical properties (Simon et al., 2000; Izsáki and Debreczeni, 1987; 1989). However, the sewage sludge may contain high concentrations of potentially toxic elements, especially Cr.

The properties of the toxic elements and their chemical forms or types of binding in soil and in sludge may strongly influence their uptake by plants or leaching. Depending on their origin, sewage sludges have different properties that affect the availability of their metal content (Kádár, 2005). The objective of this work was to compare the influence of high Cr sewage sludges on soil mobilisable (NH<sub>4</sub>-acetate +EDTA soluble) and mobile (NH<sub>4</sub>NO<sub>3</sub> soluble) fractions and barley uptake by growing on the acidic and calcareous sand and loamy soil.

## Materials and methods

A pot experiment was set up in 1999 for examining the effect of sewage sludge loads on soils and plants (Kádár and Morvai, 2007; 2008). Four soils were used from the plough layer (0-20 cm) of the field experimental stations of Research Institute for Soil Science and Agricultural Chemistry. Parameters of the investigated soils are shown in Table 1.

**Table 1. Several properties of soil samples at the establishment of the experiment in 1999 (based on Kádár and Morvai, 2008)**

Parameter	Site /soil type			
	Nyírlugos acid sand	Órbottyán calc. sand	Nagyhörcsök calc. loam	Gyöngyös acid loam
pH (KCl)	3.9 - 4.8	7.3 - 7.6	7.5 - 7.6	5.8 - 6.3
CaCO <sub>3</sub> %	-	10 - 13	8 - 10	-
Clay% (< 0,002 mm,%)	3 - 4	4 - 5	20 - 24	40 - 45
Organic matter %	0.5 - 0.8	0.6 - 0.8	2.6 - 3.0	3.0 - 3.5

The soils were treated with tannery and municipal sludge. The pre-treatment of the sludges was the following: the sludge was dried then sieved 3 times for homogenisation. The properties of the sludge are shown in Table 2.

**Table 2. Several properties of sludge samples (Kádár and Morvai, 2007; 2008)**

Parameter	Unit	Municipal sludge	Tannery sludge
pH		6.1	7.4
ash	%	45	67
organic matter	%	35	11
N	%	2.8	3.2
P	%	2.4	0.3
K	%	0.4	0.1
NH <sub>4</sub> -N	mg/kg	113	44
NO <sub>3</sub> -N	mg/kg	374	794
Cr	%	0.18	0.52
Ca	%	4.6	21.5

The mixture of air-dried soil (<5 mm particle size) and the air-dry sludge was dispensed into 10-liter pots (10 kg soil). To take soil water supply under control the pots were in field situation, but covered by roof. Soils were irrigated by deionised water according to the plants water requirement. Applied sewage sludge loads were the followings: 0, 5, 10, 20 g sludge D.M. / kg air-dry soil. Number of treatments was: 4 soil x 2 sludge x 4 load level = 32, in 4 replications.

The soil and sludge mixing was followed by 1-month incubation then spring barley (30 seeds per pot on 3<sup>rd</sup> May) was sown. The barley had 3 months growing period. Soil sampling was taken on 20<sup>th</sup> October. Composite soil samples consisted of 20 cores/pot and all above-ground total plant mass was used for analysis and yield assessment.

Determination of plant, soil pseudo total and sludge element concentrations was carried out with ICP-AES method after microwave teflon bomb digestion with cc. HNO<sub>3</sub> + H<sub>2</sub>O<sub>2</sub> (ISO 11466, 1995).

From the soil samples the mobilisable: 0.5 M NH<sub>4</sub>-acetate + 0.02 M EDTA extractable (Lakanen and Erviö, 1971) and the mobile: 1 M NH<sub>4</sub>NO<sub>3</sub> extractable (DIN 19730, 1995) element concentrations were measured by ICP-AES method.

Measurement of pH was carried out in 1:2,5 soil 1 M KCl solution 24 hours after mixing. The soil organic matter content was measured by oxidation with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> according to the method of Tyurin (Hargitai, 1988). The total N content was measured after cc. H<sub>2</sub>SO<sub>4</sub> + H<sub>2</sub>O<sub>2</sub> digestion according to the modified method of Kjeldahl (ISO 11261, 1995).

## Results and discussion

The investigated soils represent all combinations of basic soil properties: acid and calcareous sand; acid and calcareous loam.

The sludges used for the experiment had different properties (Table 2). The tannery sludge had neutral pH while the municipal sludge was slightly acidic. The organic matter content of municipal sludge was three times higher than the tannery sludge. There was a great difference in P content also: municipal sludge had 8 times more P than the tannery sludge. The total Cr content in the municipal sludge was 0.18 mg/kg and in the tannery sludge 0.52 mg/kg. In tannery sludge the Ca content was also high (21.5%). Due to these values the sludge had significant effect on soil properties. The tannery sludge increased the pH of each type of soil while the municipal sludge had only a positive effect on the pH of sandy soils. Both sludge increased the organic matter of soils and the tannery sludge had a liming effect by its high Ca content.

The mobile and mobilisable Cr fractions increased significantly on each soil after the addition of tannery sludge while the municipal sludge did not change the mobile Cr content of the loamy soils. Table 3 and 4 show the changes in the mobile and mobilisable Cr fractions of soil in the percentage of the added Cr. The original data were published in Kádár and Morvai, 2007; 2008.

**Table 3. Change of the mobile and mobilisable fraction in the percentage of the added Cr (in tannery sludge) (%)**

Soil	Load (g sludge D. M. / kg soil)			LSD <sub>5%</sub>	Average
	5	10	20		
	Cr-load, mg Cr/kg soil				
	26	52	104		
	Soil mobile (NH <sub>4</sub> NO <sub>3</sub> soluble) Cr content				
acid sand	0.156	0.197	0.131	0.008	0.161
calc. sand	0.124	0.088	0.067		0.093
calc. loam	0.026	0.025	0.024		0.025
acid loam	0.045	0.022	0.014		0.027
Average	0.088	0.083	0.059		0.077
	Soil mobilisable (ammonium-acetate + EDTA soluble) Cr content*				
acid sand	2.14	3.19	2.95	1.22	2.76
calc. sand	3.36	3.87	2.97		3.40
calc. loam	2.75	2.99	2.91		2.88
acid loam	2.34	2.28	2.33		2.32
Average	2.65	3.08	2.79		2.84

\*Based on Kádár and Morvai, 2008

**Table 4. Change of the mobile and mobilisable fraction in the percentage of the added Cr (in municipal sludge) (%)**

Soil	Load (g sludge D. M. / kg soil)			LSD <sub>5%</sub>	Average
	5	10	20		
	Cr-load, mg Cr/kg soil				
	8.8	17.6	35.2		
	Soil mobile (NH <sub>4</sub> NO <sub>3</sub> soluble) Cr content				
acid sand	0.131	0.094	0.051	0.014	0.09
calc. sand	0.057	0.045	0.031		0.04
calc. loam	0.057	0.038	0.018		0.04
acid loam	0.054	0.027	0.014		0.03
Average	0.075	0.051	0.028		0.05
	Soil mobilisable (ammonium-acetate + EDTA soluble) Cr content*				
acid sand	1.63	2.66	2.39	0.56	2.23
calc. sand	0.19	0.49	0.51		0.40
calc. loam	0.29	0.12	0.19		0.20
acid loam	1.07	0.54	0.26		0.62
Average	0.80	0.95	0.84		0.86

\*Based on Kádár and Morvai, 2007



## Comparison of municipal and tannery sludge effect on soil Cr mobility and barley bio accumulation

Investigating the solubility of the Cr fractions of the two sludge we found that the Cr from municipal sludge is less mobile than the Cr of tannery sludge. Only 0.05% of the added Cr could be found in the mobile fraction after the addition of municipal sludge in the average of four soils (Table 4). This value for tannery sludge was 0.077% (Table 3). In function of sludge loads less percentage of the added Cr can be found in the mobile fraction. The only exception is the calcareous loamy soil in municipal sludge treatments, where 0.025% of the added Cr was mobile irrespectively of the sludge loads. On the same soil the ratio between the  $\text{NH}_4\text{NO}_3$  soluble and added Cr decreased in function of tannery sludge loads.

**Table 5. Bio concentration factor (BCF) in tannery sludge treatment (Plant element concentration/soil  $\text{NH}_4$ -acetate + EDTA extractable fraction) Based on the data of Kádár and Morvai, 2008.**

Soil	Load (g sludge D. M. / kg soil)				LSD <sub>5%</sub>	Average
	0	5	10	20		
Cr transfer barley grain						
acid sand	3.53	0.47	0.19	0.09	1.20	1.01
calc. sand	3.87	0.27	0.11	0.08		0.95
calc. loam	3.48	0.44	0.12	0.07		0.89
acid loam	1.34	0.33	0.24	0.10		0.53
Average	3.05	0.38	0.16	0.08		0.85
Cr transfer barley straw						
acid sand	16.4	2.3	0.8	0.5	7.5	4.4
calc. sand	10.1	0.9	0.7	0.6		2.7
calc. loam	16.5	2.1	0.5	0.5		4.4
acid loam	8.2	1.0	0.7	0.7		2.6
Average	12.8	1.6	0.7	0.6		3.5

The 2.8% of the Cr added in the tannery sludge could be measured in the mobilisable fraction of soils (Table 3). This ratio was constant in function of load levels. In case of municipal sludge treatments only 0.86% of the added Cr could be found in the mobilisable fraction as average (Table 4). But in this treatment the ratio between the mobilisable Cr increment and added Cr decreased on the acidic loamy soil.

These results show that the relative amount soluble of Cr content in soil does not increase by the amount of sludge loads. Thus the risk of contamination of food chain and groundwater by Cr after sludge application does not increase linearly by the volume of sludge applied.

**Table 6. Bio concentration factor (BCF) in municipal sludge treatment (plant element concentration/soil  $\text{NH}_4$ -acetate + EDTA extractable fraction) Based on the data of Kádár and Morvai, 2007.**

Soil	Load (g sludge D. M. / kg soil)				LSD <sub>5%</sub>	Average
	0	5	10	20		
Cr transfer barley grain						
acid sand	3.53	1.18	0.44	0.25	1.10	1.35
calc. sand	3.87	3.53	1.22	1.03		2.41
calc. loam	3.48	2.26	1.74	1.07		2.14
acid loam	1.34	0.83	0.80	0.91		0.97
Average	3.05	1.95	1.05	0.81		1.72
Cr transfer barley straw						
acid sand	16.4	5.7	3.1	0.9	4.1	6.5
calc. sand	10.1	5.5	3.6	3.6		5.2
calc. loam	16.5	8.0	6.5	5.7		9.2
acid loam	8.2	5.5	3.6	3.6		5.2
Average	12.8	6.1	4.2	3.4		6.5

The transfer of Cr from soil to plant was also different by the type of applied sludge. The transfer of the elements from soil to plant can be described with bio concentration factor (BCF). Table 5 and 6 show the transfer of Cr to the grain and straw of barley. Definition is  $\text{BCF} = \text{plant element concentration/soil } \text{NH}_4\text{-acetate} + \text{EDTA extractable fraction}$ . The BCF of grain Cr is decreasing in function of sludge loads on each soil. This is due to the phenomena that the Cr concentration did not change in the grain while the mobilisable Cr content increased on each soil. The BCF values of Cr in straw decreased with the sludge loads like in case of grain.

Comparing the BCF values of the two sludge it can be seen that on soils treated with municipal sludge the transfer values were higher. This is because the plant Cr concentrations were similar but the soil Cr concentrations were smaller in the soils treated with municipal sludge.

### Conclusions

The relative amount soluble of Cr content in soil does not increase by the amount of sludge loads. Thus the risk of contamination of food chain and groundwater by Cr after sludge application does not increase linearly by the volume of sludge applied.

Based on the result of this experiment one can state that Cr accumulates more in the barley straw than in the grain. In function of sludge loads the BCF values for Cr lessened.

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# Management of root knot nematode with *Trichoderma harzianum* and spent mushroom compost

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## Abstract

*Trichoderma harzianum* and spent mushroom compost alone and in combination were tested against root knot nematode in tomato under field conditions at Heroshah & Jabban in Malakand division of Pakistan. The experiment consisted of five treatments; application of *T. harzianum* grown on spent mushroom compost, root coating with *T. harzianum*, application of spent mushroom compost alone, root coating + spent mushroom compost and check. The data were recorded on: 1) Number of flowers per plant 2) Number of tomato fruits per plant 3) Plant height (cm), 4) Root weight (g) 5) Number of galls per root system 6) Fruit yield per plant (kg). Significant differences were observed among different treatments. *T. harzianum* and spent mushroom compost both suppressed nematodes and enhanced growth of the tomato plants. Data regarding yield and growth parameters, root coating with the fungus in combination with spent mushroom compost inoculated with *T. harzianum* (T<sub>4</sub>) was found best among the treatments applied.

Key words: Root knot nematode, *Trichoderma harzianum*, spent mushroom compost

## Introduction

Root-knot nematodes are one of the most important pathogens of tomato (Thompson and Kelley, 1979). These nematodes are sedentary endoparasites and are considered to be the most serious among the plant-parasitic nematodes (Maqbool et al, 1986) with a host range of more than 2000 species of crop plants (Barker, 1985). They cause unlimited losses to tomato crop throughout the world especially in developing countries. Average crop losses due to these nematodes are about 25% and in individual fields may reach to 60% (Sasser & Carter, 1982).

*Trichoderma* sp. have been an exceptionally good model to study as biocontrol agent for soil borne plant pathogens (Samuels, 1996). Reduction of *M. javanica* infection with several isolates of *T. lignorum* and *T. harzianum* has been reported (Spiegel and Chet, 1998). Parasitism of *T. harzianum* on potato cyst nematode *Globodera rostochiencis* was studied *in vitro* by Saifullah and Thomas (1996). The organic amendments such as leaves of cabbage, mustard, radish, carrot, dried algal catch and spent mushroom compost have been used against many root diseases and nematodes (Kaul and Chhabra, 1993). Spent mushroom compost (SMC) inhibited the occurrence of *Fusarium* wilt of watermelon, club root of cabbage, root-knot disease of watermelon, tomato and pepper and *Pythium* root rot of tomato and watermelon (Chiu and Huang, 1997). A farmer friendly method developed for the biological management of root knot nematode is reported here.

## Materials and methods

*Trichoderma harzianum* was isolated from village Zarakhella in Malakand division of Pakistan. The fungus was mass cultured on wheat grains and spent compost of oyster mushroom. Wheat grains were soaked in tap water for 24 hrs surface dried and filled into heat resistant glass bags (250 g/bag) and autoclaved at 121°C for 45 min. After cooling the bags small blocks of about 5mm, from the pure culture of *T. harzianum*, were

transferred into each bag and incubated at  $25\pm 1^{\circ}\text{C}$  for 15 days. The bags were shaken with an interval of 3 days for uniform growth of *T. harzianum* to prevent seeds from sticking together. Spent compost of oyster mushroom was obtained from mushroom house of the Department of Plant Pathology, Agricultural University Peshawar and autoclaved at  $121^{\circ}\text{C}$  for 45 minutes. After cooling down the compost was inoculated with *T. harzianum* under sterile conditions and incubated at  $25^{\circ}\text{C}$  for 15 days.

The experiments were laid out in Randomized Complete Block (RCB) Design with four replications. Plant-plant distance was 25-30 cm and row-row distance was 70-75cm. The experiments consisted of the following five treatments; (T<sub>1</sub>) Application of *T. harzianum* grown on spent mushroom compost, (T<sub>2</sub>) Root coating with *T. harzianum*, (T<sub>3</sub>) Application of Spent mushroom compost alone, (T<sub>4</sub>) Root coating + Spent mushroom compost and (T<sub>5</sub>) Check.

The data were recorded on the following parameters during the course of experiment.

1. Number of flowers per plant
2. Number of fruits per plant
3. Plant height (cm)
4. Root weight (g)
5. Number of galls per root system
6. Fruit yield per plant (kg)

The data recorded for each parameter was individually subjected to the ANOVA techniques by MSTAT-C computer software and means were separated by using LSD test.

### Results and discussion

Significant differences ( $P = 0.05$ ) were observed in different treatments regarding number of flowers per plant, number of fruits per plant, plant height (cm), root weight (g), number of galls per root system and fruit yield per plant (kg), (Table 1) at both the locations. The fungus alone or in combination inhibited nematodes and enhanced growth of the plants. Heroshah is a frost free zone and farmers grow tomatoes in summer and winter here.

The study was focused upon the need to establish appropriate, environment friendly, sustainable and farmer friendly control measures against these wide spread and important pathogens. Species of *Trichoderma* are easy to isolate and culture, grow rapidly on many substrates, affect a wide range of plant pathogens, are rarely pathogenic to higher plants, act as a mycoparasites, compete well for food and site, produce antibiotics and have enzyme system capable of attacking a wide range of plant pathogens (Parveen *et al.*, 1993; Khan and Saxena, 1997; Hafeez *et al.*, 2000; Meyer *et al.*, 2000; Rangaswamy *et al.*, 2000; Sharon *et al.*, 2001; Sukumar *et al.*, 2005; Sua'rez *et al.*, 2005 and Sa'nchez *et al.*, 2007). However, the interaction of *Trichoderma* spp. and nematodes have been little explored (Windham *et al.*, 1989; Dos Santos *et al.*, 1992). Parasitism of *T. harzianum* on potato cyst nematode *Globodera rostochiencis* was studied by Saifullah and Thomas (1996). Testing the efficacy of *Trichoderma harzianum* and spent mushroom compost under field condition, different application methods were evaluated. All the methods were found effective in suppressing the nematodes thereby formation of less number of galls on roots and enhanced growth parameters. The spent mushroom compost was used as substrate for *T. harzianum*. These results are in line with those reported by Papavizas *et al.*, 1982; Khan and Saxena, 1997 and Meyer *et al.*, 2000. The nematicidal and growth enhancement properties of spent mushroom compost have already been reported by Kaul and Chhabra (1993). Organic amendments release nematode toxic substances into the soil during decomposition. These amendments also improve the fertility of the soil and thus increase growth and yield of plant. The decomposing residues of plant tissues release simple organic acids such as acetic, propionic and butyric acids that are toxic to phytonematodes (Sayre, 1971). Our soils are very deficient in organic matter. Application of spent mushroom compost may increase the organic matter content of the soil which in turn may increase its water holding capacity, aeration and microbial activities helping plants and the environment.

## Conclusion

Novel and farmer-friendly techniques for the application of bio-agent for the management of root knot nematodes have been developed in this project. In coating method, the wet roots of nursery plants are just inserted and shaken a bit in the inoculum of *Trichoderma harzianum* grown on wheat grains in glass bottle. Millions of spores stick to roots of tomato plants that multiply continuously with the growth of the roots. The plants with *Trichoderma harzianum* coated roots are then planted as such in the soil as routine practice. A small amount of spent mushroom (i.e. 50 g) if added to soil before transplanting, shall give fruitful results. Spent mushroom provides food for the bio-agent, as well as increases the fertility of soil. The methods are simple and can be used for many other bioagents.

## Acknowledgement

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**Table 1. Effect of *Trichoderma harzianum* and spent mushroom compost on the management of root knot nematodes**

	Flowering	Fruits per plant	Plant Height (cm)	Root wt. (g)	Galls per plant	Yield per plant (kg)
T1	117 c*	62.0 b	48.5 c	17.5 c	127 b	6.7 c
	111.8 c**	57.7 c	48.7 b	16.5 c	131 b	6.6 b
T2	122.5 b	62.0 b	53.0 b	13.7 d	98 c	7.5 b
	118.3 b	60.0 b	51.2 ab	14.0 d	101 c	7.4 a
T3	96.5 d	49.5 c	46.0 c	20.7 b	133 b	5.8 d
	84.2 d	42.2 d	48.0 b	19.7 b	137 b	5.5 c
T4	131.2 a	68.5 a	57.2 a	12.0 d	74 d	8.2 a
	125.3 a	63.7 a	56.2 a	12.7 d	75 d	7.7 a
T5	81.2 e	41.7 d	37.2 d	24.0 a	166 a	3.9 e
	72.5 e	38.5 e	32.5 c	22.2 a	170 a	3.6 d
LSD value (0.05)	4.146	3.743	3.235	1.807	6.397	0.574
	4.69	1.923	5.872	2.281	7.644	0.435

Means followed by same letter(s) are not significantly different at 5% level of significance.

\* Upper category data from Heroshah

\*\* Data in the lower category is from Jabban

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# Combined effect of soil erosion agents within a small catchment

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## Abstract

The Vasovića River, a dry watercourse and a small torrent, has specific traits, including class IV of erosion category and an erosion coefficient (Z) of 0.35, suggesting slight deep-cutting erosion. The catchment erosion factors evaluated in this study, being relief and its characteristics, lack of geological substrate resistance to erosion, climate, and protective vegetative soil cover, have contributed to the mean annual erosion sediment production of 1266.74 m<sup>3</sup> year<sup>-1</sup> and erosion intensity of 125.67 m<sup>3</sup> km<sup>-2</sup> year<sup>-1</sup>.

Key words: natural agents, soil erosion, small catchment

## Introduction

There are different erosion factors that effect a change in both soil and geological substrate, resulting in devastation or complete disappearance of soils. As soil changes can be either slow or fast, erosion can be characterised as either a slow or rapid process. Djorović (1997) reports that above 90% of total land in the Republic of Serbia suffers from different types and intensities of erosion. Erosion can have both direct and indirect impacts, inducing permanent soil disappearance. The calculated value of the total annual sediment production suggests that some 16.0 cm of soil are annually eroded off the 21,000 ha of land in Serbia (Spalević, 1997).

In the region of Čačak (Western Serbia), air temperature and precipitation show evidence of an increasing and decreasing tendency respectively (Šekularac, 2002). Such climate changes lead to deterioration of soil physical properties, an increase in soil erodibility, a reduction in the protective vegetative cover, and its hampered natural and manmade renovation. All of the above will cause intensification of both surface and deep-cutting processes of erosion.

Threats to agriculture, forestry and water management as induced by erosion intensification are becoming an increasing problem; hence the growing need to undertake erosion control works and soil amelioration measures. Empirical methods involving parameters that have an important effect on the erosion process are used to predict soil erosion (Fernandez et al., 2010). Prediction of water-induced erosion of small catchments of up to 260 ha, along with modelling, have been dealt with by Renschler and Lee (2005). The soil erodibility factor according to the USLE method was calculated by Wawer et al. (2005).

Aiming at evaluating the combined effect of erosion agents and quantifying sediment production, this study was conducted in a small catchment in part of the catchment area of the Kamenica river (part of the Zapadna Morava catchment, part of Western Serbia) i.e. its subcatchment, including its first order right tributary the Vasovića river.

## Material and methods

The reconnaissance method was used to analyse and present catchment configuration elements. The basic method was accompanied by the use of topographic, geologic and pedologic maps of adequate scale that enabled defining the traits and impacts of all natural agents on the erosion of the catchment concerned.

Meteorological parameters for the catchment area were calculated using the method of precipitation interpolation by the rainfall gradient (Bonacci, 1984), and air temperature calculations for any altitude (Dukić, 1984).

The quantitative indicators of the soil erosion process were calculated using the analytical method of Gavrilović (1972).

### Results and discussion

The size, length, circumference and shape of the catchment are among major catchment elements of importance for the soil erosion process.

The Vasovića River catchment is 2.52 km<sup>2</sup> in area (F), 2.45 km in length (L), 7.70 km in circumference (C). As regards the shape of the Vasovića River catchment, the river bed branches in the upper course of the river where soil material and loose geologic substrate are being washed away. The middle and lower course of the river have no tributaries, being hydrographically undeveloped.

Certain quantitative indicators of soil erosion in the Vasovića River catchment are based on major elements of the catchment, characteristics of relief and geologic substrate, soil distribution and method of land use.

Major relief parameters of the Vasovića River catchment i.e. agents primarily contributing to the erosion process are given in Table 1.

**Table 1. Major relief parameters of the Vasovića River catchment**

Parameters	Unit of measurement	Value
The lowest point of the main watercourse and catchment	m	560
The highest point of the main watercourse	m	660
The highest point of the catchment (E)	m	706
Average slope of the main watercourse in the catchment ( $I_a$ )	%	4.5
Mean altitude of the catchment ( $A_m$ )	m	639.83
Mean altitudinal difference of the catchment (D)	m	79.83
Mean slope of the catchment ( $I_m$ )	%	13.8
Coefficient of basin relief erosion energy ( $E_r$ )	m km <sup>-1/2</sup>	36.68

Higher relief parameter values induce more intensive soil erosion of the catchment.

The mean altitude ( $A_m$ ) of the Vasovića River catchment area is 639.83 m (Tab. 1). The method used involved marking contour lines at every 100 m increase in altitude. The mean altitudinal difference (D) of the Vasovića River catchment is 79.83 m, being the result of the difference between mean altitude of the catchment and that of the river mouth (Tab. 1). The mean Vasovića River catchment slope ( $I_m$ ) was defined using the vertical distance between contour lines (h) of 100 m; hence the ( $I_m$ ) value of 13.8% (Tab. 1). Relief of a region can also be determined by the coefficient of relief erosion energy ( $E_r$ ), the value thereof for the Vasovića River catchment being 36.68 m km<sup>-1/2</sup> (Tab. 1). The above values of relief parameters enable higher precipitation run-off, due to the quantitative effect of relief on the flow of water into the watercourse. At identical amounts of precipitation, 28.15% more water runs off the highlands as compared to the lowlands (Dukić, 1984).

Geologic substrates as another erosion agents have also contributed to the erosion process within the Vasovića River catchment area, Tab. 2.

**Table 2. Geologic substrates, coefficient of their water permeability ( $S_1$ ) and their erosion resistance within the Vasovića River catchment**

Parameters	Unit of measurement	Value
$F_{ip}$ - Impermeable rocks		
Pleistocene sandy clays and loams	km <sup>2</sup>	0.91
	%	36.00
Serpentine	km <sup>2</sup>	1.61
	%	64.00
Water permeability coefficient of the geological substrate ( $S_1$ )		1.00
Erosion resistance of geological substrate		Non-resistant



Erosion resistance of geological substrates is dependent upon their permeability. The two substrates, Pleistocene sandy clays and loams, their percentage being 0.91 km<sup>2</sup> (36.00% of catchment area), and serpentine (1.61 km<sup>2</sup> i.e. 64.00% catchment area), are impermeable. These geological substrates in the Vasovića River catchment have resulted in the water permeability coefficient of the geological substrate ( $S_1$ ) of 1.00, suggesting non-resistance of the geological substrate to the erosion process, Tab. 2.

As an erosion agent, soil and its traits contribute to a lesser or larger degree to the process.

Due to the effect of pedogenetic factors, the soil types covering the Vasovića River catchment area include pseudogley and humus silicate soil (ranker). They are classified as deep and shallow soils, respectively. A very weak degree of erodibility (below the weak degree) is found in the pseudogley, and a strong degree in the ranker soil.

Climate elements inducing and contributing to soil erosion include precipitation, air temperature and soil temperature. The mean annual total precipitation ( $P$ ) for the Vasovića River catchment is 785.9 mm, and the mean annual air temperature ( $t$ ) is 8.5°C. As compared to the mean annual precipitation total for Čačak (242 m.a.s.l.) of 620 mm (Šekularac and Stojiljković, 2009), the precondition satisfied is that stronger erosion is caused by higher total precipitation. This is due to the fact that an increase in altitude leads to increased precipitation, reduced air temperature, decreased evaporation, and increased precipitation run-off.

The proportion of another soil erosion agent: vegetation, both autochthonous and anthropogenic, and the vegetative cover coefficient ( $S_2$ ) of the catchment are given in Tab. 3.

The total area of land under forests and coppice of good spacing ( $f_f$ ) in the Vasovića River catchment is 0.25 km<sup>2</sup> (9.92%), land under grass vegetation ( $\Sigma f_g$ ) is 2.19 km<sup>2</sup> (86.91%), and land under bare soil ( $\Sigma f_b$ ) - 0.08 km<sup>2</sup> (3.17%), which contributes to protecting the catchment area against erosion (vegetative cover coefficient,  $S_2 = 0.79$ ), Tab. 3.

Table 3. Plant cadastre and vegetative cover coefficient ( $S_2$ ) of the Vasovića River catchment

Design	Parameters	Unit of measurement	Value
$F_f$	Forests and coppice of good spacing	km <sup>2</sup>	0.25
		%	9.92
	Orchards	km <sup>2</sup>	0.10
		%	3.97
$F_g$	Meadows	km <sup>2</sup>	0.70
		%	27.78
	Pastures and devastated forests and coppices	km <sup>2</sup>	1.39
		%	55.16
$\Sigma f_g$		km <sup>2</sup>	2,19
		%	86,91
$F_b$	Arable land	km <sup>2</sup>	0.08
		%	3.17
	Infertile soil	km <sup>2</sup>	0.00
		%	0.00
$\Sigma f_b$		km <sup>2</sup>	0,08
		%	3,17
Vegetation cover coefficient ( $S_2$ )			0,79
			Protected

The devastating potential of the Vasovića River course can be determined from the hydrographic and hydrologic traits of the region studied.

The traits pertaining to the family of the Dugački Potok torrent are as follows:  $F_{st}$ : D; IV;  $Z=0.35$ , indicating that the Vasovića River is a dry watercourse and a small torrent of class IV of erosion category, with an erosion coefficient ( $Z$ ) of 0.35 (slight deep-cutting erosion).

The combined effect of the above erosion factors of the Vasovića River catchment results in a certain amount of sediment production and certain intensity of erosion.

The scale of erosion of the Vasovića River catchment is presented through the mean annual amount of erosion production,  $W_{year}$  of 1266.74 m<sup>3</sup> yr<sup>-1</sup>. The mean annual volume of the total sediment production ( $G_{yr}$ )

reaching the Vasovića River confluence is  $316.69 \text{ m}^3 \text{ yr}^{-1}$ , whereas the specific annual total erosion sediment yield reaching the confluence with the Kamenica river ( $G_{\text{yr sp}^{-1}}$ ) is  $125.67 \text{ m}^3 \text{ km}^{-2} \text{ yr}^{-1}$ .

### Conclusions

The mean annual erosion sediment production and specific total erosion sediment yield of the soil within the catchment area have been induced by natural and anthropogenic factors. Human activities along with natural agents, including relief, geological substrate, soil, climate and vegetation, have contributed to the value of erosion intensity of  $125.67 \text{ m}^3 \text{ km}^{-2} \text{ yr}^{-1}$  in the catchment area of the torrential watercourse of the Vasovića river.

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# Dinamika kalija u lišću vinove loze na kiselim i karbonatnim tlima

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## Sažetak

Utjecaj reakcije tla na koncentraciju i dinamiku kalija u vinovoj lozi (*Vitis vinifera* L.) istraživana je na tri podtipa vitisola: distričnom kambisolu, ( $pH_{KCl}$  3,76), pseudogleju ( $pH_{KCl}$  4,77) i rendzini na laporu ( $pH_{KCl}$  7,27). Uzorci lišća uzimani su tri puta tijekom vegetacije: u fazi cvatnje, fazi šare i u berbi. Najveće koncentracije K u lišću vinove loze u obje godine istraživanja utvrđene su na jako kiselom tlu u fazi cvatnje, dok je najmanja koncentracije utvrđena 2008. u berbi na karbonatnom tlu. Odnos  $K/(Ca+Mg)$  bio je najširi u 2008. u fazi cvatnje na sva tri tla. U obje godine istraživanja utvrđene su veće koncentracije šećera a manje koncentracije ukupnih kiselina u moštu na karbonatnom tlu u odnosu na kisela tla.

Ključne riječi: reakcija tla, kationski odnos, mošt, kiseline, šećeri

## Potassium dynamics in grapevine leaves on acid and calcareous soils

### Abstract

Influence of soil reaction on the potassium content and dynamics in grapevine (*Vitis vinifera* L.) leaves was investigated on three vitisol subtypes: dystric cambisol ( $pH_{KCl}$  3.76), pseudogley ( $pH_{KCl}$  4.77) and rendzina on marl ( $pH_{KCl}$  7.27). Leaf samples were taken three times during the vegetation period: at the flowering and veraison stages and at harvest. The highest amounts of potassium in the grapevine leaves in both years of investigation were found on highly acidic soil at flowering stage, while the lowest amount was determined in 2008. at harvest on calcareous soil. The  $K/(Ca+Mg)$  ratio was the broadest in 2008. at the flowering stage on all three soil types. In both years of investigation higher content of sugars and smaller content of total acids in must were found on calcareous soil in relation to acidic soils.

Key words: soil reaction, cation ratio, must, acids, sugars

### Uvod

Mnogi autori navode kako je kalij jedan od najvažnijih elemenata kvalitete grožđa, mošta i vina (Fregoni, 2000, Kasimatis i Christansen, 1976, Winkler i sur., 1974). Kalij je aktivator enzima neophodnih za fotosintezu i respiraciju (Bhandal i Malik, 1988). Bitan je za osmotski potencijal stanice (značajna uloga u osmotskoj regulaciji i ionskoj ravnoteži) kao i za turgor u zaštitnim stanicama koje otvaraju i zatvaraju puči (Salisbury i Ross, 1992). Povećenje koncentracije kalija u lišću pozitivno utječe na veću akumulaciju ugljikohidrata (šećera) i potiče ranije dozrijevanje grožđa (Derunskaja, 1961, citat Ough i sur., 1968). Prema Szoke i sur. (1992), tijekom vegetacije javljaju se četiri maksimuma za kalij: rast mladica, cvatnja, početak šare i fiziološka zrelost grožđa. Isti autori utvrdili su da odnos  $Ca+Mg/K$  prati krivulju oborina tijekom

vegetacijskog razdoblja. Najširi K/Mg odnos javlja se u uvjetima bez oborina (K/Mg odnos 0,5-0,8) jer je usvajanje Mg usko vezano uz količinu biljci dostupne vode u tlu. Alkalni ioni, posebice  $\text{Ca}^{2+}$ , trajno se akumuliraju u lišću (na kraju ksilemskog toka), pa se starenjem lišća odnos Ca/K povećava.

Licul i Premužić (1985) navode da se koncentracija kalija u lišću kreće u rasponu od 0,8 do 1,5%, a prema Conradie i Saaymana (1989) te vrijednosti su značajno veće i kreću se u rasponu od 1,39-2,54% K/ST. Prema Bergmannu (1992) optimalna koncentracija kalija u fazi cvatnje kreće se u rasponu od 1,2 do 1,6% K/ST lišća. Nedostatak kalija u vinovoj lozi najčešće je posljedica niske količine kalija u tlu, nedovoljno razvijenog korijenovog sustava i nepovoljne vlažnosti tla (Christensen i sur., 1978, Cook i Carison, 1961, citat prema Christensen i sur, 1990). Latentni nedostatak kalija "proljetna groznica" koja se javlja prije cvatnje najčešće je posljedica nepovoljnih klimatskih prilika (niske temperature) u vrijeme intenzivnog rasta mladica. Dostupnost kalija biljci može biti privremeno smanjena i zbog procesa fiksacije koji nisu jednako izraženi na svim tlima. Kod minerala ilita i vermikulita fiksacija kalija moguća je u vlažnim i aridnim uvjetima (Conradie i Saayman, 1989). Isti autori navode da količina kalija u biljci može biti smanjena i uslijed interakcija s drugim elementima, a to se prvenstveno odnosi na kalcij i magnezij (Ehrenbergov zakon). Nedostaci kalija vidljivi su najčešće početkom ljetnog perioda (Christensen i sur., 1990, Fregoni, 2000, Colugnati i sur., 1999) i češći su u suhim klimatima (Pearson i Goheen, 1998).

Osim niskih vrijednosti kalija, nepovoljan utjecaj na kvalitetu vina mogu imati i prevelike količine kalija koje negativno utječu na fermentaciju i čuvanje vina. Kalij utječe na boju kože i na odnos šećera i kiselina. Primanje velikih količina kalija utječe na porast antocijana u kožici bobice i ranije dozrijevanje ali rezultira i smanjenjem kiselosti soka.

## Materijal i metode

Istraživanja su provedena tijekom 2008. i 2009. godine na području Plešivičkog vinogorja (sjeverozapadna Hrvatska), na lokacijama Rečki gaj i Borička. Utjecaj reakcije tla na dinamiku kalija u vinovoj lozi istraživan je na sorti Sauvignon Blanc (podloga SO4), na tri podtipa vitisole: distrični kambisol (pH 3,76), pseudoglej (pH 4,77) i rendzina na laporu (7,27). Kemijska svojstva tla utvrđena su u sloju 0-30 i 30-60 cm dubine (tablica 1). U sva tri vinograda primijenjena je ista agrotehnika.

Tablica 1. Kemijska svojstva istraživanih tala

Tip tla	dubina cm	pH KCl	%		mg kg <sup>-1</sup>		mg kg <sup>-1</sup> Al <sup>3+</sup>	%
			humus	UkupniN	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O		
Distrični kambisol	0-30	3,73	1,34	0,11	168,90	322,60	304,00	-
	30-60	3,76	0,92	0,08	24,50	164,60	229,50	-
Pseudoglej	0-30	4,67	1,31	0,13	162,00	333,30	5,60	-
	30-60	4,77	0,86	0,09	19,50	141,30	5,30	-
Rendzina na laporu	0-30	7,24	2,01	0,17	74,70	316,60	-	21,50
	30-60	7,27	1,26	0,13	37,40	146,60	-	20,50

Uzorci lišća vinove loze uzimani su tri puta tijekom vegetacije: u fazi cvatnje, fazi šare i na kraju vegetacije (berba). Prosječni uzorci lišća formirani su od 120 zdravih, potpuno razvijenih i neoštećenih listova, uzetih nasuprot grozdova (3 repeticije x 40 trsova), na svakom tlu.

Fosfor i kalij u tlu određeni su prema Egner-Riehm-Domingo (Egner i sur., 1960). Ukupni dušik u tlu određen je metodom po Kjeldahl-u (AOAC, 1995). Zamjenjivi aluminij u kiselim tlima određen je metodom po Sokolovoj, a količina fiziološki aktivnog vapna u karbonatnom tlu određena je po Galet-u (JDPZ, 1966).

Kalij u lišću određen je nakon digestije s koncentriranom HNO<sub>3</sub> (MILESTONE 1200 Mega Microwave Digester) plamenfotometrijski (AOAC, 1995), dok su kalcij i magnezij određeni AAS-om.

Koncentracija šećera u moštu određena je digitalnim refraktrometrom (Atago Palette PR-101) u triplikatu, a vrijednosti su prikazane u% Brix kao prosječna vrijednost. Mjerenjem koncentracija šećera refraktrometrom dobiva se podatak o količini topljivih šećera, što podrazumijeva 56,9% saharoze, 24,6% glukoze i 18,5% fruktoze (Rodriguez-Sevilla i sur., 1999). Ukupne kiseline (TA), izražene kao vinska kiselina, u moštu određene su titracijskom metodom (EEC, 1990).

Podaci su obrađeni uz pomoć statističkog programskog paketa SAS System for Win Ver. 9.1 (SAS Institute Inc., 2007).

## Rezultati i rasprava

Rezultati dvogodišnjeg istraživanja prikazani su u tablicama 2, 3 i 4.

U prvoj godini istraživanja količina K (tablica 2) kretala se od 0,92% K/ST u šari i berbi na karbonatnom tlu do 1,33% K/ST u cvatnji na jako kiselom tlu. Statistički značajne razlike utvrđene su između količine K na distričnom kambisolu i rendzini u fazi cvatnje i šare, dok razlike u koncentraciji K u fazi berbe nisu bile statistički značajne. Tijekom 2009. godine koncentracije K kretale su se u rasponu od 1,00-1,34% K/ST, sa značajnim statističkim razlikama samo između kiselih i karbonatnog tla u fazi cvatnje. U obje godine istraživanja prisutan je trend smanjenja količine K prema kraju vegetacije, što je u skladu s literaturnim navodima (Bergmann, 1992, Marschner, 1995).

Tablica 2. Količina kalija u lišću vinove loze (%K/ST) po tipovima tla i godinama

Godina	Tip tla	% K/ST		
		cvatnja	šara	berba
2008	Distrični kambisol	1,33 a	0,98 b	0,98
	Pseudoglej	1,28 ab	1,12 a	1,03
	Rendzina na laporu	1,21 b	0,92 a	0,92
2009	Distrični kambisol	1,34 a	1,00	1,10
	Pseudoglej	1,32 a	1,07	1,18
	Rendzina na laporu	1,17 b	1,10	1,19

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ .

Vrijednosti kojima nije pridruženo slovo nisu značajno različite.

Tablica 3. Odnos K/(Ca+Mg) u lišću vinove loze po tipovima tla i godinama

Godina	Tip tla	K/(Ca+Mg)		
		cvatnja	šara	berba
2008	Distrični kambisol	0,825 ab	0,375 a	0,311 a
	Pseudoglej	0,839 a	0,337 a	0,328 a
	Rendzina na laporu	0,776 b	0,264 b	0,258 b
2009	Distrični kambisol	0,550 a	0,193	0,196
	Pseudoglej	0,532 a	0,185	0,189
	Rendzina na laporu	0,354 b	0,171	0,182

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ .

Vrijednosti kojima nije pridruženo slovo nisu značajno različite.

Na kvalitetu grožđa i vina više utječe odnos K/(Ca+Mg) nego količine pojedinih elemenata. Prema Fregoniju (2000) taj odnos optimalan je u rasponu 0,30-0,40. Odnos K/(Ca+Mg) bio je najširi u fazi cvatnje (tablica 3) na sva tri tipa tla u obje godine istraživanja, a povoljan je bio na kiselim tlima u šari i berbi 2008., te na karbonatnom tlu u cvatnji 2009. Statistički značajne razlike utvrđene su između kiselih i karbonatnog tla u šari i berbi 2008. godine te u cvatnji 2009. Dobiveni rezultati u skladu su s onima koje su utvrdili Čoga i suradnici (2009) te Gluhčić i suradnici (2007). Rezultati njihovih istraživanja također su pokazali smanjenje vrijednosti kationskog odnosa prema kraju vegetacije s najmanjom vrijednošću na karbonatnom tlu.

Tijekom obje godine istraživanja veće koncentracije šećera a manje koncentracije ukupnih kiselina utvrđene su na karbonatnom tlu u odnosu na kiselina tla (tablica 4). Statistički značajne razlike utvrđene su 2008. godine u koncentraciji šećera na sva tri tipa tla kao i u koncentraciji ukupnih kiselina na svim tlima. Razlike u koncentraciji kiselina na kiselim tlima 2009. godine nisu bile statistički značajne.

Tablica 4. Količina šećera (% Brix) i ukupnih kiselina ( $\text{g L}^{-1}$ ) u moštu po tipovima tla i godinama

Godina	Tip tla	šećeri	kiseline
		% Brix	$\text{g L}^{-1}$
2008	Distrični kambisol	24,00 b	5,12 b
	Pseudoglej	22,67 c	5,95 a
	Rendzina na laporu	25,30 a	4,31 c
2009	Distrični kambisol	26,11 a	4,96 a
	Pseudoglej	23,45 b	5,15 a
	Rendzina na laporu	26,88 a	4,26 b

Različita slova predstavljaju značajno različite vrijednosti prema Tukeyevom testu,  $p \leq 0,05$ .

Vrijednosti kojima nije pridruženo slovo nisu značajno različite.

## Zaključak

Utjecaj pH reakcije tla na dinamiku kalija i odnos kationa u lišću vinove loze utvrđen je u obje godine istraživanja. Značajno veće koncentracije kalija utvrđene su na jako kiselom tlu u odnosu na karbonatno tlo u fazi cvatnje i šare u 2008., te u fazi cvatnje u 2009. godini. Na odnos kationa u lišću vinove loze tijekom vegetacije značajan utjecaj imala je pH reakcija tla. U obje godine istraživanja veće koncentracije šećera a manje koncentracije ukupnih kiselina utvrđene su u moštu na karbonatnom tlu u odnosu na kisela tla.

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# Legal aspect of hydroponics placement in organic farming system

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## Abstract

Hydroponic production increasingly gaining its influence. As non-regulated area, it is necessarily awaiting appropriate legal regulation. Legislative dilemma is intensified through fast technical progress and regionally bounded differences. Regulation and unification of basic hydroponic principles is necessary and should be placed in all stages of modern agricultural policy. Establishing the correct placement of hydroponics in the modern system of agricultural law and clearly defining its position in relation to organic farming should be the main priority.

Key words: soilless culture, law, organic agriculture, legislation

## Introduction

Hydroponic production is a method of soilless plant growth, using mineral nutrient solutions (Krese, 1989). The essential feature of hydroponic cultivation techniques is growth of roots in air, water, or in other inert media, by adding specific amounts of nutrients concentrations, necessary for successful growth (Osvald and Kogoj Osvald, 2005).

Main guidance of new legislative policy is to establish a new direction for further development of organic farming with emphasis on environmental protection, biodiversity and higher standards of animal welfare.

## Material and methods

Starting chronological overview of hydroponics legal regulations with year 1991 as European Council of Agriculture Ministers adopted Council Regulation (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs (EEC, 1991). It represents a part of common agricultural policy and the closure of process by which organic farming received official recognition of then 15 EU member-states. This regulation covers only plant products, additional provisions for production of animal products were introduced later. Use of genetically modified organisms and products made from them has been explicitly excluded from organic production. Fundamental importance of Council Regulation (EEC) No 2092/91 is creation of a common minimum standards for the entire EU.

Chronological review of acts that followed Council Regulation (EEC) No 2092/91 ([www.mkgp.gov.si](http://www.mkgp.gov.si)):

- Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labeling of organic products and repealing Council Regulation (EEC) No 2092/91 (EC, 2007);
- Council Regulation (EC) No 967/2008 of 29 September 2008 amending Regulation (EC) No 834/2007 on organic production and labeling of organic products (EC, 2008a);
- Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for implementing Council Regulation (EC) No 834/2007 on organic production and labeling of organic products with regard to organic production, labeling and control (EC, 2008b);
- Commission Regulation (EC) No 1254/2008 of 15 December 2008 amending Regulation (EC) No

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- 889/2008 laying down detailed rules for implementing Council Regulation (EC) No 834/2007 on organic production and labeling of organic products with regard to organic production (EC, 2008c);
- Commission Regulation (EC) No 710/2009 of 5 August 2009 amending Regulation (EC) No 889/2008 laying down detailed rules for implementing Council Regulation (EC) No 834/2007 regarding the establishment of detailed rules on organic aquaculture animals and seaweed production (EC, 2009a);
  - Commission Regulation (EC) No 1235/2008 of 8 December 2008 laying down detailed rules for implementing Council Regulation (EC) No 834/2007 regarding the arrangements for imports of organic products from third countries (EC, 2008d);
  - Commission Regulation (EC) No 537/2009 of 19 June 2009 amending Regulation (EC) No 1235/2008 as regards the list of third countries from which they derive some organically produced agricultural products to be marketed in the Community (EC, 2009b) and
  - Commission Regulation (EU) No 471/2010 of 31 May 2010 amending Regulation (EC) No 1235/2008 as regards the list of third countries from which they derive some organically produced agricultural products to be marketed in the EU (EC, 2010).

### Results and discussion

Council Regulation (EC) No 834/2007 refers on hydroponics only indirectly. Preservation and enhancement of soil life, as well as natural fertility, soil stability and soil biodiversity, prevent and eliminate compaction and erosion, as well as feeding plants primarily via soil, are the basic principles of organic farming. Regulation creates exceptions in a “two-levels” way. First level is based on principle of necessity, applied directly to organic production. Second level is directed in principle of protection, jointed with conservation and prevention of interference in organic production.

Commission Regulation (EC) No 889/2008 highlights need for adequate definitions already in editorials article 3. Following article 4 gives main provisions of european agricultural law, directly related to hydroponic. It is first use of term hydroponic (hydroponic growth), which we unsuccessfully searched in Council Regulation (EC) No 834/2007. This document clearly defines hydroponic growth in relation to organic farming, pointing out that organic plant production's based on nourishing plants primarily through soil ecosystem and therefore hydroponic growth should not be allowed. With this provision, based on principle of prevention, European Union takes indisputable position in matter of hydroponics place in European organic farming system. Article 5 gives additional clarification in hydroponics negation. Organic plant production involves varied cultivation practices and limited use of fertilisers and conditioners of low solubility, therefore these practices should be specified. In particular, conditions for use of certain non-synthetic products should be laid down. With this Regulation EU law takes further distance from hydroponic production. It emphasizes importance of protecting soil and provides detailed requirements for what in hydroponic production, because of the fundamental characteristics of soilless growth, consequently can't be observed.

Second article in main text of Regulation provides basic definitions; in a. part about non-organic and in g. part, there is written definition of hydroponic production; it means the method of growing plants with their roots in a mineral nutrient solution only or in an inert medium, such as perlite, gravel or mineral wool to which a nutrient solution is added. This definition is most appropriate, despite missing a significant measure of certainty, particularly in exposure of the principle of prevention, and a detailed definitions of an inert media, method of production and ways of adding nutritional supplements, since we can't ignore constant upgrade of hydroponic production and its multiple effect on production patterns variations. Article 4 provides fundamental definition of hydroponic production in relation to EU organic agriculture. Basically, it summarises previous article, although different legislative approach is present. Unlike grammatical and teleological based approach, article 4 introduces with exactly written principle of prevention, which clears the ground rule: hydroponic production is prohibited.

With exception of technical references for implementation of Council Regulation (EC) No 834/2007 and provisions relating to import of organic products from third countries, Commission Regulation (EC) No 1235/2008 doesn't contains directly affecting provisions on hydroponic production, but it presents a part of modern concept in regulations system of European organic farming. Nor Commission Regulation (EC) No 1254/2008 nor Commission Regulation (EU) No 471/2010 interferes with hydroponic production directly. Its



importance is in term of technical-operative implementation and complementary to aforementioned Regulation.

Prima lex of agriculture legislation in Slovenia is the Agriculture Act. This paper inter alia includes legal grounds of agricultural policy, planning of agricultural and rural development, agricultural policy measures, food safety and quality in all stages of production, protection of consumer interests, and an inspection ([www.mkgp.gov.si](http://www.mkgp.gov.si)). It also provides rules for adoption of the National Programme for Agricultural and Rural Development ([www.ec.europa.eu/agriculture/rurdev/index\\_sl.htm](http://www.ec.europa.eu/agriculture/rurdev/index_sl.htm)) and other agricultural policy measures. Competence to its implement has the Agency of the Republic of Slovenia for Agricultural Markets and Rural Development. Hydroponic is (still) not included.

Completely different regime is found in the US. Unique eating habits, aggressive competition in food industry and economic liberalism of the market are dictating development in different direction. Consequently, excessive efforts of food industry leaders, which would have most benefits of hydroponics in placement in organic agriculture, aren't surprising. Heart of the problem is in size of US market and less systemised and coordinated basic rules. US consumers are willing to deducted an average of plus 15% in buying same type product, marked as "organic". Federal States, each with its own rules (federal regulations), define what is allowed to be labeled as organic and therefore what conditions should be met. For even bigger confusion, in US can be found way too many certification organization. Some of them operate under authority of the central competent, others by the federal government. There are even purely commercial or self-proclaimed entities who's providing certification based only on their own criteria. Actual situation is even worse, because this type of anarchy permits individual producers to try out their luck in effort of getting certificate by different organizations so long, until they finally meet "organic" standards with their product at one of this organizations.

First certificate for organic hydroponic was given in Canada for basil growth in 2003 (Jannasch, 2009). Nevertheless, some organizations, such as Certified Organic Organizations of British Columbia and Demeter ([www.eko-kmetije.info/biodar.asp](http://www.eko-kmetije.info/biodar.asp)), took negative stand about hydroponic growth taking place in organic farming system. On the other hand, US has allowed certain exceptions in hydroponic growth, placed in The National Organic program ([www.ams.usda.gov](http://www.ams.usda.gov)). Hydroponic and other soilless systems for crop production are limited to the following, categories: (1) production of higher plants that are naturally aquatic species; (2) production of algal organisms such as spirulina ([www.chlorellafactor.com](http://www.chlorellafactor.com)) and (3) production systems that utilize compost as a growing media ([www.ams.usda.gov](http://www.ams.usda.gov)). NOP explains generally rearsness of cases certificated as hydroponic organic production. There are individual cases of controlled growth of spirulina in Europe ([www.biochlorella.de](http://www.biochlorella.de)). In New Zealand e.g., under organic farming, hydroponic is prohibited on national level, same as in United Kingdom. Most divided opinions are certainly in the US. In the State of California e.g. it is possible to obtain a certificate for hydroponic organic production only by using allowed funds for organic production. On the other hand, in the State of Oregon, certificate for hydroponic organic production can not be obtained ([www.ams.usda.gov](http://www.ams.usda.gov)).

Exceptions about organic hydroponic growth in Europe, based in the NOP report, aren't correct. Commission Regulation (EC) No 710/2009 was adopted to supplement Commission Regulation (EC) No 889/2008 by laying down detailed rules on organic aquaculture, animals and seaweed production and exclude them from hydroponic growth chapter and subjected to a different but no less stringent and consistent rules. Particularly surprising is the fact, that reporters overlooked 4th article of editorial text, as well as the 4th article of the main text of Commission Regulation (EC) No 889/2008, and even 13th article of Council Regulation (EC) No 834/2007, which also provides detailed rules, concerning seaweed growth. All these rules represent individual legal regulation that clearly exclude hydroponic growth out of organic farming system and set specific criterias for organic aquaculture animals and organic seaweed growth.

### Conclusion

Rapid technological development of agriculture can cause difficulties in precise formulation of legal rules. Hydroponic is no exception. It is necessary to expand existing and adding new rules, whose must be consistent with continuous development and modern techniques of food production.

Long terming, coordination on international level of general agriculture rules and organic farming standards is indispensable for producers protection, quality assurance and consumer safety. Consequently, the gap

between economically oriented hydroponic and successively higher organic production criterias will continue to deepening.

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# Utjecaj folijarne gnojidbe na sadržaj glikozida u lišću stevije (*Stevia rebaudiana* Bertoni)

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## Sažetak

Cilj istraživanja bio je utvrditi utjecaj folijarne prihrane dušikom na sadržaj nekoliko najvažnijih glikozida u lišću stevije (*Stevia rebaudiana* Bertoni). Stevija (*Stevia rebaudiana* Bertoni) je višegodišnji zeljasti grm iz porodice glavočika (*Asteraceae*) koja je tek prije nekoliko godina introducirana u Hrvatsku. Biljka se uzgaja zbog lišća koje odlikuje slatkast okus zahvaljujući glikozidima koji su i do 300 puta slađi od šećera. Folijarna prihrana provedena je primjenom rastućih doza visokokoncentriranog dušičnog gnojiva - UREE (46% N) u koncentracijama: 0% (kontrola), 0,2%, 0,4% i 0,8% UREE. Temeljem analize uzoraka lišća stevije najveća količina glikozida utvrđena je u kontrolnoj varijanti, a najmanja u varijanti sa 0,2% -tnom koncentracijom.

Ključne riječi: dušik, urea, folijarna analiza, steviozid i steviobilzid

## The importance of foliar fertilization on the glycoside content of stevia (lat. *Stevia rebaudiana* Bertoni)

### Abstract

The subject of this research was to determine the importance of foliar fertilization on glycosides of stevia (*Stevia rebaudiana* Bertoni). Stevia is a perennial herbaceous shrub from the *Asteraceae* family introduced in Croatia only few years ago. The fresh leaves have a sweet taste, due to glycosides that are more than 300 times sweeter than sugar. Foliar fertilization was made with highly concentrated nitrogen fertilizer - urea (46% N) in concentrations: 0% (control), 0,2%, 0,4% and 0,8%. Analysis of stevia leaves show highest value of glycosides in plants that were not applicated with urea fertilizer.

Key words: stevia (*Stevia rebaudiana* Bertoni), glycoside, urea, nitrogen

### Uvod

Stevija je višegodišnji zeljasti grm iz porodice glavočika (*Asteraceae*) podrijetlom iz Paragvaja. Budući da je u svom prvotnom staništu rasla kao samonikli, divlji grm, koristili su je i Indijanci (prije više od 1500 godina) koji su njome liječili rane, povišeni krvni tlak i šećernu bolest. Danas se stevija komercijalno uzgaja u Brazilu, Urugvaju, Izrealu, Australiji, Japanu i u mnogim drugim zemljama gdje je prepoznata kao "šećer novog doba". U Hrvatskoj se stevija počela pokusno uzgajati 2006. godine s tendencijom komercijalnog uzgoja (Novak B., 2007). Stevija je termofilna biljka koja se uspješno uzgaja na tlima slabo kisele do neutralne

reakcije. U ljudskoj prehrani najčešće se koristi lišće koje je slatkog okusa ali ne sadrži šećer i nema kalorija. Osušeno lišće stevije je 30 - 40 puta slađe od šećera, dok je ekstrakt slađi i do 300 puta. Slatkasti okus lišća stevije uzrokuju glikozidi koji su termostabilni i ne razgrađuju se u ljudskom organizmu. Najvažniji glikozidi su dominantni steviozid i nekoliko tipova rebaudiozida čija je relativna slatkoća prikazana u Tablici 1. (Kennelly, E.J., 2002).

Tablica 1. Relativna slatkoća i koncentracija pojedinih glikozida u lišću stevije (Kennelly, E.J., 2002.)

Glikozidi	Relativna slatkoća (saharoza = 1)	Koncentracija glikozida u lišću stevije (%)
Steviozid	150 - 300	4 - 14
Rebaudiozid A	250 - 450	2 - 4
Dulkozid A	50 - 120	0,4 - 0,7
Steviolbiozid	100 - 125	< 0,4

Suha tvar stevije sadrži 1,4% N, 0,3% P i 2,4% K. Kod prinosa od 7500 kg ha<sup>-1</sup>, na korijen otpada 26%, na stabljiku 35%, a na lišće čak 39% ukupne mase (Mau Tulasi, 2006). Ovisno o klimatskim uvjetima i broju žetvi prinos suhog lista može se kretati od 1500-2000 kg ha<sup>-1</sup> godišnje. Sukladno željama proizvođača da ostvare što veći prinos sa što kvalitetnijim proizvodom (lišće), nužno je provesti detaljna istraživanja o utjecaju gnojidbe na sadržaj glikozida. Budući da biljka brzo i lako usvaja dušik, potrebno je istražiti koje su optimalne količine dušika koje pozitivno utječe na razinu glikozida (steviozida i steviola) u lišću. Zahvaljujući opsežnim i temeljitim istraživanjima moguće je proizvesti zdravstveno ispravnu sirovinu pogodnu za svakodnevnu upotrebu. Prema posljednjim podacima Svjetska organizacija za aditive u hrani (JECFA) odredila je 4 mg steviola/ kg tjelesne mase kao prihvatljivi dnevni unos (ADI) steviola (Maria, H.L., 2010).

## Materijal i metode

U svrhu određivanja količina i vrsta glikozida u steviji (*Stevia rebaudiana* Bertoni) provedeno je istraživanje na pokušalištu Agronomskog fakulteta u Zagrebu. Istraživanje je provedeno u vremenu od 24. svibnja do 2. rujna 2010. godine. Presadnice stevije uzgojene su u stakleniku u pojedinačnim vegetacijskim lončićima visine i promjera 10 cm. Presadnice stare 8 tjedana ručno su presađene na gredice u sklopu pokušališta. Pokus je postavljen po slučajnom bloknom rasporedu s 4 varijante u 4 ponavljanja, gdje pojedine varijante predstavljaju različite koncentracije visokokonzentriranog dušičnog gnojiva - UREE (46% N). Tijekom trajanja pokusa provedene su dvije folijarne prihrane (14. lipnja i 5. srpnja 2010. godine) čija je primjena bila u jutarnjim satima, prije pojave jakog sunca.

Varijante pokusa su:

- I. varijanta- kontrola (bez folijarne prihrane)
- II. varijanta - 0,2% -tna. konc.UREE
- III. varijanta - 0,4% - tna. konc. UREE
- IV. varijanta - 0,8% - tna. konc. UREE

Provedena su dva uzorkovanja lišća stevije, od kojih je prvo izvršeno 12. srpnja 2010., u fazi intenzivnog formiranja lisne mase (sredina vegetacije) a drugo neposredno prije same berbe (2. rujna 2010). Analiza lišća na količinu glikozida provedena je u Laboratoriju za fizičku kemiju tragova na Institutu "Ruđer Bošković" u Zagrebu. Sadržaj glikozida - steviozida i steviola u biljnom materijalu (list) određen je pomoću voltometrijske tehnike - polarografije. Sadržaj ukupnog dušika u tlu određen je metodom po Kjeldahl-u, dok je sadržaj fosfora određen spektrofotometrijski, a kalija plamenfotometrijski (ekstrakcijom tla AL- otopinom). Rezultati kemijskih svojstava tla na kojem je postavljen pokus prikazani su u tablici 2.

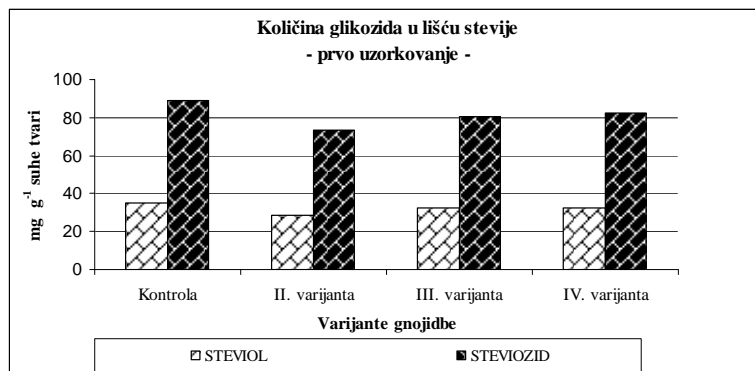
Tablica 2. Kemijska svojstva tla

	pH (H <sub>2</sub> O)	pH (1M KCl)	Humus (%)	N (%)	P <sub>2</sub> O <sub>5</sub> (mg 100 g <sup>-1</sup> tla)	K <sub>2</sub> O (mg 100 g <sup>-1</sup> tla)
Pokušalište Agronomskog fakulteta	8,00	7,05	2,72	0,14	22,52	16,20

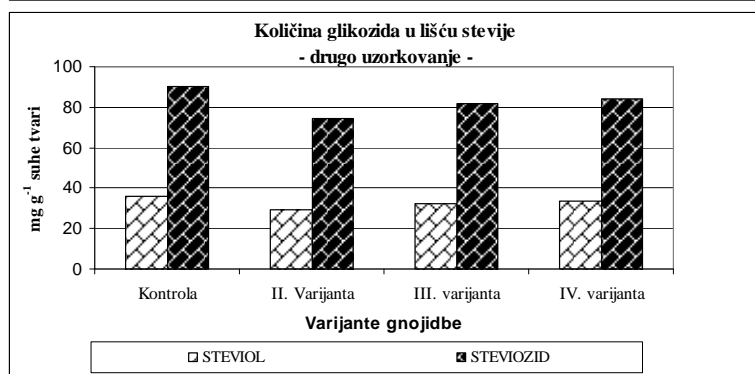
Iz rezultata kemijskih analiza razvidno je da se radi o tlu neutralne reakcije, slabo humoznom i umjereno opskrbljenom ukupnim dušikom, fiziološki aktivnim fosforom i kalijem.

### Rezultati i rasprava

Količine glikozida utvrđene u lišću stevije prikazane su u grafikonima 1 i 2.



Grafikon 1. Količina glikozida (mg g<sup>-1</sup> suhe tvari) u prvom uzorkovanju



Grafikon 2. Količina glikozida (mg g<sup>-1</sup> suhe tvari) u drugom uzorkovanju

Iz grafikona 1 i 2. razvidno je da su najveće količine glikozida, u oba uzorkovanja utvrđene na kontrolnoj varijanti, a najmanje na varijanti tretiranoj sa 0,2%-tnom koncentracijom UREE. Najveće količine steviola 35,68 mg g<sup>-1</sup> i steviozida 90,18 mg g<sup>-1</sup> suhe tvari, utvrđene su u prvom uzorkovanju, na kontrolnoj varijanti. Lagan trend porasta razine glikozida uočava se s porastom koncentracija primjenjene uree. Dobiveni rezultati u skladu su s rezultatima istraživanjima koja su dokazala kako visoka primjena dušičnih gnojiva može znatno utjecati na sadržaj glikozida koji predstavljaju kvalitativnu komponentu uzgoja stevije (Chalapathi i sur., 1997). Do sličnih rezultata došli su Das K. i sur. (2006) koji su utvrdili da biljka stevije povećava sadržaj N, P i K samo u prvih 45 dana, nakon čega dolazi do opadanja vrijednosti bez obzira na količinu primjenjenog dušika. Prema Chalapathi i sur. (1997) najpovoljniji postotak suhe tvari postiže se gnojidbom s 60 kg N ha<sup>-1</sup>, 30 kg P ha<sup>-1</sup> i 45 kg K ha<sup>-1</sup>. Brazilski znanstvenik Utumi M.M. (1999) otkrio je kako smanjena koncentracija Ca, K i S može znatno utjecati na sadržaj steviozida u lišću stevije, te samim time i na kvalitetu konačnog proizvoda. Važno je spomenuti da oko 70% svih usvojenih kationa i aniona otpada na nitratni i amonijski ion, a ta činjenica značajno utječe na omjer svih drugih kationa i aniona. Prema tome, prilikom gnojidbe stevije potrebno je uzeti sve elemente u obzir, te na taj način isključiti negativne posljedice koje mogu nastati zbog primjene previsoke doze dušičnih gnojiva. Vrijednosti steviola i steviozida ne razlikuju se značajno između dva termina uzorkovanja. Zahvaljujući ovom podatku može se planirati nekoliko vremenski odvojenih berbi, koje rezultiraju većom količinom ubranog lišća, čija kvalitativna vrijednost odgovara standardima. Pokusi poput ovog provedenog u Zagrebu učestali su u Indiji, koja je prepoznala stevijiu kao "šećer novog doba". Dvogodišnjim istraživanjima provedenim u Indiji - Ludhiana (Zahida, R., 2009), utvrđene su veće količine glikozida u lišću stevije gnojene ureom (60 kg ha<sup>-1</sup>) u odnosu na gnojidbu organskim gnojivom (45 t ha<sup>-1</sup>). Stoga je nužno provesti detaljna istraživanja koja će u većoj mjeri rasvijetliti povezanost dušika sa količinom i vrstama glikozida u lišću stevije.

## Zaključak

Na temelju provedenih istraživanja može se zaključiti da je folijarna ishrana ureom utjecala na sadržaj glikozida u lišću stevije. Količina steviola i steviozida rasla je s porastom koncentracije uree, premda su najveće količine glikozida utvrđene u kontrolnoj varijanti.

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# Irrigation conditions (soil water balance) in highland and mountainous areas

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## Abstract

Estimation of rational irrigation regime is basic problem in irrigation systems planning. Different calculation methods for actual and potential evapotranspiration are used for those purpose. All of them are based on climatic factors. This paper evaluates the soil water balance in the region of Fruška gora during a number of seasons. There is an example for water balance calculation of vertical parameters of over unsaturated zone at the meteorological stations (MS) Gladnoš and Sremska Mitrovica area.

Key words: precipitation, evapotranspiration, irrigation soil

## Introduction

An analysis of crop water requirement depends on the value of potential evapotranspiration (PET). Evapotranspiration refers to the amount of water utilized by the plant for optimal growth, which suggests that optimal soil moisture which varied depending on the precipitation regime, crops etc., should be maintained under irrigated conditions. Climate conditions and soil water relationships as well as their variable and complex interactions are factors that define successful crop production (Šimunić et al., 2008). The soil water deficiency in the area covered by the M. S. Vršac occurs during July - October at 340 mm (Stojiljković et al., 2001). An annual water deficiency in the soils of Čačak has been forecast to be 285 mm every 10 years, 235 mm every 5 years and 143 mm every 2 years (Šekularac et al., 1996). The seasonal analysis of soil water balance in the region Čačak (Western Serbia) during 20-year period (Šekularac et al., 2009). The total deficiency of water required for plant during the growing season was 185 mm. The total amount of water lost by evapotranspiration during the growing season under the agro environmental conditions of Vojvodina is higher than the total amount of precipitation in Vojvodina. This indicates the fact that the water inflow from precipitation, included irrigation, cannot satisfy the water requirement of maize in this area (Rajić, 2003). The soil water deficiency in one part of southern Italy occurs between May- October, as calculated by the Thornthwaite and Mather method used (Marsico et al., 2007).

The value of PET was estimated by an empirical method, where the soil water balance was based on the regional relation ship between PET and climate. PET as an element of water balance, among the other elements, is used to define soil water deficiency/ surplus in particular region theirs annual, seasonal, monthly and daily fluctuations in PET value. Throughout the year, the values of climate elements are also variable, inducing variability in PET values and, hence, in the soil water content. The hydro balance, providing information on water deficiency and the time of its occurrence, as well as a basis for an irrigation system, is presented in this study for the region of Fruška gora, a part of Northern Serbia.

## Material and methods

PET was calculated following the method described by THORNTHWAITE. The aeration zone index (vertical balance parameters) was determined, coupled with the proportion of monthly evapotranspiration after Thornthwaite method, for the period of thirty years. The study includes an analysis of precipitation (P), readily available soil water reserves (RAWR) and PET. The readily available water reserve of 100 mm was

added calculation. The assumption accordingly was that the soil contains 100 mm of water reserves in the rhizosphere zone and that it is, completely saturated (Dragović, 2000). The obtained data on the amount of precipitation for the region of Fruška gora (MS of Sremska Mitrovica and Gladnoš) were used in the calculation.

Water balance was calculated for the most common soil types in the region of Fruška gora including alluvial soils, pseudogley and loess.

### Results and discussion

**MS GLADNOŠ:** The mean annual precipitation across season was 153 mm during spring, 200 mm during summer, 144 mm during autumn and 145 mm during winter, giving the sum of 642 mm. The analysis of the long-term period indicates that June (84 mm), as shown in Table 1. The precipitation sum during the growing season was 361 mm.

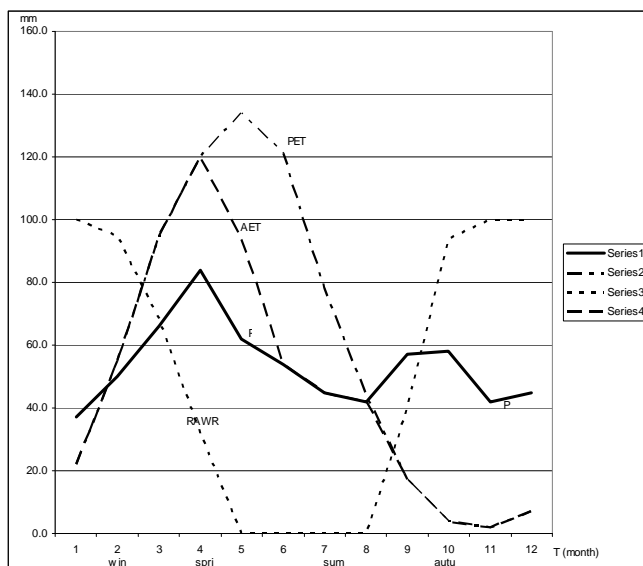
The mean annual value of PET was 699 mm, 172 mm during spring, 375 mm during summer, 139 mm during autumn and 13 mm during winter. The PET value during the growing season was 603 mm.

The plant water requirements (PET) were highest in July (134 mm), in August the plants needed 121 mm of water for their growth and development (PET), the average PET value during June was 120 mm (Table 1).

**Table 1. Average monthly sums of precipitation (P), mean monthly values of PET, mean readily available water reserves in the soil (RAWR), actual evapotranspiration (AET)**

date	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	Sum of years
MSGladnoš													
P	37.0	50.0	66.0	84.0	62.0	54.0	45.0	42.0	57.0	58.0	42.0	45.0	642.0
PET	22	55.0	95.0	120.0	134.0	121.0	78.0	44.0	17.0	4.0	2.0	7.0	699.0
RAVR	100	95.0	68.0	32.0	0.0	0.0	0.0	0.0	40.0	94.0	100.0	100.0	629.0
AET	22	55.0	95.0	120.0	94.0	54.0	45.0	42.0	17.0	4.0	2.0	7.0	557.0
MS Sremska Mitrovica													
P	39.0	50.0	57.0	82.0	65.0	50.0	42.0	42.0	54.0	48.0	38.0	36.0	603.0
PET	23	56.0	99.0	121.0	134.0	120.0	79.0	45.0	16.0	4.0	1.0	6.0	704.0
RAVR	100	94.0	52.0	13.0	0.0	0.0	0.0	0.0	38.0	44.0	100.0	100.0	541.0
AET	23	56.0	99.0	121.0	78.0	50.0	42.0	42.0	16.0	4.0	1.0	6.0	538.0

The analysis of the soil water balance in the Fruška gora region revealed that the readily available water reserves (RAWR) could be completely consumed during May-October. The soil had lowest water supply during summer (32 mm) and autumn (40 mm). During spring and winter, readily available soil water reserves were 263 mm and 294 mm, respectively. During



**Figure 1. Average monthly sums of precipitation P (series 1), mean monthly values of PET (series 2), mean readily available water reserves in the soil RAWR (series 3), actual evapotranspiration AET (series 4) in MS Gladnoš**



The growing season, in the MS Gladnoš, plants had an average supply of 195 mm of readily available soil water, which is 31% of the annual amount of readily available water, the average value is 629 mm. The lowest soil water supply was during June, July, August and September.

The sum of mean annual actual evapotranspiration (AET) in the region was 557 mm. The estimated AET during spring, summer, autumn and winter was 172 mm, 268 mm, 104 mm and 13 mm, respectively. The value during the growing season was 463 mm (90% of the average sum of annual AET value). During the growing season, AET was highest in June 120 mm, followed by May 95 mm and July 94 mm.

The soil water deficiency in MS Gladnoš was most pronounced during summer 107 mm.

**MS Sremska Mitrovica:** The mean annual precipitation across season was 146 mm during spring, 197 mm during summer, 138 mm during autumn and 122 mm during winter, giving the sum of 603 mm. The analysis of the long-term period indicates that June (82 mm), as it has been showed in Table 1. The precipitation sum during the growing season was 346 mm.

The mean annual value of PET was 704 mm, 178 mm during spring, 375 mm during summer, 140 mm during autumn and 11 mm during winter. The PET value during the growing season was 609 mm.

The plant water requirements (PET) were highest in July (134 mm), in August the plants needed 120 mm of water for their growth and development (PET), the average PET value during June was 121 mm (Table 1).

The analysis of the soil water balance in the Fruška gora region revealed that the readily available water reserves (RAWR) could be completely consumed during May-October. The soil had lowest water supply during summer (13 mm) and autumn (34 mm). During spring and winter, readily available soil water reserves were 246 mm and 244 mm, respectively. During the growing season, in the MS Sremska Mitrovica, plants where having an average supply of 159 mm of readily available soil water, which is 29% of the annual amount of readily available water, the average value is 541 mm. The lowest soil water supply was during June, July, August and September.

The sum of mean annual actual evapotranspiration (AET) in the region was 538 mm. The estimated AET during spring, summer, autumn and winter was 174 mm, 249 mm, 100 mm and 11 mm, respectively. The value during the growing season was 446 mm (32% of the average sum of annual AET value). During the growing season, AET was highest in June 121 mm, followed by May 99 mm and July 78 mm.

The soil water deficiency in MS Sremska Mitrovica was most pronounced during summer 126 mm. It was found to be 40 mm during autumn and 0 mm during spring and winter. The highest deficiency was recorded in August 70 mm, July 56 mm, followed by September 39 mm.

### Conclusions

The results of this analysis shows that the soil of the area of study does not have a sufficient supply of water during the growing season under the regional climate conditions, particularly during summer and autumn. Given results are supporting the use of irrigation practice as supplementary character in plant production.

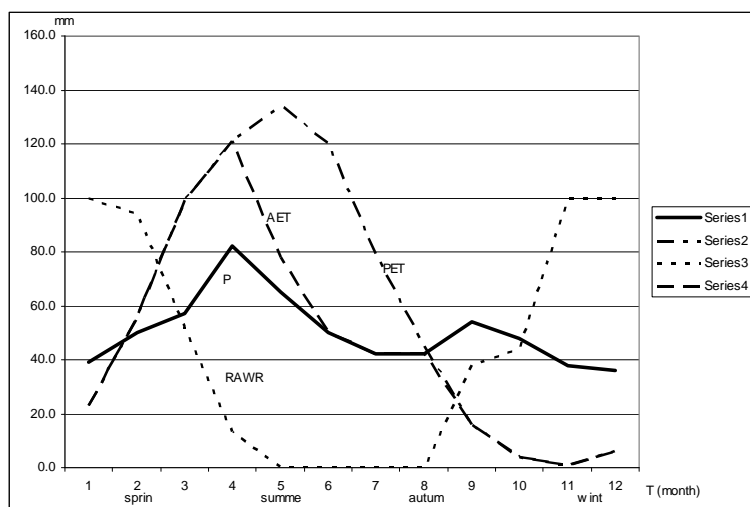


Figure 2. Average monthly sums of precipitation P (series 1), mean monthly values of PET (series 2), mean readily available water reserves in the soil RAWR (series 3), actual evapotranspiration AET (series 4) in MS Sremska Mitrovica

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# Trend smanjenja štetnih sastojaka u duhanskom dimu suvremenih cigareta

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## Sažetak

Sukladno pozitivnim spoznajama o duhanskom dimu, i sve strožih zakonskih propisa o upotrebi duhanu, proizvođači duhanskih proizvoda kontinuirano smanjuju koncentraciju štetnih sastojaka u duhanskom dimu. Osim pažljivog odabira duhanske mješavine sa nižim udjelom nikotina, smanjenje je moguće postići i uporabom različitih neduhanskih sirovina u proizvodnji. Rezultati analize duhanskog dima cigareta pokazali su da je smanjenje koncentracije nikotina oko 73%, i tara (katrana) za 84%, u zadnjih 60 godina, a od nedavno se prati i udio ugljikovog monoksida. Smanjenje se može postići primjenom cigaretnih papira veće poroznosti, kao i primjenom posebnih filtara.

Ključne riječi: Nikotin, tar, ugljikov monoksid, filtar, cigaretni papir

## Trends of decreasing a level of toxic substance in tobacco smoke of modern cigarettes

### Abstract

According to positive knowledge on tobacco smoke, and restrictions in tobacco law, tobacco companies are continuously decreasing content of toxic substances in cigarettes smoke. Besides blended tobacco, reduction of toxic substances could be made, by using different non-tobacco materials during production process. Results had shown that decrease in nicotine is about 73%, tar about 84% in last 60 years, and recently, carbon monoxide content is decreasing in tobacco smoke. Decreasing could be reached by using more porous cigarette paper as much as by using filters that dilute main stream of tobacco smoke.

Key words: Nicotine, tar, monoxide, filter, cigarette paper.

### Uvod

Proučavan je trend smanjenja koncentracije nikotina i katrana (tara) u cigaretama, tijekom zadnjih 60 godina, prema statističkim podacima iz literature, kao i prema vlastitim mjerenjima zadnjih desetljeća. U novije vrijeme uz ova dva navedena parametra, posebno se prati i koncentracija ugljik monoksida, te se prema evropskim normama, sva tri parametra moraju deklarirati na svakoj kutiji cigareta. Ako se prati koncentracija nikotina od 1950. godine kada je prosječno iznosila 1,9 mg/cigareti do 2010. godine, kada je koncentracija pala ispod 0,5 mg/cigareti. Jednako značajno u i istom vremenskom razdoblju, smanjivala se i količina katrana u cigaretama sa 38 mg/cigareti, na 6 mg/cigareti.

**Tablica 1. Smanjenje koncentracije štetnih sastojaka u duhanskome dimu u razdoblju od 1950. do 2010. godine**

Godina	Tar (mg/cig.)	Nikotin (mg/cig.)	Tar u odnosu na 1950. god. (%)	Nikotin u odnosu na 1950. god. (%)
1950	38	1,9	100	100
1960	28	1,7	73,684	89,474
1965	22	1,5	57,895	78,947
1970	20	1,4	52,632	73,684
1975	18	1,2	47,368	63,158
1980	15	1	39,474	52,632
1985	13	0,9	34,211	47,368
1990	12	0,8	31,579	42,105
1995	11	0,8	28,947	42,105
2000	10	0,7	26,316	36,842
2005	7	0,7	18,421	36,842
2010	6	0,5	15,789	26,315

### Materijal i metode

Smanjenje koncentracije navedenih sastojaka u duhanskom dimu može se postići pomnim odabirom duhanskih, ali i neduhanskih sirovina, što svakako uključuju i izbor različitih cigaretnih papira, filtara i slično.

Cigaretni papiri mogu utjecati na koncentraciju pojedinih sastojaka u dimu uslijed veće u poroznosti, a što olakšava pristup zraka i oksidacijske procese pri pirolizi, o čemu zavisi i sagorijevanje. Povećana poroznost doprinosi povećanju difuzijskog koeficijenta ugljikovoga monoksida kao i drugih lakih plinova, čime veći dio tih plinova odlazi izvan duhanskog dijela cigarete. Isto tako pri djelotvornijem filtriranju čestica aerosola, smanjuje se temperatura gorenja čime se djelomično mijenja tijekom kemijskih reakcija pri izgaranju, te smanjenju sadržaja tara i nikotina u dimu te bržem izgaranju. U radu su analizirani uzorci načinjeni uz uporabu cigaretnoga papira različite poroznosti, analizirano je 10 uzoraka grupiranih po različitoj poroznosti cigaretnoga papira Tablica 2, a u Tablici 3, različiti uzorci filtara. Svi uzorci su obrađeni na stroju za pušenje firme Heinrich Borgwaldt, standardnim metodama.

### Rezultati i rasprava

C11, C12, C13, C14 - uzorci sa standardnim cigaretnim papirom

C21, C22, C23 - uzorci s cigaretnim papirom povećane poroznosti

C31, C32, C33 - uzorci s cigaretnim papirom vrlo velike poroznosti

**Tablica 2. Utjecaj poroznosti cigaretnoga papira na sastav duhanskoga dima**

Uzorak	Broj uvlačenja	Stupanj izgaranja	Nikotin (mg/cig)	Tar (mg/cig)	CO (mg/cig)	Nikotin/ Tar	CO/ Br. uvlačenja
C11	9,21	426	1,12	15,38	17,96	0,0728	1,9501
C12	8,92	422	1,06	15,87	17,59	0,0668	1,9720
C13	8,73	431	1,08	15,67	17,68	0,0689	2,0252
C14	8,93	429	1,03	15,93	17,31	0,0647	1,9384
Prosjeak	8,95	427	1,07	15,71	17,63	0,0683	1,9714
C21	8,63	420	0,95	14,85	16,11	0,0640	1,8667
C22	8,51	417	0,97	14,27	15,87	0,0680	1,8649
C23	8,48	419	0,91	13,98	15,84	0,0651	1,8679
Prosjeak	8,54	418,7	0,94	14,37	15,94	0,0657	1,8665
C31	8,46	394	0,96	12,45	14,92	0,0772	1,7636
C32	8,43	397	0,83	12,39	14,48	0,0670	1,7177
C33	8,49	399	0,87	12,32	14,62	0,0706	1,7220
Prosjeak	8,46	396,7	0,89	12,39	14,67	0,0716	1,7344

## Trend smanjenja štetnih sastojaka u duhanskom dimu suvremenih cigareta

Iz analize rezultata Tablica 2, vidljiv je blagi pad koncentracije nikotina u uzorcima zavisno o poroznosti cigaretnoga papira: s prosječnih 1,0725 mg/cig u uzorcima sa standardnim cigaretnim papirom, na 0,9433 mg/cig u uzorcima s cigaretnim papirom povećane poroznosti, odnosno 0,8867 mg/cig u uzorcima s cigaretnim papirom vrlo velike poroznosti. Na isti način zamijećen je i pad koncentracije tara s 15,7125 mg/cig u uzorcima sa standardnim cigaretnim papirom na prosječno 14,3667 mg/cig u uzorcima s cigaretnim papirom povećane poroznosti odnosno prosječno 12,3867 mg/cig u uzorcima s cigaretnim papirom vrlo velike poroznosti te pad koncentracije ugljikovoga monoksida s prosječnih 17,635 mg/cig u uzorcima sa standardnim cigaretnim papirom na prosječno 15,940 mg/cig u uzorcima s cigaretnim papirom povećane poroznosti odnosno prosječno 14,673 mg/cig u uzorcima s cigaretnim papirom vrlo velike poroznosti.

Filtar štapići mogu utjecati na udio pojedinih komponenti u duhanskome dimu, zavisno o njihovim karakteristikama. Pri tome treba uzeti u obzir razne parametre kao npr. otpor pri uvlačenju odnosno propusnost, te različite stupnjeve retencije nikotina, dimnog kondenzata kao i perforiranost ovojnog papira cigarete. U radu su analizirani uzorci (Tablica 3) načinjeni uz uporabu filtera različite propusnosti, a analizom rezultata vidljiv je značajan pad koncentracije nikotina u uzorcima zavisno o propusnosti filtera: s prosječnih 8,7533 mg/cig u uzorcima sa standardnim filterom, na 7,5267 mg/cig u uzorcima s filterom koji razrjeđuje glavnu struju dima 25% vol., odnosno 3,9075 mg/cig u uzorcima s filterom koji razrjeđuje glavnu struju dima 50% vol.. Zamijećen je i pad koncentracije tara s 9,2767 mg/cig u uzorcima sa standardnim filterom na prosječno 7,3467 mg/cig u uzorcima s filterom koji razrjeđuje glavnu struju dima 25% vol., dok sa filterom koji razrjeđuje glavnu struju dima 50% vol., nije zamijećeno značajno smanjenje koncentracije tara.

F1, F2, F3 - uzorci sa standardnim filterom

F11, F12, F13 - uzorci s filterom koji razrjeđuje glavnu struju dima 25% vol.

F21, F22, F23, F24 - uzorci s s filterom koji razrjeđuje glavnu struju dima 50% vol.

Tablica 3. Utjecaj propusnosti filtera na sastav duhanskoga dima

Uzorak	Broj uvlačenja	Stupanj izgaranja	Nikotin (mg/cig)	Tar (mg/cig)	CO (mg/cig)	Nikotin/Tar	CO/Br. uvlačenja
F1	8,12	0,69	8,79	9,25	0,0785	1,1392	8,12
F2	8,14	0,65	8,64	9,31	0,0752	1,1437	8,14
F3	8,09	0,62	8,83	9,27	0,0702	1,1459	8,09
Prosjek	8,12	0,65	8,75	9,28	0,0746	1,1429	8,12
F11	7,59	0,58	7,91	7,33	0,0733	0,9657	7,59
F12	7,44	0,56	7,29	7,40	0,0768	0,9946	7,44
F13	7,36	0,53	7,38	7,31	0,0718	0,9932	7,36
Prosjek	7,46	0,57	7,53	7,35	0,0739	0,9845	7,46
F21	7,05	0,29	3,92	7,45	0,0740	1,0567	7,05
F22	7,10	0,21	3,87	7,41	0,0543	1,0437	7,10
F23	7,03	0,26	3,93	7,39	0,0662	1,0512	7,03
F24	7,17	0,27	3,91	7,34	0,0691	1,0237	7,17
Prosjek	7,09	0,26	3,91	7,35	0,0659	1,0438	7,09

Iz rezultata proizlazi da se koncentracija ugljikovoga monoksida smanjila sa prosječnih 0,07463 mg/cig u uzorcima sa standardnim filterom na prosječno 0,07397 mg/cig u uzorcima s filterom koji razrjeđuje glavnu struju dima 25% vol. odnosno prosječno 0,0659 mg/cig u uzorcima u uzorcima s filterom koji razrjeđuje glavnu struju dima 50% vol.

### Zaključci

Iz dobivenih rezultata istraživanja na posebno pripremljenim uzorcima cigareta različitih poroznosti cigaretnog papira, kao i različitih karakteristika filtera, te mogućnost odabira duhanske sirovine točno definiranog kemijskog sastava, može se utjecati na smanjenje udjela nikotina, tara i ugljik monoksida u dimu cigarete. Statistički podaci u zadnjih 60 godina ukazuju da je trend smanjenja nikotina, tara (katrana) i

ugljkovog monoksida u dimu cigareta značajan. Uspoređujući podatke iz 1950. godine sa današnjim iz 2010. godine, smanjenje udjela nikotina iznosi oko 73%, tara oko 84%, dok se udio ugljik monoksida prati tek u novije vrijeme i njegov udio je također u opadanju.

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# Application of multi-faceted efficiency analysis on dairy farms

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## Abstract

In Hungary, dairy sector is in a long-term critical period; therefore, it is vital for farm managers to harness the reserves in farming effectively. From side of inputs, mostly the prices of feed and animal health products, and as for outputs the fluctuation of end-product prices influence the profitability of this enterprise.

In this research the multi-faceted efficiency analysis of nine Hungarian dairy farms was made. The chosen method was the output-oriented Data Envelopment Analysis (DEA), because it makes possible to manage multiple decision problems simultaneously. After solving the model, it can be determined why either of the farms is not efficient by use of shadow prices.

Key words: deterministic DEA, efficiency, dairy enterprise, risk

## Introduction

The cattle stock of the world has been showing a decreasing tendency year by year; according to FAO data in 2008 1.35 billion heads were registered. The cattle stock of the European Union followed a slightly downward trend. According to the data of EUROSTAT 88 million components were registered in 2008. Within the EU members, the cattle stock is the largest in France (19 million heads), this is followed by Germany with around 13 million heads, than the United Kingdom with the stock of 9.9 million components. The above-mentioned three countries give the half of the European Union's cattle stock. The next group is composed by Ireland, Spain, Italy, Poland, Denmark and the Netherlands. The cattle stock of these countries is around 5 million heads. Hungary's stock is going at around 700 thousand components and thus belongs to the group of Lithuania, Sweden, Portugal, Croatia, Slovakia and Bulgaria.

In Hungary, the agricultural enterprises are partaken by 4 percent from GDP. Within this the bovine sector gives one-fourth of the animal husbandry's GDP. It has the third largest volume after swine and poultry. The cattle stock has decreased by 200 thousand heads in the last 12 years (from 900 thousand to 700 thousand heads). As far as cow stock is concerned, the number of cows has declined by 100 thousand components during 12 years (from 380 thousand to 280 thousand heads). Considering the utilization of the domestic cattle-stock in 2009, 68 percent of it is dairy, 12 percent is for meat production and 20 percent is dual-purpose.

Analysing the milk production per cattle, it can be stated that our country makes a higher than EU-average relative production. If it is analysed by other indices, it is shown that considering the income per one employed, even among the best milk producers' income, it is a little above 60 percent of the farmers' average income in the original member states. It has to do with the low labour efficiency. By the national milk producers the cattle for one employed is 11 (livestock-unit), while in the average of EU-15 this value is more than 26.

According to the declaration of the European Commission, in the average of the last four years the milk fat was 3.67 percent, the milk protein content was 3.26 percent. On the contrary, In Germany the average fat content was 4.15%, in France 4.02%, in Poland it was 3.99%, while the protein content also exceeded the

national average. This makes obviously the attention of Hungarian milk producers to focus on improving the quality parameters of the milk, especially for the fat and protein concentration. For this purpose, the breeding and feeding have to be looked after more carefully. In Hungary, the average number of milking cattle per farms is about 38 heads (Varga, 2010).

The Hungarian dairy farms are behind the Western European farms both in their state of development and in their profitability. Therefore, for the sake of convergence it is worth selecting farms of having the best practice. Comparing the efficient farms to the non-efficient ones, it can be stated which are crucial points to be improved to be more viable on a long term. A suitable method for efficiency analysis is DEA (Data Envelopment Analysis).

### Material and methods

The idea of Data Envelopment Analysis (hereinafter DEA) method is originated by Farrel (1957), who wanted to develop a method that is more suitable for measuring productivity. However, in 1978 Charnes et al. reformed this as a mathematical programming problem. This technique is a relatively new “*data-oriented*” process, which can be applied for measuring the performances of decision making units (DMU’s) producing from several inputs several outputs (Cooper et al. 2004). Recent years the method of DEA has been used in many applications for performance measurement. It has been used for measuring the efficiency of a service’s internal quality (Soteriou-Stavrinides, 2000; Becser, 2008), efficiency measurement of banks (Sherman-Ladino, 1995; Tóth, 1999), of educational (Tibenszkyné 2007) and other public bodies, and also for measuring the efficiency of business parks (Fülöp-Temesi 2000). However, its application in agricultural practice was not significant. The efficiency analysis of animal farms and agricultural production processes can be carried out by simulation methods (Szóke et al. 2009; Kovács-Nagy 2009), however, the quality of available database does not always allow the full mapping of technological processes. In these cases DEA is a more efficient tool.

DEA process has two known approaches: *input-oriented* (cost-oriented) and *output-oriented* (result-oriented). In case of the input-oriented approach it is examined how much and which proportion the inputs should be used to minimize the cost at the same emission level. In the output-oriented approach the partial increase of outputs without changing the quantity of inputs is examined (Farrel 1957; Charnes et al. 1978).

This is complicated by the fact that we must take into consideration at efficiency measurement that not every input benefits in the same way: if one calculates with the intake on the same level one counts with *Constant Return to Scale* (CRS), if not, with *Variable Return to Scale* (VRS) (Cooper et al. 2004).

It is an often arising question on a farm that in the course the operation of enterprise how efficient its units are working. The investment analysts are interested in the efficiency of competing participants within an industrial enterprise. DEA is a linear programming application by which the above-mentioned problems can be solved. In the course of DEA analysis one gets the result that at what efficient level the inputs are transformed into outputs, so it is suitable to find the unit (plant, university, restaurant, etc.) which has the “best-practice” (Albright-Winston 2007). The method of DEA was applied to determine the frontier efficiency by the efficiently operating units (Tofallis 2001; Bunkóczi-Pitlik 1999).

In this DEA model the efficiency of nine dairy farms in the North Great Plain region was examined. For this examination, the output-oriented version of DEA was used. For setting up and solving the model, the farms’ production and financial data (for the business year of 2009) were used. The direct costs, the average number of dairy cows and the number of workers as input factors, and the milk production corrigated for 305 days, from the milk quality data the average milk fat and milk protein content and the revenue as outputs were taken into consideration. The aim of the analysis was to *examine the competitiveness* of the farms, and in case of the inefficient farms to explore the critical factors, and to determine the direction of the occurring further analyses.

The examined farms are different in size, technology and also in their ownership. Two farms are owned privately, and the others operate as a company. The smallest farm has 85 cows on an average, and the largest is the one which owns 970 cows. The farms, having more than 300 cows, are considered as large scale farms in Hungary.

Results and discussion

As the first step of the examination, the analysis of the revenues and costs of farms was made. Only the direct costs of the farms were set into the model, and the overheads were left out. When calculating the revenue, the milk quota and the subsidies were not taken into consideration. By the input and output variables in the DEA model those factors can be determined that decreases the efficiency, by which the non-efficient farms can be made competitive.

For the sake of the easier clarity, in the linear programming model the constraints were marked with points, the variables with stripes and the objective function with grey colour. The gotten maximum output values by solving the LP model are in the DEA efficiency column (Figure 1.). On this basis, it can be stated that considering the given input and output constraints the third, fifth and ninth farms are operating inefficiently, (DEA efficiency value is less than 1), and the others are efficient (DEA efficiency value is equal to 1).

Using the shadow prices of the efficient farms as weights such an input and output average vector can be 'made' that regards to a complex, hypothetic farm. The input and output characteristics of this farm can be compared with the current data of non-efficient farms, so the shortcomings and the factors that worse the efficiency can be explored.

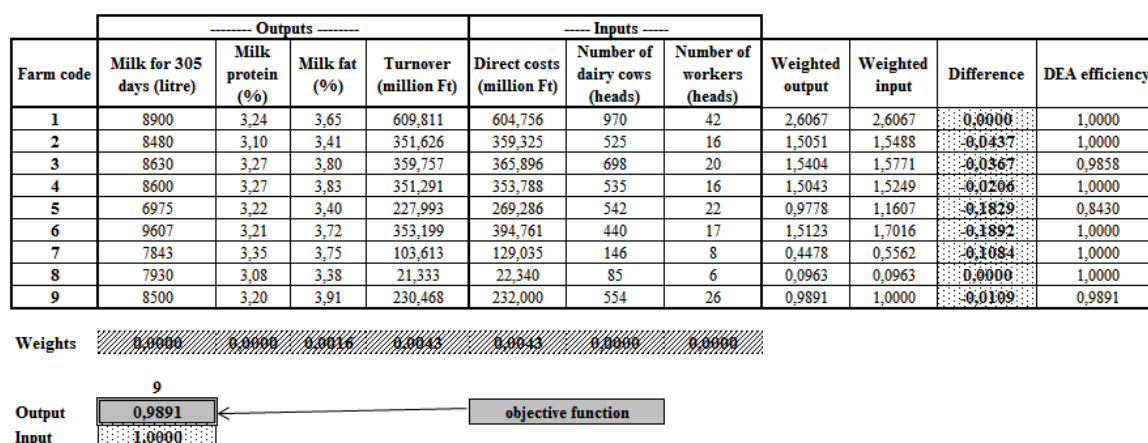


Figure 1. DEA model that is suitable for undertaking efficiency analysis on dairy farms

Source: Own model by using farm data

After this, the data of inefficient farms were compared to the optimal values, which result is summarised in Table 1.

Table 1. Summary table of the non-efficient farms

Farm code	Name	Milk for 305 days (litre)	Milk protein (%)	Milk fat (%)	Turnover (million Ft)	Direct costs (million Ft)	Number of dairy cows (heads)	Number of workers (heads)
3	Original value	8 630	3,27	3,80	359,76	365,90	698	20
	Optimal value	8 720	3,30	3,80	359,76	360,70	563	20
	Difference	90	0,03	0	0	-5,20	-135	0
5	Original value	6 975	3,22	3,40	227,99	269,29	542	22
	Optimal value	8 490	3,22	3,57	227,99	227,01	396	19
	Difference	1 515	0	0,17	0	-42,27	-146	-3
9	Original value	8 500	3,20	3,91	230,47	232,00	554	26
	Optimal value	9 292	3,53	3,91	230,47	229,48	406	19
	Difference	792	0,33	0	0	-2,52	-148	-7

Source: own calculation

The milk production of Farm 3 should be improved by 70 litres, and the average milk protein content is to be increased by 0.03 percent. Surprisingly, this farm would operate in an efficient way if without decreasing the number of workers, the number of cows would be reduced by 135 heads.

In the case of Farm 5, as for the input factors, the number of dairy cows and the variable costs as well, a lack of balance can be seen compared to the values of the composite farm. The number of dairy cows and the

direct costs shall be also cut down. It can be observed that this should be done without reducing the revenue, which presupposes the betterment of milk production and the quantity of milk fat from the quality parameters as well.

At the values of Farm 9, among the output data the quantity of milk production and milk protein must be increased, and beside these, the number of cows and the number of workers should be also decreased by 7 workers.

### Conclusions

The aim of this research was to analyse the efficiency of nine dairy farms in Hungary. According to the results, from nine farms only three were operating in an inefficient way, that is to say, that the efficient six farms' rates of outputs and inputs are 100 percent. This means that without changing the quantity of inputs, the partial increase of outputs is adequate.

The above-described data suggest that there are several significant technological, management or animal health problems on these inefficient farms. Generally speaking, by having used the shadow prices it can be stated that at a constant level of revenue, cost-reduction, yield-growth and quality improvement shall also be reached.

The results of the analysis suggest the need for further examinations. For the sake of production results and the improvement of quality considering the animal health and technological factors the proposal solution can be further fined, shaded.

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# Ekonomika obnove maslinika

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## Sažetak

Cilj rada bio je ocijeniti ekonomsku opravdanost i financijsku izvodljivost ulaganja u obnovu maslinika pri kreditnom financiranju. Na temelju tehnoloških i ekonomskih polazišta izrađen je tehnološko-ekonomski model koji se sastoji od podmodela obnove maslinika i podmodela integrirane proizvodnje. Modelnom kalkulacijom utvrđeni investicijski i proizvodni troškovi i prihodi predstavljaju ulazne parametre za financijski dio analize troškova i koristi. Analiza troškova i koristi pokazuje da je ulaganje u obnovu maslinika ekonomski opravdano i financijski izvodljivo, a vrijednosti temeljnih mjerila poslovne uspješnosti pokazuju da je integrirana proizvodnja maslina u punoj rodosti efikasna, pod pretpostavkom postizanja očekivanog uroda i uspješne prodaje maslinovog ulja.

Ključne riječi: ekonomska učinkovitost, model, obnova, integrirana proizvodnja, maslinarstvo

## Olive-grove regeneration economics

### Abstract

The aim of the paper was to evaluate the economic profitability and financial feasibility of the investment in olive-grove regeneration in case of financing loans. Based on technological and economic starting points, a technological and economic model was prepared, which consisted of olive-grove regeneration submodel and integrated production submodel. Model-calculated investment and production costs and incomes represent input parameters for a part of financial cost-benefit analysis. The cost-benefit analysis shows that the investment in olive-grove regeneration is economically profitable and financially feasible; and the values of economic indicators show that the integrated production of olives in full fertility is efficient, under the assumption of achieving full yield and successful olive oil sale.

Key words: economic efficiency, model, regeneration, integrated production, olive growing

### Uvod

Obnova postojećih starih, zapuštenih i opožarenih maslinika temelji se na vrlo dobroj regenerativnoj sposobnosti masline koja kao bazitona voćka razvija hormone rasta u osnovi, odnosno gukama. Guke su zadebljanja na korijenu ili panju masline, koja služe kao regenerativni organ masline i stvaranje guka je jedna od posebnosti masline koja je razlikuje od drugih drvenastih kultura (Miljković, 1991).

Budući da je vijek rentabilnog plodonošenja maslinika oko 50 godina, u maslinicima koji su stariji od 50 godina trebalo bi provesti obnovu uklanjanjem cijelog nadzemnog dijela (Kovačević i Perica, 1994). Važnost obnove maslinika je u podizanju proizvodnosti i ekonomičnosti proizvodnje (Strikić i sur., 2005).

Transformacija postojećih starih ekstenzivnih maslinika kroz obnovu s nadosadnjom u poluintenzivne maslinike utemeljene na principima integrirane proizvodnje maslina može biti realna opcija za proizvodnu

praksu u RH. Naime, prema procjenama maslinarskih stručnjaka oko 40% hrvatskoga maslinarskog fonda nalazi se u biološkom i proizvodnom stanju koje zahtijeva obnovu. To može biti dobra poslovna strategija za maslinare koji posjeduju takve maslinike. Međutim, njima su potrebne relevantne informacije o ekonomskoj opravdanosti i financijskoj izvodljivosti ulaganja u obnovu maslinika u hrvatskim proizvodnim i gospodarskim uvjetima. U tom kontekstu, cilj rada je ocijeniti ekonomsku opravdanost i financijsku izvodljivost ulaganja u obnovu maslinika pri kreditnom financiranju.

### Materijal i metode

U radu je za potrebe troškovne analize i ocjenu tehnoloških parametara sastavljen deterministički tehnološko-ekonomski model obnove i proizvodnje maslina. Osnovni rezultati modela su kalkulacije investicijskih i proizvodnih troškova koje su nadograđene sa pripadajućim dijelom fiksnih troškova, te izračuni ukupnog prihoda, kreditnih obveza i amortizacije osnovnih sredstava. Ti rezultati predstavljaju ulazne parametre za financijski dio analize troškova i koristi kojom se ocjenjuje ekonomska opravdanost i financijska izvodljivost ulaganja u obnovu maslinika (Olson, 2004; Rozman et al., 2009), kao i za analizu osnovnih mjerila poslovnog uspjeha (Jelavić et al., 1993). Za procjenu proizvodnog i tržišnog rizika cjelokupnog ulaganja korištena je analiza osjetljivosti (Orsag, 2002). Svi izračuni izrađeni su u kompjutorskom tabličnom programu MS Excel 2007.

U radu su kao izvori podataka korišteni normativi utrošaka materijala i rada, empirijski podaci iz proizvodne prakse, tekuće cijene na domaćem tržištu poljoprivrednih inputa i outputa, Program kreditiranja podizanja dugogodišnjih nasada Hrvatske banke za obnovu i razvitak i određeni zakonski propisi RH.

### Rezultati istraživanja i rasprava

Tehnološko-ekonomski model sastoji se od međusobno povezanih podmodela obnove maslinika i podmodela integrirane proizvodnje i predstavlja poluintenzivni način uzgoja masline. U modelu je implementirana integrirana proizvodnja prema odredbama Pravilnika o integriranoj proizvodnji poljoprivrednih proizvoda (NN br. 32/10) i smjericama International Organisation for Biological and Integrated Control (Malavolta i sur., 2002).

Tehnološka i ekonomska polazišta za izradu modela su: proizvodno usmjerenje: proizvodnja maslina za preradu u ulje, način uzgoja: poluintenzivni uzgoj, način pomlađivanja: pomlađivanje cijelog stabla, starost maslinika prije obnove: preko 50 godina, razdoblje obnove maslinika: 3 godine, razdoblje iskorištenja maslinika: 47 godina, početak rodnosti: u četvrtoj godini, puna rodnost: od osme do četrdesetpete godine, sortiment prije obnove: Oblica 100%, sortiment nakon obnove: Oblica 75%, Leccino 15%, Levantinka (ili Pendolino) 10%, površina maslinika: 2 ha, gustoća sklopa prije obnove: 8 m x 7 m, gustoća sklopa poslije obnove: 7 m x 6 m, broj stabala prije obnove: 300, broj stabala nakon obnove: 400, broj stabala predviđenih za pomlađivanje: 300, broj maslina za nadosadnju: 100, sustav navodnjavanja: "kap po kap", izvor vode za navodnjavanje: akumulacija od 1000 m<sup>3</sup>, mehanizacija: unajmljena za iskop akumulacije i jesensku obradu tla, te vlastita (motorna kosa i leđna motorna prskalica), način berbe: ručno, broj članova gospodarstva koji obavljaju poslove u maslinarstvu: 2, broj članova gospodarstva sa punim radnim vremenom na gospodarstvu koji ostvaruju dohodak od maslinarstva: 1, status obiteljskog poljoprivrednog gospodarstva: posluje kao fizička osoba koja je obveznik poreza na dohodak (NN br. 177/04, 73/08 i 80/10) i korisnik poticaja u maslinarstvu (NN br. 83/09, 153/09, 60/10 i 92/10), izvori financiranja ulaganja: 100% kreditna sredstva Hrvatske banke za obnovu i razvitak (ukupno vrijeme trajanja kredita: 12 godina, početak: 3 godine, rok otplate kredita: 9 godina, kamatnjak: 4% godišnje, način vraćanja kredita: u mjesečnim anuitetima), ekonomski vijek trajanja ulaganja: 12 godina.

U modelu je prirod kalkuliran kao produkt priroda po stablu i broja stabala po hektaru, a proizvodnja ulja uz pretpostavljeni 16%-tni randman. Od početka rodnosti u četvrtoj godini prirod se sukcesivno povećava do osme godine, koja je prva godina pune rodnosti, a u godinama pune rodnosti je konstantan. Ulje je kategorizirano kao ekstra djevičansko. Njegova otkupna cijena je 45,00 kn/kg. Ukupni prihod kalkuliran je kao suma prihoda od prodaje proizvedenog maslinovog ulja i prihoda od poticaja. Prihod od prodaje ulja kalkuliran je kao umnožak proizvedene količine ulja i njegove otkupne (prodajne) cijene, uz pretpostavku postizanja očekivanog priroda ploda, randmana ulja i njegove uspješne prodaje (Tablica 1.). Pretpostavljena dinamika priroda odgovara dinamici priroda koja je postignuta u eksperimentalnom obnovljenom masliniku sa sklopom od 150 stabala/ha (Modun, 1975). U godinama pune rodnosti prihod od prodaje ekstra

djevičanskog maslinovog ulja u strukturi ukupnog prihoda participira sa 76,7%, a prihod ostvaren od poticaja sa 23,3%.

**Tablica 1. Dinamika priroda ploda, proizvodnje ulja i ukupnog prihoda**

Proizvodnja i ukupni prihod	Godine				
	4.	5.	6.	7.	8. i daljnje
Urod ploda, kg	1200	3600	7200	9600	12000
Proizvodnja ulja, kg	176	528	1057	1409	1761
Prihod od prodaje, kn	7.926,00	23.779,00	47.559,00	63.412,00	79.266,00
Prihod od poticaja, kn	6.888,00	10.704,00	16.428,00	20.244,00	24.060,00
Ukupni prihod, kn	14.814,00	34.483,00	63.987,00	83.656,00	103.326,00

Investicijski troškovi obnove maslinika obuhvaćaju trogodišnje razdoblje bez rodnosti. Ukupna vrijednost ulaganja u obnovu 2 ha maslinika iznosi 102.314,00 kn (Tablica 2.).

**Tablica 2. Modelna kalkulacija investicijskih troškova obnove 2 ha maslinika -kn**

Vrsta troškova	1. godina	2. godina	3. godina	Sveukupno
	Iznos	Iznos	Iznos	
Sadnice	3.800,00	76,00		3.876,00
Kolci	1.500,00	30,00		1.530,00
Gnojiva	2.290,00	210,00	4.370,00	6.870,00
Sredstva za zaštitu bilja	392,00	448,00	840,00	1.680,00
Gorivo	424,00	424,00	424,00	1.272,00
Ostali materijal	1.612,00	1.772,00	2.192,00	5.576,00
Pomlađivanje	9.000,00			9.000,00
Akumulacija	56.200,00			56.200,00
Sustav za navodnjavanje	12.610,00			12.610,00
Analiza tla	700,00			700,00
Ostali troškovi	1.000,00	1.000,00	1.000,00	3.000,00
Ukupni troškovi	89.528,00	3.960,00	8.826,00	102.314,00

Troškovi podmodela integrirane proizvodnje maslina sukcesivno se povećavaju od 27.010,00 kn u četvrtoj godini do 67.133,00 kn u osmoj godini, koja je prva godina pune rodnosti (Tablica 3.).

Financijski tijek negativan je u četvrtoj i petoj godini ekonomskog vijeka trajanja ulaganja, dok je u ostalim godinama pozitivan. Vrijednost proizvodnje od početnih priroda u četvrtoj i petoj godini nije dostatna za pokriće ukupnih troškova. U ovim godinama investitor treba osigurati nedostajuća novčana sredstva iz drugih izvora.

Na temelju rezultata izrađenog tehnološko-ekonomskog modela, primjenom dinamičkih metoda investicijskog odlučivanja provedena je analiza i dinamička ocjena ekonomske opravdanosti i financijske izvodljivosti ulaganja u obnovu maslinika. Razdoblje povrata ulaganja iznosi osam godina, tj. u osmoj godini ekonomskog vijeka trajanja ulaganja kumulativna vrijednost neto primitaka iz ekonomskog tijeka veća je od vrijednosti investicije. Investicija je po ovoj metodi prihvatljiva za izvedbu jer je razdoblje povrata ulaganja unutar utvrđenog ekonomskog vijeka trajanja ulaganja.

Neto sadašnja vrijednost izračunata na temelju ekonomskog tijeka, uz diskontnu stopu od 7%, iznosi 122.277,00 kn. Budući da je neto sadašnja vrijednost pozitivna, prema ovoj metodi investicija je prihvatljiva za investitora.



Tablica 3. Modelna kalkulacija troškova integrirane proizvodnje maslina

-kn

Vrsta troškova	4. godina	5. godina	6. godina	7. godina	8. godina
	Iznos	Iznos	Iznos	Iznos	Iznos
Gnojiva	210,00	5.620,00	630,00	6.040,00	6.250,00
Sredstva za zaštitu bilja	4.220,00	4.644,00	5.068,00	5.492,00	5.492,00
Gorivo	634,00	704,00	774,00	844,00	984,00
Ostali materijal	4.132,00	3.622,00	3.752,00	3.882,00	5.252,00
Jesenska obrada	716,00	716,00	716,00	716,00	716,00
Transport plodova	218,00	436,00	872,00	1.212,00	1.744,00
Berba				4.200,00	13.200,00
Usluga prerade	1.560,00	4.680,00	9.360,00	12.480,00	15.600,00
Anuitet	13.555,00	13.555,00	13.555,00	13.555,00	13.555,00
Porez na dohodak			806,00	1.766,00	2.575,00
Ostali troškovi	1.765,00	1.415,00	1.415,00	1.415,00	1.765,00
<b>Ukupni troškovi</b>	<b>27.010,00</b>	<b>35.392,00</b>	<b>36.948,00</b>	<b>51.602,00</b>	<b>67.133,00</b>

Interna stopa povrata izračunata na temelju ekonomskog vijeka postupkom interpolacije iznosi 19%. Kako je interna stopa povrata veća od diskontne stope od 7% i po ovoj metodi investicija je prihvatljiva. Vrijednosti dinamičkih metoda investicijskog odlučivanja ukazuju na ekonomsku opravdanost i financijsku izvodljivost ulaganja u obnovu maslinika, pod pretpostavkom postizanja očekivanog uroda i uspješne prodaje maslinovog ulja. Pomoću analize osjetljivosti izolirano je promatran učinak 10% postotne promjene primitaka (10%-tno smanjenje) i izdataka (10%-tno povećanje) na efikasnost ulaganja, zadržavajući druge varijable konstantnima u visini očekivanih veličina. Kod prve varijante smanjenja primitaka za 10% analiza osjetljivosti pokazuje da je neto sadašnja vrijednost 84.198,00 kn, interna stopa povrata 16%, a povrat je u osmoj godini ekonomskog vijeka trajanja ulaganja. U drugoj varijanti povećanja izdataka za 10% analiza osjetljivosti pokazuje da je neto sadašnja vrijednost 92.618,00 kn, interna stopa povrata 16%, a povrat je u osmoj godini ekonomskog vijeka trajanja ulaganja. Prema tome, ulaganje je neznatno osjetljivije na promjene u primicima u odnosu na promjene izdataka i posjeduje zadovoljavajuću sposobnost da podnese pogoršanje proizvodnih i gospodarskih uvjeta. U osmoj godini ekonomskog vijeka trajanja ulaganja financijski rezultat je pozitivan i iznosi 36.192,00 kn, a vrijednosti proizvodnosti rada (65,00 kn/sat), ekonomičnosti (1,54) i rentabilnosti proizvodnje (53,91%) pokazuju da je integrirana proizvodnja maslina u punoj rodosti pod tehnološkim i ekonomskim pretpostavkama modela efikasna. Potrebno je istaknuti da dobiveni rezultati vrijede isključivo pod navedenim pretpostavkama i mogu poslužiti samo kao orijentacija maslinarima u procesu donošenja investicijske odluke i upravljanju maslinarskom proizvodnjom.

### Zaključak

Ukupna vrijednost ulaganja u obnovu 2 ha maslinika iznosi 102.314,00 kn, a potpuno se financira kreditnim sredstvima. Vrijednosti metoda razdoblja povrata ulaganja, neto sadašnje vrijednosti i interne stope povrata ukazuju na ekonomsku opravdanost i financijsku izvodljivost ulaganja u obnovu maslinika i integriranu proizvodnju, pod pretpostavkom postizanja očekivanog uroda i uspješne prodaje maslinovog ulja. Analiza osjetljivosti pokazuje da je ulaganje neznatno osjetljivije na promjene u primicima u odnosu na promjene izdataka i posjeduje zadovoljavajuću sposobnost da podnese pogoršanje proizvodnih i gospodarskih uvjeta. Financijski tijek negativan je u četvrtoj i petoj godini ekonomskog vijeka trajanja ulaganja, dok je u ostalim godinama pozitivan.

U osmoj godini ekonomskog vijeka trajanja ulaganja financijski rezultat je pozitivan i iznosi 36.192,00 kn, a maslinar sam mora procijeniti da li ta naknada za njegov uloženi rad zadovoljava njegova očekivanja. Vrijednosti ekonomskih pokazatelja proizvodnosti rada, ekonomičnosti i rentabilnosti proizvodnje u osmoj

godini ekonomskog vijeka trajanja ulaganja pokazuju da je integrirana proizvodnja maslina efikasna u uvjetima kada se proizvodnja ostvaruje punim kapacitetom i pri otplati preuzetih financijskih obaveza.

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# Sustainable resources management and allocation in agricultural systems: using non-linear mathematical models

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## Abstract

Sustainable agricultural development depends strongly on the socio-economic and bio-ecological attributes and optimal resource utilization as well. The high level of integration of the environmental, economic and social components of farming systems, implies that dynamics of these components need to be taken in to account in evaluation of agricultural sustainability. This paper introduces two ratio objective functions “net return / water consumption” and “labor employment / water consumption” in order to assess the sustainability of a rural farming system by simultaneously optimizing these ratio indicators and subsequently determining the optimal cropping pattern. Aimed to this, a fractional programming (FP) procedure has been employed in two forms of single and multiple objective programming. The results were finally explained and compared with the LP solutions in a quantitative manner.

Key words: sustainable farm management, optimal resources allocation, fractional programming

## Introduction

Inadequacy of one-sided economic emphasis on sustainability, the concept now viewed as a guiding tool in resources allocation and management, encompasses the environmental, economic, and social dimensions of the economy and the environment in which we live (Mittelsteadt et al, 2001). In fact, Sustainability in agricultural production depends on various interdependent aspects that require integrated analytical approaches to address the complexity involved. To analyse the sustainability of agricultural systems, the concept of sustainability has to be made operational and appropriate methods need to be designed for its measurement (Heinen, 1994). The present study was performed with the purpose of assessment the sustainability of cropping pattern and resources allocation in a rural farming system located at the east of Isfshsn, central Iran, named south Baraan with total arable lands of 12000 ha and six main crops including wheat, barley, rice, silage maize, alfalfa and onion. Mathematical programming (MP) has been a widely used tool for studying and analysing agricultural systems in recent decades. Unavoidable properties of MP models such as non-linearity and complexity of decisions, can be dealt with fractional programming (FP). FP is the most common term in MP for referring to programming models in which the objectives are quotients of two functions. So, as the Monteith (1990) discusses, the question for an operational strategy in this approach is not maximizing ‘per se’ but maximizing outputs and minimizing inputs. In the other words, maximizing the desired outputs and minimizing the undesired outputs. In fact, these ideas call for a technically efficient use of resources as a necessary condition of sustainability to achieve the maximum level of output allowed by a level of inputs or to use the minimum levels of inputs to achieve a desired level of output (Lara and Stancu-Minasian, 1999). Efficiency of water consumption is one of the most important and widespread of concern problems of farming systems sustainability. The adequate levels of net return and employment are also the essential economic and social outputs required to ensure the sustainability and maintain the population of a farming system. Although the problem can be formulated in a MCDM context with three objectives,

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maximize the levels of net return and employment and minimize the water consumption, but to treat this situation we can also formulate a problem where we maximize the ratios net return/water consumption and employment/water consumption in a multi-objective fractional programming (MOFP) context. The use of ratios in the formulation of the problem assures that only the solutions with the better achievements per unit of resource would be selected.

### Materials and methods

The mathematical structure of a single objective fractional program can be written as (Goedhart and Spronk, 1995):

$$\text{Max } g = (c^T x + \alpha) / (d^T x + \beta) \quad (1)$$

$$\text{s.t. } x \in S = \{x \in R^n \mid Ax \leq b; x \geq 0; b \in R^m\}$$

The numerator and denominator of the goal fraction are real functions defined on  $R^n$ . The approach is based on a variable change proposed by Charnes and Cooper (1962) for the FP problem and the additional assumption that the denominator  $d^T x + \beta$  is strictly positive. This transformation is:  $t = (1/d^T x + \beta)$  and  $y = x.t$ . With applying the transformation, the original fractional problem can be replaced by an ordinary linear programming format as follows:

$$\text{Max } g = c^T y + \alpha \quad (2)$$

$$\text{s.t. } Ay - bt \leq 0; d^T y + \beta t = 1; y, t \geq 0$$

In this model, if  $(y', t')^T$  is an optimum solution of the transformed linear problem, then  $x' = y'/t'$  is an optimum solution of the original fractional problem (Goedhart and Spronk, 1995). In the cases of multiple fractional objectives, the problem can be formulated as a fractional goal programming (Gómez et al, 2006) as following:

$$\text{Min } \sum_m w_m n_m$$

$$\text{s.t. } x \in S \quad (3)$$

$$\frac{c_m^T x + \alpha_m}{d_m^T x + \beta_m} + n_m - p_m = u_m \quad ; \quad n_m, p_m \geq 0$$

where  $w_m$  is the weight of the  $m$ th goal and  $n_m, p_m$  are the negative and positive deviational variables for the goals. In the case of this study, which all the goals numerators must be maximized, the deviational variables to be minimized are the negative ones.  $u_m$  is the  $m$ th fractional goal desired value which measured by solving of a single objective fractional program for each of the fractional goals. The non-linearity of the equational constraints in problem (3) can be eliminated by multiplying such non-linear constraints by denominators  $d_m^T x + \beta_m$  and the following linear goal problem is obtained:

$$\text{Min } \sum_m w_m n'_m$$

$$\text{s.t. } x \in X_S$$

$$c_m^T x + \alpha_m - (d_m^T x + \beta_m)u_m + n'_m - p'_m = 0 \quad (4)$$

$$n'_m, p'_m \geq 0$$

Problems (3) and (4) are equivalent (Caballero and Hernández, 2006) with the following relationship between their deviational variables.

$$n'_m = n_m (d_m^T x + \beta_m); \quad p'_m = p_m (d_m^T x + \beta_m) \quad (5)$$

The socio-economical needed data were collected via field operations. The irrigation water requirements (IWR) of the crops have also been provided monthly based on the two data bases Farshi et al. (1997) and Alizadeh and Kamali (2007). The groundwater and surface water resources availability have also been calculated monthly with regards to the records of the regional water organization of the Isfahan (RWOI, 2006; RWOI, 2007). Table 1 shows the overall processed data and the structure of the attributes and constraints of the study modeling.

Table 1: Coefficients matrix for attributes and constraints

Goals, attributes and constraints	Activities (main crops of the region)						RHS
	x <sub>1</sub> Wheat	x <sub>2</sub> Barley	x <sub>3</sub> Rice	x <sub>4</sub> Maize	x <sub>5</sub> Alfalfa	x <sub>6</sub> Onion	
Net return (×10 <sup>6</sup> Rs) *	8.74	7.01	18.98	29.96	8.77	19.11	Max.
Employment (man-day)	22.39	19.39	71.1	37.29	84.2	137.3	Max.
Total season duration	48	40.6	151.93	63.24	104.2	60.2	Min.
Water use April (k=1) (×10 <sup>2</sup> m <sup>3</sup> )	13.8	13.8	0	0	9.9	12.9	≤ 97656.78
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
March (k=12)	8.1	8.1	0	0	6.1	7.4	≤ 58863.2
Land use (ha)	1	1	1	1	1	1	≤ 12000
Seasonality (Rotation)	+1	+1	-1	-1	-1	+1	≥ 0
Credit (×10 <sup>6</sup> Rs)	6.06	5.59	23.02	21.04	16.53	35.49	≤ 160000

\*10<sup>6</sup> Rs = 100 USD

### Results and discussion

Several single objective (maximization of ‘net return’, ‘employment’, ‘net return / water use’ and ‘employment / water use’) and multiple-objective (‘net return and employment’ or ‘net return / water use and employment / water use’ simultaneously) models with two linear ( $A_1$ ,  $B_1$  and  $C_1$ ) and fractional ( $A_2$ ,  $B_2$  and  $C_2$ ) scenarios, were formulated with a similar structure of constraints.

Table 2: objective functions formulations for LP and FP scenarios

Linear models	
single objective programming (SOP)	
$A_1$	$Max \ 8.74x_1 + 7.01x_2 + 18.98x_3 + 29.96x_4 + 8.77x_5 + 19.11x_6 (L_1)$
$B_1$	$Max \ 22.39x_1 + 19.39x_2 + 71.1x_3 + 37.29x_4 + 84.2x_5 + 137.3x_6 (L_2)$
multiple-objective programming (MOP)	
$C_1$	Eff. $\{L_1, L_2\}$
Fractional models	
single objective programming (SOP)	
$A_2$	$Max \ \frac{8.74x_1 + 7.01x_2 + 18.98x_3 + 29.96x_4 + 8.77x_5 + 19.11x_6}{48x_1 + 40.6x_2 + 151.93x_3 + 63.24x_4 + 104.2x_5 + 60.2x_6} (F_1)$
$B_2$	$Max \ \frac{22.39x_1 + 19.39x_2 + 71.1x_3 + 37.29x_4 + 84.2x_5 + 137.3x_6}{48x_1 + 40.6x_2 + 151.93x_3 + 63.24x_4 + 104.2x_5 + 60.2x_6} (F_2)$
multiple-objective programming (MOP)	
$C_2$	Eff. $\{F_1, F_2\}$

The set of constraints include 2 land availability constraints (for two winter and spring seasons), 10 monthly water Requirement constraints, seasonality constraint, capital constraint and non-negativity constraints. The detailed objective functions are as Table 2.

By solving these scenarios, several patterns of cropping were obtained. In order to assessing the sustainability of each of these patterns, the ratios of ‘net return / water consumption’ and ‘employment / water consumption’ defined and computed as the sustainability indicators. The area allocated to different crops in each patterns accomplished by the amounts of net return, employment creation, water consumption and above mentioned two sustainability indicators have been calculated and displayed in Table 3. The last two columns show the measured values of the two fractional objectives.

Table 3: Efficient points derived from single and multi-objective fractional and linear models

Efficient points	Activities						Net return	Employment (man-day)	Water use	Net return/ water use	Employment/ water use
	x1	x2	x3	x4	x5	x6					
Current	5000	500	1000	3000	1000	1500	193500	594765	796450	0.243	0.747
A <sub>1</sub>	6546	0	260	4478	0	567	207141	409908	671039	0.308	0.610
B <sub>1</sub>	0	3703	825	1163	3012	1296	127647	605454	741109	0.172	0.817
C <sub>1</sub>	1497	2224	741	1247	3011	1279	130966	604956	744401	0.176	0.812
A <sub>2</sub>	0	4621	0	4407	0	1089	185240	403499	531875	0.348	0.758
B <sub>2</sub>	0	5365	440	2803	0	1380	156310	429310	545006	0.287	0.787
C <sub>2</sub>	0	4434	0	4339	0	1243	184828	418477	529241	0.349	0.790

As the results show, in the individual optimization of the benefit objective, the sustainability indicators of net return / water consumption and employment / water consumption, have been increased by 12.9 and 24.2 percents due to the solving of fractional programming model compared to the linear programming. In the single objective optimization of the employment function and also the multiple objective goal programming context, though the employment / water consumption indicator has been inconsiderably decreased by 3.6 and 2.7 percent, but the other indicator net return / water consumption has been increased by 66.8 and approximately twofold 98.3 percent in the case of fractional programming compared to linear one.

Compared to the current situations (existing cropping pattern: row 2 of Table 3), the simultaneous improvement in both indicators of sustainability has occurred only due to the fractional programming models. In the other words, from the efficiency point of view, none of the points  $A_1$ ,  $B_1$  and  $C_1$  dominates the current situation with regard to the both of sustainability indicators simultaneously (Table 3) and so considered as technically non-efficient points from a sustainability perspective, whereas  $A_2$ ,  $B_2$  and  $C_2$  are all dominant over the current situations. So, although in single and even multiple linear programming frameworks, points such as  $A_1$ ,  $B_1$  and  $C_1$  would be appropriate and eligible solutions, but their sustainability competence is very doubtful, because we can find solutions with a higher contribution to net return and employment creation per unit of water consumption. Such solutions could be sought applying of approaches such as fractional programming procedures. Additionally, in the context of fractional programming,  $C_2$  which corresponds to the goal programming procedure, also dominates, with considering of both sustainability indicators, both  $A_2$  and  $B_2$  which correspond to the single objective programming models.

## Conclusions

Sustainability in agricultural production is a complex issue as it depends on various interdependent aspects. Fractional programming (FP) approach preferred MCDM framework and more suitable to study sustainability problems. When the quantitative management of inputs and outputs of an agricultural system is at the core of concern, ratios is a natural and more comprehensive way of dealing with the issues related with the sustainability of systems. Defining and optimizing of the ratios such as explained and analysed at the pervious sections, elucidates the possibilities of improving the socio-economic aspects of a farming production system by reducing the use of scarce environmental resources. So, the associated environmental impacts of farming activities can be reduced by more efficient use. The approach of this study, based on the optimization of the pattern of cropping, is an attempt to find a solution to improve the sustainability of a farming system at the regional and even farm level. In this way, by identifying the determinants and obstacles of sustainable agricultural development, durability and long lasting development of the system could explicitly be supported and encouraged.

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# Tehnološki činitelji i ekonomski rezultati pri uzgoju šećerne repe

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## Sažetak

U ovom radu istraženi su tehnološki činitelji, ekonomski rezultati i organizacija uzgoja šećerne repe na proizvodnim površinama IPK Klisa d.o.o. Osijek. U 2007. godini šećernom repom zasijano je 251,93 ha. Na temelju izračunatih normi i izrađene tehnološke karte utvrđen je utrošak od 108,81 sati rada po hektaru. Ukupni troškovi iznosili su 12.856,08 kn ha<sup>-1</sup>. Cijena šećerne repe u 2007. g. iznosila je 250 kn t<sup>-1</sup> uz digestiju od 16%. Uz prinos od 47 t ha<sup>-1</sup> i ostvarene državne poticaje ostvarena je dobit od 1.393,92 kn ha<sup>-1</sup> odnosno ukupna dobit od 351.087,229 kn na navedenim površinama. Na temelju koeficijenta ekonomičnosti proizvodnje od 1,108 evidentno je da je proizvodnja šećerne repe ekonomična, a na 100 kn uloženi u proizvodnju ostvareno je 10,84 kn dobiti.

Ključne riječi: šećerna repa, tehnologija, organizacija, ekonomski rezultat, dobit;

## Technological factors and economic results of sugar beet production

### Abstract

This paper presents some technological factors, economic results and organization of sugar beet production on arable land owned by agricultural company IPK Klisa Osijek Ltd. In the year 2007 sugar beet was planted on the area of 251.93 ha. Based on calculated norms and technological plans, it was determined that 108,81 hours of work were needed per hectare. Total production costs amounted to 12856.08 HRK per ha<sup>-1</sup>. The market price of sugar beet in 2007 was 250.00 HRK per t<sup>-1</sup> with 16% digestion. If calculating with sugar beet yield of 47 t per ha<sup>-1</sup> and realized state subsidy, there was a profit of 1393.92 HRK per ha<sup>-1</sup>, or total profit of 351087.23 HRK obtained on total planted area. According to coefficient of production efficiency, which was 1108, it was concluded that production of sugar beet was cost-effective, because a profit of 10.84 HRK was gained per 100.00 HRK invested in production.

Key words: sugar beet, technology, organization, economic results, profit

### Uvod

Šećerna repa u Republici Hrvatskoj sije se na 34.300 ha. Prosječan prinos korijena šećerne repe iznosio je 46,13 t ha<sup>-1</sup>, dok je u Europi šećerna repa u 2007. g. sijana na 1.808.700 ha uz ostvaren prosječan prinos korijena od 61,04 t ha<sup>-1</sup> (Faostat, 2007). U Hrvatskoj se primarno uzgaja zbog šećera, iako ima niz nusproizvoda (Jurišić, 2008). Svaka zemlja nastoji iskoristiti svoje prirodne uvjete da vlastitom proizvodnjom podmiri potrebe stanovništva za šećerom. Slabe proizvodne rezultate pri proizvodnji šećerne repe teško se mogu bilo čime drugim objasniti osim nepravilnim radom i malim ulaganjima (Pospišil, 2008.).



Vrijednost digestije uz prinos korijena diktira otkupnu cijenu koju će šećerane isplatiti poljoprivrednim proizvođačima. Potrošnja šećera u Republici Hrvatskoj je oko 35 kg po stanovniku godišnje (Gagro, 1998).

S agrotehničkog stajališta šećerna repa zahtjeva duboku obradu, te se iza nje mogu uzgajati usjevi s plićom obradom a time se snižavaju ukupni troškovi proizvodnje.

Po pitanju kvalitete sjemena proizvođači teže većoj klijavosti i adekvatan izbor hibrida je jedan od najvažnijih čimbenika koji mogu efikasno doprinijeti poboljšanju prinosa i kvalitete korijena šećerne repe (Pospišil i sur., 2009.).

### Materijal i metode

Tehnološki uvjeti i organizacija rada pri proizvodnji šećerne repe istraživani su na površinama IPK Klisa d.o.o. Osijek u 2007. godini. Prema podacima HGK - Županijske komore Osijek, Osječko - baranjska županija posjeduje 211.811 ha pod oranicama od čega je zasijano 207.962 ha.

Poduzeće IPK Klisa d.o.o. ima ukupnu proizvodnu površinu od 2.715,88 ha. Od te površine 251,93 ha je zasijano šećernom repom što predstavlja udjel od 9,28% od ukupnih proizvodnih površina (Šafar, 2008).

Kandit Premijer d.o.o. ugovorio je sjetvu šećerne repe u Osječko - baranjskoj županiji na površini od 9.238,87 ha. Tvornica beskamatno kreditira sjeme i zaštitna sredstva uz godišnju kamatu za mineralno gnojivo od 6%. Troškove prijevoza korijena repe sa odlagališta do tvornice plaća tvornica, a troškove utovara repe navedene godine plaćali su proizvođači.

Tvornica je otkupila korijen šećerne repe po cijeni od 250 kn t<sup>-1</sup> uz prosječnu digestiju od 16%.

Tablica 1. Struktura sjetve na proizvodnim površinama Osječko - Baranjske županije za 2007. godinu

Kultura	Zastupljenost (%)
Žitarice	67
Uljarice	15,8
Krmno bilje	6,9
Šećerna repa	4,7
Krumpir	1,8
Mahunasto povrće	0,7
Duhan	0,2
Aromatično bilje	0,3
Ostalo povrće	2,6

Izvor: HGK - Odsjek poljoprivrede i šumarstva

### Rezultati i rasprava

Na temelju izračunatih normi (učinka) i izrađene tehnološke karte utvrđen je utrošak rada od 108,81 sati po hektaru. Ukupni troškovi iznosili su 12.856,08 kn ha<sup>-1</sup>. Cijena šećerne repe u 2007. g. iznosila je 250 kn t<sup>-1</sup> uz digestiju od 16%. Uz prinos od 47 t ha<sup>-1</sup> i ostvaren državni poticaj (2.500,00 kn ha<sup>-1</sup>), ostvarena je dobit od 1.393,92 kn ha<sup>-1</sup>, odnosno ukupna dobit od 351.087,23 kn.

Na temelju koeficijenta ekonomičnosti proizvodnje od 1,108 evidentno je da je proizvodnja šećerne repe navedene godine bila ekonomična, a na 100 kn uloženi u proizvodnju ostvareno je 10,84 kn dobiti.

Ukupne troškove proizvodnje, vrijednost proizvodnje, te eventualni dobitak ili gubitak računa se pomoću podataka o troškovima materijala, gnojiva, zaštitnih sredstava, rada ljudi i rada strojeva te podacima o razini ostvarenih prinosa (Kanisek i sur., 2001).

Ekonomski uspjeh proizvodnje najčešće se rasčlanjuje izračunavanjem proizvodnosti rada ljudi, ekonomičnosti rada ljudi i rentabilnosti proizvodnje.

Proizvodnost rada - predstavlja omjer ukupne proizvodnje izražene u kg ha<sup>-1</sup> i ukupnog broja radnih sati po hektaru.

$$P = \frac{Q \text{ (Prinos u kg ha}^{-1}\text{)}}{T \text{ (sati ha}^{-1}\text{)}} = \frac{47.000,00}{108,81} = 432,8 \text{ kg sat}^{-1}$$

$$P = \frac{T \text{ (sati ha}^{-1}\text{)}}{Q \text{ (prinos u t ha}^{-1}\text{)}} = \frac{108,81}{47} = 2,3 \text{ sati t}^{-1}$$

Na temelju rezultata ostvarenih u poduzeću IPK Klisa d.o.o. za sat rada proizvede se 432,8 kg repe, a za proizvodnju 1 t repe potroši se 2,3 h.

**Tablica 2. Troškovi i rezultati proizvodnje šećerne repe na IPK Klisa d.o.o. Osijek u 2007. godini**

Red.br.	Reprodukcijski materijal	Jedinica mjere	Količina po ha	Cijena u kn	Vrijednost u kn
1.	Gorivo	l	217,66	4,73	1.028,44
2.	Sjeme	s.j.	1,50	822,00	1.233,00
3.	Mineralna gnojiva	kg	1,174	2,24	3.423,89
4.	Sredstva za zaštitu	l kg	-	-	2.460,93
5.	Mazivo (ulja,masti,antifriz)	l kg	-	-	102,84
6.	Pričuvni djelovi	kom.	-	-	502,26
USLUGE					
7.	Sušenje	t	-	-	-
8.	Osiguranje usjeva	kn	-	-	-
9.	Usluga Euroinspekta	t	47	0,004	188,00
10.	Dovoz gnojiva od proizvođača	kg	1.174	0,09	105,66
OSTALI TROŠKOVI					
11.	Doprinos za vodu	kn	-	-	200,00
12.	Amortizacija	kn	-	-	874,00
13.	Opći troškovi	kn	-	-	250,00
14.	Koncesija za zemljište	kn	-	-	400,00
15.	Kamate	kn	-	-	350,00
RAD LJUDI					
16.	Plaće djelatnika	sat	14,60	33,00	481,86
17.	Povremeni radnici	sat	94,21	24,00	2.261,07
18.	Ugovor o djelu	sat	-	-	0,00
19.	Ostale plaće	sat	-	-	0,00
20.	Raspoređene plaće	sat	-	-	1.737,05
Ukupni troškovi					12.856,08

**Tablica 3. Vrijednost proizvodnje šećerne repe na IPK Klisa d.o.o.**

Red.br.	Prihodi	Jedinica mjere	Količina po ha	Cijena u kn	Vrijednost u kn
1.	Prinos	t	47	250,00	10.810,00
2.	Poticaj	kn	-	2.500,00-	2.500,00
Vrijednost proizvodnje					14.250,00
Dobit					1.393,92

Ekonomičnost proizvodnje - izračunava se na osnovi elemenata obračunske kalkulacije.

$$E = \frac{\text{Vrijednost proizvodnje (kn ha}^{-1}\text{)}}{\text{Ukupni troškovi (kn ha}^{-1}\text{)}} = \frac{14.250,00}{12.856,08} = 1,108$$

*Rentabilnost proizvodnje* - izražava se stopom rentabilnosti u postotku, a izračunava se iz odnosa dobiti i ukupnih troškova. Rentabilnost proizvodnje pokazuje koliko se kuna dobije na 100 kn uloženi tijekom procesa proizvodnje.

$$R = \frac{\text{Dobit (kn ha}^{-1}) \times 100}{\text{Ukupni troškovi (kn ha}^{-1})} = \frac{139.392,00}{12.856,08} = 10,84\%$$

Pri proizvodnji šećerne repe u poduzeću IPK Klisa d.o.o. na osnovi izračunatih ekonomskih pokazatelja na 100 kn uloženi u proizvodnju ostvareno je 10,84 kn dobiti.

### Zaključak

Navedene godine (2007.) prinos korijena šećerne repe bio je značajno niži (47 t ha<sup>-1</sup>) u odnosu na europski prosjek. Naime, ukupna proizvodnja uz prosječni prinos korijena od 50-60 t ha<sup>-1</sup> trebala bi se kretati u okviru od 1,5-1,8 milijuna tona. Ista ne podmiruje raspoložive kapacitete za preradu u domaćim šladoranama, te su one prisiljene ugovarati proizvodnju sa susjednim zemljama.

Područje Slavonije i Baranje klimatski i edafski povoljno je područje za uzgoj šećerne repe. Proizvodnja šećerne repe zahtjeva visoku razinu ulaganja materijala, sati rada ljudi i strojeva te stručnog znanja.

U ovom radu istraženi su tehnološki činitelji, ekonomski rezultati i organizacija uzgoja šećerne repe na proizvodnim površinama tvrtke IPK Klisa d.o.o. Osijek. Na navedenom poduzeću šećernom repom bilo je zasijano 251,93 ha. Ukupni troškovi iznosili su 12.856,08 kn ha<sup>-1</sup>. Cijena šećerne repe u 2007. g. iznosila je 250 kn t<sup>-1</sup> uz prosječnu digestiju od 16%.

Uz nizak prinos od 47 t ha<sup>-1</sup> i ostvarene državne poticaje od 2.500,00 kn ha<sup>-1</sup> ostvarena je i relativno niska dobit od 1.393,92 kn ha<sup>-1</sup>, odnosno ukupna dobit na navedenoj površini od 351.087,229 kn.

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# Investicije u poljoprivredi kao oblik dodatnog upošljavanja u Bosni i Hercegovini - analiza investicijskog projekta nabavke plastenika za proizvodnju povrća

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## Sažetak

Kada se upravitelj poljoprivrednog gospodarstva odlučuje za investicije u poljoprivredi? U pravilu onda, kada je do krajnjih granica fizički i vrijednosno iskoristio postojeću imovinu. Rjeđe vlastiti, a češće posuđeni novac ulaže se u manje ili veće poboljšanje postojeće proizvodnje ili povećanje njenog obujma. Osnovni motivi kod većih ulaganja su veća dobit/dohodak od proizvodnje, dok se manja ulaganja provode radi zadržavanja postojeće dobiti/dohotka (Čejvanović i sur., 2010).

Poljoprivredna gospodarstva u Bosni i Hercegovini u prošlom su se razdoblju, u pravilu, razvijala postupno, što se može dobro vidjeti u organizaciji ekonomskih dvorišta. Ekonomski objekti se nastavljaju jedan na drugi, jer kako je gospodarstvo razvijalo svoju proizvodnju, tako je postupno povećavalo kapacitete. Često su takva ulaganja bila modifikacija tehničkih rješenja, gdje se na štetu maksimalnih proizvodnih rezultata štedjelo na ulaganjima. Takav stav, ponašanje poljoprivrednih proizvođača treba mijenjati i korigirati prema formi investicijskog ulaganja tj. novom konceptu u poljoprivrednoj proizvodnji. Cilj ovog rada je ekonomska analiza jednog investicijskog projekta koji sadrži dodatno upošljavanje. U radu su korištene statičke i dinamičke metode ocjene investicijskog projekta što je rezultiralo da je investicija ekonomski opravdana i dugoročno isplativa jer su ekonomski pokazatelji pozitivni.

Ključne riječi: Poljoprivredno gospodarstvo, investicijsko ulaganje, upošljavanje

## Investments in agriculture as a form of additional employment in Bosnia and Herzegovina - analysis of the investment project: procurement of greenhouse for vegetable production

### Abstract

When the manager of the family farm would decide for an investment in agriculture? Mainly, after he would completely, physically and financially utilize his existing property. Less frequently own, and more frequently borrowed money is invested in the improvement, or volume increasing of the existing production. The larger scale investments are mainly motivated with higher profit/revenue from production and smaller scale investments are mainly exercised to preserve the existing profit/revenue (Čejvanović and others, 2010).

In the past, agricultural households in Bosnia and Herzegovina have been developing gradually,

what can be easily recognized in the structure/organization of their farm yards. Production buildings are attached to each other subsequently, increasing the production capacities as the agricultural business was developing. Quite often in such investments, due to the “intentional savings”, technical propositions were modified on the account of maximal production results. Such an attitude and practice of the farmers should be changed and corrected towards full deployment of the investment means - as the new concept in the agricultural production. The purpose of this research paper is the analysis of one investment project which is generating additional labor employment. In the research several static and dynamic methods of evaluation have been used. The evaluation has proved that investment is, economically justified and long term profitable since all the economic indicators were positive.

Key words: Agricultural farm, Agricultural household, investment in agriculture, employment

## Uvod

Danas se u pravilu koriste povoljni kreditni programi za razvoj poljoprivrede, pri čemu se značajnije investira u osuvremenjivanje i proširenje kapaciteta. Takvi kreditni programi vrlo su povoljni, što u uvjetima relativno visokih ulaganja u poljoprivredu, omogućuje nešto lakše otplaćivanje kreditnih obveza. Ovo je posebno važno, jer se poljoprivredni projekti odlikuju visokim ulaganjima po jedinici kapaciteta, a zbog niske stope profita i prirode proizvodnje (dugi vremenski ciklus) potrebno je duže vremensko razdoblje povrata ulaganja.

Svaka investicija je ulaganje sredstava (vlastitog ili tuđeg) na dulji rok, s obvezom njihovog vraćanja izvoru financiranja, uz određenu naknadu. Ta naknada se kod korištenja tuđih sredstava mjeri kamatom, a kod vlastitih sredstava stopom profita.

Svako ulaganje, pa tako i ovo predstavlja određeni rizik, pa investitori prije ulaska u investiciju moraju detaljno obuhvatiti više kritičnih točaka u planiranju i provođenju investicijskog projekta (Claudiu i sur, 2008).

Osim čimbenika unutar samog poljoprivrednog gospodarstva (organizacija rada i proizvodni učinci na poljoprivrednom gospodarstvu), isplativost investicije u poljoprivredi ovisi o vanjskim čimbenicima (klimatske prilike, cijene inputa i outputa, mjere agrarne politike...). Nakon obuhvaćanja svih čimbenika poslovanja cijelog projekta u vremenu njegovog iskorištenja (do novog fizičkog i ekonomskog zastarijevanja) donosi se investicijska odluka - ući ili ne ući u investicijski ciklus?

## Materijal i metode

Materijal korišten u ovom radu je prikupljen u okviru internog projekta Vlade Brčko distrikta BiH pod nazivom “Analiza učinaka plasiranih poticajnih sredstava i katalog kalkulacija u poljoprivredi”. Primijenjene su poznate metode u ocjeni ekonomske opravdanosti investicijskih projekata, odnosno korištene su statičke i dinamičke metode ocjene investicijskih projekata. U radu su korištene statičke i dinamičke metode ocjene projekata (Čejvanović i sur, 2010):

Vrijeme povrata investicijskih ulaganja (povrata investicije):  $T = Ip_v / D$  ( $T$  - Vrijeme povrata investicijskih ulaganja,  $Ip_v$  - Predračunska vrijednost investicije,  $D$  - Dobit).

Ekonomičnost proizvodnje:  $k_E = U_p / U_r$  ( $k_E$  - Koeficijent ekonomičnosti,  $U_p$  - Ukupan prihod,  $U_r$  - Ukupan rashod).

Akumulativnost proizvodnje  $s_A = (D / U_p) \times 100$  ( $s_A$  - Stopa akumulativnosti,  $D$  - Dobit,  $U_p$  - Ukupan prihod).

Rentabilnost investicije (predračunska vrijednost investicije)  $s_{RI} = (D / IPV) \times 100$  ( $s_{RI}$  - Stopa rentabilnosti investicijskih ulaganja,  $D$  - Dobit,  $IPV$  - Predračunska vrijednost investicije).

Produktivnost proizvodnje ( $P_p$ )  $P_p = U_p / U_{br}$  ( $U_p$  - Ukupan prihod,  $U_{br}$  - ukupan broj radnika).

Neto sadašnja vrijednost investicijskog projekta (NSV), diskontna stopa ( $i = 0,10$ ) kada se svedu na početni trenutak eksploatacije ( $n = 0$ ), daju internu stopu rentabilnosti (ISR):

$$ISR = i_{min} + (i_{max} - i_{min}) \times \frac{NSV(+)}{NSV(+)+|NSV(-)|}$$

### Rezultati istraživanja i diskusija

Investicijske kalkulacije su računski postupak ocjene isplativosti trajnih ulaganja kapitala u neki projekt u agrobiznisu korištenjem priliva i odliva novčanih sredstava tijekom vremena trajanja projekta (Subić, 2003). Posebnosti projekata u poljoprivredi određena su razdobljem ulaganja u zasnivanje projekta, te vremenom trajanja projekta ili povrata ulaganja. U ovom radu prikazan je investicijski projekt nabavke dva velika plastenika u kojima se odvija proizvodnja krastavaca.

Da bi se unaprijedila poljoprivredna proizvodnja na poljoprivrednom gospodarstvu i bolje iskoristilo raspoloživo poljoprivredno zemljište, poljoprivredno gospodarstvo planira nabavku dva plastenika (60 m x 12 m = 720 m<sup>2</sup> po plasteniku, odnosno ukupne površine 1.440 m<sup>2</sup> = 0,144 ha). U plastenicima se planira postavljanje sustava za navodnjavanje kap po kap, a proizvodnja krastavaca će se odvijati u kontroliranim uvjetima uz maksimalno izbjegavanje utjecaja vanjskih čimbenika (Čejvanović i sur, 2010).

Pored članova obiteljskog gospodarstva (nositelj i četiri člana gospodarstva), planira se angažiranje pet vanjskih radnika zbog velikog obujma posla. U tablici 1. prikazani su ukupni troškovi investicijskog projekta za razdoblje od tri godine.

Tablica 1. Ukupni troškovi (EUR)

Red.br.	Naziv troškova	Godine eksploatacije projekta		
		I	II	III
I	materijalni troškovi	2.977,73	5.644,74	5.644,74
1.	gorivo	2.667,01	5.334,02	5.334,02
2.	ostali materijalni troškovi	310,72	310,72	310,72
II	Nematerijalni troškovi	11.564,04	15.627,47	14.104,86
1.	amortizacija	10.010,44	10.010,44	10.010,44
2.	radna snaga	1.553,60	3.107,20	3.107,20
3.	kamata po kreditu	0,00	2.509,82	987,21
UKUPNO (I+II)		14.541,78	21.272,21	19.749,60

Izvor: Čejvanović i suradnici (2010)

U tablici 2. predočen je račun dobiti i gubitka u razdoblju eksploatacija investicijskog projekta

Tablica 2. Račun dobiti i gubitka (EUR)

Red.br.	Naziv	Godine eksploatacije projekta		
		I	II	III
I	UKUPAN PRIHOD	20.507,51	41.015,02	41.015,02
II	UKUPNI RASHODI (1+2+3)	4.531,33	13.771,59	10.726,37
1.	Materijalni troškovi	2.977,73	5.644,74	5.644,74
2.	Radna snaga	1.553,60	5.617,02	4.094,41
3.	Kamata na kredit	0,00	2.509,82	987,21
III	BRUTO DOBIT (I-II)	15.976,18	27.243,43	30.288,65
IV	POREZ NA DOBIT (10%)	1.597,62	2.724,34	3.028,86
V	NETO DOBIT (III-IV)	14.378,56	24.519,09	27.259,78

Izvor: Čejvanović i suradnici (2010)

Da bi mogli kvalitetno ocijeniti učinkovitost investicijskog poduhvata nabavke i eksploatacije plastenika neophodno je izvršiti ocjenu projekta. Ovdje smo koristili statičke i dinamičke metode ocjene investicijskih projekata. Statička ocjena investicijskog projekta se odnosi na posljednju (u ovom slučaju) 3 godinu projekta.

**Produktivnost proizvodnje** iznosi:  $P_p = 4.101,50$  EUR. Sukladno gornjem proračunu, ostvareni prihod od prodaje po jednom angažiranom radniku iznosi 4.101,50 €.

**Ekonomičnost proizvodnje iznosi:**  $k_E = 3,82$ . Koeffcijent ekonomičnosti je veći od jedan, što ukazuje na činjenicu da je ukupan prihod veći od ukupnog rashoda.

**Akumulativnost proizvodnje iznosi:**  $s_A = 66,46\%$ . Stopa akumulativnosti je veća od  $5,00\%$  (pretpostavljena ponderirana cijena kapitala). Sukladno tome, može se konstatirati da je investicijski projekt akumulativan.

**Rentabilnost investicije (predračunske vrijednosti investicije) iznosi:**  $s_{RI} = 41,96\%$ , Stopa rentabilnosti je veća od  $5,00\%$  (pretpostavljena ponderirana cijena kapitala). Sukladno tome, može se konstatirati da je investicioni projekt rentabilan.

**Vrijeme povrata investicionih ulaganja (povrata investicije) iznosi:**  $T = 2,38$ . Sukladno gornjem proračunu, investicijski projekt će se isplatiti za 2,38 godine. Dakle, vrijeme povrata investicije iznosi 2 godine i 4,56 mjeseci ( $0,38 \times 12$  mjeseci).

Kao dinamičke metode ocjene učinkovitosti investicijskog projekta koristili smo metodu neto sadašnje vrijednosti i metodu interne stope rentabilnosti.

**Neto sadašnja vrijednost investicionog projekta (EUR).** U promatranom primjeru, investicija u periodu od tri godine eksploatacije (godine eksploatacije projekta) omogućila bi investitoru ukupno povećanje dobiti, računskom operacijom pomoću diskontne stope ( $i = 0,10$ ) na početni trenutak eksploatacije ( $n = 0$ ), u iznosu od  $11.143,34$  € ( $NSV = 11.143,34$  €)

**Interna stopa rentabilnosti (ISR)**, kao pokazatelj ekonomske učinkovitosti ulaganja finansijskih sredstava u projekt, u odnosu na plasman tih sredstava na tržište novca po određenoj diskontnoj stopi ( $i = 10\%$ ), računa se svođenjem  $\sum NSV = 0$ , što u konkretnom slučaju znači:

$$ISR = 0,15 + (0,20 - 0,15) \times \frac{3.593,36}{3.593,36 + 2.864,86} = 0,1778 \text{ (odnosno, } ISR = 17,78\%)$$

Sukladno metodologiji, interna stopa rentabilnosti treba biti najmanje jednaka, odnosno veća od kamatne stope davatelja kredita, (odnosno, ponderirane kamatne stope svih izvora financiranja). Dakle, investicija je rentabilna jer je interna stopa rentabilnosti projekta veća od kreditne kamatne stope ( $17,78\% > 5,00\%$ ), odnosno od diskontne/ponderirane stope ( $17,78\% > 10\%$ ).

Sa stajališta upošljavanja, potreba za kvalitetnim investicijskim projektima više je nego potrebna, jer će omogućiti upošljavanje određenog broja ljudi. Poznato je da zaposlenost predstavlja jednu od osnovnih ekonomskih varijabli koja pokazuje stanje i stupanj razvijenosti određenog društva. Proizvodnja u plastenicima predstavlja jedan sigurniji način uzgoja krastavca, jer vanjske čimbenike svodi na manju razinu. Isto tako po rezultatima ovog projekta može se zaključiti da proizvodnja u plastenicima ekonomski pokazuje pozitivne učinke.

## Zaključak

Osnovni oblici investiranja u poljoprivredi su ulaganje u povećanje kapaciteta izgradnju novih ekonomskih objekata, nabavku modernih strojeva i opreme, kupnju osnovnog stada i zemljišta. Unaprjeđenje sadašnje razine proizvodnje bez povećanja njenog obujma odnosi se na adaptaciju ili dogradnju dotrajalih objekata i zamjenu opreme. Investicijskim ulaganjima potiče se upošljavanje što je od izuzetne važnosti ne samo na novozaposlene nego i za društvo u cjelini (Vasiljević i sur, 2007). Kao primjer investicijskog ulaganja u ovom radu, dali smo konkretan primjer iz prakse, investicijskog projekta u proizvodnji krastavaca. Pravilno upravljanje investicijskim projektom od izuzetne je važnosti jer se poljoprivredni projekti odlikuju visokim ulaganjima po jedinici kapaciteta, a zbog niske stope profita i prirode proizvodnje (dugi vremenski ciklus) potrebno je dulje vremensko razdoblje povrata ulaganja.

Nakon obuhvaćanja svih čimbenika poslovanja cijelog projekta u vremenu njegovog iskorištenja (do novog fizičkog i ekonomskog zastarijevanja) donosi se investicijska odluka - ući ili ne ući u investicijski ciklus.

Nabavku dva plastenika za proizvodnju krastavaca i upošljavanje pet osoba ocijenili smo statičkim i dinamičkim metodama. Investicija je ekonomski opravdana i dugoročno isplativa jer su ekonomski pokazatelji pozitivni (Čejvanović i sur, 2010).

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# Ekonomska uspješnost vinogradarsko-vinarske proizvodnje - studij slučaja na području Ravnih kotara

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## Sažetak

U radu se analizira ekonomsku opravdanost ulaganja u vinogradarsko-vinarsku proizvodnju na području Ravnih kotara u slučajevima prodaje različitih finalnih proizvoda: grožđa, vina u rinfuzi i vina u boci. Podaci su prikupljeni intervjuiranjem suvremenog obiteljskog gospodarstva koje obrađuje 4 ha vinograda na kojem obujmu je kapacitirana i vlastita vinarska proizvodnja. Dobiveni rezultati ukazuju ukoliko gospodarstvo prodaje grožđe ostvaruje se dobit od 140.276 kn, proizvodnost od 118 kn/sat, ekonomičnost ima koeficijent 1,9 i rentabilnost ulaganja iznosi 13%. Ako se opredijeli za prodaju vina u rinfuzi dobit se povećava za 155%, proizvodnost je dvostruko veća, ekonomičnost raste za 27%, a rentabilnost za 52%. Ukoliko gospodarstvo cjelokupnu proizvodnju vina umjesto u rinfuzi plasira kroz bocu dobit se se povećava za 124%, proizvodnost raste za 48%, ekonomičnost se smanjuje za 2%, dok rentabilnost ima 79% višu vrijednost.

Ključne riječi: obiteljsko gospodarstvo, troškovi, grožđe, vino, dobit

## Economic feasibility of vitiviculture production - a case study in Ravni Kotari area

### Abstract

In this paper it is analyzed the economic feasibility of investment in vitiviculture production in Ravni kotari area in cases of sale of different final products: grapes, bulk wine and bottled wine. Data were collected by interviewing a modern family business that handles 4 ha of vineyards with its own wine production. The results indicate that if grapes are marketed, it is achieved a profit of 140.276 kn, a productivity of 118 kn/h, cost-effectiveness has a coefficient of 1.9 and profitability of investment is 13%. If bulk wine is marketed, the profit increases 155%, the productivity is doubled, the cost-effectiveness is 27% higher and the profitability is 52% higher. If the entire production of wine is marketed in bottle instead of bulk wine, the profit increases by 124%, the productivity increases 48%, the cost-effectiveness is reduced by 2%, while the profitability is 79% higher.

Key words: family farm, costs, grapes, wine, profit

## Uvod

Ravni kotari su prostor koji se nalazi između rijeke Krke, Zrmanje i mora i sadrži oko 45.000 ha obradivih površina. Uz maslinu i autohtonu kulturu višnju marasku, vinova loza stoljećima je održavala život u velikom dijelu Zadarske županije, osobito u Ravnim kotarima. Prema statističkim podacima kotar Zadar je 1920. godine imao 9.285 ha vinograda, dok je u kotaru Benkovac 1927. godine evidentirano 3.080 ha vinograda. Na području današnje Zadarske županije 1956. godine vinogradima je bilo zasađeno 7.683 ha. Do 1970. godine površine se smanjuju na 6.225 ha na kojoj razini ostaju do 1990. godine (6.269 ha pod vinogradima) (Bilosnić, 2007). U razdoblju od 1945. do 1990. godine dolazi do stagnacije i smanjenja vinogradarske i vinarske proizvodnje na području Ravnih Kotara na što je utjecalo nametanje seljačkih radnih zadruga, nedostatak velikih vinarija, niske otkupne cijene grožđa, nedovoljna educiranost u proizvodnji vina, slaba opremljenost podruma. Sve to uvjetovalo je da seljačka vina ostanu izvan tržišta, pa su te količine služile za vlastite potrebe u obitelji (Bilosnić, 2007). Prema statističkim podacima iz popisa poljoprivrede 2003. godine Zadarska županija ima ukupno 2.619 ha vinograda. Najveće su površine na području grada Benkovca sa 1.183 ha ili 42,25%, slijedi općina Stankovci sa 160 ha, grad Zadar sa 84 ha, Ražanac sa 81 ha itd. (HZPSS, 2009). U tijeku su procesi osnivanja malih, obiteljskih vinarija sa ciljem proizvodnje prepoznatljivih vina i plasmana putem trgovine, ugostitelja i ruralnog turizma u svrhu kojega je oformljena i vinska cesta Ravnih kotara. Cilj ovoga rada je ocijeniti ekonomsku opravdanost ulaganja u vinogradarsko-vinarsku proizvodnju na području Ravnih kotara u slučajevima prodaje različitih finalnih proizvoda: grožđa, vina u rinfuzi i vina u boci.

## Materijal i metode

Podaci su prikupljeni intervjuiranjem jednog obiteljskog poljoprivrednog gospodarstva na području Ravnih kotara koje reprezentira suvremena gospodarstva koja su tijekom zadnjih desetak godina intenzivirale vinogradarsku i vinarsku proizvodnju. U radu je korištena metoda kalkulacije pri čemu je prema vremenu korištena naknadna kalkulacija, prema području mikroekonomska i prema sadržaju analitička i investicijska kalkulacija. (Karić i sur. 2002). Za utvrđivanje financijskog rezultata u proizvodnji pojedine kategorije proizvoda korištena je analiza troškova i koristi. Analizom ekonomske uspješnosti vinogradarsko-vinarske proizvodnje obuhvatiti će se cjelokupni proizvodni proces: od utvrđivanja troškova podizanja nasada vinograda, što je neophodno za izračun visine godišnje amortizacije, pa sve do troškova proizvodnje grožđa, vina u rinfuzi, odnosno krajnjeg proizvoda - vina punjenog u boce. Ovakvom analizom obuhvaćen je cjelokupni proizvodni proces grožđa i vina završno sa tri finalna tržišna proizvoda koja se javljaju na analiziranom gospodarstvu. Udio pojedinog finalnog proizvoda razlikuje se od godine do godine i ovisi prvenstveno o mogućnosti plasmana proizvoda više razine finalizacije. Troškovi su grupirani u 3 osnovne skupine: trošak materijala, trošak rada ljudi i trošak rada sa poljoprivrednim strojevima. Ekonomske obrade temeljene su na utrošcima i cijenama koji su bili važeći u poslovnoj 2009. godini.

## Rezultati i rasprava

Gospodarstvo posjeduje ukupno 7 ha poljoprivrednog zemljišta te se pored vinogradarske bavi i voćarskom proizvodnjom. Poslove na gospodarstvu obavljaju 4 radno aktivna člana kućanstva od kojih su dvoje stalno uposleni na gospodarstvu. Pozitivna razvojna perspektiva gospodarstva ogleda se u činjenicama da je nositelj s 55 godina najstariji član kućanstva, a njegov sin (25 godina) je inženjer vinarstva i voditelj je vinogradarske i vinarske proizvodnje. Za vrijeme trajanja sezonskih poslova (rezidba, berba) gospodarstvo angažira 2-3 sezonska radnika. Vinogradarske proizvodnja odvija se na oko 4 ha vinograda u kojima se uzgajaju bijeli (Debit, Maraština) i crni (Plavina, Syrah, Merlot i Cabernet sovignon) kultivari vinove loze.

**Tablica 1: Troškovi podizanja vinograda kroz četiri godine ulaganja**

Godina ulaganja	Vrsta troška	Vrijednost po ha (kn)
1.	Materijalni troškovi	25.000
	Rad traktora i strojeva	13.610
	Radna snaga	560
	Ukupno	39.170
2.	Materijalni troškovi	39.160
	Rad traktora i strojeva	7.297
	Radna snaga	3.660
	Ukupno	50.117
3.	Materijalni troškovi	35.450
	Rad traktora i strojeva	5.220
	Radna snaga	7.390
	Ukupno	48.060
4.	Materijalni troškovi	5.314
	Rad traktora i strojeva	5.670
	Radna snaga	4.300
	Ukupno	15.284
Sveukupno		152.631

Izvor: Istraživanje autora

Investicija podizanja mladog nasada vinograda proteže se kroz 4 kalendarske godine. U prvoj godini odvija se priprema terena, u drugoj se sade lozni cijepovi u trećoj se postavlja armatura, a u četvrtoj godini se vrši formiranje uzgojnog oblika i njega mladog nasada.

Trošak podizanja vinograda na površini od 1 hektara iznosi 152.631 kn iz čega proizlazi da je anketirano gospodarstvo u 4 ha višegodišnjih nasada uložilo ukupno 610.524 kn. Najviši troškovi u prvoj godini ulaganja (priprema terena) predstavljaju troškovi materijala (63% od ukupnih) odnosno unutar njih trošak nabave i razbacivanja 40 t/ha stajskog gnoja na kojeg otpada 40% od ukupnih troškova u ovoj godini. U drugoj godini ulaganja (godina sadnje lozних cjevova) na troškove materijala otpada 78% od ukupnih među kojima je najveći trošak nabava lozних cjevova na koje otpada 48% od ukupnih troškova u ovoj godini. Sadnja 3.496 lozних cjevova po hektaru obavila se je strojno po cijeni od 0,80 kn/cijepu. Materijalni troškovi su najviši i u trećoj godini ulaganja na koje otpada 73% od ukupnih troškova, a najveći pojedinačni trošak predstavlja nabava plastičnih rednih stupova kojih je po hektaru postavljeno 590 komada, a nabavljeni su po cijeni od 3.276 kn/komadu. Za potrebe obavljanja agrotehničkih radova u vinogradu gospodarstvo posjeduje traktor vinogradar, kultivator, deponator mineralnog gnoja, atomizer, međurednu roto drljaču, redni kultivator s ticalom i sumporaču čija ukupna nabavna vrijednost iznosi oko 337.000 kn. Dobra opremljenost strojno-traktorskog parka omogućuje visoku mehaniziranost radnih operacija u rodnom vinogradu tako da se godišnji utrošak rada sa strojevima iznosi 37 sati/ha, a ljudskog rada 523 sata/ha. Od radnih operacije sa strojevima najviše se utroši na obradu tla između i u redu (22 sata/ha). Uzgojni oblik je dvokraki Guyot iz čega proizlazi i veliki utrošak ljudskog rada u radnim operacijama rezidbe i vezidbe (ukupno 290 sati/ha), dok se za berbu 11.000 kg grožđa po hektaru utroši 160 sati.

**Tablica 2: Troškovi vinogradarske proizvodnje**

Redni broj	Skupina troškova	Vrijednost (kn)	
		1 ha	4 ha
1.	Materijalni troškovi	6.572	26.288
2.	Rad traktora	6.660	26.640
3.	Radna snaga	10.460	41.840
4.	Trošak financiranja	1.185	4.740
5.	Ostali izdaci	474	1.896
6.	Amortizacija vinograda i mehanizacije	28.005	46.320
Ukupno		53.356	147.724

Izvor: Istraživanje autora

Uz prosječni prinos od 12.000 kg/ha proizlazi da cijena koštanja grožđa iznosi 4,45 kn/kg.

Tablica 3: Troškovi vinarske proizvodnje - proizvodnja vina u rinfuzi

Redni broj	Skupina troškova	Iznos za obujam prerade 48 t grožđa
1.	Troškovi proizvodnje grožđa	147.724
2.	Materijalni troškovi	11.946
3.	Radna snaga	11.640
4.	Trošak financiranja	5.414
5.	Ostali izdaci	472
6.	Amortizacija podruma i vinarske opreme	64.200
Ukupno		241.396

Izvor: Istraživanje autora

Uz prosječnu prodajnu cijenu grožđa od 6 kn/kg ostvaren je ukupni prihod od 72.000 kn/ha odnosno ukupno 288.000 kn na obujmu od 4 ha vinogradarske proizvodnje.

Vinarski podrum ima površinu od 110 m<sup>2</sup> i vrijednost oko 120.000 kn.

U podrumu je instalirana suvremena vinarska oprema kapaciteta prerade 50 t grožđa, odnosno proizvodnje i čuvanja 380 hl vina čija nabavna vrijednost iznosi 538.500 kn. Pojedinačno, najveća je vrijednost pneumatske preše kapaciteta 1.100 litara (95.000 kn) i inoks tankova za vino (261.000 kn). U strukturi materijalnih troškova najveći izdatak predstavljaju enološka sredstva (54% od ukupnih) i električna energija (35% od ukupnih materijalnih troškova). Za proizvodnju i čuvanje 338 hl vina na gospodarstvu se utroši ukupno 282 sata rada od čega 150 sati (53%) otpada na rad enologa u tijeku prerade i čuvanja vina. Od 48.000 kilograma grožđa, uz randman od 63%, za tržište se proizvede oko 30.000 litara vina. Prodajna cijena vina u rinfuzi iznosila je oko 20 kn/lit. iz čega proizlazi da gospodarstvo prodajom vina u rinfuzi ostvaruje ukupni prihod od 600.000 kn.

Ukoliko gospodarstvo cjelokupnu količinu proizvedenog vina puni i prodaje u bocama od 0,75 lit., površina podruma treba biti za 35 m<sup>2</sup> veća tako da njegova vrijednost iznosi 150.000 kn. Vrijednost dodatne opreme za čuvanje i punjenje vina u boce iznosi 122.545 kn od čega 45% otpada na punilicu i etiketirku, a 47% na sustav za hlađenje i čuvanje vina u tankovima.

Tablica 4: Troškovi vinarske proizvodnje - proizvodnja vina u boci

Redni broj	Skupina troškova	Iznos za obujam proizvodnje 300 hl vina
1.	Troškovi proizvodnje vina u rinfuzi	241.396
2.	Materijalni troškovi	270.084
3.	Radna snaga	5.880
4.	Trošak financiranja	9.564
5.	Ostali izdaci	9.754
6.	Amortizacija podrumskog prostora i opreme za punjenje vina u boce	23.875
Ukupno		560.553

Izvor: Istraživanje autora

Tablica 5: Ekonomski pokazatelji uspješnosti vinogradarske i vinarske proizvodnje

Red. br.	Ekonomski pokazatelji	Vrijednost po proizvodima		
		grožđe	vino - rinfuza	vino - boca
1.	Dugotrajna imovina (kn)	947.524	1.606.024	1.758.569
2.	Ukupni prihod (kn)	288.000	600.000	1.365.000
3.	Ukupni troškovi (kn)	147.724	241.396	560.553
4.	Bruto dobit (kn)	140.276	358.604	804.447
5.	Proizvodnost rada (kn/sat)	118	236	350
6.	Koeficijent ekonomičnosti	1,9	2,5	2,4
7.	Rentabilnost ulaganja (%)	13	19	35

Izvor: Istraživanje autora

U postupku punjenja vina u boce najviši su troškovi materijala, odnosno boce, čep i etikete na koje otpada 68% ukupnih troškova u fazi punjenja i prodaje vina u bocama. U ovoj fazi finalizacije vinarske proizvodnje utroši se ukupno 194 sata rada od čega 57% otpada na poslove koji se odnose na punjenja vina u boce, a 38%

otpada na poslove povezane sa prodajom. Troškovi organizacije, planiranja, marketinga i slično, budući da se radi o općim troškovima, sadržani su u skupini ostalih izdataka.

Od 30.000 litara vina, nakon što se odbije kalo i rasip, na tržište se plasira 39.000 boca zapremine 0,75 litara. Uz prosječnu prodajnu cijenu od 35 kn/boci gospodarstvo ostvaruje ukupni prihod od 1.365.000 kn. Primjetno je da su svi pokazatelji ekonomske uspješnosti pozitivni te da se njihove vrijednosti osjetno poboljšavaju sa povećanjem stupnja finalizacije proizvoda. Kada gospodarstvo prodaje grožđe ostvaruje se dobit od 140.276 kn, proizvodnost od 118 kn/sat, ekonomičnost ima koeficijent 1,9 i rentabilnost ulaganja iznosi 13%. Ako se opredijeli za prodaju vina u rinfuzi dobit se povećava za 155%, proizvodnost je dvostruko veća, ekonomičnost raste za 27%, a rentabilnost za 52%. Ukoliko gospodarstvo cjelokupnu proizvodnju vina umjesto u rinfuzi plasira kroz bocu dobit se se povećava za 124%, proizvodnost raste za 48%, ekonomičnost se smanjuje za 2%, dok rentabilnost ima 79% višu vrijednost.

### Zaključak

Ekonomska analiza vinogradarsko-vinarske proizvodnje na području Ravnih kotara pokazala je da je ova proizvodnja uspješna u svim slučajevima finalnog proizvoda, bilo da se na tržište plasira grožđe, vino u rinfuzi ili vino u boci. Ustanovljeno je da se najbolji ekonomski rezultati ostvaruju ako se na tržište plasira vino u boci. Stoga se može zaključiti da su ulaganja u podizanje novih vinograda i izgradnju obiteljskih vinarija na prostoru Ravnih kotara u postojećim tržišnim uvjetima ekonomski potpuno opravdana pri čemu gospodarstva trebaju težiti višem stupnju finalizacije proizvoda.

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# Financijska analiza poslovanja hrvatske prehrambene industrije u uvjetima recesije

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## Sažetak

U radu se analizira poslovanje vodećih hrvatskih tvrtki iz djelatnosti poljoprivrede, proizvodnje hrane i pića, prije i za vrijeme recesije. Izračunom pokazatelja ekonomičnosti, tekuće likvidnosti i stope povrata kapitala uspoređuju se rezultati poslovanja subjekata iz prehrambene industrije s rezultatima poslovanja poduzeća neprehrambene djelatnosti. U usporednoj analizi provjerava se pretpostavka da su zbog male dohodovne elastičnosti hrane tvrtke iz prehrambenog sektora u svom poslovanju otpornije na loše gospodarske prilike. Na temelju financijskih izvješća odabranih prehrambenih tvrtki utvrđen je pad prihoda u 2009. za oko 4% te smanjenje stope profitabilnosti kapitala s 9% na 7%. Utjecaj recesije na poslovanje prehrambenih tvrtki manji je u odnosu na poslovne rezultate neprehrambenih tvrtki kod kojih je, uz pad prihoda za oko 13%, stopa profitabilnosti gotovo prepolovljena u odnosu na prethodnu godinu.

Ključne riječi: financijska analiza, prehrambena industrija, recesija

## Financial analysis of Croatian food industry in recession

### Abstract

The paper analyzes the business performance of the leading Croatian food companies before and during a recession. In a comparative analysis with non-food companies authors examine the assumption of food companies as more resilient to adverse economic conditions because of low food income elasticity. Financial statements of selected food companies show fall in revenues up to 4% in 2009 and decreased return on equity (ROE) from 9% to 7%. Negative changes are still less notable than in non-food sector in which the drop of revenues for the 13% almost halved ROE achieved in the previous year.

Key words: financial analysis, food industry, recession.

### Uvod

U Rječniku bankarstva (1998.) recesije se definira kao povremeno usporavanje u gospodarske aktivnosti neke zemlje praćeno pogoršanjima opće ekonomske klime i agregiranih ekonomskih pokazatelja. Često se u praksi navodi definicija recesije kao pojave kad se izlazne vrijednosti gospodarstva smanjuju tijekom dva uzastopna godišnja kvartalna razdoblja. U skladu s navedenim, početkom recesije u Republici Hrvatskoj smatra se posljednji kvartal 2008. godine kad je zabilježen gospodarski pad od 0,5% na godišnjoj razini (Banka, 2009.). Sve do danas svjedoci smo pogoršanja ekonomskih pokazatelja (pad BDP-a, porast nezaposlenosti, pad realnog dohotka...) koji traje već pune dvije godine. U takvim okolnostima dolazi do smanjenja osobne potrošnje i pogoršanja uvjeta poslovanja većine poslovnih subjekata. U radu su prikazani rezultati istraživanja utjecaja recesije na poslovne rezultate hrvatske prehrambene industrije u usporedbi s ostalim gospodarskim djelatnostima. Pretpostavka rada je da prehrambeni sektor zbog dohodovno neelastičnog

karaktera prehrambenih proizvoda uspješnije odolijeva gospodarskoj krizi što je provjereno financijskom analizom poslovnih rezultata vodećih prehrambenih tvrtki u Hrvatskoj. Iako samo financijska izvješća ne mogu u cijelosti pružiti sve relevantne informacije o učincima krize na poslovanje, one omogućuju izračun pokazatelja koji u određenom vremenskom slijedu daju prikaz financijskog stanja neke tvrtke prije i tijekom trajanja krize.

### Materijal i metode

Pretpostavka rada provjerit će se izračunom financijskih pokazatelja na temelju uvida u financijska izvješća tvrtki iz prehrambenog i drugih sektora. S tim ciljem izračunat će se sljedeći pokazatelji:

- a) Ekonomičnost poslovanja (e) kao odnos ukupnih prihoda i ukupnih rashoda tvrtke daje informaciju o racionalnosti upravljanja troškovima prilikom ostvarivanja određenih poslovnih učinaka. Vrijednost ovog pokazatelja treba biti što veća, a svakako veća od 1 ukoliko se poslovna aktivnost tvrtke može definirati kao ekonomična.
- b) Tekuća likvidnost koja daje uvid u mogućnost podmirenja kratkoročnih obveza tvrtke, a izračunava se omjerom tekuće imovine i tekućih obveza tvrtke. Vrijednost pokazatelja trebala bi iznositi više od 2, iako su moguća i odstupanja od ove orijentacijske vrijednosti ovisno o vrsti poslovne djelatnosti (Atrill, 2006.). Neki drugi izvori navode 1,5 kao graničnu vrijednost ovog pokazatelja.
- c) Stopa povrata kapitala (eng. Return on equity) predstavlja najznačajniji pokazatelj profitabilnosti. Pokazuje koliko novčanih jedinica dobiti poduzeće ostvaruje na jednu jedinicu vlastitog kapitala. Vrijednost ovog pokazatelja trebala bi biti što veća, a barem veća od nerizične kamatne stope koja se može odrediti iz aktualne prosječne kamatne stope bankarskih depozita. Ovaj se pokazatelj određuje odnosom bruto dobiti i kapitala,

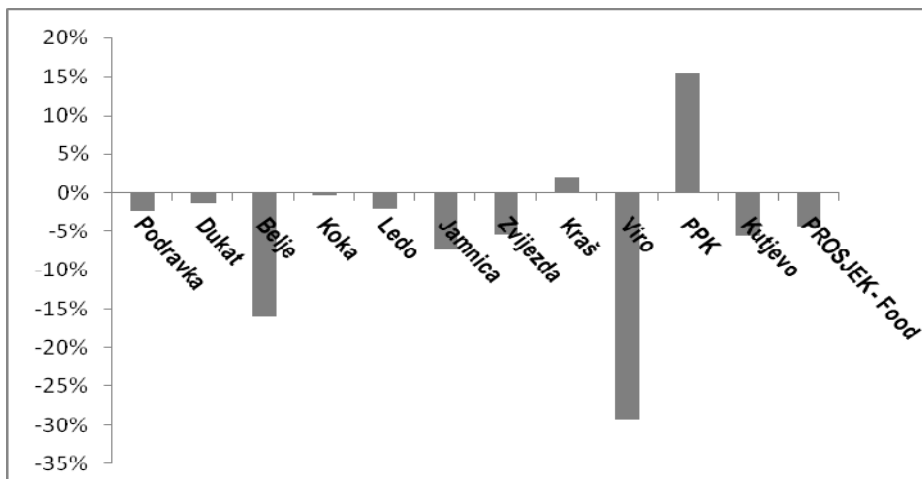
Analiza se temelji na podacima iz godišnjih financijskih izvješća tvrtki (bilanca, račun dobiti i gubitka) za 2007., 2008. i 2009. godinu. Važno je napomenuti da financijska izvješća, iako najčešći i najtransparentniji, ne mogu biti i jedini pokazatelj poslovanja tvrtke jer se neke stavke u njima mijenjaju pod utjecajem aktivnosti koje nisu izravno vezane uz poslovanje što je u radu objašnjeno na primjeru Podravke.

U izboru tvrtki odabrano je jedanaest najvećih poduzeća sektora hrana, pića i poljoprivreda prema kriteriju ostvarenih godišnjih prihoda od najmanje 300 milijuna kuna (Lider, 2010.) uz uvjet dostupnosti financijskih izvješća za analizirano razdoblje. Udio prihoda pojedine tvrtke u 2009. u ukupnim приходima odabranih kompanija poslužio je kao ponder kod izračunavanje prosječnih, agregiranih vrijednosti pokazatelja sektora.

Za usporednu analizu odabrano je i jedanaest najvećih hrvatskih tvrtki s najmanje milijardu kuna godišnjih prihoda iz različitih neprehrambenih sektora. Kod njihovog odabira vodilo se računa o ravnomjerno zastupljenosti različitih neprehrambenih djelatnosti pa ovu usporednu skupinu čine tvrtke iz sektora trgovine, elektroničke opreme, farmaceutike, financijskog posredovanja, građevinarstva, telekomunikacija, izdavaštva i naftne i kemijske industrije.

### Rezultati i rasprava

Analiza ekonomičnosti poslovanja obavljena je izračunom koeficijenta ekonomičnosti iz prihoda i rashoda poslovanja. Uvidom u račun dobiti i gubitka odabranih prehrambenih tvrtki vidljivo je da su najviši prihodi ostvareni u 2008. godini nakon čega slijedi značajan pad u 2009. Samo dvije od 11 prehrambenih tvrtki u 2009. godini ostvarilo je rast prihoda dok su ostale zabilježile smanjenje prihoda od 0,3 do 29,3%. Prosječni pad odabranih kompanija u 2009. iznosi -4,3%. U istom razdoblju smanjeni su i prihodi neprehrambenih tvrtki, ali u nešto većoj mjeri. Njihov prosječni pad u 2009. iznosi 12,7%.



Graf 1. Promjena prihoda prehrambenih tvrtki u 2009. godini u odnosu na 2008.

Čak i u uvjetima smanjenja prihoda, sve analizirane prehrambene tvrtke relativno su uspješno ublažile smanjenje prihoda u 2009. odgovarajućim smanjenjem troškova poslovanja tako da su sve osim Podravke ostvarile dobit. U slučaju Podravke poslovni gubitak nije posljedica slabijih operativnih rezultata već rizičnih transakcija koje su uvjetovale porast rezervacija iz operativne dobiti. Racionalnost poslovanja razvidna je iz koeficijenta ekonomičnosti koji je u sve tri analizirane godine bez značajnih promjena i veći od 1, dok u 2009. bilježi čak i blagi rast u odnosu na prethodnu godinu.

Tabela 1. Ekonomičnost poslovanja prehrambenih tvrtki u razdoblju 2007. - 2009. god.

2007.	2008.	2009.
1,048	1,041	1,043

Tijekom istog razdoblja neprehrambene tvrtke ostvarile su nešto veću ekonomičnost ali s izraženijim negativnim pomakom u 2009. godini.

Tabela 2. Ekonomičnost poslovanja neprehrambenih tvrtki u razdoblju 2007. - 2009. god.

2007.	2008.	2009.
1,156	1,132	1,088

U pogledu likvidnosti, recesijska 2009. godina nije uzrokovala pogoršanje vrijednosti koeficijenta tekuće likvidnosti prehrambenih tvrtki koji je stabilan, ali ne i zadovoljavajući, u sve tri analizirane godine. Vrijednosti niže od 1,5 ukazuju da tvrtke imaju blage probleme s podmirenjem svojih tekućih obveza. U odnosu na prehrambene, tvrtke iz neprehrambenih sektora još su nelikvidnije obzirom da je prosječni koeficijent tekuće likvidnosti oko 1,3 u sve tri analizirane godine godini s blagim rastom u 2009.

Tabela 3. Koeficijent tekuće likvidnosti prehrambenih tvrtki u razdoblju 2007. - 2009. god.

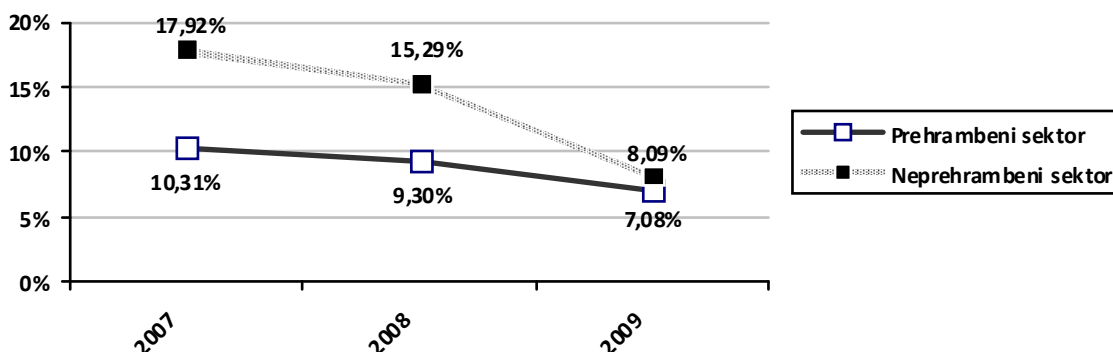
2007.	2008.	2009.
1,471	1,393	1,460

Najvažniji financijski pokazatelji ekonomske analize su pokazatelji profitabilnosti (Hadelan, 2010.) od kojih se najčešće koriste stopa povrata imovine (ROA) i stopa povrata kapitala (ROE). Kao granična zadovoljavajuća vrijednost potonjeg najčešće se uzima kamata na višegodišnje državne obveznice. Ministarstvo financija Republike Hrvatske 2007. godine izdalo je obveznice pod službenom oznakom RHMF-O-172A čija je kamatna stopa 4,75% dok je zbog pogoršanog stanja na financijskom najnoviji paket obveznica (RHMF-O-203A) izdan po kamatnoj stopi 6,75%.

Profitabilnost najvećih tvrtki prehrambenog sektora u sve tri analizirane godine je zadovoljavajuća obzirom da je i u najlošijoj 2009. godini vrijednost ROE bila iznad nerizične kamatne stope. Međutim, zabrinjavajući je pad profitabilnosti u 2009. za oko 2% u odnosu na prethodnu godinu. Analiza ovog pokazatelja za



neprehrambeni sektor pokazuje još veći negativni pomak tako da je izuzetno visoka ROE vrijednost iz 2007. godine u recesijskoj 2009. više nego prepolovljena.



Graf 2. Kretanje pokazatelja ROE u razdoblju 2007.-2009.

Pokazatelj profitabilnosti u najvećoj mjeri potvrdio pretpostavku ovog rada da su prehrambene tvrtke otpornije na negativna gospodarska kretanja od ostalih djelatnosti. To je ujedno i potvrda prvog Engelovog zakona prema kojem "Izdaci domaćinstva za hranu, u odnosu na prihod nisu elastični". Rezultati pokazuju slabije rezultate u recesijskoj 2009. godini, ali je ovo pogoršanje ipak blaže od posljedica utjecaja recesije na istovrsnu industriju u Europi (Fusaro, 2009.). Rezultati nažalost određuju našu zemlju i kao slabije razvijenu obzirom da recesija naročito pogađa razvijenija gospodarstva u kojima životni standard stanovništvo dozvoljava čestu prehranu izvan vlastitog domaćinstva (Horeca segment) čije je poslovanje izuzetno osjetljivo na recesiju (Van den Bossche i sur, 2003.). Nadalje, recesija jače utječe na prehrambene tvrtke koje proizvode najskuplje prehrambene robne marke zbog promjene orijentacije potrošača prema jeftinijim zamjenskim proizvodima (Mitchell, 2009.). U tom slučaju stabilnost tvrtki u recesiji može biti pokazatelj male vrijednosti domaćih prehrambenih robnih marki.

Istraživanje na temelju provedene financijske analize pokazalo je veću otpornost poduzeća prehrambene industrije na recesiju u odnosu prema poduzećima iz ostalih gospodarskih djelatnosti uz blagu nelikvidnost, ali zadovoljavajuću ekonomičnost i profitabilnost poslovanja. U uvjetima krize ne smanjuje se potrošnja hrane, a nužna štednja se postiže manjim udjelom prehrane u restoranima odnosno preraspodjelom potrošnje prehrambenih proizvoda u korist osnovnih, jeftinijih namirnica.

## Zaključak

Recesija koja je u Hrvatskoj prisutna od kraja 2008. godine nejednako utječe na pojedine gospodarske sektora. Jedna od djelatnosti koja najbolje prkosi negativnim gospodarskim kretanjima je svakako poljoprivreda i industrija hrane i pića. U 2009. godini smanjeni su prihodi analiziranih poduzeća za oko 4% što je rezultiralo i padom profitabilnosti za oko 2%. Unatoč tome, izračunata vrijednost ROE pokazatelja vodećih prehrambenih tvrtki od 7% viša je od nerizične kamatne stope što ukazuje na još uvijek zadovoljavajuće financijske rezultate. U godinama prije pojave recesije neprehrambene tvrtke u Hrvatskoj ostvarivale su značajno bolje rezultate koji su u trenutnim gospodarskim okolnostima prema kriteriju profitabilnosti prepolovljeni. Za razliku od njih, prehrambeni sektor ostvaruje stagnaciju što je potvrdilo prvi Engelov zakon o dohodovnoj neelastičnosti troškova prehrane.

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# Ekonomska ocjena tradicionalnog i suvremenog uzgoja vinove loze u Istri

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## Sažetak

U radu se obrađuju ekonomski aspekti tradicionalnog i suvremenog načina uzgoja vinograda u Istri. Podaci su prikupljeni anketiranjem triju gospodarstava kojima je vinogradarstvo osnovna grana poljoprivredne proizvodnje. Kod suvremenog vinogradarstva vrijednost ulaganja u poljoprivrednu mehanizaciju je čak 4,1 puta veća dok je iznos ulaganja u podizanje vinograda viša za 7%. Troškovi vinogradarske proizvodnje su kod primjene tradicionalne tehnologije za 5.050 kn/ha veći kod tradicionalnog uzgoja dok je sam prihod manji za 8.000 kn/ha. Dobit od vinogradarske proizvodnje je za 75% viša u slučaju primjene suvremene tehnologije uzgoja.

Ključne riječi: vinogradarstvo, tehnologija, troškovi, ekonomski pokazatelji

## Economic evaluation of traditional and modern viticulture production in Istria

### Abstract

Economic aspects of traditional and modern methods of viticulture production in Istria are discussed in this article. Data were collected by surveying three farms where viticulture is the basic sector of agricultural production. In modern viticulture the value of investments in agricultural mechanization is 4,1 times higher, while the amount of investment in vineyard establishment is 7% higher. In traditional viticulture the cost of viticulture production is 5.050 kn/ha higher, while the income is 8.000 kn/ha lower. The profit from viticulture production is 75% higher in the case of application of modern technologies.

Key words: viticulture, technology, costs, economic indicators

### Uvod

Nekada su položaji vinogradarske Hrvatske zauzimali gotovo 200 tisuća hektara (Šimunović, 2004.) U godinama visoke potražnje za vinom na europskom tržištu, kad je filoksera uništila vinograde u Europi, a u nas se još nije pojavila, godišnje se samo u Istri sadilo više od tisuću hektara vinograda (Vitolović, 1969). Nakon haranja filoksera, vinogradarske su površine stagnirale i ta tendencija traje (Vivoda, 1988). Najvažnija proizvodno-ekonomska obilježja vinogradarske proizvodnje su višegodišnje razdoblje investicijskih ulaganja, relativno visoka ulaganja po jedinici površine, dugo razdoblje povrata, visok utrošak ljudskog rada po jedinici površine, značajan utjecaj lokalnih pedoklimatskih uvjeta, osobito na kvalitetu proizvoda itd (Oplanić i sur. 2010). Pogodnost uzgoja vinove loze je što se može uzgajati i na površinama nepovoljnim za uzgoj drugih kultura poradi čega je ona duboko ukorijenjena u tradiciji istarske poljoprivredne proizvodnje (Milotić i sur. 2001). Cilj ovog rada je utvrditi ekonomsku uspješnost primjene tradicionalne i suvremene tehnologije u vinogradarskoj proizvodnji. Pod tradicionalnom tehnologijom podrazumijeva se način uzgoja

koji se je koristio prije 20 - 30 godina, odnosno tijekom osamdesetih godina prošlog stoljeća, dok se suvremeni način uzgoja primjenjuje u sadašnjem vremenu kod naprednijih vinogradara koji su se opremili modernom mehanizacijom i opremom, odnosno specijalizirali se u vinogradarskoj proizvodnji.

### Materijal i metode

Prikupljanje podataka vršeno je putem sekundarnih i primarnih izvora pri čemu je od primarnih izvora korištena metoda ankete kojom su obuhvaćena 3 gospodarstva u Istri na kojima su prikupljeni podaci o tehnologiji vinogradarske proizvodnje koja je primjenjivana prije 20 do 30 godina te podaci kako ta gospodarstva danas vrše vinogradarsku proizvodnju. Podaci koji su izneseni u ovom radu odnose se na površinu od jednog hektara vinograda. Analiza troškova izvršena je na način da su oni grupirani u tri osnovne skupine: troškovi rada sa strojevima, troškovi radne snage i troškovi materijala. Korištena je metoda kalkulacije pri čemu je prema vremenu vršena naknadna kalkulacija, prema području mikroekonomska i prema sadržaju analitička (Karić i sur. 2002). Ekonomske prednosti i nedostaci tradicionalnog i suvremenog načina vinogradarske proizvodnje vrednuju se i uspoređuju analizom troškova i koristi kod koje je utrošak materijala i rada promjenljivi faktor, dok su cijene iste u oba načina uzgoja, važeće u 2009. godini. Cijena ljudskog rada iznosi 40 kn/sat. Visina prodajne cijene grožđe ovisi o njegovoj kvaliteti prema odnosu kakav je vrijedio u 2009. godini.

### Rezultati i rasprava

Vinogradarstvo se je u prošlosti više oslanjalo na ljudsku radnu snagu što je rezultiralo većim utroškom rada u vinogradu tijekom godine. Uobičajeni traktori koji su korišteni u vinogradarskoj proizvodnji na području Istre bili su obični ratarski traktori od kojih se navode nekoliko najučestaliji: IMT od 33 i 39 KS, Ursus od 50 KS, Zetor od 45 KS, Univerzal od 45 KS i Fiat od 45 KS. Od priključaka koristili su se kultivator, dvobrazdni plug, nošena traktorska prskalica, tanjurača i traktorska prikolica. Nabavna vrijednost ove poljoprivredne mehanizacije procjenjuje se na oko 110.000 kn od čega oko 45.000 kn otpada na vrijednost traktora. Suvremena vinogradarska proizvodnja odlikuje se osjetno vrijednijom mehanizacijom u koju spada vinogradarski traktor sa osnovnim priključcima: kultivator, malčer, vučeni traktorski atomizer, podriivač s deponatorom mineralnog gnojiva, traktorska sumporača, priključak za zelenu rezidbu i traktorska prikolica. Vrijednost ove poljoprivredne mehanizacije iznosi 432.160 kn od čega 204.400 kn otpada na vrijednost traktora. Vrijednost ulaganja u poljoprivrednu mehanizaciju je čak 4,1 puta veća kod suvremenog načina. Viša nabavna vrijednost poljoprivredne mehanizacije u značajnom udjelu iziskuje kreditno zaduživanje vinogradara, dok je cijena sata rada sa strojevima viša od 50 - 100% nego kod tradicionalnog načina uzgoja, ovisno o radnoj operaciji.

Tablica 1: Troškovi podizanja vinograda u pojedinom sustavu proizvodnje po godinama ulaganja

Godina ulaganja	Vrsta troška	Jed. mj.	Utrošak po ha		Vrijednost po ha (kn)	
			tradicionalni	suvremeni	tradicionalni	suvremeni
1.	Rad traktora i strojeva	sati	56	39,5	14.700	15.375
	Radna snaga	sati	30,5	15,5	1.220	620
	Materijalni troškovi	-			4.000	2.800
	Ukupno		80,5	55	19.920	18.795
2.	Rad traktora i strojeva	sati	71	52	7.100	11.300
	Radna snaga	sati	209	114	8.360	4.560
	Materijalni troškovi	-			36.062	41.312
	Ukupno		280	166	51.522	57.172
3.	Rad traktora i strojeva	sati	39,5	52,5	3.950	11.025
	Radna snaga	sati	443	226	17.720	9.640
	Materijalni troškovi	-			17.442	22.347
	Ukupno		482,5	278,5	39.112	43.012
4.	Rad traktora i strojeva	sati	38	40,5	3.800	6.075
	Radna snaga	sati	300	261	12.000	10.440
	Materijalni troškovi	-			2.795	2.795
	Ukupno		385	339,5	18.595	19.310
Sveukupno					129.149	138.289

Izvor: Istraživanje autora

Utrošak rada ljudi u tradicionalnom načinu podizanja vinograda je za 37,3%, a utrošak rada sa strojeva za 9,8% veći nego kod primjene suvremenih metoda što može negativno utjecati na optimalnost rokova i ukupnu uspješnost izvođenja pojedinih agrotehničkih zahvata. U godini pripreme zemljišta za sadnju (1. godina ulaganja) kod tradicionalnog načina je utrošeno za 29,5% više vremena rada sa strojevima i za 50% više rada ljudi na što je u najvećoj mjeri utjecalo ručno razbacivanje gnojiva za meliorativnu gnojidbu. Nasuprot tome, cijena sata rada sa strojevima je za 67% viša kod suvremenog vinogradarstva zbog njihove više amortizacijske kvote. U drugoj godini ulaganja je najvažnija razlika u postupku sadnje vinove loze koja se u suvremenom vinogradarstvu obavlja strojno koja je financijski gledano jeftinija 8,6% uz istovremeno 20 puta manji utrošak ljudskog rada. Gnojidba stajnjakom je tradicionalno vršena ručnim razbacivanjem u sadni jarak prije sadnje za što je potrebno 71,5% više vremena i predstavlja 62,3% veći trošak nego kod se stajnjak sa rasipačem razbacuje širom. Za potporanj mladoj lozi u suvremenom uzgoju koriste se željezne šipke koje su 2,5 puta skuplje o drvenih kolaca. U trećoj godini ulaganja najznačajnija razlika evidentirana je u troškovima postavljanja armature. Iako se koriste stupovi od istog materijala (bagrem) tradicionalni način njihovog postavljanja (ručno zabijanje maljem) iziskuje čak 9 puta veći utrošak ljudskog rada.

Tablica 2: Direktni troškovi u pojedinom sustavu proizvodnje u rodnom nasadu vinograda

Red. br.	Vrsta troška	Jed. mj.	Utrošak po ha		Cijena po jed (kn)		Vrijednost (kn)	
			tradic.	suvrem.	tradic.	suvrem.	tradic.	suvrem.
I	Rad sa strojevima							
1.	Gnojidba	sati	4	2	100	150	400	300
2.	Jesenska obrada	sati	6	4	100	150	600	600
3.	Mljevenje rozgve	sati		2		150		300
4.	Vršikanje - 2x	sati		8		150		1.200
5.	Kultivacija - 4x	sati	16	16	100	150	1.600	2.400
6.	Sumporenje - 2x	sati		2		150		300
7.	Prskanje	sati	6	8	100	150	600	1.200
	Ukupno	sati	32	40			3.200	6.300
II	Rad ljudi							
1.	Rezidba	sati	36	36	40	40	1.440	1.440
2.	Iznošenje rozgve	sati	35		40		1.400	
3.	Kopanje - 3x	sati	105		40		4.200	
4.	Vezivanje	sati	35	35	40	40	1.400	1.400
5.	Plijevljenje - 2 x	sati	80	80	40	40	3.200	3.200
6.	Vršikanje - 2x	sati	45		40		1.800	
7.	Sumporenje - 2x	sati	18		40		720	
8.	Berba grožđa	sati	220	220	40	40	8.800	8.800
	Ukupno	sati	574	371			22.960	14.840
III	Materijali							
1.	KAN	kg	200	150	2,80	2,80	560	420
2.	NPK 7-20-30	kg	400	300	4	4	1.600	1.200
3.	Modra galica	kg	32	16	30	30	960	480
4.	Sumpor	kg	90	90	3,50	3,50	315	315
5.	Mikal	kg		5		130		650
6.	Dithane M45	kg	2	2	66	66	132	132
7.	Ultracid	lit	3	3	79	79	237	237
8.	Hercules 480	lit.		4		85		340
	Ukupno						3.804	3.774
	Sveukupno						29.964	24.914

Utrošak rada sa strojevima je kod suvremenog načina uzgoja vinograda u rodu za 8 sati/ha ili za 25% veći nego u tradicionalnom uzgoju, ali je istovremeno utrošak rada ljudi niži za 203 sata/ha. Radnje čijim se mehaniziranjem ostvaruje znatna ušteda sati rada ljudi su mljevenje rozgve, zelena rezidba - vršikanje i sumporanje. Promatrano financijski ušteda u izvođenju ove tri radne operacije u suvremenom načinu proizvodnje iznosi 2.120 kn/ha. Nadalje, visoki udio od ukupnog utroška rada ljudi u tradicionalnoj tehnologiji otpadao je na okopavanje trseva, dok se u suvremenom vinogradarstvu taj problem rješava herbicidima što rezultira uštedom od 3.860 kn/ha. Utrošci mineralnih gnojiva u tradicionalnom načinu uzgoja bili su veći za oko 25% te se može konstatirati da je postojalo njihovo neracionalno trošenje što je u prvom redu posljedica neprovođenja kemijske analize tla, a i činjenice da su ova gnojiva tada bila znatno jeftinija.

Tablica 3: Ocjene ekonomske uspješnosti po pojedinim sustavima vinogradarske proizvodnje

Red. broj	Ekonomski pokazatelj	Jed. mjere	Vrijednost po sustavu proizvodnje (po ha)	
			Tradicionalni	Suvremeni
1.	Utrošak rada ljudi u razdoblju podizanja vinograda	sati	982,5	616,5
2.	Utrošak rada strojeva u razdoblju podizanja vinograda	sati	204,5	184,5
3.	Iznos ulaganja u podizanje vinograda	kn	129.149	138.289
4.	Iznos ulaganja u poljoprivrednu mehanizaciju	kn	105.120	432.160
5.	Utrošak rada ljudi u rodnom vinogradu godišnje	sati	574	371
6.	Utrošak rada sa strojevima u rodnom vinogradu godišnje	sati	32	39
7.	Ukupni troškovi proizvodnje u rodnom vinogradu godišnje	kn	35.130	30.445
8.	Prosječni prinos grožđa	kg	13.000	12.000
9.	Prosječna prodajna cijena grožđa	kn	4,00	5,00
10.	Ukupni prihod vinogradarske proizvodnje godišnje	kn	52.000	60.000
11.	Dobit godišnje	kn	16.870	29.555
12.	Proizvodnost ljudskog rada	kn/sat	91	162
13.	Proizvodnost rada strojeva	kn/sat	1.625	1.538
14.	Ekonomičnost		1,48	1,97
15.	Rentabilnost ulaganja	%	7,2	5,2

Ukupni troškovi vinogradarske proizvodnje predstavljaju zbroj direktnih troškova i amortizacije koja kod tradicionalno podignutog vinograda iznosi 5.166 kn/ha, a suvremenog vinograda 5.532 kn/ha. Ukupni prihod je za 8.000 kn/ha viši u suvremenom načinu proizvodnje grožđa jer je ona orijentirana na niži prinos koji je preduvjet veće kvalitete i više prodajne cijene grožđa. Niži troškovi i viši prihod u suvremenom načinu proizvodnje grožđa rezultiraju višom dobiti. U suvremenom načinu proizvodnje proizvodnost ljudskog rada je za 43,8%, a proizvodnost rada strojeva je za 5,4% veća nego kod tradicionalnog načina proizvodnje. Ekonomičnost vinogradarske proizvodnje je kod suvremenog načina proizvodnje viša za 33%. Rentabilnost ulaganja ima kod suvremenog načina proizvodnje nižu stopu što je pokazatelj da su visoka ulaganja u poljoprivrednu mehanizaciju na proizvodnoj površini od 1 ha vinograda upitne ekonomske opravdanosti.

### Zaključak

Na osnovu ustanovljenih rezultata vidljivo je da je vinogradarstvo perspektivna grana poljoprivrede kod koje se modernizacijom tehnološkog procesa postiže značajno poboljšanje ekonomskih pokazatelja poslovanja. Suvremeni način proizvodnje podrazumijeva veću mehaniziranost radnih operacija čime je omogućeno da gospodarstvo s istim brojem radnika obrađuje veće vinogradarske površine. Stvaraju se pretpostavke za okrupnjivanje zemljišnih površina i specijaliziraju proizvodnje što su preduvjeti razvoja vrhunskih proizvoda s kojima se može biti konkurentno na globalnom tržištu. Nasuprot tome, tradicionalni načini proizvodnje se zbog ekonomskih interesa napuštaju, ali ostaje njihov značaj kao dio kulturne i povjesne baštine nekog prostora.

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# Analysis and comparison of prices of wine grapes and table wine in the Republic of Macedonia

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## Abstract

The aim of this paper was to analyse and compare the prices of wine grapes as well as of table wine in the Republic of Macedonia in the period 2003-2008, with emphasis on parity processing prices as a tool for planning the processing and marketing alternatives. The parity price of grapes processed into bulk and bottled wine was 0.22 euros/kg and 0.33 euros/kg, respectively, thus indicated economical justification. The thresh-hold parity prices of wine were under the franco winery prices; The margin was positive ranging from 0.06 to 0.13 euros/l for bulk wine; and 0.22 to 0.29 euros/l for bottled wine. The study highlights the sub-sector development prospects and could be used by the grape and wine industry stakeholders, as well as for further research in this field.

Key words: bottled table wine, bulk table wine, processing parity prices, purchase price, wine grapes.

## Introduction

Grape and wine production is traditionally an important segment of Macedonian agriculture, contributing with 18.2% to the gross domestic agricultural product (EAA, 2003-2008). The average area under grapes in the period 2003-2008 was 24 thousand hectares, producing 244.2 thousand tons annually (SSO, 2004-2009). Wine grapes take 70% of the total vineyards' area. Most of the grapes were processed into wine, and around 20% were exported as raw. In the same period, the wine production on annual level reached 88.9 million litres (SSO, 2004-2009). Wine is a major export commodity, recognised by the policy makers as one of the strategic agricultural products with strong development potential and competitiveness. In 2008, 70.3 million litres were exported with value of around 39 million euros i.e. 10.4% of the total value of agri-food exports (SSO, 2009). Since most of the Macedonian wine is exported as bulk, the reasoning of this study was to derive the additional value added by producing wine, both as bulk or bottled. One alternative for analysing the effect of procesing the grapes into wine is through processing parity prices. The aim of this paper was to provide an empirical analysis of the prices of wine grapes and table wine, with emphasis on parity processing prices as a tool for planning the processing and marketing alternatives. Theoretically, the study highlights the sub-sector development directions and prospects. The study can be used by the sub-sector stakeholders, as well as for further research in this field.

## Materials and methods

The main source of data with regard to the purchase prices were the annual and monthly reports from the State Statistical Office (SSO). The cost of production data for grapes were gathered through several surveys where panel data from family farmers were collected (Manevska-Tasevska 2010; Martinovska-Stojceska 2008). Three wineries provided data for calculation of the production cost of wine. The study was delimited

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only to wine grapes as raw material and table wine<sup>1</sup> as final product. The research period for this ex-post analysis was from 2003 to 2008.

The data were analysed using standard descriptive statistics. The cost of production values were calculated using analytical enterprise budgets based on full costs.

The processing prices of raw material and final product were calculated using various levels of grape purchase i.e. buy-out price ( $p_{1x}, p_{2x}, p_{3x}, \dots p_{nx}$ ) and wine purchase prices ( $p_{1y}, p_{2y}, p_{3y}, \dots p_{ny}$ ). Wine sold as bulk and bottled wine were distinguished as separate final products. The costs of processing were calculated per unit ( $t_y$ ). The yield ratio of grapes conversion to wine was determined as X:Y. The processing price per unit raw material - grapes (1) and the processing price of unit final product - wine (2) were calculated as follows (Milanov, Martinovska-Stojčeska, 2009):

$$p_x = \frac{Yp_y - Yt_y}{X} \quad (1) \quad p_y = \frac{X}{Y} p_x + t_y \quad (2)$$

## Results and discussion

The average quantity of the total grape purchase during the period from 2003 to 2008 was 69,261 tons, with an average value of 12.29 million euros (see Table 1). Approximately two-thirds of the total purchased quantity and value were produced at family farms with an average purchase price of 0.18 euro/kg, with moderate variation throughout the years.

**Table 1. Purchase quantity, value and price of grapes in the period 2003-2008**

Year/ indicator	Total purchase of grapes (in tons)	Purchase of grapes from family farms (in tons)	Total purchase of grapes (‘000 euros)	Purchases of grapes from family farms (‘000 euros)	Purchase price (euros/l)	Purchase price family farms (euros/l)
2003	117160	100200	21069	17971	0.18	0.18
2004	67769	49504	12153	8553	0.17	0.18
2005	94841	72980	14754	11528	0.16	0.16
2006	32367	11828	5535	2014	0.17	0.17
2007	75523	45581	14299	8748	0.19	0.19
2008	27906	12446	5931	2611	0.21	0.21
Average	69261	48757	12290	8571	0.18	0.18
Min	27906	11828	5535	2014	0.16	0.16
Max	117160	100200	21069	17971	0.21	0.21
St.dev.	31784	31427	5374	5410	0.02	0.02
CV	45.89	64.46	43.72	63.13	9.23	9.59

Source: SSO, SY 2004-2009; own calculations

The average quantity and value of the total wine purchase in the same period was 38.38 million litres, and 22.1 million euros, respectively (see table 2). The average purchase price was 0.59 euro per litter of wine. However, the price was presented as an aggregate price, without distinction between bulk and bottled wine. There is a slight downward trend in the purchase price throughout the years.

Parity prices are useful in terms of planning the processing and marketing alternatives, as well as calculation of the feasible returns. Processing (parity) prices can be calculated for the raw material used (i.e. grapes) and for the end processed product (i.e. wine). From processor’s perspective, the parity prices indicate the highest price to be paid for purchase of the raw material. From producer’s perspective, the parity prices support the decision whether the product should be sold as raw or processed.

As shown in table 3, the parity price of grapes processed into bulk wine was 0.22 euros/kg, which was higher than the average purchase price (ranging from 0.16 to 0.21 euros/kg from 2003-2008) and thus indicated economical justification. Moreover, the parity price of grapes processed into bottled wine was 0.33 euros/kg, suggesting even higher added value. The sensitivity of the grape parity prices was also tested by

<sup>1</sup> Table wine refers to wine without geographic origin label, exclusively made by wine grapes (varieties such as Smederevka and Vranec) and with alcohol amount of not less than nine percent.



increase/decrease of the franco winery prices of wine; hence, by lowering the prices of wine by 20%, the parity price of grapes would decrease below the level of the purchase price, indicating high sensitivity. The parity price of grapes processed into bulk wine is expectedly more sensitive to the change in wine prices. Higher prices of wine (franco winery) would proportionally increase the parity price of grapes.

**Table 2. Purchase quantity, value and price of wine in the period 2003-2008**

Year/ indicator	Total purchase of wine (in tons)	Total purchase of wine ('000 euros)	Purchase price (euros/l)
2003	26821	16470	0.61
2004	28009	18014	0.64
2005	33917	23398	0.69
2006	40977	25243	0.62
2007	46422	27916	0.60
2008	54151	21536	0.40
Average	38383	22096	0.59
Min	26821	16470	0.40
Max	54151	27916	0.69
St.dev.	9842	3960	0.09
CV	25.64	17.92	15.54

Source: SSO, SY 2004-2009; own calculations

**Table 3. Sensitivity of processing parity prices of 1 kg of grapes at bulk and bottle wine franco winery prices (in euros)**

	Franco-winery price of 1 l bulk wine ( $p_{y \text{ bulk}}$ )	Processing (parity) prices of 1 kg grapes ( $p_{x \text{ bulk}}$ )	Franco-winery price of 1 l bottled wine ( $p_{y \text{ bottled}}$ )	Processing (parity) prices of 1 kg grapes ( $p_{x \text{ bottled}}$ )
-20%	0.33	0.17	0.96	0.17
-10%	0.37	0.19	1.08	0.25
$\bar{X}$	0.41*	0.22	1.20*	0.33
+10%	0.45	0.25	1.32	0.41
+20%	0.49	0.28	1.44	0.49

Source: \*Winery data; own calculations

Three levels of prices were taken into consideration for calculation of the processing parity price of wine (see table 4). At cost of production of 0.13 euro/kg of grapes, the processing parity price of bulk wine was 0.28 euros/l and 0.91 euros/l for bottled wine, respectively. At purchase price level of 0.18 euro/kg of grapes, the processing parity price of bulk wine was 0.34 euros/l on average level and 0.35 euros/l on family farms level, followed by 0.98 euros/l for bottled wine.

The calculated wine production cost was 0.37 euros/l for bulk wine and 1,02 euros/l for bottled wine. The grapes as raw material are a major cost, with a share of 78% in bulk wine production and 43% in bottled wine production.

**Table 4. Processing parity prices of wine at different grape price levels (in euros)**

		( $p_x$ )	( $p_{y \text{ bulk}}$ )	( $p_{y \text{ bottled}}$ )
1	Cost of production* ( $p_{1x}$ )	0.13	0.28	0.91
2	Purchase price (average 2003-2008)** ( $p_{2x}$ )	0.18	0.34	0.98
3	Purchase price family farms (average 2003-2008)** ( $p_{3x}$ )	0.18	0.35	0.98

Source: \*Farm surveys \*\* SSO; own calculations

These processing parity prices ( $p_{y \text{ bulk}}$  and  $p_{y \text{ bottled}}$ ) could be regarded as thresh-hold or break-even prices i.e. the wine lowest selling price. When these prices were compared to the franco winery prices, the margin for bulk wine reached 0.13 euros/l at cost level or 0.06 euros/l at purchase level of grapes. The positive margin was even larger in the case of bottled wine, with net return of 0.29 euros/l at cost level or 0.22 euros/l at purchase level.

## Conclusion

This study analysed the prices of wine grapes and table wine in the Republic of Macedonia in the period 2003-2008. The additional value added attained by processing the grape into bulk and bottled wine was derived by using parity processing prices as a tool for planning the processing and marketing alternatives.

The study indicated economical justification of processing wine grapes both into bulk and bottled wine. The analysis showed that the average purchase price of grape was 0.18 euro/kg and the aggregated average purchase price of wine was 0.59 euro/l. The parity price of grapes processed into bulk wine was calculated at 0.22 euros/kg, i.e. 0.33 euros/kg for grapes processed into bottled wine. The thresh-hold analysis demonstrated that the parity prices of wine were moderately lower than the prices franco winery. This resulted into a positive margin of 0.13 euros per litre at production cost level or 0.06 euros per litre at purchase level for bulk wine. The margin was higher in the case of bottled wine with 0.29 euros per litre at production cost level or 0.22 euros per litre at purchase level for bottled wine, which provided a clear indication of the advantage of marketing bottled over bulk wine. Following these findings, it can be recommended that the sub-sector development should move into the direction of increasing the production quantities of bottled wine, which is in line with the country's agricultural policy strategy .

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# Poljoprivredno zemljište - čimbenik uspješnosti vinogradarske proizvodnje

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## Sažetak

Vinogradarski posjedi u Republici Hrvatskoj su usitnjeni te je njihovo povećanje preduvjet za specijalizaciju i ekonomski uspješno poslovanje gospodarstava. U tom procesu veliki potencijal leži u poljoprivrednom zemljištu u vlasništvu države koje se još uvijek u značajnom dijelu nalaze neobrađene. Cilj istraživanja je ustanoviti kako različiti načini stjecanja prava korištenja poljoprivrednog zemljišta utječu na financijski rezultat vinogradarske proizvodnje na primjeru dvaju gospodarstava koja se razlikuju po intenzivnosti svoje proizvodnje. Dobiveni su rezultati koji ukazuju da je za gospodarstva koja teže povećanju vinogradarskih površina ekonomski najprihvatljivije uzimanje poljoprivrednog zemljišta u dugogodišnji zakup. Tržna cijena za kupnju zemljišta kreće se u širokom rasponu. Izvršena ekonomska analiza vinogradarske proizvodnje u slučajevima kupnje zemljišta po cijeni od 5 kn/m<sup>2</sup> i 10 kn/m<sup>2</sup> pokazala je da najviša prihvatljiva cijena zemljišta ovisi o intenzivnosti i uspješnosti ove proizvodnje na pojedinom gospodarstvu.

Ključne riječi: državno poljoprivredno zemljište, zakup, prodaja, cijena

## Agricultural land - success factor in viticultural production

### Abstract

Viticulture estates in Croatia are very small in acreage and their increase is required for specialization and economically successful viticulture production. In this process, great potential is in the agricultural land owned by the state, which in considerable part is still uncultivated. The aim of this research is to determine how different ways of acquiring rights to use land affect the financial results of viticulture production in the case of two farms which differ in the intensity of their production. The results indicate that for the farms which tend to increase the vineyard area, taking agricultural land in lease is economically most acceptable. Market price for the purchase of agricultural land varies widely. The economic analysis of viticulture production in the case of land purchase price of 5 kn/m<sup>2</sup> and 10 kn/m<sup>2</sup> showed that the maximum acceptable price of land depends on the intensity and efficiency of production in each farm.

Key words: state-owned agricultural land, leasing, sale, price

### Uvod

Karakteristično za vinogradarsku proizvodnju u našoj zemlji je rascjepkanost zemljišnih površina tako da je prosječna površina nasada manja od 1 hektar (MPŠVG, 2004). Ukupna površina vinograda u Republici Hrvatskoj u 2008. godini iznosila je 32.741 ha što predstavlja 2,6% od ukupno korištenih poljoprivrednih površina i svega petinu površina vinograda koje su na ovim prostorima postojale na početku 20. stoljeća. U

2008. godini proizvedeno je 185.256 t grožđa iz čega proizlazi da prosječni prinos grožđa iznosi 5,66 t/ha odnosno 1,5 kg/trsu (Oplanić i sur. 2010). Najznačajnije i podesne poljoprivredne površine za uzgoj vinove loze nalaze se na onim proizvodnim prostorima na kojima se većina poljoprivrednih kultura ne može uzgajati (na brdovitim, višim terenima s južnom ekspozicijom), što je pogodna činjenica s obzirom da nema previše konkurentnih kultura (Milotić i sur. 2001). U posljednjih desetak godina, nakon propadanja plantaža društvenih vinograda, javlja se sve veći broj specijaliziranih vinogradara-vinara sa suvremenim nasadima i vrhunskom proizvodnjom vina. Oko 90% površina vinograda i proizvodnje grožđa je na obiteljskim poljoprivrednim gospodarstvima. Dob vinograda u prosijeku je 25 godina, s prorijeđenosti nasada oko 25% i stopom nestajanja nasada od 4% godišnje (Strategija razvitka RH, 2001). Jedan od najvećih, ako ne i najveći, problem u poljoprivredi (a time i u vinogradarstvu) predstavlja zemljište što je posljedica neodgovarajuće legislative oko nasljeđivanja, neriješeni imovinsko-pravni odnosi, visoki udjel državnog zemljišta, nerazvijeno tržište i slično (Strategija gospodarenja poljoprivrednim zemljištem u vlasništvu države, 2001). Strategijom raspolaganja poljoprivrednog zemljišta u vlasništvu države predviđena su dva osnovna načina korištenja: zakup i kupnja. Cilj istraživanja je ustanoviti kako različiti načini stjecanja prava korištenja poljoprivrednog zemljišta utječu na financijski rezultat vinogradarske proizvodnje na primjeru dvaju gospodarstava koja se razlikuju po intenzivnosti svoje proizvodnje.

### Materijal i metode

Analiza ekonomske uspješnosti vinogradarske proizvodnje s obzirom na različite načine stjecanja zemljišta izvršiti će se na primjeru dvaju gospodarstava kojima je vinogradarstvo primarna grana, ali se razlikuju prema intenzivnosti obavljanja ove proizvodnje. Podaci o ekonomskim obilježjima vinogradarsko-vinarske proizvodnje dobiveni su anketiranjem dvaju gospodarstava u Istri na kojima su prikupljeni podaci o tehnologiji, utrošcima inputa i cijenama. Podaci koji se iznose u radu odnose se na površinu od jednog hektara vinograda. Korištena je metoda kalkulacije pri čemu je prema vremenu vršena naknadna kalkulacija, prema području mikroekonomska i prema sadržaju analitička (Karić i Štefanić, 1999). Za utvrđivanje financijskog rezultata vinogradarske proizvodnje korištena je metoda troškova i koristi (Cost-benefit analiza). Cijena ljudskog rada, cijene materijala i prodajna cijena grožđa koje se koriste u kalkulacijama za oba gospodarstva ista. Cijena ljudskog rada iznosi 40 kn/sat, a prodajna cijena grožđa je 6 kn/kg. Podaci o raspolaganju poljoprivrednim zemljištem u vlasništvu države prikupljeni su anketiranjem u 8 jedinica lokalne samouprave na području Istre. Prikupljeni su podaci o tome da li se ovo zemljište prodaje ili daje u zakup, te po kojim cijenama.

### Rezultati i rasprava

Podaci koji su prikupljeni anketiranjem gradova i općina ukazuju da oni u pravilu veće komplekse poljoprivrednog zemljišta u vlasništvu države daju u zakup, dok su za prodaju namijenjene manje, izdvojene površine. Minimalne cijene prodaje i zakupa državnog poljoprivrednog zemljišta kreću se velikom rasponu budući da je njihovo formiranje u nadležnosti područne porezne uprave. Visina ovisi o prosječnoj cijeni po kojoj se je zemljištem na tom području trgovalo u proteklom razdoblju. Cijena zakupa se kreće od 0,05 - 0,20 kn/m<sup>2</sup> dok cijena zemljišta namjenjenog za prodaju iznosi od 4,00 - 15,00 kn/m<sup>2</sup>. Pored lokacije, na cijenu poljoprivrednog zemljišta utječe i njegova kategorija u katastarskoj zemljišta i njegovoj lokaciji. U analizi poslovanja gospodarstava koristiti će se cijena od 0,1 kn/m<sup>2</sup> godišnje u slučaju zakupa, odnosno cijene od 5 kn/m<sup>2</sup> i 10 kn/m<sup>2</sup> u slučaju kupnje zemljišta.

Gospodarstvo I je primjer ekstenzivne vinogradarske proizvodnje. Ima u vlasništvu vinograd površine 4,5 hektara, starosti 40 godina, koji je u cijelosti amortiziran. Sadašnja vrijednost dugotrajne imovine ovog gospodarstva (poljoprivredne mehanizacije) iznosi 150.000 kn. Prinos grožđa iznosi oko 6.500 kilograma po hektaru. Gospodarstvo je usmjereno na proizvodnju i prodaju grožđa te nema stalno zaposlenih radnika već po potrebi uzima sezonske radnike. U narednoj tablici prikazano je aktualno poslovanje gospodarstva, kao i simulacija poslovnog rezultata u slučaju da gospodarstvo zemljište za vinogradarsku proizvodnju ima u zakupu, odnosno da ga kupuje.

Izvršena ekonomska analiza ukazuje da je poslovanje gospodarstva I u situaciji posjedovanja vlastitog zemljišta pozitivno, odnosno da ostvaruje bruto dobit od 7.267 kn po hektaru. Koeficijent ekonomičnost od 1,20 ukazuje da ovakva proizvodnja ostvaruje izvjesnu akumulaciju koja se može iskoristiti za intenziviranje proizvodnog procesa. Rentabilnost ulaganja od 13,2% je visoka prvenstveno iz razloga što je nasad vinograda

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u cjelosti amortiziran tako da njegova vrijednost ne sudjeluje u formiranju sadašnje vrijednosti dugotrajne imovine gospodarstva. Vidljivo je da se financijska uspješnost poslovanja značajnije ne pogoršava u slučaju korištenja zemljišta kroz zakup. Međutim, u slučaju kupnje zemljišta po cijeni od 5 kn/m<sup>2</sup> poslovanje je na granici ekonomske opravdanosti budući da godišnja bruto dobit iznosi 474 kn/ha, ekonomičnost je 1,01 a rentabilnost 0,9%. U slučaju kupnje zemljišta po cijeni od 10 kn/m<sup>2</sup> vinogradarska proizvodnja na ovom gospodarstvu postaje ekonomski neuspješna jer ostvaruje gubitak od 5.683 kn/ha, ekonomičnost ima koeficijent 0,88 dok rentabilnost iznosi -10,4%.

Ovdje treba napomenuti da se u slučaju kupnje zemljišta sredstva osiguravaju putem bankovnog kredita čiji se godišnji troškovi izračunavaju na temelju kamate od 6% godišnje i roka otplate od 10 godina.

Gospodarstvo II primjenjuje intenzivniju vinogradarsku proizvodnju. Posjeduje 8,8 ha vinograda prosječne starosti 15 godina na kojemu postiže prosječni prinos grožđa od 11.000 kg/ha. Sadašnja vrijednost dugotrajne imovine gospodarstva II, u što je uključena vrijednost nasada i poljoprivredne mehanizacije, iznosi 540.000 kn.

**Tablica 1: Uspješnost vinogradarske proizvodnje na gospodarstvu I s obzirom na različite vlasničke oblike raspolaganja zemljištem**

Red broj	Ekonomska veličina	Vrijednost za 1 ha (u kn)
I	Ukupni prihod	43.409
II	Ukupni trošak	42.935
1	Rad traktora i usluge	4.263
2	Rad ljudi	14.495
3	Trošak materijala	6.893
4	Amortizacija	2.455
5	Osiguranje vinograda	4.545
6	Ostali izdaci u poslovanju	3.491
III	Bruto dobit kada se vinogradarska proizvodnja vrši na vlastitom zemljištu	7.267
7a	Godišnji trošak zakupa zemljišta	1.000
IIIa	Bruto dobit ako bi se vinogradarska proizvodnja vršila na zemljištu koje je u zakupu po cijeni od 0,1 kn/m <sup>2</sup>	6.267
7b	Godišnji trošak za kupnju zemljišta po cijeni od 5 kn/m <sup>2</sup>	6.793
IIIb	Bruto dobit ako bi se vinogradarska proizvodnja vršila na zemljištu koje se kupuje po cijeni od 5 kn/m <sup>2</sup>	474
7c	Godišnji trošak za kupnju zemljišta po cijeni od 10 kn/m <sup>2</sup>	12.950
IIIc	Bruto dobit ako bi se vinogradarska proizvodnja vršila na zemljištu koje se kupuje po cijeni od 10 kn/m <sup>2</sup>	- 5.683

Izvor: Istraživanje autora

**Tablica 2: Uspješnost vinogradarske proizvodnje na gospodarstvu II s obzirom na različite vlasničke oblike raspolaganja zemljištem**

Red broj	Ekonomska veličina	Vrijednost za 1 ha (u kn)
I	Ukupni prihod	68.500
II	Ukupni trošak	51.592
1	Rad traktora i usluge	6.390
2	Rad ljudi	17.280
3	Trošak materijala	8.272
4	Amortizacija	9.250
5	Osiguranje vinograda	6.600
6	Ostali izdaci u poslovanju	3.800
III	Bruto dobit kada se vinogradarska proizvodnja vrši na vlastitom zemljištu	16.908
7a	Godišnji trošak zakupa zemljišta	1.000
IIIa	Bruto dobit ako bi se vinogradarska proizvodnja vršila na zemljištu koje je u zakupu po cijeni od 0,1 kn/m <sup>2</sup>	15.908
7b	Godišnji trošak za kupnju zemljišta po cijeni od 5 kn/m <sup>2</sup>	6.793
IIIb	Bruto dobit ako bi se vinogradarska proizvodnja vršila na zemljištu koje se kupuje po cijeni od 5 kn/m <sup>2</sup>	10.115
7c	Godišnji trošak za kupnju zemljišta po cijeni od 10 kn/m <sup>2</sup>	12.950
IIIc	Bruto dobit ako bi se vinogradarska proizvodnja vršila na zemljištu koje se kupuje po cijeni od 10 kn/m <sup>2</sup>	3.958

Izvor: Istraživanje autora

Poslovanje gospodarstva II u slučaju kada vinogradarsku proizvodnju vrši na vlastitom zemljištu daje vrlo dobre ekonomske rezultate budući da godišnja bruto dobit iznosi 16.908 kn/ha, ekonomičnost ima koeficijent 1,33 a rentabilnost ulaganja iznosi 9,9%. Poslovanje ovog gospodarstva rezultira značajno većom dobiti po jedinici površine nego kod gospodarstva I što znači da ono ima i više mogućnosti za ulaganja u daljnje intenziviranje ove proizvodnje. Stopa rentabilnosti ulaganja je za 3,3 postotne jedinice niža nego kod gospodarstva I iz razloga jer ovo gospodarstvo raspolaže sa puno vrijednijom poljoprivrednom mehanizacijom, a nasadi vinograda samo su dijelom amortizirani. Ukoliko gospodarstvo za vinogradarsku proizvodnju koristi zemljište u zakupu, isplativost ove proizvodnje je neznatno manja, ekonomičnost iznosi 1,30 a rentabilnost je 9,2%. Kod ovog je gospodarstva prihvatljiva kupnja zemljišta po cijeni od 5 kn/m<sup>2</sup> i 10 kn/m<sup>2</sup> budući da se u oba slučaja ostvaruju pozitivni ekonomski pokazatelji. Ukoliko bi gospodarstvo kupovalo poljoprivredno zemljište po cijeni od 10 kn/m<sup>2</sup>, godišnji troškovi u njegovom poslovanju uvećavaju se za 12.950 kn/ha tako da se dobit značajno smanjuje, na 3.958 kn/ha. Ekonomičnost tada ima koeficijent 1,06 a rentabilnost ulaganja iznosi 2,1% što su granično prihvatljive vrijednosti koje ukazuju da je 10 kn/m<sup>2</sup> gornji iznos cijene za kupnju poljoprivrednog zemljišta koja je ekonomski prihvatljiva u vinogradarskoj proizvodnji.

### Zaključak

Rezultati istraživanja koji su prezentirani u ovom radu mogu se sažeti u sljedeće:

- na cijenu poljoprivrednog zemljišta, bilo da je riječ o zakupu ili prodaji, najviše utječe njegova lokacija, odnosno ovisi o tome na području koje jedinice lokalne samouprave se zemljište nalazi. Cijena također ovisi o kategoriji zemljišta i kvaliteti.
- gospodarstvo koje se bavi ekstenzivnom vinogradarskom proizvodnjom i postiže niske prinose najviša prihvatljiva cijena za kupnju poljoprivrednog zemljišta iznosi 5 kn/m<sup>2</sup>. Na takvom gospodarstvu prisutan je problem niskih prihoda i dobiti iz kojih se ne mogu pokriti dodatni izdaci koji bi proizašli iz više kupovne cijene zemljišta.
- na gospodarstvu sa suvremenom vinogradarskom proizvodnjom granično prihvatljiva cijena kupnje poljoprivrednog zemljišta iznosi 10 kn/m<sup>2</sup>. Kupnja poljoprivrednog zemljišta iziskuje velike troškove koji su ekonomski prihvatljivi samo gospodarstvima koja u vinogradarskoj proizvodnji ostvaruju visoke vrijednosti pokazatelja ekonomske uspješnosti.
- ukoliko gospodarstvo ne posjeduje vlastito zemljište, sa ekonomskog aspekta najprihvatljiviji način korištenja poljoprivrednog zemljišta je njegovo uzimanje u zakup na duže vremensko razdoblje, odnosno na razdoblje koliko će na njemu trajati eksploatacija nasada vinograda.

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# Impact of potassium fertilisation on grassland production costs

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## Abstract

Intensive potassium (K) fertilisation of grassland influences the increase of forage K content which may cause different diseases of dairy cows due to the large part of such forage in a ration. Too high levels of K fertilisation may negatively affect the yield and unnecessarily increase the forage production costs. On account of all that we decided to evaluate the height of grassland forage production costs at fertilisation with different K rate. Model calculations for farms made by Agricultural Institute of Slovenia were used as a tool for cost estimation. A model of hay production in the field (three cut use) was used with the variation of the quantity of K added and yield. The results have shown that the forage production costs at the fertilisation with 100 kg K<sub>2</sub>O/ha (rate with the optimum content of K in grassland forage for dairy cows) and by one tenth lower yield were lower by little more than 5% than the forage production costs of the initial model (8.5 ton DM/ha; 200 kg K<sub>2</sub>O/ha).

Key words: potassium, fertilisation, grassland feed, production cost

## Introduction

Intensive grassland forage (intensive fertilisation, early cut...) often contains too high levels of potassium (K) (Babnik et al., 2008), which is the most critical point in the feeding ration of dry cows and due to which metabolic diseases appear after calving (Curtis et al., 1984, Oetzel et al., 1988). This results in an increase of production costs and, as a rule, in a decrease of milk produced, both of them decreasing the production economy. Also, Bewley and Amaral-Phillips (2009) report about K surplus in forage as being the key problem of metabolic disorders, so that the strategy of reduction of metabolic diseases in cows should be based on the decrease of K content in rations before calving. Since the production of basic forage is intended for feeding in the entire production period, reduction of K content in forage and not in the feeding ration should be considered.

In spite of the fact that the results of monitoring of the Slovene grassland soil fertility sometimes indicate a poor supply with K available to plants (Sušin, 2001), the results obtained by chemical analyses of grass silage samples (Verbič, 2006) indicate high K content in silage. The two opposite facts are probably the consequence of the so-called luxury consumption of K by plants (Verbič, 2006, Funderburg et al., 2009). In this case the grassland often utilises more K than estimated on the basis of AL analyses of K accessible in soil. Due to the reasons mentioned above Babnik et al. (2008, 2009) warn that the supply of meadows with K should be evaluated also through K concentration in forage. According to the expert recommendations valid in Slovenia (Leskošek and Mihelič, 1998) when determining fertilisation rates, K fertilisation with regard to desired yield and K supply in soil is considered.

Investigation carried out by Babnik et al. (2009) indicated that in the field experiment with soil poor in supply of K the highest hay yield was obtained at the fertilisation with 150 kg K<sub>2</sub>O/ha with the forage containing 4 g K in one kg of dry matter more than the recommended upper limit of 20 g K in one kg of dry matter. The yield was on the same level as if it had been reached following the currently valid recommendations using 200 kg K<sub>2</sub>O/ha (Leskošek, 1993). At the same time it was established that by increasing the fertilisation intensity above 150 kg K<sub>2</sub>O/ha, the content of K available in soil and in forage increases while the yield decreases. With the fertilisation rate of 100 kg K<sub>2</sub>O/ha, which is only half of the

quantity currently recommended for the grassland fertilisation at the optimum K supply of soil, the dry matter yield was by 10% lower than the maximum reached yield, but in this case the forage K content was optimal (15 g K in one kg of dry matter). Based on the investigation results, Babnik et al. (2009) found out that even if soil supply of K is poor grassland required lower K rates than recommended. At the same time they report that for the evaluation of the actual K supply of grassland, K content in forage was a more reliable criterion; all this considered, more accurate recommendations should be prepared in order to reach desired quantities and optimum quality of forage and optimum value of K.

The investigations mentioned above have proved that the currently valid fertilisation rates for grassland fertilisation with K are probably too high both from the viewpoint of reaching the highest yield as that of the forage K content. Due to the significant effect of the fertilisation on the grassland forage production costs (Zbirnik rastlinskih kalkulacij, Modelna kalkulacija za seno..., 2008) and of the great part of such a forage in the ration of dairy cows as well as in total milk production costs (Volk, 2001), these at the first sight small changes in feed costs are severely reflected in the economy of milk production. Therefore, in the current paper we want to show to what extent the consideration of different fertilisation rates for K fertilisation influences the grassland forage production costs.

### Material and methods

The effect of K fertilisation on grassland forage production costs was evaluated using model calculations made for farms by Agricultural Institute of Slovenia (Rednak, 1998, Splošna metodološka izhodišča ..., 2008). It is a simulation model with functional dependencies built in, which, based on selected input technological parameters, allows estimation of input and work used, and along with that the total production costs of individual products. Production costs and values are evaluated according to prices valid in a certain period. For the needs of the current project, prices valid in 2009 were used for the calculation of production costs and value.

For the needs of the current project we made a model of hay production in the field, which envisages a three cut meadow with the expected yield of 8,500 kg of dry matter (DM) per hectare (basic model - M1) or - at 86% DM content in storage and losses at harvest (15%) - 8,400 kg net yield of hay per hectare. Models M2, M3 and M4 (Table 1) derive from the basic model. The difference between them exists in the quantity of fertilisers used and, in one case, in the size of yield expected (lower yield due to lower fertiliser rate). Similar to basic model, model M2 envisages fertilisation with slurry and fertilisation with mineral nitrogen (N) and phosphorous (P) fertilisers, but not fertilisation with mineral K. M2 is based on the presumption saying that in spite of the monitoring results of soil fertility of Slovene grassland indicating lack of K (Sušin, 2001), farmers decide to reduce the K fertilisation. Considering the farm management aspect they fertilise only with animal manure as they do not have the necessary land (mainly fields with field crops) for their application. In such a case, requirements for N and P are the only criterion for reaching the desired yield.

Table 1: Fertilising rates and fertilising management

Model	M1	M2	M3	M4
Yield (kg SS/ha)	8.500	8.500	8.500	7.650
Net yield of hay (kg/ha)	8.400	8.400	8.400	7.560
Fertilising rate (kg of nutrient/ha):				
N	150	150	150	150
P <sub>2</sub> O <sub>5</sub>	70	70	70	70
K <sub>2</sub> O	200	140*	150	100
Slurry (kg)	35.000	35.000	35.000	25.000
Fertilisers (kg)	328	182	202	365

\* Real use of only 140 kg K<sub>2</sub>O/ha from animal manure without adding K via mineral fertilisers

Model **M3** considers lower K requirements of grassland to reach the same yield as M1. The envisaged K requirements derive from the results of an investigation carried out by Babnik et al. (2009), in which the highest yield of 8.5 tons DM/ha and fertilisation with 150 kg K<sub>2</sub>O/ha was obtained on grassland poorly supplied with K. Based on investigation results concerning the impact of forage K content the optimal forage K content was determined. While data which could more accurately show the framework of fertilisation rates and yield with regard to optimal forage K content are fewer. In spite of that, **M4** model considered the recommendation of Babnik et al. concerning the optimal K content in grassland forage. It was reached at one



half lower fertilisation rate (100 kg K<sub>2</sub>O/ha) than the currently valid fertilisation recommendations. The quantity of K in this case allows 10% lower yield than that envisaged in the basic model M1.

In the basic M1 model, recommendations for grassland fertilisation are considered (Leskošek, 1993). In addition to that, the calculations take into account the quantity of fertilisers envisaged in frame of legal limits concerning the application of dangerous substances in the environment (Decree on the limit input concentration values ..., 2005) and for animal fertilisers the limit at the rate of stocking for sustainable animal breeding, which is 1.9 LU/ha (Slovene Agri - Environmental Programme ..., 2001). To reach the envisaged fertilisation rates in individual models, the quantities of mineral fertilisers required are calculated from the difference between the nutrient requirements of plants and nutrient quantities applied with slurry. Different quantities of slurry and mineral fertilisers result in differences of work generated from the preparation and application of all fertilisers while in the case of M4 model the use of work at harvest is different, too.

Changes occurring due to taking into account different fertilisation rates were evaluated on the basis of hay production costs. The height of costs in particular models and the changes between the basic model and other models (indexes of changes) are presented on the level of **total costs**. Fertiliser costs are indicated separately for mineral fertilisers and slurry. The results are also presented on the level of **total costs reduced by subsidies** (regional payment for grassland and repayment of part of the excise duty for fuels) and on the level of **total costs per product unit reduced by subsidies** (production price).

### Results and Discussion

Planning of fertilisation results in a more rational utilisation of fertilisers and changes in production costs which is presented in table 2. The results indicate that the costs of grassland forage production are lower if the use of fertilisers is lower. This is also true in the M4 model which anticipates by one tenth lower yield due to a lower K dose.

**Table 2: Cost estimate of three cut hay production according to different fertilisation management and production intensity (EUR)**

Model	M1	M2	M3	M4	Index_M2 M1	Index_M3 M1	Index_M4 M1
Yield (kg DM/ha)	8.500	8.500	8.500	7.650	100,0	100,0	90,0
Total costs	2.039	1.923	1.946	1.796	94,3	95,4	88,1
of this: total fertilisers	572	472	487	413	82,6	85,1	72,1
mineral fertilisers	157	57	72	116	36,4	45,8	74,0
slurry	415	415	415	296	100,0	100,0	71,4
Subsidies	393	392	393	390	99,9	100,0	99,2
Costs, reduced by subsidies	1.647	1.531	1.553	1.407	93,0	94,3	85,4
<i>Costs, reduced by subsidies/kg</i>	0,196	0,182	0,185	0,186	93,0	94,3	94,9

Source: Model calculations by Agricultural Institute of Slovenia

The highest fertilisation costs as well as the highest production price of produced forage was evaluated for the initial model M1 (fertilisation with 200 kg K<sub>2</sub>O/ha). The fertilisation costs in the model M1 are by 15%, 17% and 28% higher than in models M3, M2 and M4 while the costs reduced by subsidies per production unit in models M3, M2 and M4 are lower by 7%, less than 6% and more than 5%.

The costs of hay production are the lowest in the model M2 in which only fertilisation with K from animal fertilisers was expected. Further estimates indicate that the production price of hay in the case of the lowest fertilisation dose (100 kg K<sub>2</sub>O/ha) and at the yield lower by one tenth are on the similar level as at the fertilisation norm of 150 kg K<sub>2</sub>O/ha.

According to the estimations of grassland forage production the differences in the production price between models M2, M3 and M4 are small. Due to important share of grassland forage in feeding ration in the total costs of milk and meat production even the small differences between production prices importantly affect the economy of production.

## Conclusions

Excessive K content in the forage of dairy cows during lactation is not problematic, but feeding such forage in the dry off time may lead to health problems of dairy cows after calving. Since in the practice we are often confronted with difficulties in the separation of grassland forage (later harvested forage contains less K), beside lower production costs, this is an additional reason for taking into account recommendations indicating that for cows the optimal forage K content is reached at half lower fertilisation rates than the currently valid recommendations (100 kg K<sub>2</sub>O/ha). Fertilisation with 100 kg K<sub>2</sub>O/ha does not allow reaching the highest yields (10% lower yield), but the costs of grassland forage production decrease faster (lower fertilisation costs) than the yield decreases. At the fertilisation rate which still allows the highest yield of grassland forage (150 kg K<sub>2</sub>O/ha) as also at fertilisation rate of 100 kg K<sub>2</sub>O/ha, the calculated forage price is significantly lower than the price calculated according to the current recommendations for K fertilisation.

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# Protected Geographical Indications as a tool for valorising traditional and typical agro-food products and improving rural livelihoods in Serbia: Case of “Pirotski Kachkaval” cheese from Stara Planina region

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## Abstract

Typical and traditional agro-food products have become synonymous of sustainable food and have an important place in people's life. However, many of them risk to be lost if they are not protected properly. Evidence from the EU countries showed that that can be achieved through Protected Geographical Indications (PGI). This work aims at analysing how PGI can allow preserving and valorising traditional Pirotski Kachkaval (PK) cheese from Stara Planina region. The paper is based on literature, and SWOT and stakeholder analyses. Valorisation of PK is important for preserving Karakachan culture and identity, Karakachan sheep and flora biodiversity, and sustainable development of local rural communities.

Key words: geographical indications, Pirotski Kachkaval, Serbia

## Introduction

Diffusion of labelled, branded and certified food consumption is a major trend that was mainly driven by changes in consumer attitude towards health and food safety. There is a stronger relationship between tradition, culture, health and traditional food. Nowadays, traditional products valorise local knowledge and are safer thanks to technological and scientific advances. Typical products demand increased also due to market changes determined by globalization, urbanization, and rural and regional development policies. High production costs increase sale prices. Traditional products are produced by small producers that can not always insure a regular supply. Communication media and methods are, sometimes, inadequate and information provided to potential consumers is, often, insufficient. Globalization, competition and changing consumption habits can cause disappearance of local culture, identity and knowledge linked to traditional foods and drinks. Many countries are trying to protect their agro-food heritage and customs. Consumers in the EU show an increasing interest in Protected Geographical Indications (PGI) products. Their number has increased significantly, over the last decade, and market is growing (EC, 2007). GI products receive premium prices, generate higher incomes to small producers and have significant economic and social impacts on many territories of the EU (Stojkovic, 2009). Case studies carried out by the JRC/IPTS showed that food quality assurance and certification schemes, including GI, can bring about significant multifaceted benefits not only to farmers and producers but also to retailers, consumers, rural areas and the society as a whole. However, the same case studies showed also that they may but not necessarily do improve the income of producers, especially small-scale ones, because benefits are not evenly distributed among the actors the value/supply chain and also because they can imply higher investment and certification costs (Gay, 2007). However, it is not clear if similar results can be achieved in Serbia.

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Many Serbian authentic agro-food products risk to be lost if they are not properly protected. A new Law on Indications of Geographical Origin was issued in 2010 (Official Gazette of the Republic of Serbia No.18/2010) but geographical indications of typical products are not well developed and exhaustive studies on their social and economical benefits are missing. The main problems are lack of knowledge, information, organizational and marketing skills, financial resources, institutional support and an effective control system. In this paper is presented a case study about valorisation of “Pirotski Kachkaval” (PK) hard cheese which is produced in Stara Planina (SP) mountainous region, south-eastern Serbia.

The objective of this work is to provide insights into the determinants of PK cheese choice by consumers, its availability as well as regulatory and legislative tools to protect it and their possible economical and societal benefits and impacts. The paper also analyses whether PK cheese has an appropriate marketing mix and a successful marketing plan. Some proposals have been made to improve PK marketing and to protect it through GI.

### Material and methods

The work has been based on an extensive desk research and field visits that aimed at getting more familiar with production practices and PK cheese producers’ living conditions. Desk research has been focused on collection and analysis of available data on the main actors and organizations involved in geographical indication programs in Serbia and research papers and literature about PK cheese and Karakachan sheep and people. The paper deals mainly with descriptive methods. SWOT analysis has been used. PK protection effects were considered not only on producers but on all actors dealing with PK production and marketing. Linkages between all stakeholders and their roles have been analyzed as well.

### Results and discussion

The story of PK cheese production in SP is strongly linked to that of nomadic sheep breeders, known as “Crnovuci” or “Karakachani” (Black-wool people) (Dervisis et al., 2006). Nomads in the Balkans developed centuries ago Kachkaval cheese production. Kachkaval was made exclusively from sheep milk, during the grazing period (May-September) in “Bačija” (Bachija) dairies. In 1903, 160 wagons of Kachkaval were exported to Vienna and Budapest. “Bachija” dairy represents cooperative organization for joint sheep keeping, grazing, production and processing of all products (e.g. wool, meat and milk) (Stojanovic & Katic, 2003). Production of PK was the same at all “Bachija” dairies on SP. Processing of milk was carried out in wood tubs containing warm water and “Bachija” dairies had tables for arrangement, salting and ripening of cheese (Dozet et al., 1996). PK cheese is well known in Serbia but no serious efforts have been made to further promote it and link it with SP region. Nowadays, it is very difficult to find this cheese in the market. Therefore, traditional Kachkaval risk to disappear. There are few “Bačija” dairies in SP which are producing traditionally Kachkaval. The main characteristic that defines the unique quality of traditional Kachkaval comes from authentic Karakachan (Karakacaan) sheep breed, specificities of SP region, and natural and unpolluted pastures (Mijacevic & Bulajic, 2002). Nomadic way of sheep breeding with constant movement at large distances and difficult climatic and environmental mountain conditions created, certainly, this very resistant sheep breed (Dervisis et al., 2006). SP is a mountainous region where there is a long tradition of sheep milk and cheese production. It has a high biodiversity and a specific “Terroir” giving special attributes to Kachkaval cheese. However, changes in animal breeding conditions and increasing number of cattle in this region led to a significant reduction in sheep number and, consequently, Kachkaval production decrease. In nearest past there was approximately 500,000 sheep but today they are a few thousands (Ivanov, 2005; Mijacevic & Bulajic, 2002). This cheese is also known as Pirotski Kačkavalj (Kachkaval), Pirot is a big city in SP region. Nowadays, cheese made from any kind of milk from this region is called Kachkaval and there is, even, a risk that “Kachkaval” becomes a generic word for all hard cheeses from Serbia. In Tzintzar language the word “Kach” means cheese (Mijacevic & Bulajic, 2002). Kachkaval production skills and knowledge had passed on to the people of SP, who improved it to the perfection and kept it until today (Petrovic, 1997). PK high quality is due to the specificity of SP geographical area, including human and natural factors (Mijacevic et al., 2005). Production and ripening in SP give a typical spicy and salty taste to PK. Revitalizing the traditional Kachkaval production also means preserving SP region cultural identity (Mijacevic & Bulajic, 2002). Strengths, weaknesses, opportunities and threats of PK are presented in table 1.

Table 1. SWOT analysis of Pirotski Kachkaval hard cheese from Stara Planina region.

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>- Ideal climatic and environmental conditions (plant biodiversity, climate, altitude);</li> <li>- Very appreciated PK characteristics (colour, flavour, hardness, etc.) by consumers;</li> <li>- PK uniqueness and authenticity;</li> <li>- Traditional (artesian) production methods and high producers' commitment;</li> <li>- Strong market recognition of PK as a high value product;</li> <li>- PK helps protecting high value ecosystem;</li> <li>- Price premium for most producers;</li> <li>- Karakachan sheep have very low breeding costs and are resistant to diseases.</li> </ul>	<ul style="list-style-type: none"> <li>- Low producer income: Low sale prices and high production costs;</li> <li>- Enormous fragmentation and absence of producers' associations for collective production and marketing;</li> <li>- No production insurance system;</li> <li>- Lack of knowledge to improve PK quality and of a standardized production procedure;</li> <li>- Absence of an annual production plan;</li> <li>- Insufficient marketing skills and marketing problems;</li> <li>- Limited milk production (small herds and low productivity) and decreasing Bachija dairies number not allowing a regular supply;</li> <li>- Lack of knowledge and financial means for PK packaging, labelling and/or branding.</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>- Existence of EU pre-accession funds supporting local products valorisation;</li> <li>- Positive trend of dairy products market;</li> <li>- EU-recognized labelling authority was recently established;</li> <li>- Increasing interest of consumers and development agencies;</li> <li>- Increasing demand for traditional products and possibility to develop export;</li> <li>- NGOs and agencies support dairy sector;</li> <li>- Product promotion through rural tourism.</li> </ul>	<ul style="list-style-type: none"> <li>- Conflicts among stakeholders;</li> <li>- Instability of markets and prices volatility;</li> <li>- Changes in climate conditions and new sheep diseases;</li> <li>- Limited differentiation and innovation;</li> <li>- Interbreeding with other sheep breeds;</li> <li>- High competition with speciality cheeses;</li> <li>- Slow implementation of rural development policies;</li> <li>- Migration of sheep breeders and loss of traditional production knowhow;</li> <li>- “Kachkaval” refers generically to all hard cheeses;</li> <li>- Weak infrastructure making hard market access.</li> </ul>

Objectives of any integrated strategy for the valorisation and protection of PK should be conserving traditional production methods and skills; protecting its name and reference to its origin by developing a PGI, stopping fraud and imitation and preserving Karacharan sheep. The ultimate objective should be to improve milk and PK cheese producers' income and living conditions in SP region, and preserving of heritage and culture of Karakachan people. Specific objectives could be to promote the production of PK through adding value by processing and marketing activities; improving PK quality; insuring higher prices to producers; improving producers' access to markets, etc. For achieving these objectives many activities should be carried out: PK producers' and consumers' awareness raising about importance of PK preservation; establishing working groups for the preparation of a Code of Practices for PK production; meeting with stakeholders to define all the aspects of certification; establishing milk and PK cheese producers' associations and a consortium for the promotion of PK; training sessions for milk and cheese producers to improve PK quality; organization of promotional events; improvement of producers' linkages with buyers and consumers; standardizing and homogenising PK quality, etc. In order to achieve these objectives many public, private and civil society stakeholders should be involved (Box 1). The success of such an initiative depends on many factors such as institutional and governmental support; producers' willingness to participate, to create associations, to attend training sessions and other promotional activities and to adopt the Code of Practices; local restaurants willingness to promote PK and to pay good prices to producers; etc. Risks that can hinder this initiative include also all the threats identified thanks to SWOT analysis.

Box 1. Roles of actors that should be involved for the preservation and valorisation of PK.

- Karachan sheep breeders and PK producers: Producers and breeders from Rsovci, Dojkinci, Topli Do and Visocka Rzana villages in SP and Pirot city need knowledge and technical assistance for standardizing PK production process and improving its quality and for preserving Karakachan sheep.
- Agricultural Institute of Dimitrovgrad: It can provide technical assistance on all the production stages (fermentation, ageing, storage, etc.) and carry out PK analyses.
- Food and Veterinary Agency: It can set up the Code of Practices for PK production.

- NGOs and other organisations (e.g. “Natura Balkanika”): They need help to improve promotion and support actions. Some NGOs already had been involved in establishing producers’ groups and improving PK quality.
- Media (e.g. Radio Television of Serbia (RTS), Pirot TV, “Kanal PI”, etc.): They can contribute to PK promotion and Karakachan sheep preservation at local and regional levels.
- Municipality of Pirot: It coordinates the work of agencies and NGOs and improves rural and market infrastructures. It can provide subsidies to PK producers, support organization of promotional events (e.g. fairs, exhibitions, etc.) and contribute to the PGI implementation.
- Rural Advisory Agency: It can provide producers with knowledge on best practices and new technologies, and support the supply chain development.
- Restaurants and ethno houses: They are main promoters of typical products but need help for creating a better and direct connection with PK producers.
- Ministry of Agriculture, Forestry and Water Management (MAFWM): It has a plan for preservation of Karakachan sheep and can provide financial and technical support to breeders.
- Ministry of Tourism: It can promote rural tourism in the region.
- Consumer associations: They can raise awareness and inform consumers about existing PK imitations and frauds.
- Ministry of Environment: It can help in conservation of pastures and forests in SP

### Conclusions

Many years of neglect led to a significant reduction of Karakachan sheep herd, “Bachija” dairies number and PK production. There is an unbreakable connection between protection of PK cheese, Karakachan sheep and Karakachan people, that create a unique heritage that should be conserved. Already famous Kachkaval from Senokos and Dojkinci villages justify the protection of PK with a geographical origin label. Tests proved that all characteristics of traditional PK cheese are kept thus satisfying requisites for obtaining a GI label. PK cheese certification and protection is vital because it will guarantee an adequate profit for producers and benefits for SP as a whole. For that a consortium for PK promotion including producers, local government, competent ministries, supporting institutions and private operators should be established. Organisation of PK producers in associations can improve their incomes through a better marketing strategy (higher prices, better access to markets, standardized product quality, etc.) that can also increase consumers’ awareness. Main objectives of any strategy should be protection and stopping imitation of PK and preservation of Karacharan sheep and traditional methods of production. Valorisation of PK cheese by processing and marketing activities means also improving Karakachan people’s living quality and preservation of their heritage and culture. Future projects can be designed taking into account that the MAFWM has already a plan for preserving Karakachan sheep. This case study can be useful for the valorisation of other typical and traditional agro-food products in Serbia.

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# Razvoj ruralnog turizma kroz osnivanje klastera - primjer regionalno-turističkog klastera “Kuna”

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## Sažetak

U radu se prikazuje primjer udruživanja poduzetnika u regionalno-turistički klaster “Kuna” na području gradova Pakraca i Lipika, kako bi kroz ruralni turizam unaprijedili i proširili svoje poslovanje. S obzirom da je osnivanje klastera u Hrvatskoj u samom začetku, a naročito u ruralnom turizmu, cilj rada je kroz intervju s članovima klastera napraviti SWOT analizu odnosno prikazati pozitivne i negativne elemente ovog oblika udruživanja.

Istraživanje je pokazalo da će s vremenom buduću odgovornost za uspješno poslovanje klastera morati preuzeti sami članovi, jer još uvijek najveću organizacijsku ulogu u razvoju analiziranog klastera ima Poduzetnički centar Pakrac. Ipak, ključnu ulogu u daljnjem razvoju klastera imati će budući upravitelj klastera, koji bi trebao iskoristiti sadašnje prednosti i buduće prilike klastera u prepoznatljivosti ruralno turističke ponude na stranom i domaćem tržištu.

Ključne riječi: klasteri, regionalno-turistički klaster, razvoj ruralnog turizma, upravitelj klastera

## Rural tourism development through establishment of cluster - example of regional-tourism cluster “Kuna”

### Abstract

This paper shows an example of good practice when entrepreneurs join in “Kuna” regional-tourism cluster in the area of towns Pakrac and Lipik, in order to improve and expand their business using rural tourism. Considering the fact that cluster formation in Croatia is in the early days, particularly clusters in rural tourism, the task of this paper is to describe positive and negative elements of this form of association interviewing the members and doing SWOT analysis.

For the time being, Pakrac Entrepreneurial Centre has the biggest organisational part in development of analysed cluster. However, the research has shown that with time, the members themselves will have to take future responsibility for successful cluster management. Still, the future cluster manager will play the key role in cluster development and use the present advantages and future cluster opportunities, so that he recognises offer of rural tourism on domestic and foreign market.

Key words: cluster, regional-tourism cluster, development of rural tourism, cluster manager



## Uvod

Poduzetnici koji danas posluju na području gradova Pakraca i Lipika većinom spadaju u male poduzetnike odnosno mala obiteljska poljoprivredna gospodarstva, koja ne mogu ponuditi objedinjenu turističku ponudu. Stoga se javila želja i potreba za udruživanjem nekolicine poduzetnika koji su turističku djelatnost prepoznali kao mogućnost implementacije vlastitih poduzetničkih ideja kroz plasman svojih proizvoda i usluga. Osnivanje regionalno-turističkog klastera iskazala se kao jedno od najboljih rješenja problema i organizacijski oblik za postizanje što boljih rezultata u budućoj zajedničkoj turističkoj ponudi.

Kao ključni pojmovi u definiranju klastera najčešće se spominju zajednički proizvodi, zemljopisna koncentracija, međusobna povezanost, specijalizacija, aktivna uključenost obrazovnih institucija i državnih tijela, te zajednička tržišta (Horvat, 2006). Stoga se klasteri mogu definirati kao zemljopisna koncentracija međusobno povezanih poduzeća i institucija u određenoj gospodarskoj grani (Porter, 2010).

Turistički klaster predstavlja zajedništvo inicijative privatnog i javnog sektora, a samim time i cijelog niza subjekata koji su povezani s turističkom djelatnošću i time pridonose uspostavi klastera. Te tvrtke zajedno čine veću vrijednost za kompletnu turističku destinaciju, nego pojedinačni gospodarski subjekt budući da na taj način tvore sinergiju više elemenata (Podoljak, 2010). Kao osnovne prepreke ovakvog oblika udruženja najčešće se ističu nedostatak zajedništva i suradnje među članicama, nestandardizacija ponude, te nedostatak financijskih sredstava, ljudskih resursa, institucionalne i zakonske podrške. Suprotno navedenom, kao pozitivni razlozi sudjelovanja u klasteru najčešće se spominje zajednički nastup na tržištu, smanjenje troškova, integriranje ponude, zajednički marketing, edukacija članova i veći utjecaj na poslovno okruženje (Podoljak, 2010).

Meler i Horvat (2007) naglašavaju da ruralni turizam u Hrvatskoj nema važnost koju nesporno zaslužuje, osobito u odnosu na postojeća globalna kretanja na tom području. Razlog tomu autori vide u činjenici da ruralni turizam nije organiziran, odnosno strukturiran na način kako su to učinile zemlje koje su na tom polju daleko naprednije (Francuska, Austrija, Italija). Stoga kao jedan od načina predlažu strukturiranje ruralnog turizma kroz proces klasterizacije, odnosno proces poticanja i razvijanja klastera. Također i Hak (2010) ističe slab razvoj ruralnih krajeva koji povezuje sa slabim razvojem ruralnog turizma, pa predlaže razvoj klastera u ruralnom prostoru odnosno organiziranje turističkih subjekata kako bi se međusobnom suradnjom stvorila posebna turistička ponuda.

U Hrvatskoj danas postoje brojne inicijative udruživanja poduzetnika u klaster<sup>1</sup>, međutim još uvijek ne postoji osmišljen i sustavni pristup njihovom razvoju, te nije dovoljno osviještena spoznaja o potrebi udruživanja poduzetnika u klaster kao mogućeg odgovora na izazove rastuće globalizacije (Lacković, Stavlić, 2008.).

## Materijali i metode

U radu se prikazuje regionalno-turistički klaster "Kuna" (klaster "Kuna") kao primjer dobre prakse udruživanja poduzetnika, kako bi kroz ruralni turizam unaprijedili i proširili svoje poslovanje. Klaster "Kuna" sastoji se od jedanaest članova kojih čine šest obiteljskih poljoprivrednih gospodarstava, poljoprivredni obrt, trgovački obrt, biciklistički klub, planinarsko društvo i tiskara. S članovima klastera obavljen je intervju kako bi se dobio uvid u prednosti, nedostake, prilike i prijetnje takvog oblika udruživanja na temelju četiri glavna pitanja: "Koji su trenutni potencijali i mogućnosti razvoja svakog člana? Što svaki

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<sup>1</sup> Npr. prijedlog organiziranja klastera turističke ponude Grada Đakova čime bi se postigla organizirana ponuda svih sadržaja značajnih za lokalne proizvođače tradicionalnih gastronomskih proizvoda (kulena, slavonske šunke i dr.), proizvođače vina, suvenira i rukotvorina, proizvođače opreme za konje, kovača jedinog u istočnoj Hrvatskoj i drugo, te bi se na taj način postigao rast zaposlenosti na tom području (Mašek, Križanović, 2010). Također i na području Valpovštine postoji inicijativa za osnivanjem poslovnog klastera koji bi omogućio paralelan razvoj više različitih agroturističkih djelatnosti, primjerice: pokretanje lokalne turističke agencije koja bi imala za cilj nuditi agroturističke aranžmane lokalnog područja; izgradnju ekonomskog dvorišta ili više njih s ciljem razvitka proizvodnje autohtonih, ekoloških i atraktivnih proizvoda lokalnog područja; razvitak knjigovodstvenih i savjetodavnih usluga za članove klastera; razvoj lokalnog poduzetničkog inkubatora za agroturizam i slično, što je prepoznato i od strane lokalne uprave i lokalnog stanovništva kao mogućnost razvijanja novih radnih mjesta, posebno u selima (Tolić, Pušić, 2010).

član donosi u klaster? Što svaki član očekuje od rada klastera? Kakvu će korist imati od klastera i klaster od njih?”

Na osnovu tih pitanja napravljena je SWOT<sup>2</sup> analiza, te se predlažu mogućnosti daljnjeg razvoja klastera “Kuna” kroz prepoznatljive turističke aranžmane na domaćem i stranom tržištu, uz naglasak na elemente atraktivnosti Požeško-slavonske županije.

### Rezultati i rasprava

Prema Regionalno operativnom programu Požeško-slavonske županije potencijal Županije je znatan baš kao i poteškoće kao što su visoka nezaposlenost, niski prihodi, nedostatak komercijalnih ulaganja i neadekvatna fizička, gospodarska i socijalna infrastruktura. Stoga se očekuje da će politika klastera predstavljati vodeći koncept regionalnog poticanja gospodarstva kroz ruralni turizam. Udruživanjem u klaster očekuje se iskorištavanje poduzetničko-turističkih mogućnosti koje su svakom članu pojedinačno nedostupne te predstavlja suradnju u kojoj će članovi zadržati svoju samostalnost i vlastitu kreaciju, pa stoga neće biti samo partneri nego i konkurenti. Za očekivati je da će se povećati pojedinačni naponi za poboljšanje vlastitog proizvoda i usluga što će u konačnici rezultirati povećanjem bruto dobiti. Kroz postavljene ciljeve klastera članovima će se otvoriti mogućnosti koje bi njima, kao pojedincima, bile zatvorene ili bi bile teško ostvarive.

U slučaju regionalno-turističkog klastera “Kuna”, osim uobičajenih prednosti kao što su zajednička nabava, nastup na tržištu, zajednički “brend” i ostalo, kao dodanu vrijednost članovi ističu nadoknadu ljudskih resursa, upravljačke strukture i svih potrebnih znanja koja im nedostaju za uspješno poslovanje. Na taj način se svaki član može koncentrirati na svoje jake strane, a slabe strane kompenzirati s drugim članovima, pogotovo ako se uzme u obzir da je to vertikalni klaster koji okuplja članove iz različitih djelatnosti sa zajedničkim identitetom pružatelja usluga u području ruralnog turizma. Naravno da je za uspjeh klastera vrlo važan međusobni odnos i povjerenje među članovima, što je jedna od najznačajnijih prednosti klastera “Kuna” gdje se svi članovi međusobno dobro poznaju i do sada su dosta surađivali.

Potrebno je istaknuti posebnu prednost koju ima analizirani regionalno-turistički klaster “Kuna”, a to je da ga maksimalno podupiru sve relevantne institucije na području grada Pakraca kao što su Poduzetnički centar Pakrac, Turistička zajednica grada Pakraca i grad Pakrac, što je važan čimbenik na razvojnom putu klastera. Još jedna, za sada, značajna prednost ovog klastera je što se nalazi na području posebne državne skrbi zbog čega su mu dostupne neke državne, a i lokalne povlastice za olakšavanje početka poslovanja. Uz sve navedene prednosti, regionalno-turističkom klasteru “Kuna” su uz pomoć potporne institucije Poduzetničkog centra Pakrac odobrena početna financijska sredstva od Ministarstva gospodarstva rada i poduzetništva i Ministarstva turizma, što je ubrzalo proširivanje i razvoj klastera.

Osim gore navedenoga, klasteru “Kuna” svakako ide u prilog trend prepoznavanja ruralnog prostora kao mjesta za zdrav i ugodan odmor s posebnim doživljajima koje su gosti spremni platiti. U Hrvatskoj danas postoje pokušaji determinacije mogućih pravaca turističkog djelovanja usmjerenog na pojedine turističke lokalitete kako bi se razvio “brend” destinacije<sup>3</sup>. S obzirom na određene elemente atraktivnosti područja u kojem članovi klastera žive i rade, logičan je naglasak na specifičnoj turističkoj ponudi kroz osmišljavanje dva tematska puta “*Stazama lipicanaca i kune*”, čime bi se razvio “brend” grada Lipika i Pakraca<sup>4</sup>.

Osim prednosti ovakvog udruživanja postoje i nedostaci koji bi se mogli odraziti na samo poslovanje, kao na primjer činjenica da su članovi analiziranog klastera na različitoj razini razvoja, uspješnosti i standardizacije, pa bi se moglo dogoditi da nisu svi spremni ni kvalitetom, a ni kvantitetom odgovoriti potrebama tržišta. U tom slučaju, rješenje treba potražiti u inovativnosti i dodatnoj aktivnosti razvijenijih i uspješnijih članova klastera, kako bi inicirali i pomogli razvoj ostalih. Kao drugi nedostatak regionalno-turističkog klastera

<sup>2</sup> SWOT analiza je akronim engleskih riječi strenghts (snaga/prednosti), weaknesses (slabosti/nedostaci), opportunities (prilike), threats (prijetnje).

<sup>3</sup> Postoje i konkretni prijedlozi mogućih turističkih klastera unutar Osječko-baranjske županije: Osijek – poslovni grad s bogatim kulturnim nasljeđem, Bilje – doživljaj tradicionalnog načina života i gastronomije, Đakovo – ugođaj vjere i mira, Kopački rit – oaza prirodnih vrijednosti, Bizovac – odmor duše i tijela u pravom smislu riječi, Baranja – aktivni odmor zasnovan na prirodnim vrijednostima (Kristić, 2007).

<sup>4</sup> Lipicanac – plemenita životinja. Kuna ima važnu ulogu u povijesnoj baštini Pakraca (grb grada Pakraca - oslikana kuna, Slavonki banovac - prvi hrvatski novac kovan u Pakracu 1256. godine ukrašen je kunom).

"Kuna" mogao bi biti dobna i obrazovna struktura članova, pa će jedna od zadaća budućeg upravitelja klastera biti naglasak na obrazovanju članova i poticanju novih mlađih poduzetnika da se uključe u klaster. Iako su regionalno-turističkom klasteru "Kuna" odobrena početna financijska sredstva, jedna od prijetnji bi mogao biti daljnji nedostatak financija, ukoliko se na vrijeme ne odabere upravitelj klastera koji će imati potrebne kompetencije i moći svojim radom ostvariti dovoljno financijski sredstava za svoj rad i rad klastera. Dakako da su za uspjeh ili neuspjeh važna realna i jasna očekivanja i usmjerenost na interes i povjerenje kao temelj aktivnog sudjelovanja članova u klasteru te spremnost na razmjenu znanja i informacija. U tablici 1. prikazana je SWOT analiza regionalno-turističkog klastera "Kuna" na temelju provedenog intervjua, koja ukratko prikazuje nedostatke i buduće prijetnje kao ograničenja u daljnjem razvoju klastera, te prednosti i buduće prilike koje bi upravitelj klastera trebao iskoristiti u prepoznatljivosti turističke ponude na stranom i domaćem tržištu.

Tablica 1. SWOT analiza regionalno-turističkog klastera "Kuna"

Prednosti	Nedostaci
Neiskorišteni prirodni resursi (voda, krajobraz, čista poljoprivredna proizvodnja, pogodna klima)	Nedovoljno organizirana proizvodnja
Raznovrsna ponuda članova klastera	Nejednakost u standardu
Međusobno povjerenje	Nema upravitelja klastera
Podrška lokalnih institucija	Starija dobna struktura
Područje posebne skrbi	Neujednačen kontinuitet proizvodnje
Izrađen web portal	Nisu definirani turistički aranžmani
Osmišljen zajednički logotip	Nema strategije marketinga
Rekreacijski turizam (biciklizam, lov, ribolov), Osmišljavanje tematskih puteva	
Prilike	Prijetnje
Uzlazni trend potražnje ruralnih destinacija	Nedovoljna financijska sredstva za daljnji razvoj klastera
Sve veća potražnja domaćih i stranih gostiju za mirnim destinacijama i zdravom hranom	Promjene zakonske regulative
Povratak stanovništva u ruralne krajeve	Recesija
Financijska potpora resornih Ministarstava	Političke promjene
EU fondovi	Elementarne nepogode
Izrada nacionalne strategije ruralnog turizma	
Podrška lokalnih vlasti i institucija	
Ruralno-turistički razvoj okolnih regija	

Izvor: vlastito istraživanje

### Zaključak

Udruživanjem poduzetnika u regionalno-turistički klaster "Kuna" na području Požeško-slavonske županije daje se nova dimenzija ruralnog razvoja, čime se kroz ruralni turizam prvenstveno potiče cjelokupno gospodarstvo Županije i sprečava odlazak stanovništva s ruralnih područja. Ovakav model bi trebao doprinijeti povećanju produktivnosti svakog pojedinog člana klastera koji će se reflektirati na povećanje gospodarskog rasta, novog zapošljavanja i razvoja novih proizvoda i usluga. Svakako da bi promatrano interesno udruživanje trebalo rezultirati i jačanjem konkurentnosti i prepoznatljivosti analiziranog područja kroz isticanje atraktivnosti neiskorištenih prirodnih resursa.

Rezultati istraživanja pokazali su da su se članovi klastera dobrovoljno udružili, zadržavaju svoju samostalnost i vide svoje interese u udruživanju, što daje za pravo očekivati da analizirani klaster svoj razvoj temelji na dinamičnoj i otvorenoj suradnji među svim članovima, što bi mogao biti ključ uspjeha regionalno-turističkog klastera "Kuna".

Unatoč potpunoj podršci svih relevantnih institucija na području Požeško-slavonske županije, odgovornost za uspješno poslovanje analiziranog klastera s vremenom će ipak morati preuzeti sami članovi. Stoga će ključnu ulogu u poticanju interesa novih članova klastera za udruživanje imati buduće izabrani upravitelj klastera, koji će morati različitim marketinškim strategijama i postizanjem prepoznatljivosti kroz tematske puteve "Stazama lipicanaca i kune" utjecati na usklađivanje i zadovoljavanje tržišnih potreba s mogućnošću i kvalitetom ponude klastera .

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# Comparison of profitability and competitiveness of field crops suitable for energy production and woody energy crops

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## Abstract

Considering the aims of the European Union the utilisation of biomass for energy purposes gets more and more attention, since the balance of CO<sub>2</sub> emission is quite favourable. In Hungary the Northern Great Plain region has heterogeneous agroecological endowments; the rate of less-favoured areas is also significant, which makes reasonable the profitability analysis of crops for energy production. In this article beside the conventional arable crops (corn, wheat, rape, sunflower), the profitability of woody energy plants (locust, poplar, willow) were examined, since the price of this energy can be considered as competitive in contrast to the gas or any other fossil fuel. In the course of enterprise analyses, brake even point was calculated, the competitiveness was analysed by multi-periodic linear programming model with and without subsidy.

Key words: energy orchards, production structure, simultaneous linear programming model

## Introduction

Field crops can not only be raw materials for food and feed, but alternative fuels - bioethanol from corn and wheat, biodiesel from rape and sunflower - can also be produced (HENNIGES, 2004; EBB, 2006). Arable crops areas sown are still significant, and these are produced on those lands, where energy crops can also be grown (BABICZ, 2010).

In this article the competitiveness of the four most important Hungarian arable crop enterprises (corn, wheat, turnsole, rape) and energy crops (energy locust, energy poplar, energy willow) was examined.

In this article model calculations were made. It was analysed that how energy crops are competitive compared to arable crops with and without subsidy according their gross margins. Of course, by the involvement of conventional arable crops in the energy sector, we would not like to reduce the quantity of raw material needed for food production, but a novel solution is to be given for the deduction of the excess.

## Material and methods

The data for the competitiveness analysis of conventional arable crops and energy crops were given by the Central Agricultural Office (MGSZH), Research Institute of Agricultural Economics (AKI), Ministry of Agriculture and Rural Development (FVM), and by a Hungarian company that plays an important role in producing raw material for bio energy. Our choice was based on the fact that this company is located in Eastern Hungary, in Szakoly and it was founded in 2007 for supplying the bio plant of South-Nyírség. During its 3-year operation it extended its activity for several regions of the country. Nowadays, it produces energy crops on 600 hectares. Part of this area is poldered, so these could be used for agricultural food production uneconomically, but from the point of energy production these areas are suitable for the production of energy willow and poplar species. The other part is sandy, where conventional agricultural production cannot be done because of the precipitation. For this soil type almost any of the locust species can be planted.

For this research to reach the targeted aims, in practice used technological, production, cost and revenue data, and the amount of subsidies for crop production were needed. We built upon our own data collection for the enterprise technologies raw data needed for the linear programming and simulation model.

For the database of linear programming models unified crop production technologies were developed, which base was given by the companies. The resources needed for the technologies, and for the capacity vector of the linear programming model were determined by the resources of a company participating in this research. For modelling, sample technologies of 100 hectares were created (CSÁKI - MÉSZÁROS, 1981), which were compiled by Microsoft Excel.

The comparison of enterprises was made according to the cumulated gross margins, for which the data of the agricultural companies and Ministry of Agriculture and Rural Development were used. Gross margin was calculated by the difference of production value and direct variable cost. When determining the gross margin of energy crops, it was considered that harvest is not done every year. We calculated with a 3 year harvesting cycle for the locust and willow, and with 2 years for poplar. For all crops, from the second year by 5 percent revenue and 4 percent cost increase were calculated.

The competitiveness of crop cultures was examined by a multiperiodic production structure model, and for its assemblage, first of all, single crop production models were made for one year. After this, these models were built into a common LP model. Each year was bound by rotation cycle transfer variables.

The technologies are broken by decades. The examined interval is 12 years, which was justified by the more precise modelling of the perennial energy orchards. This linear programming model contains 120 variables and approximately 1000 constraints. The constraints by each year refer to the area, the machine work, the available labour force and requests to comply to rotation cycle's rules.

In case of orchards, contrary to arable crop cultures, a special constraint had to be developed. If once a woody energy plant gets into the production structure it will remain on the same area for 15-20 years depending on the species.

In the objective function of the linear model the gross margin of 12 years was maximized.

When having assembled the model, we tried to make it in a way to reflect the reality as much as possible, and to be manageable from the point of mathematics and informatics.

The compiling of mathematical model led to a relatively large model also in case of simpler variables, so the use of aggregated variables was aimed to reduce the labour of model editing.

## Results and discussion

### The results of enterprise calculations

The cumulated gross margins were used for the comparison of the profitability of crop enterprises. Analysing the value of the cumulated gross margin, significant differences can be seen with and without subsidies (Figure 1. and 2.). In case of corn the highest cumulated gross margin can be reached by the end of 12<sup>th</sup> year among the arable crops. With subsidy this amount is 8441€ for one hectare, without subsidy it is 5540€. It is followed by the rape, which value is 6870€ with subsidy, and 3968€ without it by the end of 12<sup>th</sup> year. The lowest cumulated gross margin value can be reached by the sunflower (Figure 1.).

By determining the cumulated gross margin value of energy orchards, it becomes possible to calculate the return on investment. In case of energy orchards the first revenue can be counted for the 2<sup>nd</sup> and 3<sup>rd</sup> year, and the initial plantation payment can largely influence the time of return. With subsidy in the first cutting cycle positive gross margin can be realized in case of all three plants, while without subsidy only in the 4<sup>th</sup> (poplar), and in the 6<sup>th</sup> year (locust and willow). By the end of 12<sup>th</sup> year the highest gross margin can be reached by Swedish willow, which value is 9472€ per hectare. The lowest cumulated gross margin has the poplar, with the value of 8393€ (Figure 2.).

The income increasing effect of payments is specifically high in case of the wheat and sunflower (higher than 100%) and the lowest at corn (52,4%). Such large-scale difference cannot be demonstrated among the woody energy plants (Table 1.).

## Comparison of profitability and competitiveness of field crops suitable for energy production and woody energy crops

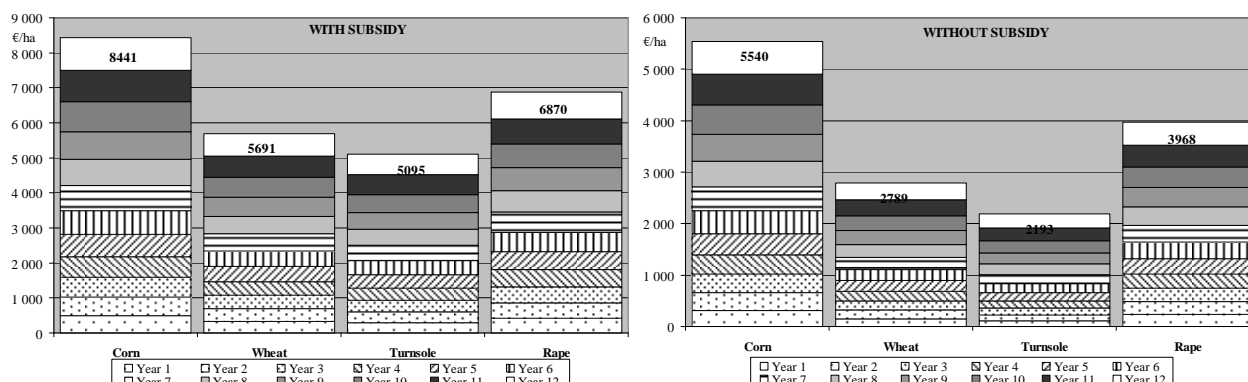


Figure 1. Cumulated gross margin values of the conventional arable crops with and without subsidy in the examined 12 years

Source: own calculation

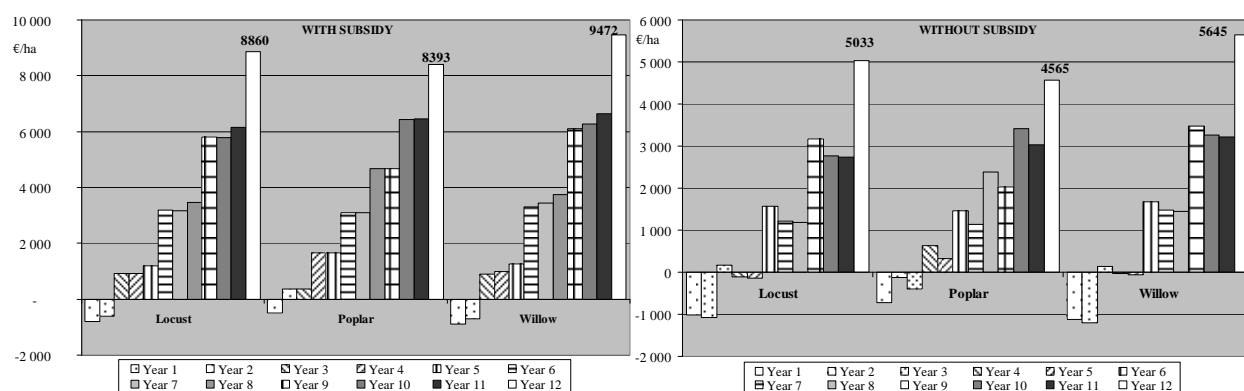


Figure 2. Gross margin values of energy crops with and without subsidy in the last 12 years

Source: Own calculation

Table 1. The subsidies income increasing effect of the examined crops

Arable crops				Woody energy plants		
Corn	Winter wheat	Sunflower	Rape	Locust	Poplar	Swedish willow
52,4%	104,0%	132,3%	73,1%	76,0%	83,8%	67,8%

Source: Own calculation

### Competing the enterprises by applying multi-periodic linear programming model

The comparison of enterprises was executed with and without subsidy considering a sample farm of 500 hectares.

In case of the conventional arable crop cultures, we counted with the area payments, while for energy orchards beside this subsidy we could count with grants given for the plantation similarly to the previous calculations.

After solving **the model considering the subsidy**, we can see that in the first year of the planned production structure all crop culture got in (Figure 3.). In the production structure the major share had the cereals in app. 40%, after this come the energy orchards' 26%, and the turnsole's and rape's 15-20 percent share. Regarding the crop structure for 12 years, the role of energy orchards will not change, since by a given plantation we engage the area for long term.

In the fifth year, compared to other years, a major change can be experienced since the rate of turnsole reduced to 9.5%, and the area of wheat increases from 20% to 25%. By running the model on 500 hectares for 6 years we can reach 3.81 million EURO maximum gross margin. This means that we can calculate for the average of 12 years with 635€ gross margin.

	□ Corn	■ Turnsole	■ Wheat	■ Rape	■ Locust	□ Poplar	▨ Willow	
Year 1	28,2%		14,8%	10,6%	20,0%	5,0%	15,4%	6,0%
Year 2	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%
Year 3	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%
Year 4	29,3%		20,0%	4,4%	20,0%	5,0%	15,4%	6,0%
Year 5	18,8%	9,5%	25,4%		20,0%	5,0%	15,4%	6,0%
Year 6	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%
Year 7	28,2%		14,8%	10,6%	20,0%	5,0%	15,4%	6,0%
Year 8	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%
Year 9	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%
Year 10	28,2%		14,8%	10,6%	20,0%	5,0%	15,4%	6,0%
Year 11	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%
Year 12	28,2%		20,0%	5,5%	20,0%	5,0%	15,4%	6,0%

Figure 3. The production structure of field crops in the calculated 12 years with subsidy

Source: Own calculation

After solving the model not considering the subsidy a similar production structure can be achieved compared to that of with subsidy, and according to this, the conclusion can be drawn that these crop cultures are in the same competition with and without subsidy as well.

### Conclusion

In this article the profitability and competitiveness of conventional arable crops and energy orchards, which are the main raw materials for energy production, were compared considering an interval of 12 years. Enterprise profitability analysis was made by the cumulated gross margins and built on the technology and resources of a sample farm of 500 hectares the examined crops were competed in a multi-periodic linear programming model. By the calculations, the national and domestic area payments were also considered that are available for the producers.

Considering the cumulated gross margins for 12 years, the order of Swedish willow, locust, corn, poplar, rape, winter wheat, and sunflower can be established among the crops with payments. Without subsidy the locust and the corn switch places, the other crops occupy the same places. The significance of subsidies is the greatest for the wheat and sunflower - so the income increasing effect is higher than 100% -, it is lower in case of the other crops, but the corn's, which has the lowest value, is still above 50%. In the LP model presenting the competitiveness of each enterprise, the total share of woody energy plants of high income is 26%, and it is practical to utilise the remained area with conventional arable crops with and without payments as well. The harvesting cycle of woody energy plants plays an essential role in it, since it is 2-3years, which means that especially in the initial period it will only give a positive cumulated gross margin balance in 2<sup>nd</sup>-6<sup>th</sup> year depending on the subsidy.

On the whole it can be stated that beside the conventional arable crops the woody energy plants are also competitive in the field crop production, which means a new opportunity for alternative biomass utilisation. However, it cannot be ignored that this statement is only valid primarily from the point of producers with payments. The further penetration of biomass energy use can only be successful if the end-product energy is competitive with the conventional energy sources.



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# Analiza poljoprivrede privatnog sektora u južnom dijelu Kosova

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## Sažetak

Uzimajući u obzir značaj poljoprivredne proizvodnje na Kosovu i razvoj ruralnih područja u radu smo analizirali poljoprivrednu proizvodnju i potencijale u općinama na Kosovu (Dragašu, Prizrenu i Štrpcu). Anketirano područje je u većem dijelu obuhvaćalo brdsko planinsko područje sa pretežno zastupljenom stočarskom proizvodnjom. Istraživanje je provedeno na 98 farmi, koje raspolažu sa ukupno 613 ha poljoprivrednog zemljišta, radi se o obiteljskim gospodarstvima sa prosječnom veličinom farme od 6,26 ha. Ispitivane farme su nedovoljno opskrbljene poljoprivrednom mehanizacijom i ostalom opremom, a ujedno su relevantni potencijali i vitalni faktori za razvoj i pokretanje ruralnih područja.

Ključne riječi: poljoprivredna proizvodnja, brdsko-planinsko područje, stočarstvo

## Agricultural situation in the private sector in southern Kosovo

### Abstract

Given the importance of agriculture and rural development in Kosovo, this study analysed the situation and agricultural potential of Kosovo municipalities (Dragaš, Prizren and Štrpce). The area surveyed mostly covered upland and highland regions dominated by livestock production. The survey was conducted on 98 family farms that are on average 6.26 ha in size and have a total of 613 ha of agricultural land. Apart from being under-stocked in farm machinery and other equipment, the farms analysed are considered relevant resources and vital factors in the development and stimulation of rural areas.

Key words: agricultural production, uplands and highlands, livestock production

### Uvod

U gospodarstvu Kosova poljoprivreda učestvuje sa 25% u BDP, a oko 35% stanovništva je zaposleno u poljoprivrednoj proizvodnji koja je glavni izvor egzistencije i ima značajnu ulogu u opskrbi stanovništva osnovnim prehrambenim namirnicama. No bez obzira na to Kosovo je inače veliki uvoznik poljoprivrednih i prehrambenih proizvoda. Prema podacima UNMIK za 2005. godinu uvoz ovih proizvoda iznosio je 288 milijuna EUR, što je činilo 24% od ukupnog uvoza. U usporedbi Kosova sa drugim zemljama u okruženju i Europi udio ruralnog stanovništva je relativno visok. Poljoprivredna djelatnost je glavna aktivnost kojom se stanovništvo pretežno bavi. Prema ispitivanju poljoprivrednih domaćinstava SOK iz 2004. ukupna poljoprivredna populacija se procjenjuje na oko 1 milijun stanovnika od toga je 60% poljoprivrednog stanovništva ispod 30 godina starosti. Naime Kosovo je i najmlađa nacija u Europi jer je 40% stanovništva u dobi od 1-15 godina. Ukupna površina zemljišta na Kosovu je 1,1 milijun ha, od toga 51,9% čini obradivo poljoprivredno zemljište, a 48,1% je šumsko zemljište. Prema podacima FAO procjenjuje se da 180.000 ha pripada brdskim pašnjacima, koji su ujedno veliki prirodni potencijal, ali nedovoljno iskorišteni za razvoj

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stočarske proizvodnje. Privatnom sektoru i poljoprivrednim gospodarstvima pripada 86% zemljišta, u vlasništvu zadruga je 1%, dok preostalih 13% površina pripada društvenim poduzećima koja su u procesu privatizacije. Prosječni zemljišni posjedi po poljoprivrednom gospodarstvu iznose 2,2 ha, što je opet usitnjeno u prosjeku od 8 parcela. Podaci iz mjesečnog biltena SOK (2004.) pokazuju da je oko 80% farmi veličine od 0,5-2 ha. Prema ispitivanjima obiteljskih domaćinstava koje je proveo Riinvest institut 2004. godine poljoprivrednim strojevima je opskrbljeno 49% domaćinstava koja imaju traktore, 8,5% posuđuje, 23% iznajmljuje i 19% domaćinstava ne koristi traktore, a velika je potreba za adekvatnim priključnim strojevima. Prema spomenutim istraživanjima 70% ruralnih domaćinstava raspolaže u prosjeku sa 1,7 kravom po domaćinstvu. Stočarska proizvodnja na ovom području ima dugu tradiciju i dobre agroekološke uvjete, ona je u većoj mjeri revitalizirana uvozom kvalitetnih pasmina radi unapređenja proizvodnje.

### Materijal i metode

U cilju analize stanja poljoprivrede na Kosovu korišteni su podaci UNMIK-a (Departman za lokalnu administraciju) i Ministarstva poljoprivrede, šumarstva i ruralnog razvoja MPŠRR, kao i brojna istraživanja za potrebe Zavoda za statistiku Kosova i ekonomskog razvoja: ispitivanja obiteljskih budžeta HBS, ruralnih familija Institut Riinvest, mjerenja životnog standarda LSMS, ispitivanja radne snage LFS, koja su provedena od strane međunarodnih organizacija MMF, Svjetske banke, FAO, UNDP a korišteni su i službeni statistički podaci i mjesečni bilteni SOK. Analiza poljoprivredne proizvodnje južnog dijela Kosova u našim istraživanjima odnosi se na tri vodeće općine ovog područja i to Prizren, Dragaš i Štrpce. Seosko područje ovih općina pripada većinom brdskom području koja su na obroncima Šar planine i u podnožju Crnog Vrh, a pojedina sela se nalaze u prizrenskom polju u dolinama rijeka Belog Drima i Bistrice. Za potrebe analize koncipirana je i provedena anketa. Ona je obuhvatila 13 sela i 98 obiteljskih gospodarstava na ispitivanom području. Anketa je sastavljena u vidu upitnika u kojoj su vlasnici farme unosili tražene podatke. Podaci ankete su obuhvatili: osnovne podatke o farmi i obitelji, površini i kvaliteti zemljišta kojima raspolažu, proizvodnoj strukturi i proizvodnji kojom se bave prosječnim prinosima koje postižu, broju stoke po vrstama, pasminama i kategorijama, broju traktora i priključnih strojeva, uvjetima tržišta i prodaji vlastitih proizvoda. Nakon izvršene ankete podaci su grupirani i obrađeni matematičko statističkim metodama i prikazani tabelarno i grafički.

### Rezultati i rasprava

Analiza je obuhvatila područje južnog Kosova i to ruralne dijelove dve regije Prizren (Dragaš) i Uroševac (Štrpce). Klimatski i agroekološki uvjeti u ispitivanom području pogodovali su razvoju pojedinih poljoprivrednih proizvodnji. Pored toga što anketirana sela pretežno pripadaju brdsko-planinskom području treba napomenuti i Prizrensku kotlinu u kojoj zbog utjecaja blage mediteranske klime postoje povoljni uvjeti za voćarsku, vinogradarsku i povrćarsku proizvodnju. Analizom strukture poljoprivrednih površina može se vidjeti da općina Prizren raspolaže većim obradivim površinama kojima pripadaju oranice i vrtovi u odnosu na općine Dragaš i Štrpce. Sve tri općine raspolažu velikim bogatstvom pašnjaka, pri čemu najveću površinu pod pašnjacima ima Dragaš. Od ukupnog poljoprivrednog zemljišta u općinama 38,4% čine pašnjaci, što je 28,6% pašnjaka u odnosu na ukupnu površinu pašnjaka na Kosovu.

Struktura poljoprivrednih površina u tablici 1. pokazuje da općine Dragaš i Štrpce imaju veće površine pod livadama nego pod oranicama. Ovakvo bogatstvo livada i pašnjaka kao i sama konfiguracija terena i drugi agroekološki uvjeti utjecali su da se na ovom području razvija stočarska proizvodnja prije svega govedarska i ovčarska, koje su od tradicionalne i prirodne prerasle u komercijalnu proizvodnju na pojedinim farmama.

Promatrani predio raspolaže i značajnim površinama pod šumom koje čine 33,4% od ukupnih površina u općinama, što je 9,4% površina pod šumom na Kosovu.

Tablica 1. Struktura poljoprivrednih površina u općinama južnog dijela Kosova

Općine Pokazatelji	Dragaš	Prizren	Štrpce	Ukupno općine	Ukupno Kosovo
Stanovništvo	50.000	222.000	13.600	285.600	2.100.000
Poljoprivredno zemljište u ha					
Oranice, vrtovi	3.596,34	13.603,5	2.457,78	19.657,62	214.500
Voćnjaci	-	726,68	207,89	934,57	4.500
Vinogradi	-	1.297,11	0,27	1.297,38	5.000
Livade	5.194,61	4.795,46	3.338,79	13.328,86	86.000
Pašnjaci	26.038,89	14.096,83	7.645,94	47.781,66	167.000
Šume	6.433,65	24.799,86	10.331,78	41.565,29	442.000
Ukupna površina	41.263,49	59.319,44	23.982,45	124.565,38	919.000

Izvor: Zavod za statistiku Kosova

Ciljna grupa ankete su bile reprezentativne obiteljske farme sa uvjetima za razvoj poljoprivredne proizvodnje. Anketirano je 13 sela, pri čemu je najviše na području općine Dragaš 8 sela i 64 farme, Prizrenu 3 sela i 25 farme i Štrpcu 2 sela i 9 obiteljskih farmi. U općini Dragaš ispitivana su dva područja i to brdsko-ravničarski Opolje i brdsko-planinski kome pripada Gora čija su sela smještena na obroncima Šar planine. Prosječna veličina farme u anketiranom području iznosi 6,26 ha (tab. 2.)

Općine	Broj anketiranih sela	Broj anketiranih farmera	Ukupna površina u ha	Prosječna veličine farme ha
Prizren	3	25	105	4,20
Štrpce	2	9	65	7,22
Dragaš	8	64	443	6,92
Ukupno	13	98	613	6,26

Izvor: Rezultati ankete, izračun autora

U analizi koja je obuhvatila 98 obiteljskih farmi najviše su zastupljene farme veličine od 3-6 ha sa učešćem od 44,9% i sa ukupnom površinom od 190 ha. Velika je zastupljenost i malih farmi do 3 ha ali one nemaju veliki udio u poljoprivrednim površinama. Mogu se izdvojiti farme, koje gravitiraju planinskom rajonu Gore veličine 10-15 ha upravljaju s posjedom od 150 ha i učestvuju u ukupnim površinama sa 24,47% (tab. 3.) a uopšte ne posjeduju traktore.

Tablica 3. Veličina posjeda na obiteljskim farmama

Veličina posjeda farme ha	Broj farmera	Udio %	Ukupna površina u ha	Udio %
do 3,0	28	22,45	55	8,97
3,1-6,0	44	44,90	190	31,0
6,1-10,0	12	12,24	74	12,07
10,1-15,0	13	13,26	150	24,47
15,1-20,0	4	4,08	75	12,23
preko 20,0	3	3,07	69	11,26
Ukupno	98	100	613	100

Izvor: Rezultati ankete, obračun autora

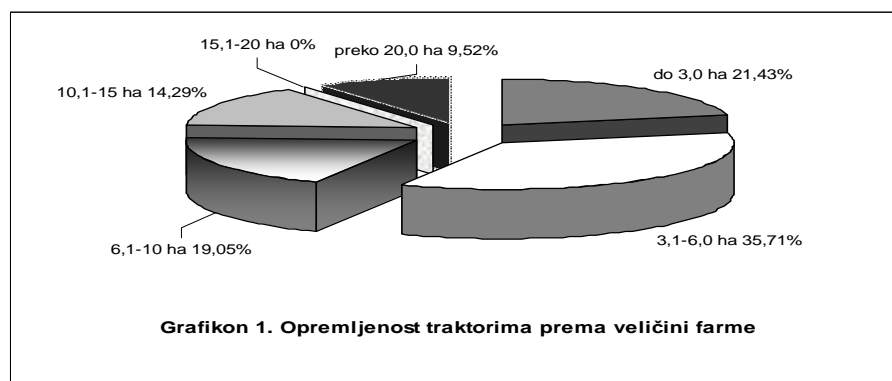
Rezultati ankete pokazuju da su u općini Prizren u rajonu Sredačke župe i Hasa postotno najviše zastupljena gospodarstva sa površinom do 6 ha, što je ograničeno njihovim geografskim položajem. U općini Štrpce skoro je ujednačeno sudjelovanje farmi s posjedom manjim od 6 ha i od 6-15 ha. U općini Dragaš od ukupne površine zemljišta 45,15% pripada farmama u Gori gde je predio pretežno brdsko-planinski i prevladavaju livade i pašnjaci. Ostale farme su u brdskom i ravničarskom dijelu područja Opolja.

U anketiranom području ukupno ima 42 dvoosovinska traktora, prosječne snage motora 35,80 kW koji su opterećeni sa 14,60 ha zemljišta, odnosno na 100 ha zemljišta dolazi 6,85 traktora.

Od ukupnog broja traktora preko 57% je na domaćinstvima koja raspolažu sa manje od 6 ha poljoprivrednog zemljišta (grafikon 1).

Anketirano područje još uvijek je slabo obezbjeđeno sa sredstvima mehanizacije jer na jedan traktor dolazi tek 2,67 priključnih strojeva. Porodična gospodarstva će morati preko udruženja i dalje nabavljati potrebnu mehanizaciju (Koprivica i sur., 2010).

## Analiza poljoprivrede privatnog sektora u južnom dijelu Kosova



U promatranom području općina najviše ima goveda i ovaca, što istovremeno predstavlja 10,1% goveda i 11,2% ovaca od ukupnog brojnog stanja stoke na području Kosova. Sa najviše goveda raspolaže općina Prizren, dok su u Dragašu ovce i goveda skoro podjednako zastupljeni (tablica 4.) Govedarska i ovčarska proizvodnja su na ispitivanom području najrazvijenije i jedan broj farmi je specijaliziran i opremljen za proizvodnju mlijeka i mesa. Stoka se uzgaja u stajama u zimskom periodu, a ljeti u prosjeku oko 5 mjeseci primjenjuje se ispašni sustav uzgoja. Radi unapređenja proizvodnje i distribucije proizvoda pojedini farmeri su osnovali udruženja, što je pomoglo opremanju farmi i daljoj komercijalizaciji.

Tablica 4. Brojno stanje stoke u južnom dijelu Kosova i u anketiranim općinama

Općine	Goveda	Ovce	Konji	Koze	Svinje
Dragaš	8.276	8.000	1.850	150	-
Prizren	12.964	1.357	2.502	1.300	839
Štrpce	2.933	1.099	456	481	1.513
Ukupno općine	24.173	10.456	4.808	1.931	2.352
Ukupno Kosovo	238.857	93.313	12.261	13.344	53.222
Anketirano područje u općinama južnog dijela Kosova					
Anketirano Dragaš	639	3.331	53	25	/
Anketirano Prizren	135	659	12	240	/
Anketirano Štrpce	40	/	/	/	35
Ukupno anketirano	814	3.990	65	265	35

Izvor: Zavod za statistiku Kosova; Rezultati ankete

Primjer uspješnih farmi na ovom području je u selu Kosava, farmeri su se organizirali da dnevno po 100 litara mlijeka predaju zajedničkoj mljekari u kojoj proizvode sir, a ostale količine mlijeka idu u dalji otkup. Trećina od ukupnog broja konja na Kosovu je u anketiranim općinama. Tradicija uzgoja konja izražena je u planinskim selima, konji se koriste kao prijevozno sredstvo, a neophodni su za rad u polju i šumi i predstavljaju jedinu alternativu uslijed nedostatka mehanizacije. Analizirane farme na privatnom sektoru predstavljaju dobre primjere za povećanje i intenziviranje stočarske proizvodnje gdje se farmeri samoinicijativno organiziraju u cilju rješavanja problema proizvodnje. Osnovni ograničavajući faktori razvoja proizvodnje su ekonomska nerazvijenost područja, nepostojanje potrebne infrastrukture, nedovoljna opremljenost sredstvima mehanizacije, tržišna neorganizovanost, neinformiranost i nedovoljna znanja o suvremenoj tehnologiji proizvodnje stočne hrane.

## Zaključak

Obiteljska gospodarstva u južnom dijelu Kosova u ispitivanim općinama su glavni nositelji stočarske proizvodnje. U anketiranom području prosječna farma rasplaže sa 6,26 ha zemljišta uglavnom livada i pašnjaka sa kojih se proizvodi hrana za 8,30 goveda, 40 ovaca i 2,7 koza. Oskrbljenost traktorima je još uvijek nedovoljna jer svega 42,85% anketiranih farmera posjeduje traktor, a trećina koristi animalnu snagu konja, ostali farmeri ili ne koriste mehanizaciju ili je iznajmljuju. Radi unapređenja stočarstva neophodno je opremiti farme suvremenom mehanizacijom, intenzivirati i komercijalizirati proizvodnju. U cilju boljeg iskorištenja livada i pašnjaka educiraju se farmeri da proizvedu kvalitetnu i jeftinu stočnu hranu, da bi se postigli bolji rezultati u proizvodnji mlijeka i mesa.

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# Suvremeni prehrambeni trendovi

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## Sažetak

U ovom radu prikazani su najvažniji suvremeni prehrambeni trendovi koji predstavljaju razvojne prigode za agrobiznis. Agrobiznis ne može na njih značajnije utjecati, ali može prilagoditi svoju ponudu. Za domaću poljoprivredu i prehrambenu industriju, s obzirom na njihovu specifičnu strukturu, najveće prigode predstavljaju specifične skupine proizvoda kao što su funkcionalni, ekološki, regionalni i čisti proizvodi te proizvodi raspoložena.

Ključne riječi: hrana, trendovi, razvojne prigode

## Modern food trends

### Abstract

This research lists the most important modern food trends which are potential development opportunities for agribusiness. Trends cannot be significantly influenced by agribusiness but products can be adapted to follow them. Having in mind the specific characteristics of domestic agricultural and food industry, the biggest opportunities are presented in the market of functional, organic, regional, safe food and mood food.

Key words: food, trends, development opportunities

### Uvod

Hrana je osnovna životna potreba i da bi živjeli, ljudi moraju jesti. Međutim, postoje velike razlike u tome koliko jedu, što jedu, kojim redoslijedom jedu, s kim jedu, te u kojim prigodama jedu. Prehrambene navike su u prošlosti bile razmjerno stabilne i najviše su oblikovane pod utjecajem prirodnih i klimatskih čimbenika odnosno lokalne poljoprivredne proizvodnje. Danas se prehrambene navike mijenjaju vrlo brzo, a na njih najviše utječu društveni mega trendovi.

Cilj rada je prikaz najvažnijih suvremenih prehrambenih trendova u razvijenim zemljama u svijetu. Rezultati istraživanja upućuju na razvojne prigode za agrobiznis.

### Materijal i metode

U radu je korištena metoda desk istraživanja, odnosno analiza i sinteza podataka dobivenih iz sekundarnih izvora. Informacije su dobivene putem interneta te iz različitih studija dostupnih u stručnoj literaturi.

### Rezultati i rasprava

#### Najvažniji mega trendovi

Društveni mega trendovi značajno utječu na svakodnevne odluke o prehrani. Jedan od najvažnijih društvenih trendova je povećanje broja obrazovanih i zaposlenih žena. Žene više nemaju dovoljno vremena

za obavljanje kućanskih poslova. Tradicionalni obiteljski ručak je praktično nestao iz svakodnevnice, a sve rjeđe se pripremaju i blaguju zajedničke večere.

Drugi mega trend, koji ima značajni utjecaj na današnje prehrambene navike, je smanjenje kućanstva i smanjenja broja djece po kućanstvu. Paralelno se odvija i proces individualizacije što dodatno pridonosi nestanku tradicionalnog obiteljskog objeda (Karmasin, 1994.).

Stanovništvo u razvijenim zemljama postaje sve starije. Starenje stanovništva stvara nove potrebe i mijenja strukturu potražnje na tržištu. Ova skupina potrošača ima povećanu svijest o zdravlju, više je orijentirana na usluge i kupuje kvalitetnije proizvode.

Globalizacija je povećala međunarodnu trgovinu hranom. Posljedica su širi izbor namirnica i prehrambenih proizvoda, odnosno mogućnost raznovrsne prehrane tijekom cijele godine te niže cijene sirovina i prehrambenih proizvoda. Sve veći broj poslovnih i turističkih putovanja donosi sa sobom povećanu otvorenost za nove okuse i začine, odnosno za regionalne specijalitete i etničku hranu (Rützler, 2005.).

Bezobzirno korištenje prirodnih resursa i zagađivanje okoliša, čemu su značajno pridonijeli intenzivna poljoprivredna proizvodnja i prehrambena industrija, doveli su do klimatskih promjena koje opasno ugrožavaju opstanak života na zemlji. "Monokulturna" poljoprivreda je smanjila biološku raznolikost i "proizvela" veći broj "prehrambenih skandala". Patnje životinja i iscrpljivanje radne snage, ponovo zbog povećanja profita u proizvodnji hrane, narušavaju osnovne etičke principe suvremenog svijeta (Rützler, 2005.).

#### Važniji suvremeni prehrambeni trendovi

Društveni mega trendovi utjecali su na stvaranje novih prehrambenih potreba. Moguće ih je sažeti u tri dimenzije: praktičnost, užitak i zdravlje (Grunert, 2009., [www.suvremena.hr](http://www.suvremena.hr)). Praktičnost znači jednostavnu i brzu prehranu, a užitak je stvar osjećaja. Također, sve veću važnost za potrošače ima i pridržavanje etičkih principa u proizvodnji hrane. Zdravlje se usko povezuje s kvalitetom prehrane, a ispravna prehrana izjednačava sa zdravom prehranom. Novi zahtjevi potrošača doveli su do novih tendencija na tržištu hrane odnosno novih prehrambenih trendova.

#### Praktična hrana (Convenience food)

Kratka definicija *praktične hrane* označuje hranu koja se može brzo i jednostavno pripremiti. *Praktična hrana* štedi vrijeme potrebno za pripremu objeda, duže traje, a pri tome ne gubi arome i nutrijente. *Praktična hrana* se proteže na sve više proizvoda od gotovih juha i gotovih jela u vrećicama, limenkama ili aluminijskim posudicama, preko ohlađenih i duboko smrznutih gotovih i polugotovih jela do delikatesnih i svježih salata. Posebni segment praktične hrane odnosi se na snackove. *Praktična hrana* je posebice dobro prihvaćena od mlađih, obrazovnijih potrošača koji rado koriste svako olakšanje koje im priprema prehrambena industrija (Rützler, 2005.).

#### Brza hrana (Fast food)

Definicije brze hrane u literaturi su različite. Neki autori je definiraju široko kao pakirane ili brzo pripremljene, prigodne obroke, dok drugi uzimaju užu definiciju brze hrane kao one hrane koja se kupuje u jednom od velikih lanaca brze hrane kao što je McDonalds (Kirsten i ostali, 2008.). Prema istraživanju provedenom u Hrvatskoj, potrošači kao fast food proizvode najčešće percipiraju: burgere, pizzu, pomfrit, burek, kebab i ćevape (Kovačić i ost., 2010.). Zbog sve učestalijih i oštrijih kritika na račun brze hrane, industrija brze hrane uvodi nove "zdravije" proizvode, te ekološka pakiranja kako bi udovoljila zahtjevima potrošača. Uspjeh industrije brze hrane usko je povezan s intenzivnim marketinškim aktivnostima i učinkovitim marketinškim kampanjama.

#### Fast casual food

Jedan novi prehrambeni koncept, nazvan *fast casual food*, "obećava" da će riješiti konflikt između potrebe da se jede na "brzinu" i želje da se ipak ne odustaje od zdrave i kulinarski ukusne prehrane (Rützler, 2005.). To je hrana koja se priprema na brz način, ali zadržava sve hranjive vrijednosti. Osnovna obilježja novog prehrambenoga trenda su sljedeća: brza i uvijek raspoloživa hrana, veći udio povrća, voća i ribe, odnosno,



zdrava hrana, visoka kakvoća i povoljna cijena, svježa priprema pred očima potrošača, individualno određivanje veličine porcije, ugodan ambijent i poticajna atmosfera te naglasak na prezentaciju.

### Hrana s nogu (Finger food ili Hand held food)

*Finger food* označuje tip prehrane u kojoj se izravno koriste ruke umjesto vilice i noža. Povijest *finger food-a* seže sve do rimskog doba, a danas, zbog sve zahtjevnijih potrošača, poprma nove vrste, oblike i okuse (Rützler, 2005.). *Finger food* obuhvaća širok spektar proizvoda u koji ulaze različite vrste sendviča, pizze, pite, rolade, panirani odresci povrće i voće, krekeri... Nude se za prodaju u gotovom obliku ili se pripremaju u ugostiteljstvu.

### Jeftina hrana (Cheap food)

Cijena je postala ključni kriterij kupnje hrane. "Magija" povoljne kupnje "očarala" je siromašne kupce, ali i one koji vrlo dobro zarađuju (Rützler, 2005.). U trgovinama se smanjuje broj proizvoda s markom i kvalitetnih proizvoda, a povećava ponuda trgovačkih marki. Radi se o proizvodima koje trgovački lanci daju jeftino proizvoditi i prodaju isključivo u vlastitim trgovačkim kućama. *Jeftina hrana* štedi novac. Cijena koja se za to plaća je gubitak na kvaliteti hrane koju kupujemo. Jeftini prehrambeni proizvodi sadrže sve više zamjenskih sastojaka, stabilizatora, boja i aroma te imaju isti okus u svim zemljama (Mikinovic, 2009.).

### Etička hrana (Ethic Food)

Danas, u vrijeme izobilja, raste krug potrošača koji ne žele konzumirati hranu čija je proizvodnja povezana s iskorištavanjem radne snage, patnjom životinja i/ili uništavanjem okoliša. Dobar primjer etičkog konzumerizma su proizvodi s oznakom "fair trade"(pravedna trgovina), čija prodaja posljednjih godina bilježi veće stope rasta. Radi se o ponudi kave, čaja, soka od naranče, čokolade itd., koji se uvoze iz zemalja trećeg svijeta. Proizvođači ovih proizvoda, neovisno od kolebanja cijena na svjetskom tržištu, dobivaju minimalnu cijenu za robu i prerađevine. Za uzvrat moraju ispunjavati čitavi niz strogo kontroliranih socijalnih i ekoloških kriterija. Jedan dio minimalne cijene uzima se za fond iz kojeg se financira opskrba pitkom vodom, izgradnja kuća, medicinske potrepštine ili školovanje u zemljama proizvođača sirovina (Rützler, 2005.).

### Eko hrana (Organic food)

*Eko proizvodi* su proizvodi dobiveni ekološkim uzgojem. U ekološkoj proizvodnji je zabranjena upotreba većine mineralnih gnojiva i većine pesticida te uporaba genetski izmijenjenih organizama i svih proizvoda koji sadrže njihove sastavne dijelove ili su proizvedeni od tih organizama. Ekološka hrana "čuva" ljudsko zdravlje i okoliš (Rützler, 2005.). Proizvodnja i potrošnja *eko proizvoda* je značajno porasla posljednjih tridesetak godina. Međutim, njen udio na tržištu hrane, u razvijenim zemljama, je još uvijek skroman, svega nekoliko postotaka. U Hrvatskoj je proizvodnja i potrošnja eko proizvoda još uvijek vrlo mala.

### Proizvodi sa zemljopisnim oznakama (Food with geographical indication)

Zbog povećanog straha vezanog uz sigurnost hrane, te povjerenja potrošača u kvalitetu proizvoda s poznatim podrijetlom, nostalgije za lokalnim i regionalnim proizvodima, kao i zbog želje za očuvanjem lokalnog i regionalnog gospodarstva raste potražnja za tradicionalnim poljoprivredno-prehrambenim proizvodima s poznatim podrijetlom (Belletti i sur., 2007., Ilbery i Kneafsey, 1998.). Zaštićeno podrijetlo proizvoda jamči visoku kakvoću proizvoda čije posebne karakteristike proizlaze iz vrijednosti njihovih sastojaka, načina proizvodnje i prerade te podneblja iz kojeg dolaze. S ciljem zaštite i promicanja proizvoda s podrijetlom, EU je uvela sustav zaštite oznakom zemljopisnog podrijetla i oznakom izvornosti koji je preuzet i u RH. Vrijednost 820 zaštićenih proizvoda na veleprodajnoj razini u EU 2007. godine je iznosila 14,2 milijardi eura ([http://ec.europa.eu/agriculture/quality/schemes/newsletter-2010\\_en.pdf](http://ec.europa.eu/agriculture/quality/schemes/newsletter-2010_en.pdf)). Danas se na tržištu EU nalazi već više od 950 proizvoda zaštićenih jednom od zemljopisnih oznaka.

### Čista hrana (Clean food)

Porast alergija na prehrambene proizvode i netolerantnosti na hranu su povećali potražnju za clean food-om. *Čista hrana* je hrana koja je načelno slobodna od alergena ili hrana na kojoj su deklarirani svi alergeni.

Prehrambene alergije su vjerojatno posljedica promjene prehrambenih navika. Učestalost pojavljivanja alergija i netolerantnosti na hranu značajno ovise o alergijskom potencijalu hrane i dodacima hrani. Poznati alergijski okidači su kravlje mlijeko i pileće bjelančevine, kikiriki, soja i pšenica, lješnjaci, celer, jabuke, soja, dodaci jelima, salicilati i arome, te biogeni amini i enzimski defekti.

#### Hrana raspoloženja (Mood food)

Potreba za *hranom raspoloženja* javlja se u trenucima tuge, bezvoljnosti ili stresa, ali i kada se ljudi žele osobno nagraditi. Najčešća definicija *hrane raspoloženja* jest da je to zasitna i brza hrana (čokolada, sladoled, čips, pommes frites). Međutim, velik broj ljudi opredjeljuje se i za domaću hranu koja je povezana s određenim ugodnim emocijama. Znanstvenici su primijetili povezanost između učestalog stresa, anksioznosti i depresije te posezanja za kaloričnom, slatkom i masnom hranom.

#### Funkcionalna hrana (Functional food)

*Funkcionalna hrana* je naziv za skupinu proizvoda koji uz osnovnu nutritivnu vrijednost imaju i pozitivan utjecaj na opće zdravlje ljudi ili pomažu u smanjenju rizika za razvoj pojedinih bolesti (Markovina i sur., 2010.). *Funkcionalna hrana* ima cijeli niz povoljnih učinaka na zdravlje. Ovdje ćemo radi ilustracije navesti samo nekoliko: reguliranje probave, smanjenje kolesterola i triglicerida u krvi, smanjenje stresa, smanjuju rizik od raka, proizvodi namijenjeni dijabetičarima i bubrežim bolesnicima. Usprkos velikim očekivanjima industrije i znanstveno dokazanih povoljnih učinaka na zdravlje potrošači nisu u većoj mjeri prihvatili ove proizvode. Značajniji tržišni udio postigli su tek probiotički jogurti, a veći uspjeh bi se mogao očekivati i u sektoru pića.

#### Zaključak

U buduću treba očekivati daljnji porast potražnje za praktičnim i jeftinim proizvodima koji će vjerojatno biti baza buduće prehrane. Temeljem dosadašnjih istraživanja očekuje se da će paralelno rasti potražnja i za specifičnim skupinama proizvoda kao što su funkcionalni, ekološki, regionalni i čisti proizvodi te proizvodi raspoloženja. Iako se radi o proizvodima koji zauzimaju razmjerno male tržišne udjele, zbog veličine europskog tržišta, radi se o velikim razvojnim prilikama za agrobiznis. Agrobiznis ne može na njih značajnije utjecati, ali može prilagoditi svoju ponudu promjenom opsega i/ili strukture proizvodnje, dodavanjem vrijednosti proizvoda, proširenjem asortimana itd.

S obzirom na strukturu domaće poljoprivrede i prehrambene industrije držimo da bi se ona trebala usmjeriti upravo prema razvoju i proizvodnji specifičnih skupina proizvoda.

U budućim istraživanjima bi trebalo utvrditi koliko su ovdje navedeni prehrambeni trendovi prisutni na domaćem tržištu, postoje li u nas specifičnosti u odnosu na globalne trendove te postoje li specifični prehrambeni trendovi na hrvatskom tržištu.

#### Napomena

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# Evidencija o proizvodnji u vinogradarstvu i podrumarstvu vlastinstva Turković u Kutjevu od 1925. do 1945. godine i aktualnost takve statistike u današnje vrijeme

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## Sažetak

Danas moderno vinogradarstvo i vinarstvo u Republici Hrvatskoj prima vrlo visoke novčane potpore od strane države s očekivanjima da će se to nastaviti ulaskom u Europsku Uniju u nešto drugačijem obliku. Cilj rada je prikazati značaj vođenja sustavne evidencije u proizvodnji grožđa i vina te ujedno ukazati na trenutne nedostatke istih. Pregledom povijesnih evidencija vlastinstva Turković u periodu od 1925. do 1945. godine iz Državnih arhiva zaključeno je da bi sustavna i temeljita evidencija o vinogradarskoj proizvodnji kakvu je vodio Zdenko Turković mogla poslužiti kao izvrstan primjer u budućem ustroju registra vinograda osnovanog prema pravilniku (Narodne novine 121/10), a uz male preinake u evidencijskim obrascima i njihovim povezivanjem u višegodišnji slijed dobio bi se kvalitetan "registar vinograda".

Ključne riječi: vinogradarstvo, statistika, Turković, Kutjevo

## Production records in viticulture and wine estate Turkovic from Kutjevo from 1925. until 1945 and the actuality of such statistics in the current site has

### Abstract

Today, modern viticulture and winemaking in Croatia receives a very high financial support by the state with the expectation that it will continue joining the European Union in somewhat different form. The aim is to show the importance of keeping systematic records in the production of grapes and wine, and also point to the current deficiencies of the same. A review of historical records of the estate Turkovic during the period from the year 1925 until 1945 from the state archives, shows that it is systematic and thorough records of vineyard production is what led Zdenko Turkovic could serve as an excellent example of the future structure of the register of vineyards established according to the code "Narodne novine 121/10", and with small changes in the patterns' record and their connectivity in a multi-year sequence got to be good vineyard register.

Key words: wine, statistics, Turkovic, Kutjevo

## Uvod

Uvod ćemo započeti znamenitim citatom Zdenka Turkovića “Stotinu godina nije veliko razdoblje ako se radi o razvoju jedne tako konzervativne i prastare grane gospodarstva kakovom se može smatrati kultura vinove loze”(Turković). Ali izuzetno je važno da se za svaku od tih stotinu godina zabilježe najvažniji podatci kao što su: početak berbe za svaku pojedinu sortu, vrijednosti sladora i kiselina po sortama, prinosi grožđa po tablama i po trsovima. Mali broj vinogradara i vinara tako je predano i precizno vodio takvu statistiku kao što je to vodio Zdenko Turković. Kad se otvore i pogledaju pojedine stranice i tablice, postavlja se pitanje: Da li netko danas nastavlja taj i takav rad? Pravilnik o registru vinograda, obaveznim izjavama, pratećim dokumentima i podrumskoj evidenciji N.N. 121/10 propisuje na koji način se vodi evidencija o proizvodnji i zalihama vina u vinogradarstvu i vinarstvu, međutim kada se napravi usporedba sa sustavnom evidencijom kakvu je na posjedu vodio Zdenko Turković u Kutjevu uočljive su prednosti i velika vrijednost takve evidencije, u odnosu na zamišljeni registar vinograda.

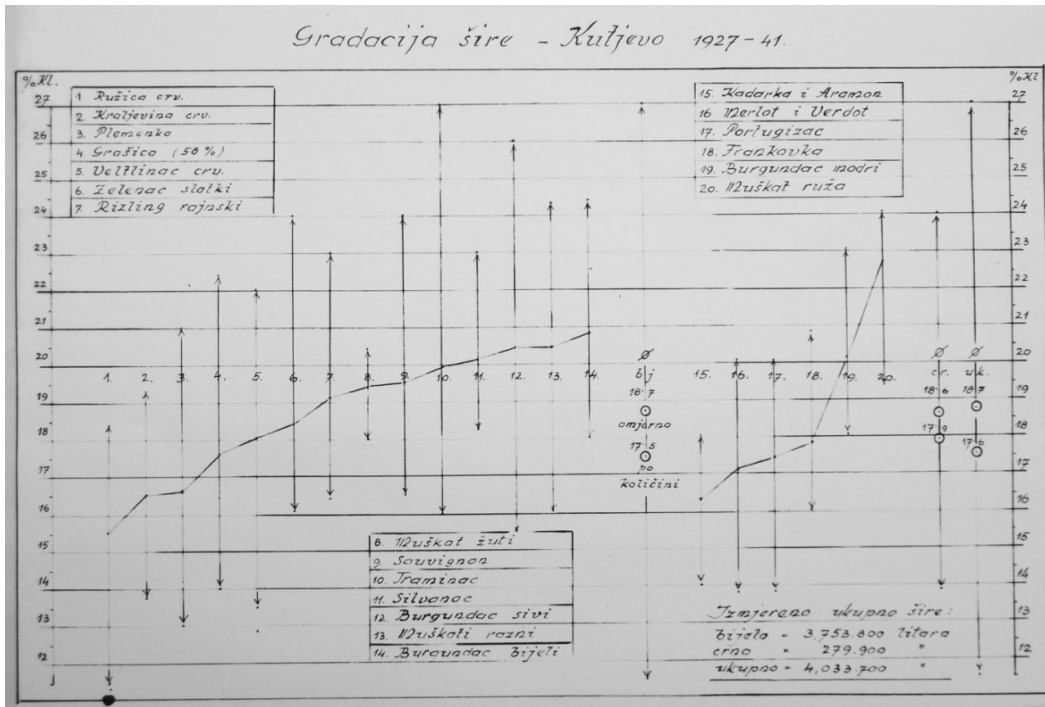
## Materijal i metode

Knjigovodstvo se vodi po američkom, odnosno kontrolnom “Ruf” - sustavu. Za svaki pojedini nasad ili grupu nasada vodi se jedan “Glavni račun”, a svaki od tih glavnih računa ima odgovarajući broj “Podračuna” (subkonta). Za vinograde: rezanje, vezanje, tamanjenje uzročnika bolesti i štetočina, obrađivanje, uzdržavanje armature, inventara, zgrada, putova, berba, gospodarski proizvodi, gnojenje, plaće, trsovi, grožđe, odvoz mošta, razno. Za podrum: rasvjeta, burad stalna, burad transportna, vino, žestoka pića, uzdržavanje zgrada, posuda, inventara, prešanje, plaća, razno. Sva knjiženja vode se svake godine strogo na isti način. U protivnom slučaju moglo bi se dogoditi da pojedini glavni ili podračuni iskazuju razlike, koje bi bezrazložno pokvarile konačnu sliku. Zbroj svih podračuna prenosi se mjesečno na glavni račun, a ti opet tromjesečno sačinjavaju takozvanu “sirovu bilancu”, koja se upisuje na pregledni način, godina do godine. Konačni godišnji obračun pruža općeniti i pojedinačni pregled svih mogućih rezultata, koji se opet slažu, po petogodišnjima, u pregledne statistike po svim zanimljivim pojedinostima. Kako naglašava Zdenko Turković: pojedinačni podatci jedne godine nemaju nikakove pregledne vrijednosti, već tek onda ako se skupe u najmanje 5 ili 10 godišta. Ako dakle netko, a možda još i onako “od oka”, kaže da je te i te godine imao neki osobiti rezultat, onda to ne znači baš ništa, ako je prošlih godina na istom mjestu imao neuspjeha iz mnogih razloga, koji su konačno mjerodavni za prosuđivanje nasada (Turković, 1939). Godine 1926. gospodin Zdenko Turković uvodi sustav vođenja pojedinih parametara u vinogradu i podrumu formulare tzv. “Opis sastojina”, koji sadrže slijedeće podatke: statistika uroda grožđa, gradacija mošta, odnos količine i kakvoće uroda, te takove podatke bilježi u periodu od 1925. do 1944. godine (Turković, 1939).

Statistika uroda grožđa (hl)  
na vinogradu i podrumu u Kutjevu 1925-1939

Godina	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1925-39 1915-39	
<b>Uroda vinograde</b>																	
Bijela	107.20	94.30	94.30	94.30	94.30	(96.21)	99.00	120.3	118.00	154.00	158.00	(16.22)	76.00	75.00	71.00	74.00	(71.20)
Crna	36.80	37.00	37.00	37.00	37.00	(38.41)	38.00	38.00	38.00	38.00	(38.41)	38.00	38.00	38.00	38.00	38.00	(38.21)
Mlička	15.40	15.40	15.40	15.40	15.40	(15.40)	15.40	15.40	15.40	15.40	(15.40)	15.40	15.40	15.40	15.40	15.40	(15.40)
Ukupno	159.40	146.70	146.70	146.70	146.70	(150.02)	152.40	173.70	171.40	207.40	211.40	(26.02)	129.40	128.00	124.40	127.40	(124.81)
<b>Uroda podrumskih vinograde</b>																	
Bijela	25.90	23.00	23.00	23.00	23.00	(23.00)	23.00	23.00	23.00	23.00	(23.00)	23.00	23.00	23.00	23.00	23.00	(23.00)
Crna	25.00	25.00	25.00	25.00	25.00	(25.00)	25.00	25.00	25.00	25.00	(25.00)	25.00	25.00	25.00	25.00	25.00	(25.00)
Mlička	25.00	25.00	25.00	25.00	25.00	(25.00)	25.00	25.00	25.00	25.00	(25.00)	25.00	25.00	25.00	25.00	25.00	(25.00)
Ukupno	75.90	73.00	73.00	73.00	73.00	(73.00)	73.00	73.00	73.00	73.00	(73.00)	73.00	73.00	73.00	73.00	73.00	(73.00)
<b>Uroda vinograde s podrumom</b>																	
Bijela	133.30	119.70	119.70	119.70	119.70	(123.01)	125.40	146.70	144.40	130.00	134.00	(19.22)	102.40	103.00	97.00	101.40	(98.20)
Crna	61.80	62.00	62.00	62.00	62.00	(63.41)	63.00	63.00	63.00	63.00	(63.41)	63.00	63.00	63.00	63.00	63.00	(63.21)
Mlička	41.30	40.80	40.80	40.80	40.80	(40.80)	40.80	40.80	40.80	40.80	(40.80)	40.80	40.80	40.80	40.80	40.80	(40.80)
Ukupno	216.40	222.50	222.50	222.50	222.50	(227.22)	229.20	250.50	248.20	211.60	237.80	(29.24)	206.20	206.80	200.80	205.20	(201.21)

Slika 1: Statistika uroda grožđa od 1925. do 1939. godine (Turković, 1939)



Slika 2: Gradacija mošta (Turković)

### Rezultati i rasprava

Iz preglednih tabela vidimo točne podatke o proizvodnji grožđa u vinogradima vlastinstva Kutjevo od 1925. do 1944. godine, kao i vrijednosti sladora i kiselina u moštu. Na posebnom grafikonu vidimo gradaciju mošta u periodu od 1927. do 1941. U grafikonima vidimo odnos količine i kakvoće uroda u istom periodu. Da je ovakva evidencija sustavno nastavljena bilo bi lakše odgovoriti na slijedeća pitanja:



Slika 3: Da li je ovo vinograd?

Važno je napomenuti da je u arhivu spremljena evidencija za svaku katastarsku česticu te bi bilo preporučljivo prikazati sve te podatke. Ovo su zbirni podaci za pojedine objekte. Ako pokušamo napraviti usporedbu tablica iz priloga sa obrascima predviđenim u Pravilniku o registru vinograda, obaveznim izjavama i podrumskoj evidenciji Narodne novine 121/10, uočiti ćemo nepovezanost obrazaca predviđenih za

evidencije, a samim tim nepreglednost stanja u vinogradima. Isto tako nedostaje vremenski slijed od godine do godine, kao i višegodišnje analize. Malim korekcijama i povezivanjem evidencija, dobili bi sustavno višegodišnje praćenje stanja u vinogradu, poželjno bi bilo kada bi se to vodilo za svaku katastarsku česticu, te na taj način sačinjavalo banku podataka, po vinogorjima i regijama na sveopću korist.



Slika 4: Kakav je ovo vinograd?

### Zaključak

Evidencija o proizvodnji i kvaliteti grožđa u vinogradarskoj proizvodnji jednako je važna kao i sama proizvodnja. Ako se ne vodi kvalitetna evidencija o proizvodnji grožđa i kvaliteti mošta po pojedinim katastarskim česticama ili tablama nasada proizvođači lako mogu dospjeti u poteškoće a da toga nisu ni svjesni. Pored godišnjih evidencija o kvaliteti grožđa, prinosima po hektaru, datumu berbe i svim ostalim radnjama na svakoj katastarskoj čestici potrebno je praviti i pet i desetgodišnje analize kako bi se iz preglednih analiza mogli donositi konkretni zaključci. Sustavna i temeljita evidencija o vinogradarskoj proizvodnji kakvu je vodio Zdenko Turković mogla bi poslužiti kao izvrstan primjer u budućem ustroju registra vinograda osnovanog prema pravilniku Narodne novine 121/10 , a uz male preinake u evidencijskim obrascima i njihovim povezivanjem u višegodišnji slijed dobio bi se kvalitetan “registar vinograda”.

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# Kupovno ponašanje i preferencije potrošača vina na području Dubrovačko - neretvanske županije

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## Sažetak

S ciljem identifikacije kupovnih i potrošačkih preferencija potrošača vina provedeno je anketno ispitivanje na uzorku od 100 ispitanika na području Dubrovačko-neretvanske županije. Rezultati istraživanja su pokazali da najveći broj ispitanika kupuje vino barem jednom mjesečno, najčešće u supermarketima, trgovinama i izravno od proizvođača. Od vanjskih obilježja vina ispitanicima je najvažnija kvaliteta (prosječna ocjena važnosti 4,57) i cijena vina (4,22), a od unutarnjih obilježja okus (4,57) i miris vina (4,22). Većina ispitanika preferira crno vino, uravnoteženog okusa i jače izraženog mirisa. Vino se najčešće pije nekoliko puta mjesečno, većinom kod prijatelja i u restoranima. Najviše ispitanika kupuje vino po cijeni od 21 - 40 kn dok bi za bocu idealnog vina najveći broj ispitanika bio spreman izdvojiti između 60-100 kn. Ukupnom ponudom vina u Dubrovačko neretvanskoj županiji je zadovoljno približno dvije trećine ispitanika. Rezultati ovog istraživanja daju podlogu za poboljšanje ponude vina u Dubrovačko neretvanskoj županiji.

Ključne riječi: Dubrovačko-neretvanska županija, vino, potrošači, anketa

## Buying behavior and preferences of wine consumers in the area of Dubrovnik - Neretva County

### Abstract

The aim of this paper was to identified buying behavior and preferences of wine consumers in the area of Dubrovnik - Neretva County. In order to collect necessary data a survey with 100 randomly chosen wine consumers was conducted. The results showed that most respondents buy wine at least once a month. Wine is most often bought in supermarkets, shops and directly from producers. The most important extrinsic wine attribute is quality (with an average grade of 4,57) and price of wine (4,22). Regarding intrinsic wine attributes the consumers pay most attention to the taste of wine (average importance 4.63) and smell of wine (4.24). The majority of the respondents prefer red wine with balanced taste and moderately defined smell. Most of the respondents drink wine several time a month by friends and in restaurants. Majority of the consumer buy wines that cost from 21 to 40 kunas per a bottle and for the bottle of perfect wine they are ready to pay from 60 to 100 kunas. Almost two third (63%) of all respondents are satisfied with wine supply in Dubrovnik - Neretva county. The results of this research will provide an information basis for the improvement of wine supply in Dubrovnik - Neretva County.

Key words: Dubrovnik - Neretva County, wine, consumers, survey

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## Uvod

Vinogradarstvo i vinarstvo je oduvijek predstavljalo jednu od vodećih privrednih grana u Dubrovačko-neretvanskoj županiji. Temeljem Upisnika proizvođača grožđa, vina i drugih proizvoda od grožđa i vina te voćnih vina kojeg vodi Zavod za vinogradarstvo, vinarstvo i voćarstvo za područje Dubrovačko neretvanske županije upisano je 2.723 proizvođača i 2.246 ha vinogradarskih površina. Na području županije dominantan je sljedeći sortiment: Plavac mali 46%, Pošip 10%, Plavina 10%, Maraština 9% i Vranac 5% (HCPHS, 2010.).

U posljednjih nekoliko godina potrošnja vina u Hrvatskoj je u laganom porastu i kreće se oko 25 litara po stanovniku godišnje uz manje oscilacije. Hrvatska je do 2002. godine bila samodostatna u vinu, da bi se do 2008. godine stupanj samodostatnosti smanjio na 91%

(MPRRR, 2009.). Prema prognozama stručnjaka domaćem vinarstvu najveće opasnosti prijete od velike ponude uvoznih vina, nižih cijena tih vina i njihovog jakog reklamiranja (Božić, 2008.). Domaći vinari ipak imaju sreću da potrošači pokazuju lojalnost hrvatskim vinima, kao i regionalnu lojalnost u smislu konzumacije vina prema regiji podrijetla (Hendal market research, 2009.). Pitanje je doduše hoće li domaći vinari znati zadržati tu lojalnost ili će ih pobijediti jeftiniji i agresivniji konkurenti iz uvoza. Konkurentnost domaćeg vinarstva moguće je povećati većim ulaganjem u razvoj marke (zajednički marketing), poboljšanjem tehnologije proizvodnje i njege vina, izgradnjom imidža hrvatskih vina i jačim reklamiranjem vina (Radman i sur., 2004., Grgić i sur., 2009.). Autohtona vina s posebnostima ovog podneblja treba prezentirati kao dio turističke ponude (Duboković, 2007), a promociju vina treba usmjeriti na regionalne razlike, autentičnost sorte i na povijest kraja iz kojeg sorta potiče (Cerjak, Kovačić, 2003.).

Otkrivanje potrošačkih preferencija prema vinu, njihovih stavova i kupovnog ponašanja omogućuje definiranje odgovarajućeg marketing programa koji bi zadovoljio potrošača, te poboljšao prodaju i potrošnju vina na području Dubrovačko - neretvanske županije.

## Materijal i metode

U istraživanju je rabljena metoda ispitivanja, a kao instrument strukturirana anketna upitnica. Anketno ispitivanje potrošača je provedeno na uzorku od 100 slučajno odabranih ispitanika na području Dubrovačko-neretvanske županije. U prvom dijelu anketnog ispitivanja je utvrđeno ponašanje potrošača u kupnji i potrošnji vina. Sljedeća skupina pitanja se odnosila na važnost pojedinih obilježja vina koja su mjerena na ljestvici od pet stupnjeva (1= potpuno nevažno, 5 = jako važno), a mjerena su sljedeća obilježja vina: kvaliteta, cijena, način proizvodnje, ime proizvođača, oblik boce i etiketa. Od unutarnjih obilježja vina mjerena je važnost okusa, mirisa, boje i starosti vina. Posebna skupina pitanja se odnosila na preferencije prema vinu i zadovoljstvo ponudom vina. Posljednjom skupinom pitanja su prikupljeni podaci o sociodemografskim obilježjima ispitanika: spol, dob, školska sprema i dohodak. Prikupljeni podaci unijeti su i obrađeni u statističkom programskom paketu (SPSS). Obrada prikupljenih podataka je provedena pomoću jednovarijantne (frekvencije, distribucija podataka) i dvovarijantne analize podataka (hi-kvadrat test).

## Rezultati i rasprava

### Opis uzorka

U anketnom istraživanju je sudjelovalo 59% žena i 41% muškaraca. Prosječna dob ispitanika koji su sudjelovali u istraživanju je 34 godina (u rasponu od 18 do 70 godina). Najveći broj ispitanika ima završenu srednju školu (65%), trećina ispitanika ima višu ili visoku školu (32%), a najmanji broj ispitanika je sa završenom osnovnom školom (3%). Najviše ispitanika ima mjesečna primanja preko 6 000 kuna (43%), 37% ispitanika između 4000-6000 kn, a 12% manje od 4 000 kuna.

### Ponašanje potrošača u kupnji i potrošnji vina

Najveći broj ispitanika kupuje vino jednom mjesečno (42%) ili više puta mjesečno (36%). Jednom tjedno kupuje 16% ispitanika, a ostali kupuju nekoliko puta tjedno (6%). Najviše ispitanika kupuje crno vino (67%) dok ostali kupuju bijela vina. Žene više kupuju crna vina u odnosu na muške ispitanike ( $p=0,04$ ). Potrošači najčešće kupuju domaća vina (73%), dok samo 4% kupuje uvozna vina. Ostali ispitanici podjednako kupuju domaća i strana vina. Potrošači više preferiraju domaća vina zbog bolje kvalitete i poznatog podrijetla. S

obzirom na podrijetlo regije 2/3 ispitanika preferira mediteranska vina, zatim 26% ispitanika preferira vina bez obzira na podrijetlo, a najmanji broj ispitanika (6%) preferira kontinentalna vina. Najučestalije mjesto kupnje vina su supermarketi (31%), trgovine i izravno od proizvođača (25%). U vinotekama kupuje 14% potrošača, a manji broj ispitanika vino kupuje u specijaliziranim trgovinama (3%) i na sajmovima. Rezultati su pokazali da žene više kupuju u specijaliziranim trgovinama i supermarketima, dok muškarci više kupuju izravno od proizvođača ( $p=0,005$ ). Potrošači vino najčešće piju nekoliko puta mjesečno (Tablica 1). Kod muškaraca je utvrđena veća učestalost potrošnje vina u odnosu na žene ( $p=0,00$ ). Ispitanici nižeg obrazovanja konzumiraju vino učestalije u odnosu na ispitanike višeg obrazovanja ( $p=0,00$ ).

**Tablica 1 Raspodjela ispitanika prema učestalosti potrošnje vina**

Koliko često kupujete vino?	Udio ispitanika (%)
Dnevno	10%
Više puta tjedno	19%
Jednom tjedno	16%
Nekoliko puta mjesečno	28%
Jednom mjesečno	6%
Rjeđe	21%
Ukupno	100,0%

Izvor: vlastito istraživanje

Ispitanici najčešće vino piju kod prijatelja (36%) te u kafićima i restoranima (34%). Više od petine ispitanika (28%) vino najčešće konzumira kod kuće. Izravno kod proizvođača pije samo 2% ispitanika. Najčešće se pije Plavac mali (29%), Graševina (20%) i Babić (7%). Ostala vina su zastupljena u manjem postotku. Nešto više od trećine ispitanika najčešće pije čisto vino (37%), petina ispitanika pije vino pomiješano sa sokom ili nekim drugim alkoholnim pićem (mješavina vina i Coca-Cole-bambus, mješavina vina sa Fantom). Podjednak broj ispitanika (17%) pije vino pomiješano s gaziranom vodom (gemišt) i običnom vodom (bevanda). S obzirom na cjenovno ponašanje, više od trećine ispitanika (39%) kupuje vino po cijeni od 21 do 40 kuna po boci, zatim po cijeni od 41 do 60 kuna/boci 23% ispitanika, a neznatno manje ispitanika po cijeni od 16 do 21 kuna (22%). Najmanje je potrošača koji kupuju vina skuplja od sto kuna (6%). Za bocu idealnog vina najviše ispitanika spremno je izdvojiti od 60 do 100 kn. Potrošači s većim dohotkom i višim obrazovanjem (*sss/vss*) bi izdvojili više novaca za litru idealnog vina u odnosu na ispitanike nižeg dohotka i niže stručne spreme ( $p \geq 0,05$ ).

#### Važnost unutarnjih i vanjskih obilježja vina

Važnost pojedinih obilježja je mjerena na ljestvici od 5 stupnjeva pri čemu je 1 značilo - potpuno nevažno obilježje, a 5 - jako važno obilježje. Rezultati istraživanja su pokazali da je od vanjskih obilježja ispitanicima najvažnija kvaliteta vina (prosječna ocjena na ljestvici od 5 stupnjeva iznosi 4,57), zatim cijena vina (4,22), način proizvodnje (3,59) i ime proizvođača (3,07). Najmanje važno vanjsko obilježje vina je oblik boce ili etikete (2,52).

**Tablica 2 Važnost vanjskih obilježja pri kupnji vina**

Vanjska obilježja	Srednja vrijednost (1 - nevažno 5 - jako važno)	Standardno odstupanje
Kvaliteta	4,57	0,756
Cijena	4,22	0,970
Način proizvodnje	3,59	1,248
Ime proizvođača	3,07	1,233
Oblik boce i etiketa	2,52	1,159

Izvor: Vlastito istraživanje

Od unutarnjih obilježja ispitanicima su najvažniji okus (4,37) i miris vina (srednja ocjena 4,22). Manje važna obilježja su starost i boja vina.

Tablica 3 Važnost unutarnjih obilježja pri kupnji vina

	Srednja vrijednost (1 - nevažno 5 - jako važno)	Standardno odstupanje
Okus	4,37	0,825
Miris	4,22	0,848
Starost	3,85	1,290
Boja	3,47	1,181

Izvor: Vlastito istraživanje

Više od polovice ispitanika preferira uravnotežen okus vina, 16% slatkast okus, a najmanji broj ispitanika (11%) preferira kiselkast okus vina. Kod žena je utvrđena veća sklonost slatkastim vinima, dok muškarci više preferiraju kiselkastiji okus ( $p=0,01$ ). Ispitanici najviše preferiraju (39%) jače izražen miris vina, dok ih neznatno manje preferira slabije izražen miris vina (36%). Manji broj ispitanika preferira voćni (17%) i cvjetni miris vina (8%). Ispitanici uglavnom preferiraju srednje jaka vina od 11 do 13 vol. alk (55%), dok ih znatno manje preferira slabija vina do 11 vol. alk (19%). Manji broj ispitanika (10%) preferira jaka vina s više od 13 vol. alk. Među ispitanicima niže stručne sprema je najviše onih koji preferiraju jaka vina, dok ispitanici srednje i visoke stručne sprema više preferiraju srednja jaka vina, od 11 do 13 vol.alk ( $p=0,00$ ). Ostali ispitanici su bez jasnih preferencija u odnosu na jakost vina. Polovica ispitanika preferira pakiranje od 0,75 l (butelje), dok nešto više od petine ispitanika preferira pakiranje od 1l. Veća pakiranja preferira 19% ispitanika (2l, 5l). Ostali ispitanici preferiraju manja pakiranja od 0,5 litara. Istraživanjem je utvrđeno da muškarci preferiraju veća pakiranja vina u odnosu na žene ( $p=0,02$ ). Najviše ispitanika smatra da su cijene vina na području Dubrovačko-neretvanske županije visoke. Nešto manje ih smatra da su cijene vina umjerene (41%). Ostali ispitanici smatraju da su cijene vina jako visoke ili jako niske. Ukupnom ponudom vina na području Dubrovačko-neretvanske županije je zadovoljno 40% ispitanika, 23% je jako zadovoljno, trećina ispitanika je niti zadovoljna niti nezadovoljna. Samo 4% ispitanika je nezadovoljno ponudom vina.

### Zaključak

Istraživanje je pokazalo da su ispitanici zadovoljni ukupnom ponudom vina na području Županije, te da postoji potražnja za kvalitetnim autohtonim vinima. Najveći broj ispitanika kupuje vino barem jednom mjesečno i to najčešće u supermarketima, trgovinama i izravno od proizvođača. Utvrđeno je da žene više kupuju u specijaliziranim trgovinama i supermarketima, dok muškarci više kupuju izravno od proizvođača. S obzirom na podrijetlo ispitanici preferiraju domaća vina jer smatraju da su bolje kvalitete i okusa u odnosu na uvozna vina. Najčešće se pije Plavac mali, Graševina i Babić. Od vanjskih obilježja vina ispitanicima je pri kupnji najvažnija kvaliteta i cijena vina, a od unutarnjih obilježja okus i miris vina. Većina ispitanika preferira crno vino, uravnoteženog okusa i jače izraženog mirisa. Istraživanje je pokazalo da žene više preferiraju crno vino slatkastog okusa, dok muškarci više preferiraju bijela vina kiselkastijeg okusa ( $p=0,04$ ). Također, utvrđene su razlike u učestalosti potrošnje vina s obzirom na spol i obrazovanje ispitanika, pa je tako kod muškaraca utvrđena veća učestalost potrošnje vina u odnosu na žene ( $p=0,00$ ), dok ispitanici nižeg obrazovanja piju vino učestalije u odnosu na ispitanike višeg obrazovanja ( $p=0,00$ ). Najviše ispitanika kupuje vino po cijeni od 21-40 kn, dok bi za bocu idealnog vina najveći broj ispitanika bio spreman izdvojiti između 60-100 kn. Kako bi se povećala potrošnja i prodaja vina u Dubrovačko - neretvanskoj županiji, neophodno je osigurati veća ulaganja u manifestacije koje promoviraju kvalitetu autohtonih vina (degustacije, gastro tematski putevi, vinske ceste) i u edukaciju potrošača o vinu i načinu konzumiranja vina.

### Napomena

Podaci iznijeti u ovom radu predstavljaju rezultate istraživanja provedenog za potrebe izrade završnog rada Nade Repušić

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# Usporedba potrošnje maslinovog ulja Osječko - baranjske i Splitsko - dalmatinske županije

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## Sažetak

Maslinovo ulje karakteristično je za mediteransko podneblje i mediteranski način prehrane. Cilj ovog istraživanja bio je usporediti potrošnju maslinovog ulja među mlađom populacijom Splitsko-dalmatinske županije s njegovom potrošnjom u Osječko-baranjskoj županiji. Kao predstavnike ovih dviju županija uzeli smo studente u dobi 20 do 25 godina te anketirali 60 splitskih studenata i 60 osječkih. Rezultati su pokazali kako je konzumiranje maslinovog ulja u Dalmaciji puno učestalije jer ga konzumira čak 90% ispitanika, dok u Slavoniji to čini 40% ispitanika. Također smo utvrdili kako ispitanici obje županije maslinovo ulje većinom koriste pri pripremi salata. Ono što je bilo i za očekivati je to da Dalmatinci većinom maslinovo ulje nabavljaju iz domaće proizvodnje budući da je uzgoj i proizvodnja ovog ulja dio njihove tradicije. Zanimljivo je što su razlozi nekonzumiranja maslinovog ulja različiti u ove dvije županije, u SDŽ razlog je njegov okus, dok u OBŽ navode kao razlog to što ono nije uobičajeno u njihovom kućanstvu. Smatramo kako je potrebno više informirati potencijalne potrošače o povoljnim utjecajima maslinovog ulja na zdravlje te potaknuti i razvijati proizvodnju hrvatskog maslinovoga ulja, kako bi ono bilo dostupnije i pristupačnije i ostalim dijelovima Republike Hrvatske.

Ključne riječi: maslinovo ulje, potrošnja, Osječko-baranjska županija, Splitsko-dalmatinska županija

## Comparison of olive oil consumption in the Osječko-baranjska and Splitsko-dalmatinska counties

### Abstract

Olive oil is typically used in the Mediterranean region and in Mediterranean cuisine. The objective of this research was to compare olive oil consumption within the youth population in the Splitsko-dalmatinska County and in the Osječko-baranjska County. The research was carried out on a sample of 60 students from Split and 60 students from Osijek, aged 20-25, who were interviewed about their habits regarding olive oil consumption. The results showed that olive oil consumption was much more widespread in Dalmatia, since as many as 90% of the interviewees from Dalmatia are in the habit of consuming olive oil, compared to 40% of the interviewees from Slavonia. We also established that interviewees from both counties used olive oil predominantly in the preparation of salads. Interviewees from Dalmatia expectedly stated that they mostly used homemade olive oil, since olive cultivation and olive oil production is a part of their tradition. Interestingly, interviewees from the two counties specified different reasons for not consuming olive oil: interviewees from the Splitsko-dalmatinska County said its taste was the reason why they did not consume it, and interviewees from the Osječko-baranjska

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Proceedings. 46<sup>th</sup> Croatian and 6<sup>th</sup> International Symposium on Agriculture. Opatija. Croatia (271-275)

County said the reason was that olive oil use was not customary in their households. It is our opinion that potential consumers should be better informed about the beneficial effects of olive oil on their health, and that Croatian olive oil production should be encouraged and developed in order to make it more available and accessible to the inhabitants of other Croatian regions.

Key words: olive oil, consumption, Osječko-baranjska County, Splitsko-dalmatinska County

## Uvod

Maslinovo ulje neizostavan je dio mediteranskoga načina prehrane. Svakodnevno smo obasipani informacijama o izrazito povoljnom učinku tog *čudotvornog ulja* na zdravlje te uopće ne čudi podatak kako je maslinovo ulje postalo sinonim zdravog načina prehrane. Ljekovita svojstva maslinovog ulja su dobro dokumentirana u znanstvenoj literaturi. Unos ove drevne namirnice pruža zaštitu od kroničnih degenerativnih bolesti i povezuje se sa smanjenim rizikom od bolesti srca, prevencijom karcinoma te osnaženjem imunološkog sustava. Također, pripisuju mu se i protuupalna svojstva te zaštitni učinak na želučanu sluznicu (Žanetić, Gugić, 2006.)

Maslinovo ulje je ulje koje se dobiva izravno iz ploda masline te se ulja razvrstavaju u kategorije: djevičanska ulja, rafinirano ulje, miješano djevičansko i rafinirano ulje, sirovo ulje komine, rafinirano ulje komine te miješano rafinirano ulje komine i djevičansko ulje (Pravilnik o uljima ploda i komine maslina, NN 07/09). Proizvodnja maslinovog ulja stoljećima je zaštitni znak mediteranskog dijela Republike Hrvatske te samim time taj dio Hrvatske ima i veliku svakodnevnu potrošnju te prehrambene namirnice (Sladonja i sur., 2006.). Širenjem tržišta i podizanjem zdravstvene svijesti stanovništva maslinovo ulje postaje sve popularnije i u ostalim dijelovima Republike Hrvatske.

Na prigodnom uzorku studentske populacije usporedili smo potrošnju maslinovoga ulja u Splitsko-dalmatinskoj županiji s njegovom potrošnjom u Osječko-baranjskoj županiji. U radu smo željeli prikazati razlike koje se odnose na čestoću konzumiranja maslinovoga ulja između dviju županija. Također smo usporedili informiranost ispitanika o maslinovom ulju.

## Materijal i metode

Anketom priređenom za potrebe ovog istraživanja anketirana je prigodna skupina ispitanika, 60 studenata Sveučilišta Josipa Jurja Strossmayera u Osijeku te isto toliko studenata Sveučilišta u Splitu. Ispitanici su bili u dobi od 20 do 25 godina. Anketa je sadržavala 10 pitanja i bila je sastavljena iz dva dijela. U prvom dijelu pitanja su se odnosila na potrošnju maslinovog ulja, a drugi dio odnosio se na pitanja informiranosti o proizvodu. Studentima su podijeljeni anketni listovi te je anketiranje, koje je bilo dobrovoljno i anonimno, provedeno u lipnju 2010. godine.

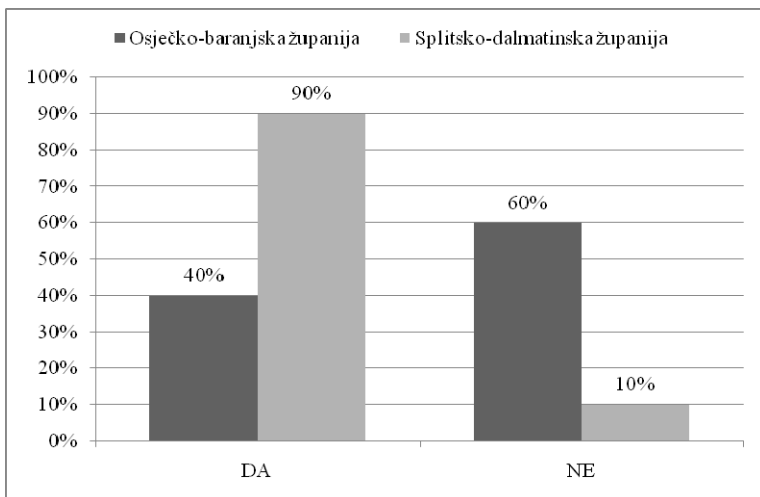
## Rezultati i rasprava

Od 60 anketiranih studenata osječkoga sveučilišta njih 24 koristi maslinovo ulje u svojoj prehrani što čini 40%. Nasuprot tome, od istog broja ispitanih studenata splitskoga sveučilišta maslinovo ulje konzumira 54 ispitanika što je 90%. (Rezultati su grafički prikazani na slici 1.)

Ovakvi rezultati bili su očekivani jer je konzumiranje maslinovoga ulja okosnica mediteranskoga načina prehrane, a posebno Splitsko-dalmatinske županije. Pozitivno je što ispitanici Osječko-baranjske županije u određenoj mjeri konzumiraju i uključuju u svoju prehranu maslinovo ulje. Ipak iz dobivenih rezultata vidljivo je kako potrošači SDŽ to čine češće. Naime, 35% Dalmatinaca svakodnevno konzumira maslinovo ulje, 52% ih to čini par puta tjedno, a samo 13% konzumira maslinovo ulje manje od jednom tjedno. Posve obrnuta situacija je u OBŽ, od ukupnog broja ispitanika koji konzumiraju maslinovo ulje, čak 92% ih to čini manje od jednom tjedno, a nitko ga ne konzumira svakodnevno. Takvi rezultati daju nam naslutiti kako je maslinovo ulje u slavonskoj prehrani još uvijek nedovoljno zastupljeno unatoč pozitivnom mišljenju o njegovoj zdravstvenoj vrijednosti koje je vidljivo iz rezultata ankete. (Slika 2 i 5)

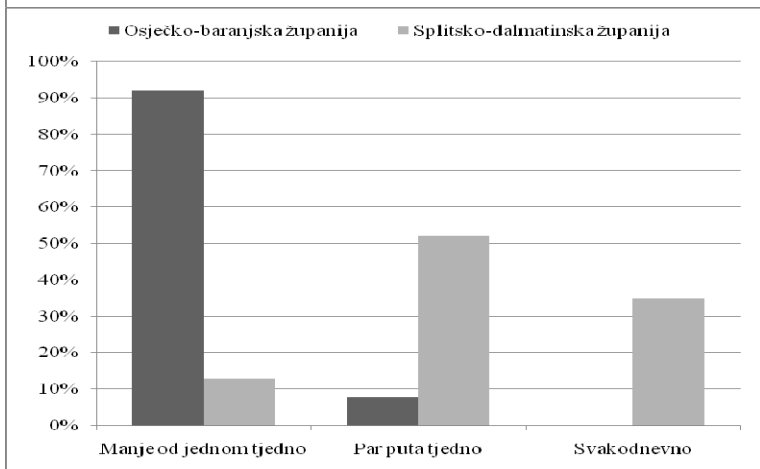
Što se tiče namjene, rezultati su gotovo identični u obje županije pa tako većina ispitanika maslinovo ulje koristi za pripremu različitih salata, Osječko-baranjska 78%, a Splitsko-dalmatinska 79%.

## Usporedba potrošnje maslinovog ulja Osječko - baranjske i Splitsko - dalmatinske županije



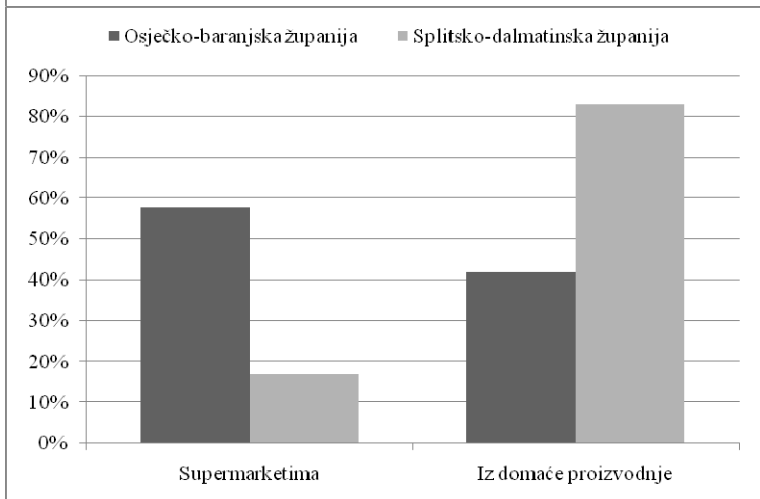
Slika 1. Usporedba potrošnje maslinovog ulja u Osječko-baranjskoj i Splitsko-dalmatinskoj županiji

(Grafikon zgotovili autori)



Slika 2. Učestalost konzumiranja maslinovog ulja

(Grafikon zgotovili autori)

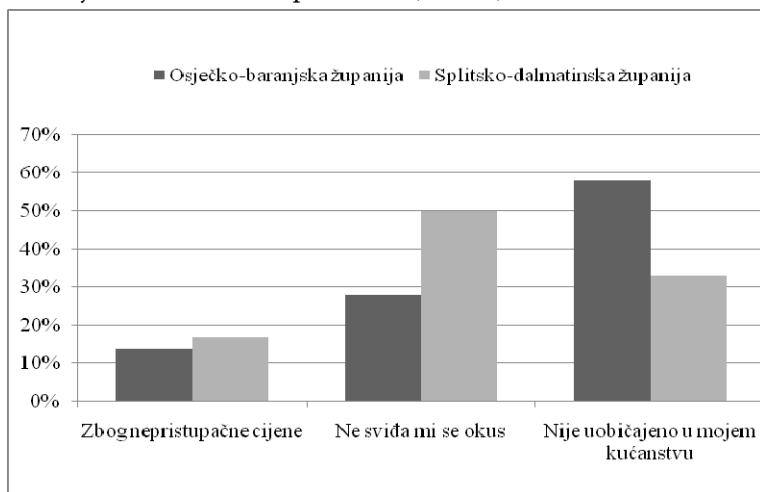


Slika 3. Mjesta nabave maslinovog ulja u OBŽ i SDŽ

(Grafikon zgotovili autori)

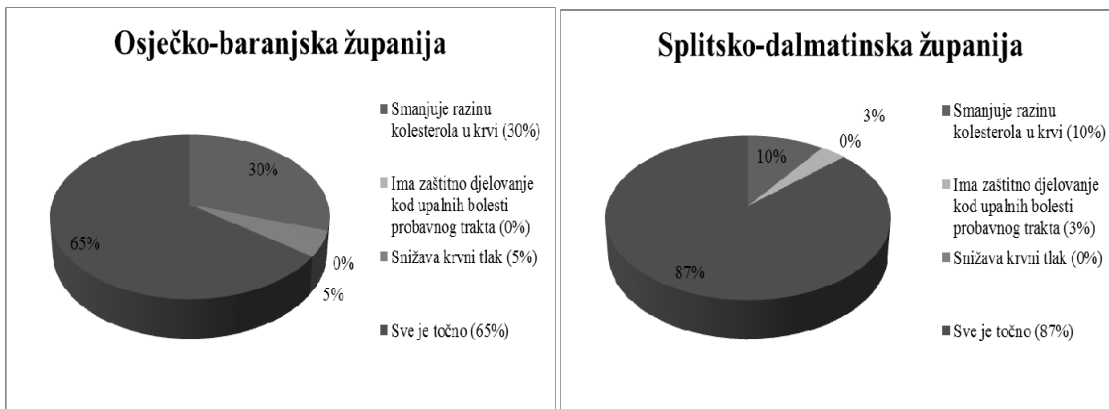
Sljedeći, također očekivani, rezultat odnosi se na izvore nabavljanja ispitivanog ulja. Kao što je vidljivo iz slike br. 3, većina ispitanika SDŽ, njih čak 83% maslinovo ulje nabavlja iz domaće proizvodnje, dok više od pola ispitanika OBŽ maslinovo ulje kupuje u supermarketima (58%). Ovakvi rezultati su očekivani jer je uzgoj maslina i proizvodnja ulja od masline jedna od vodećih grana poljoprivrede Splitsko-dalmatinske županije. Zbog širenja tržišta i poticanja malih proizvođača maslinovog ulja, visokokvalitetno hrvatsko maslinovo ulje sve je prisutnije i dostupnije širokim masama putem supermarketa te se tako može kupiti i u ostalim dijelovima Republike Hrvatske.

Od ukupnog broja ispitanika OBŽ (60%) koji ne konzumiraju maslinovo ulje kao najčešći razlog izabiru odgovor: *nije uobičajeno u mojem kućanstvu* (58%) dok se splitski ispitanici (njih 10%) odlučuju za sljedeći odgovor: *ne sviđa mi se okus* (50%). Ovakav rezultat ponovno nas dovodi do teze kako maslinovo ulje nije uobičajeni dio slavonske prehrane. (Slika 4)



Slika 4. Razlozi nekonsumiranja maslinovog ulja u OBŽ i SDŽ, usporedba (Grafikon zgotovili autori)

Drugi dio ankete odnosio se na informiranost ispitanika o maslinovom ulju i njegovom utjecaju na zdravlje. Dobiveni rezultati bili su podjednaki u obje ispitane skupine. Smatramo kako je spomena vrijedno prikazati (slika 5) da su ispitanici Splitsko-dalmatinske županije ipak nešto svjesniji sveobuhvatnog povoljnog učinka ispitivanog objekta na ljudsko zdravlje.



Slika 5. Odgovori na pitanje: Maslinovo ulje ima koristan učinak za koja stanja?

(Grafički prikaz zgotovili autori)

### Zaključak

Maslinovo ulje je namirnica koja se već stoljećima pripravlja u mediteranskom dijelu RH i postala je sastavni dio tradicije te regije. Širenjem tržišta i povećavanjem zdravstvene svijesti ta namirnica se polako širi i na ostale dijelove RH. Iz dobivenih rezultata provedenog istraživanja vidljivo je kako se u OBŽ maslinovo ulje znatno manje konzumira nego u SDŽ zbog, smatramo, velikog utjecaja tradicije prehrambenih navika podneblja u kojem žive. Isto tako, informiranost o toj namirnici je u OBŽ manja nego u SDŽ. Kako je ispitivani uzorak u obje županije bio prigodan, bilo bi zanimljivo provesti istraživanje na nacionalnoj razini, na puno većem uzorku različitih starosnih grupa koji bi bio reprezentativan. Pretpostavljamo kako bi tako dobiveni rezultati bili slični rezultatima ovog istraživanja jer su studenti specifična skupina populacije koja još uvijek nije potpuno samostalna te su njihove prehrambene navike u velikom broju slučajeva odraz prehrambenih navika njihovih ukućana. Kako bismo poboljšali potrošnju maslinovog ulja u ostalim regijama Republike Hrvatske potrebno je više informirati potencijalne potrošače o povoljnim utjecajima maslinovoga



ulja na zdravlje, a posebno mlade ljude koji će uskoro samostalno odlučivati o prehrani u svom kućanstvu. Također je potrebno poticati i razvijati proizvodnju hrvatskog maslinovoga ulja, kako bi kvalitetno maslinovo ulje bilo dostupnije i pristupačnije i ostalim dijelovima Republike Hrvatske.

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Pravilnik o uljima ploda i komine maslina. Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja (NN 07/09)

[www.vitamini.hr](http://www.vitamini.hr)

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# Percepcije potrošača o sigurnosti i rizicima povezanim s hranom

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## Sažetak

Sigurnost i kvaliteta hrane su u zadnjih petnaestak godina postali aktualna medijska tema uslijed takozvane krize hrane u Europi i svijetu. Cilj rada bio je na temelju ankete potrošača s područja Istočne Hrvatske utvrditi njihove osnovne percepcije o sigurnosti hrane te zdravstvenim rizicima povezanim s konzumiranjem hrane. Rezultati istraživanja pokazali su da većina ispitanika osjeća zabrinutost prilikom kupnje hrane. Glavne asocijacije povezane sa sigurnošću hrane su kvaliteta, povjerenje i ekološka proizvodnja. Ispitanici su spremni izdvojiti više novca za veću sigurnost. Ispitanici najopasnijim smatraju rizike koji uzrokuju direktne bolesti i smetnje (salmonela i pokvarena hrana), dok manje opasnim smatraju rizike koji indirektno utječu na zdravlje (pesticidi, hormoni, konzervansi, GMO). Ispitanici su slabo informirani po pitanju sigurnosti hrane pa je efikasnija potrebno efikasnije informiranje edukacija potrošača po pitanju sigurnosti hrane neophodna. Potrošači uvažavaju institucionalne, zakonodavstvene i medijske napore koji se zadnjih 10-15 godina polažu po pitanju sigurnosti hrane jer u većini smatraju da je sigurnost hrane danas veća nego prije 15 godina.

Ključne riječi: percepcije potrošača, sigurnost, hrana, rizik, izvori informacija

## Consumer perception regarding food safety and health risks

### Abstract

Food quality and safety have been highly topical for the past 15 years due to recent so called food crisis in Europe and wider. The paper was aimed to define consumers' perceptions related to food safety and health risks via survey carried out in East Croatia. The great majority of respondents feel concern during daily food shopping. The main associations related to food safety were: quality, confidence and organic production. Respondents are willing to pay extra money for higher food safety. Health risks which affect diseases directly are considered as the most dangerous (salmonella and spoiled food), while risks which affect health indirectly are considered as less dangerous (pesticides, hormones, preservatives, GMO). Generally, consumers are poorly informed about food safety so more efficient consumers' education about food safety is necessary. Consumers respect institutional, legislative and media efforts regarding food safety since mostly they consider food safety today higher than 15 years ago.

Key words: consumer perceptions, safety, food, risk, communicators

## Uvod

Sigurnost i kvaliteta hrane su u zadnjih 15 godina postali vruća medijska tema uslijed takozvane krize hrane u Europi i svijetu. Pojmovi kvaliteta i sigurnost hrane najčešće se upotrebljavaju naizmjenično ili zajedno. Sam pojam sigurnosti hrane može se definirati u širem ili užem smislu (Ritson i Mai, 1998). U užem smislu, sigurnost hrane suprotna je pojmu rizika povezanog s hranom, ili drugim riječima, sigurnost hrane je vjerojatnost da nećemo oboljeti od bolesti uslijed konzumiranja određene hrane. U širem smislu, pod sigurnošću hrane može se smatrati briga potrošača o osobinama njima nepoznate hrane, kao npr. nepovjerljivost prema genetički modificiranoj hrani.

Prije tzv. krize uzrokovane kravljim ludilom (Burton i Young, 1996), krize s dioksinom u Belgiji (Verbeke, 2001) te daminozidom (Alar-spor) u Sjedinjenim Američkim Državama (Hermann i sur., 1997; Auld, 1990) većina je potrošača očekivala da je svaka hrana na tržištu kvalitetna i sigurna. Međutim, situacija se promijenila zadnjih godina, sigurnost hrane postala je poželjna karakteristika kvalitete hrane (Brunso i sur., 2002).

Radi ponovnog zadobivanja povjerenja potrošača u kvalitetu hrane, javne ustanove utječu na industriju hrane i stočne hrane razvijanjem sveobuhvatnog sustava upravljanja kvalitetom kako bi se poboljšala sigurnost hrane, na restrukturiranje sustava inspekcije hrane te na poboljšanje informiranja potrošača. Stoga, većina prehrambenih proizvođača u Europi, te u manjem broju u Hrvatskoj, provodi sustave za osiguranje sigurnosti i kvalitete hrane (ISO 9001, ISO 22000:2005., HACCP i druge).

Cilj rada bio je na temelju ankete potrošača s područja Istočne Hrvatske utvrditi njihove osnovne percepcije o sigurnosti hrane i zdravstvenim rizicima povezanim s konzumiranjem hrane, te utvrditi uočavaju li potrošači promjene te napore koji poduzimaju nadležne institucije.

## Materijal i metode

Anketa o percepcijama potrošača o sigurnosti hrane i rizika provedena je tijekom svibnja 2010. godine. U anketi je sudjelovalo 150 ispitanika starijih od 18 godina s područja Osijeka, Đakova i Našica. Anketa je sastavljena uz djelomičnu pomoć rezultata istraživanja provedenih u Njemačkoj u rasponu od 1994.-2002. godine (Röhr i sur., 2004) u smislu sastavljanja ankete te usporedbe rezultata.

Anketa se sastojala od 13 pitanja koja se mogu podijeliti na tri segmenta:

1. Percepcije potrošača o sigurnosti hrane i zdravstvenim rizicima,
2. Cjenovna spremnost ispitanika za kupnju hrane sigurne od rizika,
3. Stavovi potrošača prema izvorima informacija vezanim za sigurnost hrane.

Podaci dobiveni anketnim ispitivanjem statistički su obrađeni PC aplikacijama SAS for Windows (SAS Institute Inc., Cary, NC, USA), StatSoft Statistica i Excel za utvrđivanje analize varijance (ANOVA), korelacija i multiregresijskih ovisnosti.

## Rezultati i rasprava

### Analiza osnovnog skupa

U anketi je sudjelovalo 150 ispitanika, od čega je bilo 61% ženskih i 39% muških ispitanika.

Prosječna životna dob ispitanika bila je 39 godina. Kada se ispitanici podjele po dobnim skupinama, 44,7% ispitanika bilo je mlađe od 35 godina, 30% ispitanika bilo je od 35-49 godina, 21,3% od 50-64 godine te 4% ispitanika starijih od 64 godine.

Prema broju osoba u domaćinstvu, prevladavali su ispitanici iz domaćinstava s 4 osobe (29%), zatim s tri osobe (27%), dvije osobe (24%), a najmanje je ispitanika bilo iz jednočlanih domaćinstava (11%) te iz domaćinstava s više od četiri osobe (9%).

Među ispitanicima je bio jednak broj osoba iz obitelji s djecom te iz obitelji bez djece. Među ispitanicima iz obitelji s djecom, najviše ih je bilo s djecom koja su starija od dvanaest godina (53%), zatim iz obitelji s djecom dobi od dvije do šest godina (24%), zatim dobi šest do dvanaest godina (17%), a najmanje ih je bilo s djecom mlađom od dvije godine (5%).

## Percepcije potrošača o sigurnosti hrane i zdravstvenim rizicima

Pitanje o zabrinutosti potrošača pri kupnji hrane postavljeno je s ciljem kako bi se inicijalno utvrdila zabrinutost, odnosno indiferentnost ispitanika po pitanju sigurnosti hrane (tablica 1.).

Veliki broj ispitanika (79%) zabrinut je prilikom kupnje hrane. 25% potrošača zabrinuto uvijek, a 54% potrošača ponekad. Nasuprot tome, istraživanje u Kielu pokazalo je da je čak 77% ispitanika zabrinuto pri kupnji hrane uvijek, od kojih 18% ponekad. Iz ovog proizlazi da su naši potrošači ipak nešto sigurniji u kvalitetu hrane u odnosu na njemačke potrošače jer ima trostruko manje potrošača koji su konstantno zabrinuti sigurnošću hrane. Nadalje, percepcija potrošača se razlikuje ovisno o njihovoj pripadnosti pojedinim grupama (spol, dob, broj osoba u obitelji itd.). Podjela ispitanika prema spolu nije donijela značajne statističke razlike u odgovorima. Općenito gledano, veću zabrinutost za sigurnost hrane osjećaju mlađi ispitanici, ispitanici iz manjih obitelji te ispitanici koji nemaju djecu. Ovi ispitanici imaju statistički značajno odstupanje u odnosu na ostale ispitanike. Ispitanici koji imaju malu djelu (do dvije godine) najmanje osjećaju zabrinutost pri kupnji hrane.

Na ponuđeno pitanje da ispitanici sami navedu tri asocijacije koje u njima pobuđuje pojam sigurnosti hrane, 42% ispitanika nije navelo niti jednu asocijaciju. 51% ispitanika koji su odgovorili na pitanje rekli su da je to kvaliteta (dokaz povezanosti sigurnosti i kvalitete u percepciji potrošača), 34% povjerenje, a 27% da je to ekološka proizvodnja.

Tablica 1. Zabrinutost ispitanika pri kupnji hrane po kategorijama ispitanika

	Zabrinutost pri kupnji hrane (%)			Signifikantost	p
	Da	Ponekad	Ne		
Spol					n.s.
Muški	29,9	43,1	27,6	a	
Ženski	25,0	59,8	15,2	a	
Dob					0,04
<34	32,8	50,8	16,4	b	
35-49	22,2	62,2	15,6	a	
50-64	21,9	43,8	34,4	a	
>65	16,74	66,7	16,7	a	
Broj osoba					0,01
1	12,5	50,0	37,5	b	
2	16,7	52,8	30,5	b	
3	31,7	58,5	9,8	a	
4	37,2	51,1	11,6	a	
>4	21,4	50,0	28,6	a	
Djeca					0,02
Da	33,3	53,3	13,3	a	
Ne	20,0	53,3	26,78	b	
Dob djece					0,04
0-2	100	-	-	a	
2-6	38,9	50,0	38,9	b	
6-12	7,7	84,6	7,7	b	
>12	32,5	50,0	17,5	b	
Ukupno	25	54	20		
Ukupno (Röhr)	77	18	5		

## Cjenovna spremnost ispitanika za kupnju hrane sigurne od rizika

Slijedeće pitanje u anketi bilo je da li su ispitanici spremni ili ne izdvojiti višu cijenu za proizvod dokazane kvalitete koji ima umanjen zdravstveni rizik. Velika većina ispitanika odgovorila je da je spremna (87%).

Nadalje, pokušala se utvrditi visina cjenovne spremnosti ispitanika za ponuđene vrste hrane (jaja, meso, riba i jabuke) od 10% pa do 100% (tablica 2).

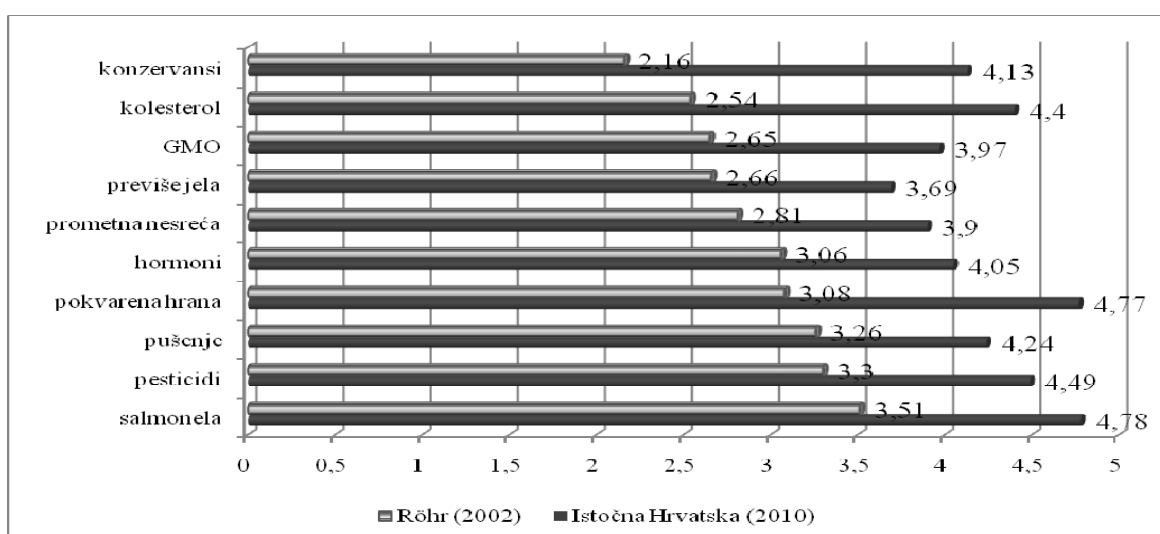
Ispitanici su najviše spremni platiti za sigurnost mesa i ribe jer je 50%, odnosno 30% ispitanika spremno platiti 50 i 100% višu cijenu za veću sigurnost. Visina cjenovne spremnosti ispitanika u pozitivnoj je

korelaciji je s prethodnim pitanjem, odnosno njihovom spremnosti da plate više za zdravstveno sigurne proizvode. Koeficijent korelacije (r) iznosi 0,32\*\* za jaja, 0,20\* za meso, 0,26\*\* za jabuke i 0,29\*\* za ribu.

Tablica 2. Cjenovna spremnost ispitanika za veću sigurnost hrane (%)

	Jaja	Meso	Jabuke	Riba
+10%	24,7	15,3	22,7	22,7
+20%	23,3	15,3	24,7	23,3
+30%	17,3	22,7	26,0	23,3
+50%	13,3	23,3	18,7	20,0
+100%	21,3	23,3	8,0	10,7

Usporedno gledajući, potrošači Istočne Hrvatske više su zabrinuti pojedinim zdravstvenim rizicima u odnosu na njemačke potrošače (grafikon 1.). Ispitanici najopasnijim smatraju rizike koji uzrokuju direktne bolesti i smetnje (salmonela i pokvarena hrana), dok manje opasnim smatraju rizike koji indirektno utječu na zdravlje (pesticidi, hormoni, konzervansi, GMO)



Grafikon 1: Percepcija zdravstvenih rizika (Likert skala: 1 - bezopasno, 5 - jako opasno)

Percepcija rizika potrošača u značajnoj je korelaciji s pojedinim karakteristikama potrošača te s njihovim stavovima. Tako je percepcija rizika od pokvarene hrane u korelaciji s ispitanicima koji imaju djecu ( $r=0,24^{**}$ ) te s ispitanicima čija su djeca starije dobi ( $r=0,21^{**}$ ). Rizik od GMO i hormona u korelaciji je s zabrinutosti potrošača pri kupnji hrane ( $r=0,24^{**}$ , odnosno  $r=19'$ ).

Po pitanju educiranosti potrošača o standardima povezanih sa sigurnošću hrane (ISO 9001 i HACCP), 14% ih je odgovorilo da zna što ti standardi znače, a 63% da je čulo o tome, ali da ne zna pojedinosti. Međutim u slijedećem pitanju kad su ispitanici bili zamoljeni definirati svojim riječima što ti standardi znače, niti jedan ispitanik nije odgovorio ništa iz čega njihova informiranost iz prethodnog odgovora dolazi u pitanje.

Na pitanje kojem izvoru informacija potrošači najviše vjeruju kada su u pitanju zdravstveni rizici, potrošači najviše povjerenja imaju u informacije dobivene od obitelji i prijatelja (45%), te od liječnika (40%). 10% ispitanika vjeruje medijima, 9,3% društvu za zaštitu potrošača, 7,3% proizvođačima i 6,6% prehrambenoj industriji. Indikativno je da ispitanici najmanje vjeruju institucijama nadležnim direktno za sigurnost hrane (Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja i Hrvatske agencija za hranu).

Na kraju, željelo se vidjeti da li ispitanici primjećuju i uvažavaju institucionalne napore, aktivnost po pitanju donošenja zakona te medijsku promociju koja se zadnjih 10-15 godina ulaže u sigurnost hrane. Odgovor je da uvažavaju, budući je 63% ispitanika odgovorilo da smatraju sigurnost hrane većom danas u odnosu na prije 15 godina, 9% smatra da nema promjena, a 28% ispitanika smatra da je danas sigurnost hrane manja nego prije. Ustanovljena je pozitivna korelacija percepcije sigurnosti danas s dobi ispitanika ( $r=0,22^{**}$ ) te s njihovom cjenovnom spremnosti za veću sigurnost hrane ( $r=0,24^{**}$ ).

## Zaključci

Na temelju anketnog upitnika provedenog na području Istočne Hrvatske u proljeće 2010, može se zaključiti da većina ispitanika osjeća zabrinutost pri kupnji hrane. Najčešće asocijacije ispitanika pri spomenu hrane su kvaliteta, povjerenje te ekološka proizvodnja. Ispitanici su spremni izdvojiti više novca za veću sigurnost, ponajprije za meso i ribu, a nešto manje za jabuke i jaja. Ispitanici najopasnijim smatraju rizike koji uzrokuju direktne bolesti i smetnje (salmonela i pokvarena hrana), dok manje opasnim smatraju rizike koji indirektno utječu na zdravlje (pesticidi, hormoni, konzervansi, GMO). Većina ispitanika je slabo informirana o sigurnosti hrane, jer iako je 77% ispitanika izjavilo da zna što standardi sigurnosti znače (ISO 9001 i HACCP), nitko nije znao definirati ove standarde. Stoga je efikasnija edukacija potrošača po pitanju sigurnosti hrane neophodna. Potrošači najviše povjerenja imaju u osobne izvore informacija: obitelj, prijatelji i liječnici, a najmanje u institucije koje su direktno nadležne za sigurnost hrane (Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja te Hrvatska agencija za hranu). Ipak, potrošači primjećuju napore koji se zadnjih 10-15 godina polažu po pitanju sigurnosti hrane jer u većini smatraju da je sigurnost hrane danas veća nego prije 15 godina.

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# The estimation of land favorability for different crops and calculation of land price in an agricultural region in Romania

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## Abstract

The aim of this paper is to establish the agricultural potential of an agrarian region located in south of Romania, in eastern part of city capital, by indicating its suitability for a number of 7 field crops (winter wheat, barley, maize, sun-flower, peas and beans, soybean), in the specific environment and soil condition; another goal of the paper was the estimation of land value in the area, by calculating the price of one hectare of agricultural land, according to the current Romanian methodology. The study consisted of two stages: at first, environmental factors influence on soil cover was analysed and soils main features have been enunciated (based on field and laboratory determination); in the second stage, land evaluation was applied, based on agricultural crops requirements in relation to soil and environment. As a result of calculation, most of the agricultural land is part of 3rd class of favorability (according to its natural condition), reflecting a moderate fertility potential, but with increasing opportunities, if land reclamation and correct technologies are applied; small surfaces belong to 4th class of favorability. As the estimation of soil favorability indicated, the land is best suitable for cereal crops.

Key words: soil type, coefficients, favorability class, agricultural crops, land price

## Introduction

Today, when more than ever preservation of soil is regarded as a very actual issue, evaluation of funded resources has become extremely important; but the evaluation can not be made without a complex knowing of soil cover, especially of its main features and properties. The researched region is located in one of Romania's agrarian areas and was arranged for agriculture, benefiting from draining-drainage system, as well as deep loosening in the 80's. Located in proximity of the city capital, it has attracted many investors during the last 20 years, who wanted to change arable land initially destination. At the beginning of the 90's, when funded law started to be applied at national level, the land was returned to the former owners, but the lack of resources contributed to low productivity. Today, the 2100 hectares are represented by arable land and pastures, but a high pressure is put on new construction development. In this context, the question is if there is still agricultural potential in the area and if so, what is the real value of agricultural land. As a result of that, the paper is focused on indicating this land favorability for a considerable range of agricultural crops, as well as on calculation of land price per hectare, in Romanian national currency and Euro.

## Material and methods

Estimation of land favorability, as a first step in land evaluation, was made in accordance to current methodology (Teaci, 1980), based on a table scoring system, consisting of points from 0 to 1 which are assigned to the agricultural land, in correlation to soils natural fertility. The soils have been analysed in relation to environmental components which contributed to their genesis and have influenced their agricultural potential (Andreiași Claudia, 2008). The study first stage consisted of a detailed identification

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and description of soil cover, taking into account soils most representative features (table 1). In the second stage, land evaluation was applied, based on estimation of ecological and pedological factors influence on a range of crops, such as winter wheat, barley, maize, sun-flower, peas and beans, soybean. To each ecological and pedological factor a coefficient was given that ranged between 0.1 to 1, suggesting the restriction or favorability of that factor for a certain crop (0.1 reflects maximum restriction and 1 - perfect suitability). The following indicators have been considered: climate (temperatures and rainfalls), relief slope, ground water depth - as ecological indicators - and soils texture, pH, pseudogleyization, porosity and humus reserve - as pedological indicators. In evaluation, both climate indicators are corrected: temperature, depending on land slope and exposition and rainfalls, depending on land slope and soil permeability. Land evaluation score per crop was obtained as a produce between coefficients and 100, according to the formula: coefficient 1  $\times$  coefficient 2  $\times$ ... $\times$  coefficient n  $\times$  100 (Teaci, 1980). The general land evaluation score was determined as an arithmetic average between the considered crops (tables 2 and 3), indicating the soils potential for each of the 7 crops. The land evaluation score allowed the estimation of land favorability: soils have been divided into favorability areas, according to their agronomic potential (5 land favorability classes, with 20 points evaluation score/class). Last stage was represented by the calculation of agricultural land price. In estimation methodology, winter wheat score is regarded as most important (as being country standard crop), because it reflects soil potential yield: soil potential yield (kg/ha) was given by the produce between evaluation score for winter wheat (calculated before) and the equivalent in kg product/evaluation point (estimated at 40 in Romania) (Mihalache, 2001). In this way, yield value (lei or euro/ha) was calculated as a produce between potential yield and the price of winter wheat in the current agricultural year - 0.5 lei/kg (0.12 euro/kg) in 2010. The value of agricultural land (in Romanian currency or euro/ha) was calculated using formula: VL (= (YV-PC)  $\times$  25, where VL - value of land (lei or euro/ha), YV - yield value (lei or euro/ha), PC - production costs (which are considered, usually, at 85% of yield value) (Lazăr T., 1999). Also, the ratio euro/national currency (lei) is 1: 4,2.

### Results and discussions

The 1295 hectares arable land lie in a plain region, with increased temperature (10,1°-11°C annual average) and low level of precipitation (551-600 mm). A particularity of relief is represented by saucers presence (microcavities under topographic level) where rainfalls accumulate and stagnate considerable periods during the year. Mollic preluvosol, the dominant subtype in the area (occupying around 70% of the total surface) was formed on plane relief. Below saucers luvisols appear, covered by water that caused gleyization; on small surfaces argic chernozems are spreaded. All soil types are susceptible to compaction, due to their clayey texture and low permeability (reflected by values of total porosity and bulk density) (table 1); this kind of soils require deep loosening after few years of cultivation (Canarache, 1995; Crăciun, 1996). As the table 1 data indicate, argic chernozem is, potentially, the most preferable soil to agricultural exploitation, due to its higher humus content, favorable soil reaction and a humus reserve appreciated as medium.

Table 1. Principal indicators for soils within the territory (on 0-80 cm soil profile)

Horizon	Depth (cm)	Texture (%)	Total porosity (%)	Bulk density (g/cm <sup>3</sup> )	pH	Humus (%)	Humus reserve (to/ha)
Mollic Preluvosols							
Am	0 - 20	Silty loam	50	1.32	5.4	1.23	73,2
ABt	21 - 50	Silty clay	44	1.48	6.8	0.92	(decreased)
Bt <sub>1</sub>	51 - 75	Silty clay	40	1.59	6.7	0.68	
Stagni - Albic Luvisol							
Ea(w)	0 - 20	Loamy sand	49	1.35	5.5	1.05	53.6
EBw	21 - 40	Silty loam	37	1.65	5.6	0.62	(very
Bt1w	41 - 60	Silty clay	40	1.59	5.4	0.31	decreased)
Bt2w	61 - 85	Silty clay	42	1.55	5.8	0.13	
Argic Chernozem							
Am	0 - 25	Silty clay	46	1.44	6.8	2.4	127.3 (medium)
ABt	26 - 37	Silty clay	44	1.48	7.1	1.3	
Bt1	38 - 80	Silty clay	43	1.53	7.2	0.9	



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Ecological and pedological factors that characterize soils have been estimated in accordance with their limits in the methodology and noted with a coefficient depending on each crop requirements (tables 2 and 3). Land evaluation application indicated 20% restriction for ground water depth and 10% restriction for annual average rainfall, pH and humus reserve, in case of Mollic preluvosol, which has totalised 57 points, as evaluation score (table 2). The level of ground water represents a restrictive factor for all 7 agricultural crops considered. Soil reaction is also a restrictive factor, especially for peas and beans, which are the most sensitive among the crops in terms of soil pH (0,8 coefficient value); that it also reflected by land evaluation score per crop: 51 points for peas and beans, compared with 57 points for rest of the crops. That translates into a more increased potential for winter wheat, barley, maize, sun-flower and soybean, in case of Mollic preluvosol. Stagni-albic luvisol, with only 23 points, is significantly restricted, compared to Mollic preluvosol; in its case, restrictions refer to acid pH, low humus reserve and inundability (table 3). Inundability is a consequence of clayey texture associated with the presence of saucers and represents the most severe factor that causes agricultural limitations for all 7 crops considered. For Stagni-albic luvisol, limitation in terms of agricultural potential, is also generated by soil pH (0,8 coefficient for winter wheat and maize, respectively 0,7 for barley, sun-flower, peas and beans). The 57 points, in case of Mollic preluvosol, make the researched region a 3rd class favorability one.

Table 2. Value of land evaluation coefficients in case of Mollic preluvosol - Soil unit 1

Land evaluation indicators	Estimation code used in methodology	Indicator value in the area	Land evaluation coefficients for agricultural crops					
			Winter wheat	Barley	Maize	Sun-flower	Peas and beans	Soybean
Land slope (%)	01 - 03	0-5	1	1	1	1	1	1
Ground water depth (m)	10	5,1-10	0,8**	0,8**	0,8**	0,8**	0,8**	0,8**
Annual average temp. (°C)	11	10,1-11	1	1	1	1	1	1
Annual average rainfall (mm)	055	551-600	0,9*	0,9*	0,9*	0,9*	0,9*	0,9*
Total porosity (%)	NO	50	1	1	1	1	1	1
Soil texture (0-20 cm)	PL	Silty loam	1	1	1	1	1	1
Soil pH	58 (5,5-5,8)	5,6	0,9*	0,9*	0,9*	0,9*	0,8**	0,9*
Humus reserve (t/ha)	120 (61-120)	73,2	0,9*	0,9*	0,9*	0,9*	0,9*	0,9*
Land evaluation score per crop			58	58	58	58	51	58
General land evaluation score (arable use)			57					

\*10% restriction; \*\*20% restriction.

Table 3. Value of land evaluation coefficients in case of Stagni-albic luvisol - Soil unit 2

Land evaluation indicators	Estimation code in method.	Indicator value in the area	Land evaluation coefficients for agricultural crops					
			Winter wheat	Barley	Maize	Sun-flower	Peas and beans	Soy-bean
Land slope (%)	01 - 03	0-5	1	1	1	1	1	1
Ground water depth (m)	10	5,1-10	0,8**	0,8**	0,8**	0,8**	0,8**	0,8**
Inundability (frequency)	RM	once/year and often	0,6****	0,6****	0,7****	0,7****	0,7****	0,7****
Annual average temp. (°C)	11	10,1-11	1	1	1	1	1	1
Annual average rainfall (mm)	055	551-600	0,9*	0,9*	0,9*	0,9*	0,9*	0,9*
Total porosity (%)	MI	40	0,9*	0,9*	0,9*	0,9*	0,9*	0,9*
Soil texture (0-20 cm)	PL	Silty loam	1	1	1	1	1	1
Pseudogleyization (intensity)	PZM	Moderate	0,9*	0,9*	0,9*	0,9*	0,9*	0,9*
Soil pH	54 (5,1-5,4)	5,4	0,8**	0,7****	0,8	0,7****	0,7****	0,7****
Humus reserve (t/ha)	060	53,6	0,8**	0,8**	0,8**	0,8**	0,8**	0,8**
Land evaluation score per crop			22	20	26	23	23	23
General land evaluation score (arable use)			23					

\*\* 20% restriction; \*\*\*30% restriction; \*\*\*\*40% restriction.

That translates into moderate agricultural potential (estimated for soil natural condition, with no improvements at all). Smaller surfaces corresponding to saucers area occupied by Stagni-albic luvisols belong to 4th favorability class, with low agricultural potential for winter wheat, barley, maize, sun-flower, peas and beans and soybean. As a result of calculation, land belonging to 3rd favorability class (most of the region) was evaluated at 1018 euro/ha (4275 lei/ha), while 4th class land values 411 euro/ha (1725 lei/ha).

## Conclusions

A study regarding the establishing of land favorability for 7 agricultural crops was developed in an agricultural plain area in Romania, with characteristics of steppe region climate. The soil cover corresponding to 1295 hectares arable land is represented by mollic preluvosols (most extended), argic chernozems and luvisols. As the most extended soil type in the area is Mollic preluvosol (included in 3<sup>rd</sup> class of favorability), the region shows a moderate agricultural potential for the agricultural crops, but with significantly large possibilities of improvement. On surfaces occupied by Stagni-albic luvisol there is low favorability for all agricultural crops, especially barley. The favorability was determined only for soils natural conditions, with no land improvements at all; if reclamation measures would be applied, the land can be included into a superior favorability class. Since a part of the region requires reclamation measures and no associative form of land exploitation is practiced, there is quite hard to consider this land as an agricultural destination one in the future, although agricultural potential still exists. The major disadvantage is represented by its proximity to the city, which limits the possibilities to be exploited. Results showed a moderate fertility for cereal crops and a cheaper land price, compared to other European countries; that, along with its location, increases the possibility for its initially destination to be changed, more probably for selling on the real estate. It is, unfortunately, the case of many agrary lands located close to urban areas. On the agricultural market, land should not be sold under the calculated limit, because any lower price would not correctly reflect its real productive potential.

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# Imidž Istre i načini informiranja mladih o agroturističkoj ponudi Istre

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## Sažetak

Cilj rada je dobiti informacije važne za kreiranje marketinške koncepcije koja bi dovela do povećanja broja posjetitelja mlađe/srednje životne dobi na agroturističkim gospodarstvima Istre. U tu je svrhu provedeno preliminarno istraživanje metodom intervjua na uzorku od 43 ispitanika u dobi od 25-35 godina. Rezultati istraživanja pokazuju da su gotovo svi ispitanici izrazito slabo upoznati s agroturističkom ponudom Istre, a kao tipično navode tradicionalnu istarsku arhitekturu i ambijent, tradicionalnu istarsku kuhinju, te prirodne i kulturne znamenitosti.

Svi su se ispitanici izjasnili da kao glavno sredstvo informiranja koriste Internet što daje smjernice za pojačanje promotivnih aktivnosti kroz taj medij.

Ključne riječi: agroturizam, Istra, mladi, internet

## The image of Istria and gatherin information of young people about Istrian agritourism supply

### Abstract

The aim of this paper is to gain information that could help to create a marketing concept which would lead to increased number of young/middle-aged visitors at agritourism farms in Istria. For this purpose, a preliminary study with the sample of 43 respondents aged between 25-35 years was conducted by means of an interview.. The results of the study show that almost all of the respondents are very poorly informed about agritourism supply in Istria, and as typical characteristics of Istrian agritourism they state traditional Istrian architecture and ambiance, Istrian traditional cuisine and natural and cultural heritage. All of the respondents use the Internet as a main source of information suggesting strenghtening of promotional activities through that media channel.

Key words: agritourism, Istria, young people, Internet

### Uvod

Agroturistički proizvod je kompleksan jer ga čine usluge, dobra, djelatnosti poput smještaja, prehrane, zabave, rekreacije i ostalog. Uspješna prodajna strategija turističkog proizvoda ima za cilj pronalaženje turista, otkrivanje njihovih potreba radi kojih su zainteresirani za turistički proizvod i na kraju odrediti kako turistički proizvod prezentirati, prodati i kako zadržati vezu s kupcima. Agroturizam jedan je od pokretača daljnjeg razvoja poljoprivrede i drugih poduzetničkih aktivnosti (obrta i servisi) u Istri jer omogućuje znatno širenje tih tržišta. Također zaustavlja migracije stanovništva koje se nakon rata preseljavalo u gradove ili u inozemstvo. Pojavom agroturizma započeta je obnova sela i gradića te su se otvorila nova radna mjesta što

proces migracije okreće u drugom smjeru - iz grada u selo (Ružić, 2009.). Kako bi se omogućio daljnji razvoj tih pozitivnih promjena, nužno je osigurati konstantu posjećenost agroturističkih gospodarstava između ostalog privlačeći stare, ali i nove kupce agroturističkih proizvoda i usluga. Da bi agroturističko gospodarstvo definiralo cilj poslovanja najprije treba proučiti i definirati sadašnje stanje sa svim jakim i slabim stranama, potom odrediti trendove u agroturizmu, kamo ide razvoj agroturizma općenito kao i razvoj značajnih segmenata tržišta. Na kraju se pristupa primjeni odgovarajućih marketinških instrumenata (izrada ponude, politika cijene, reklama, prodaja). Značajniji razvoj agroturizma u Istri započeo je prije petnaestak godina i tek je nedavno počeo dobivati na značaju. Kako bi se privukao što veći broj potencijalnih turista, važno je odaslati im jasnu poruku o sadržaju istarske agroturističke ponude (Ružić, 2009.). Današnji potrošači agroturističkih usluga u Istri uglavnom pripadaju seniorskoj skupini stanovništva (više od 30% svih posjetitelja), te skupini potrošača roditelji s djecom, dok mladi čine manji dio posjetitelja (Brščić, 2005.).

Cilj ovog rada je dobiti saznanja na što mlade ljude asocira na agroturizam u Istri te koliko su uopće upoznati s agroturističkom ponudom Istre. Pokušat će se odgovoriti na pitanje što bi privuklo mlade da posjete agroturističko gospodarstvo u unutrašnjosti Istre te koji bi se načini oglašavanja trebali koristiti za komunikaciju s tim potrošačima u svrhu povećanja njihove potrošnje na agroturističkim gospodarstvima Istre.

### Materijali i metode

U radu su korišteni podaci dobiveni istraživanjem provedenim tijekom rujna i listopada 2010. godine. Istraživanje je provedeno na prigodnom uzorku od 52 ispitanika (pretežno Grada Zagreba i Zagrebačke županije) dobi od 25-35 godina.

Podaci su prikupljeni metodom intervjua u izravnom razgovoru s ispitanicima, a svaki je intervju u prosjeku trajao 15-20 minuta. Izuzetak su dva anketna upitnika koji su poslani i ispunjeni vraćeni elektronskom poštom (jedan ispitanik iz Rijeke, a drugi iz Ljubljane, Slovenija).

Analizirani su samo odgovori ispitanika koji dosad još nisu posjetili niti jedno agroturističko gospodarstvo (u Hrvatskoj ili inozemstvu) tako da su u konačnici analizirani rezultati 43 ispitanika.

### Rezultati i rasprava

Gotovo nitko od ispitanika da dosad nije bio u prilici posjetiti neko agroturističko gospodarstvo, ali su naveli da bi to svakako voljeli. Većina ih nije razmišljala o posjetu agroturističkim gospodarstvima jer nisu upoznati s njihovom ponudom, dok je tek polovina ispitanika dala isključivu prednost odmoru na obali.

Kao asocijacije na agroturističku ponudu Istre mladi navode vino (49% ispitanika), gastronomsku ponudu - fuži, tartufi, istarski pršut, maslinovo ulje, šparoge, začini (46% ispitanika), tradicionalnu istarsku arhitekturu - kamene kuće (33% ispitanika), a samo je jedan ispitanik kao odgovor naveo slogan koji je Turistička zajednica Istarske županije osmislila za postizanje prepoznatljivosti Istre "Istra-terra magica". Razvojem agroturističkog imidža destinacije otvara se put za marketing jer ljudi unaprijed mogu očekivati kakvu će uslugu dobiti (Hajdaš, 2006.).

Mladi kao najvažnija obilježja agroturističke ponude u Istri navode istarske prirodne pejzaže i bogatstvo prirodne raznolikosti, nakon toga tradicionalnu istarsku arhitekturu i ambijent te tradicionalnu istarsku kuhinju, a tek potom povijesne i kulturne znamenitosti i vinske ceste. Prilično je začuđujući podatak da je mladima najmanje važna dostupnost kulturnih i sportskih sadržaja u agroturističkoj ponudi Istre (tablica 1).

Tablica 1. Značaj sastavnica istarske agroturističke ponude (n=43)

Sastavnice	Udio ocjena važno i jako važno (% ispitanika)
Prirodni istarski pejzaži i raznolikosti	72
Tradicionalna istarska arhitektura i ambijent	67
Tradicionalna istarska kuhinja	67
Vinske ceste i medni punktovi	62
Povijesne i kulturne znamenitosti	62
Dostupnost sportskih sadržaja	48
Kulturne manifestacije	33

Svi ispitanici kao opće sredstvo informiranja, ali i kao sredstvo za informiranje o izboru mjesta gdje će provesti odmor koriste Internet, tek u manjoj mjeri ostale medije. Međutim, nitko od ispitanika nije uočio niti jednu reklamu o agroturističkim uslugama u Istri, a tek jedna ispitanica je vidjela reklamu za agroturističko gospodarstvo u Slavoniji, ali se te reklame dobro ne sjeća.

Prema rezultatima prijašnjih istraživanja (Brščić, 2005.) najveći je broj agroturističkih gospodarstava u Istri trošio oko 1.000 kn godišnje za promociju, a u većoj su se mjeri oslanjali na grupno predstavljanje na Internetu financirano od strane Turističke zajednice Istarske županije. Uzevši u obzir rezultate istog istraživanja koji govore da vrlo mali broj poljoprivrednika ima odgovarajuće obrazovanje za obavljanje kako poljoprivredne tako i ugostiteljsko-turističke djelatnosti (Brščić i sur., 2010.), niti ne čude minimalni izdaci i angažiranost vezana za promociju agroturističkog gospodarstva.

Sve to ukazuje na potrebu jače promotivne aktivnosti agroturističkih gospodarstava Istre. Istra, u odnosu na neke druge regije Hrvatske ima brojne prednosti poput povoljnog geografskog položaja (blizina mora, granica s Italijom i Slovenijom), blage mediteranske klime, bogatog kulturnog nasljeđa, jedinstvene i prepoznatljive gastronomske ponude, čistog mora i dr., no gledajući s marketinškog aspekta vrlo je važno izdvojiti ono tipično i najprivlačnije te na tome inzistirati. To se svakako treba odvijati zajedničkim nastupom više agroturističkih gospodarstava na tržištu jer troškovi promocije i marketinga zahtijevaju vrlo velika sredstva ako ih obavlja svako seljačko gospodarstvo pojedinačno (Bošković, 1999.).

Prednosti Interneta kao što su jednostavnija i brža distribucija informacija kao i učestala uporaba Interneta od strane mladih, ukazuje na potrebu jače promocije agroturističke ponude Istre putem elektronskih medija. Na Internetu se može oglašavati i/ili promovirati putem vlastite web stranice preko koje je moguće ostvarivati kontakte s postojećim i novim kupcima, na Internetu je moguće obavljati prodaju i kupnju proizvoda i usluga, sadržaje na stranici moguće je vrlo lako i brzo mijenjati. Oglašavanje i promocija na Internetu ima značajnu prednost i u tome što su troškovi za izradu Internet stranica znatno manji od oglašavanja i promocije u ostalim medijima.

### Zaključak

Agroturizam je kao turistička djelatnost vrlo kompleksna u odnosu na ostale turističke djelatnosti. Preduvjet za povećanje posjećenosti agroturističkih gospodarstava, a time posljedično i povećanje dobiti je prilagođavanje zahtjevima tržišta kroz osluškivanje želja i potreba postojećih i potencijalnih kupaca naših proizvoda i usluga.

Rezultati istraživanja pokazuju da su mladi izrazito slabo upoznati s agroturističkom ponudom Hrvatske, a posljedično i Istre te da je to jedan od glavnih razloga što ispitanici dosad niti jednom nisu posjetili neko agroturističko gospodarstvo. Međutim, prihvaćanjem promotivne koncepcije može se kreirati tržišno transparentna ponuda koja bi dovela do povećanja poznatosti agroturističkih gospodarstava, a time i do većeg broja gostiju, odnosno povećanja dobiti agrogospodarstava, u čemu agrogospodarstvima u najvećoj mogućoj mjeri treba pomoći Turistička zajednica Istarske županije. Uz promocijske aktivnosti potpomognute od strane Turističke zajednice Istarske županije, agroturističkim gospodarstvima pomoć trebaju pružiti i nadležna ministarstva (Ministarstvo turizma i Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja i to u vidu educiranja vlasnika agroturističkih gospodarstava kako bi ona pružila što bolju i kvalitetniju uslugu kao i odobravanjem kredita s nižom kamatnom stopom u svrhu poboljšanja kvalitete smještaja i usluga.

Provedeno istraživanje ukazuje da su mladima u cjelokupnoj agroturističkoj ponudi Istre najvažnija tradicionalna istarska arhitektura i ambijent, tradicionalna istarska kuhinja, te prirodne i kulturne znamenitosti, tebi te motive trebalo koristiti u daljnjoj promociji.

Svi ispitanici koriste Internet kao sredstvo informiranja, te je u promociji agroturističkih gospodarstava potrebno veliki naglasak staviti na oglašavanje putem Interneta, kao relativno jeftinog i jednostavnog promotivnog medija.

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# Teaching semantic fields: beef

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## Abstract

Teaching English for Special Purposes (ESP) in an agricultural university or faculty is challenging because of the large number of specialty terms undergraduates need to acquire. One way to do it easily and properly is to learn about the entire semantic field of a term. Learning about beef, for instance, also means learning about all the nouns (compounds, derivatives), adjectives, and verbs belonging to the semantic field of beef: animals (*beefalo*, *steer*); bones (*aitchbone*); breeds (*Aberdeen*, *Brangus*, *Devon*); cuts (*baron*, *beefsteak*, *bottom round*); dishes (*beef bourguignon*, *beef Stroganoff*, *beef Wellington*) etc. Learning about the etymology of all of these terms broadens the cultural horizon of the undergraduates, opening a new perspective over globalization.

Keywords: English for Special Purposes, semantic field, beef

## Introduction

Teaching English for Special Purposes in an agricultural university - particularly in a university where they teach not only about livestock, but also about food processing or about food services - is challenging because of the large number of specialty terms undergraduates need to learn. One way to assist students with vocabulary acquisition easily and properly is to learn about the entire **semantic field** of a term ('a range or system of referents that have some aspect of meaning in common', Chalker & Weiner 1994: 150). In this paper, we present the semantic field of the term **beef** ('a full-grown steer, bull, ox, or cow, especially one intended for use as meat; the flesh of a slaughtered full-grown steer, bull, ox, or cow').

## Material and Methods

We have inventoried all the terms related to the term **beef** in Soukhanov's *The American Heritage Dictionary of the English Language* (2000). We then grouped them according to their semantic sub-fields such: *animal husbandry*, *food processing*, *food service*, etc., thus making up inventories of beef-related terms specific to different subjects (animal husbandry, food processing technologies, tourism services, etc.) that undergraduates should learn as basic English vocabulary of their field specialization.

## Results and Discussion

The most frequently used synonym for **beef** 'a full-grown steer, bull, ox, or cow, especially one intended for use as meat; the flesh of a slaughtered full-grown steer, bull, ox, or cow' [< ME < OF *buief* < L *bos*, *bov*-] is **red meat** 'meat, especially beef, that is dark-coloured before being cooked'.

There is a single noun derived from **beef** - **beefiness** 'beef quality' and a compound with **beef** used informally - **beefcake** 'minimally attired men with muscular physiques, as in photographs or motion pictures' [BEEF + (CHEESE) CAKE].

Such adjectives as **beefed-up** 'having been made greater or stronger' and **beefy** 'muscular in build, brawny, substantial, filling; filled with beef' are the only adjectives derived from **beef**. A verb most frequently used in relation to **beef** is **to corn** 'to preserve (beef, for example) in brine'.

The terms making up the semantic field of the term beef can be grouped into the following semantic sub-

fields (presented here in alphabetical order):

*Anatomy:* **aitchbone** ‘the rump bone, especially of cattle’.

Animal husbandry:

*animals:* **beefalo** (*pl.* **beefalo** or **beefalo(e)s**) or **cattalo** ‘a hybrid that results from a cross between the American buffalo, or bison, and beef cattle and is typically 8 buffalo and 8 bovine. Beefalo yields leaner beef than conventional breeds of cattle’ [BEEF + (BUFF)ALO], **steer** ‘a young ox, especially one castrated before sexual maturity and raised for beef’ [< ME *steer* < OE *stēor*], *breeds:*

**Aberdeen / Black Angus** ‘a breed of black, hornless beef cattle that originated in Scotland’ [After Aberdeen and Angus, former counties of *Scotland*.],

**Devon** ‘any of a breed of reddish cattle originally developed in the English county of Devon and raised primarily for beef’,

**Durham / shorthorn** ‘any of a breed of beef or dairy cattle that originated in northern England, having short, curved horns or no horns and usually red, white, or roan in colour’, **Hereford** ‘any of a breed of beef cattle developed in England and having a reddish coat with white markings’ [< *Hereford*],

**Santa Gertrudis** ‘any of a breed of large beef cattle that are highly resistant to heat and insects, developed in the United States by crossing Brahmans and shorthorns’ [< the *Santa Gertrudis* section of the King Ranch in Kingsville, Texas];

*cattle feed:* **monensin** ‘a broad-spectrum antibiotic, C<sub>36</sub>H<sub>62</sub>O<sub>11</sub>, obtained from the actinomycete *Streptomyces cinnamonensis* and used chiefly as an additive to beef cattle feed’ [< NL (*cinna*)*monēns(is)*, species name].

Dishes:

**beef Stroganoff** ‘thinly sliced beef fillet sautéed and mixed with onions, mushrooms, sour cream, and herbs, often served on a bed of noodles or rice. [< *Count Paul Stroganoff*, 19<sup>th</sup>-century Russian diplomat],

**beef Wellington** ‘a fillet of beef covered with pate de foie gras, encased in pastry, and baked’ [< *Wellington?*],

**burger** ‘a sandwich consisting of a bun, a cooked beef patty, and often other ingredients such as cheese, onion slices, lettuce, or condiments; a sandwich with a nonbeef filling’ [Short for HAMBURGER],

**carpaccio** ‘very thinly sliced raw beef or tuna garnished with a sauce’ [< It *carpaccio* < *Vittore Carpaccio*, who favoured red pigments.],

**fil(l)et** ‘a boneless strip of meat rolled and tied, as for roasting’,

**goulash** ‘a stew of beef or veal and vegetables, seasoned mainly with paprika. [< Hung *gulyas* (*hus*) ‘herdsman’s (meat), goulash’ < Hung *gulya* ‘herdsman’],

**hamburg(er)** ‘ground meat, usually beef, or patty of such meat; sandwich made with a patty of ground meat usually in a roll or bun’ [Short for *Hamburger steak* < *Hamburg*],

**meat loaf / meatloaf** ‘a mounded or moulded dish, usually baked, of ground beef or a combination of various meats and other ingredients’,

**mortadella** ‘an Italian sausage made of pork, beef, and cubes of pork fat, flavoured with wine and spices and smoked, steamed, or baked’ [< It *mortadella*, feminine diminutive of *murtato* ‘seasoned with myrtle berries’],

**moussaka** ‘a Greek dish consisting of layers of ground lamb or beef and sliced eggplant topped with a cheese sauce and baked’ (Croatian *musaka*),

**pepperoni** (*pl.* **pepperonis**) ‘highly spiced pork and beef sausage; a slice of this type of sausage’ [< It *peperoni*, *pl.* of *peperone* ‘pimento, red pepper’, augmentative of *pepe* ‘pepper’ < L *piper*],

**Reuben** ‘a hot sandwich consisting of corned beef, Swiss cheese, and sauerkraut usually served on rye bread’ [< *Reuben*],

**runza** ‘*Nebraska*. A pastry consisting of cabbage and usually beef and pork encased in yeast dough’ [Originated in Russia during the 1800s (pirogi like; bierock) and was sent to Germany before being served to the US]

**Salisbury steak** ‘a patty of ground beef mixed with eggs, milk, onions, and various seasonings and broiled, fried, or baked’ [< *James Henry Salisbury* (1823-1905), American physician]

**steak tartar** or **tartar steak** ‘raw ground beef mixed with onion, seasoning, and raw egg, eaten as an appetizer’ [< E *steak* + F *tartare* ‘Tartar’]



**surf and turf** ‘seafood and beefsteak served as the main course of a meal, as in a restaurant’

**wienerwurst** ‘a smoked pork or beef sausage similar to a frankfurter’ [< G *Wiener* + *Wurst* ‘Viennese sausage’]

**Yorkshire pudding** ‘a popover-like quick bread served with roast beef, made by baking a batter of eggs, flour, and milk in the drippings of the beef’ [< *Yorkshire*].

*Food processing (cuts):*

**aitchbone** ‘the cut of beef containing the rump bone’,

**baron** ‘a cut of beef consisting of a double sirloin’ [< ME < OF < G?]

**beefsteak** ‘a slice of beef, such as one taken from the loin or the hindquarters, suitable for broiling or frying

**bottom round** ‘a cut of meat, such as steak, taken from the outer section of a round of beef’, **eye** ‘a choice centre cut of meat, as of beef’

**fil(l)et** ‘a strip or compact piece of boneless meat or fish, especially the beef tenderloin’

**flanken** ‘a cut of meat taken from the short ribs of beef’ [< Yiddish *flanken* < G *Flanken*, pl. of *Flanke* ‘flank, side’ < F *flanc*]

**fil(l)et** ‘a strip or compact piece of boneless meat or fish, especially the beef tenderloin’

**hindquarter** ‘the posterior portion of a side of beef, lamb, veal, or mutton, including a hind leg and one or two ribs’

**plate** ‘a thin cut of beef from the brisket’

**porterhouse (steak)** ‘a cut of beef taken from the thick end of the short loin, having a T-bone and a sizable piece of tenderloin’, **pot roast** ‘a cut of beef that is browned and then cooked until tender, often with vegetables, in a covered pot’, **rib roast** ‘a cut of red meat, such as beef or venison, containing the sizable piece located along the outside of the rib’, **rump** ‘a cut of beef or veal from the rump’ [< ME *rumpe* < Scandinavian origin].

*Food service:*

**steak house / steakhouse** ‘a restaurant that specializes in beefsteak dishes’.

*Others:* **beefeater** ‘a yeoman of the British monarch’s royal guard’.

*Terms related only informally to beef*

**Australian pine** or **beefwood** or **casuarina** ‘any of various Australian evergreen trees or shrubs of the genus *Casuarina*, having jointed stems, scale-like whorled leaves, and small fruits grouped in woody, cone-like structures; the wood of any of these plants, often used in construction’ and

**beefsteak fungus** ‘an edible fungus (*Fistulina hepatica*).

The terms **beefeater** and **hamburger** are a good opportunity to “teach” undergraduates British and American culture by supplying information concerning their etymology and development. Thus, the following two texts can be used as a starting point for different approaches (grammar, translation, etc.): “Tourists in England who have seen the warders of the Tower of London and the Yeomen of the Guard know that these men dressed in 15<sup>th</sup> century uniforms are called *beefeaters*. Not all tourists are aware, however, that the original use of the term (recorded in 1610) was pejorative, referring to a well-fed servant. In a work published before 1628 the word was also said to have been used contemptuously by the French for an Englishman or an English soldier. The word *beefeater* has thus risen in the world, for the well-fed, well-muscled beefeaters of today (this use was first recorded in 1671) are considered by many to be a national treasure.” (for **beefeater**) and “After having eaten countless hamburgers, one may perhaps be interested in knowing more about the origins of the name. By the middle of the 19<sup>th</sup> century people in Hamburg, Germany, the busiest port in West Germany today, enjoyed pounded beefsteak in some form. Perhaps brought to America by the large numbers of Germans who migrated around that time, this sort of dish with the name **Hamburg steak** may have appeared on a menu as early as 1836. The first recorded use of *Hamburg steak* is found in 1884 in the *Boston Journal*, with **hamburger steak** being first recorded in a Walla Walla, Washington, newspaper in 1889.

In our opinion, one of the definitions for **tea** contains a mistake: **tea** ‘Any of various beverages, made as by steeping the leaves of certain plants or by extracting an infusion especially from beef.’

### Conclusions

The largest semantic sub-fields are *dishes* (46), *processing* (23), and *animal husbandry* (9). They should be the basis for the learning of a minimum of specialised terms in our faculties of animal husbandry, food processing technologies, and tourism services. The rest of the terms more or less related to **beef** should be taught for their anecdotic aspect or to make undergraduates aware of the fact that they should be avoided because of lack of relevance.

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# Stavovi vlasnika o daljnjem razvoju agroturizama u Istarskoj županiji

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## Sažetak

U zadnjih petnaestak godina razvoja turizma na ruralnom području, razvijao se i koncept turizma na obiteljskom gospodarstvu tzv. agroturizam. Koncept po kojem je turizam dodatna djelatnost na gospodarstvu i dodatni izvor prihoda u Istri je prihvaćen i u razvojnim strategijama i tržišno valoriziran. U međuvremenu, na većini gospodarstava pojavio se trend suprotan očekivanjima - prihodi iz turizma nadmašuju prihode iz poljoprivrede, a postojeća poljoprivredna proizvodnja ne zadovoljava potrebe turističke potrošnje na gospodarstvu. Stoga smo uočili problematiku daljnjeg razvoja te u sklopu znanstveno istraživačkog projekta "Agroturizam, čimbenik održivog razvoja" izvršili anketno istraživanje da bi saznali koji su problemi u djelatnosti poljoprivrede i djelatnosti turizma i da li se dodatno multipliciraju u agroturizmu. Rezultati istraživanja pokazuju da vlasnici agroturizama u Istri smatraju kako je za daljnji razvoj ove poslovne aktivnosti bitno uvesti dodatne poticaje i subvencije, pokrenuti programe za poticaj razvoja agroturizama unutar programa poticanja poduzetništva, izgraditi dodatnu infrastrukturu za neometano obavljanje turističke djelatnosti, te valorizirati kulturne i povijesne znamenitosti koje predstavljaju dodatnu ponudu agroturizama i motiv privlačenja turista u ruralne krajeve.

Ključne riječi: agroturizam, stavovi vlasnika, Istarska županija

## Owners' attitudes and opinions on developing potentials and limitations of farm tourism in the County of Istria

### Abstract

In the last fifteen years of rural tourism development was followed by the concept of agritourism. This concept had an intention that tourism is an additional activity and to create extra income on family farms. This concept is accepted in development strategies of Istria and currently marketable. In the meanwhile on most family farms the trends became twisted so tourism income became the major and existing agricultural production couldn't follow tourism needs.

Therefore on the scientific and research project "Farm tourism, a factor of sustainable development", we have collected the opinions and attitudes of their owners in order to, as realistically as possible, analyse which problems exist in agriculture and tourism and if they multiply through agritourism. Results showed that farm tourism owners in Istria believe that, in order to further develop this business activity, it is important to introduce additional incentives and subventions for farm tourism owners, to initiate programmes of stimulation for farm tourism development within the programme of business stimulation, build additional infrastructure for unhindered conduct of the tourist activity, as well as to valorise cultural and historical landmarks which represent additional farm tourism choice variety and a motive for attracting tourists to rural areas.

Key words: farm tourism, owners' attitudes, County of Istria

## Uvod

Agroturizam u Istri ima sve predispozicije za prerastanje u vrlo važan čimbenik atraktivnosti turističke destinacije Istarske županije, što će biti moguće ukoliko se sustavno provedu odgovarajuće aktivnosti definiranja, repositioniranja i provedbe zakona, strategija razvoja, povezivanje sudionika na ruralnom turističkom tržištu te sustavnom edukacijom članova obitelji agroturističkih gospodarstava (uz implementaciju inozemnih iskustva npr. Italije, Austrije). Za takav tip turizma potreban je i geografski identitet područja i zanimljivosti (Chee et al., 2005.), a na razini gospodarstva dodatni rad (od 20 do 720 sati mjesečno - najmanje za obilazak gospodarstva, a najviše za dulji boravak gostiju) i dodatni kapital u iznosu od 25 do 200 tisuća eura (Huyenbroek et al., 2006.). U Istri trenutno postoje ograničenja za sve navedene parametre spomenute u literaturi, a realno stanje analizirali smo sukcesivno kroz pet godina u sklopu znanstvenog projekta "Agroturizam, element održivog ruralnog razvoja".

## Materijali i metode

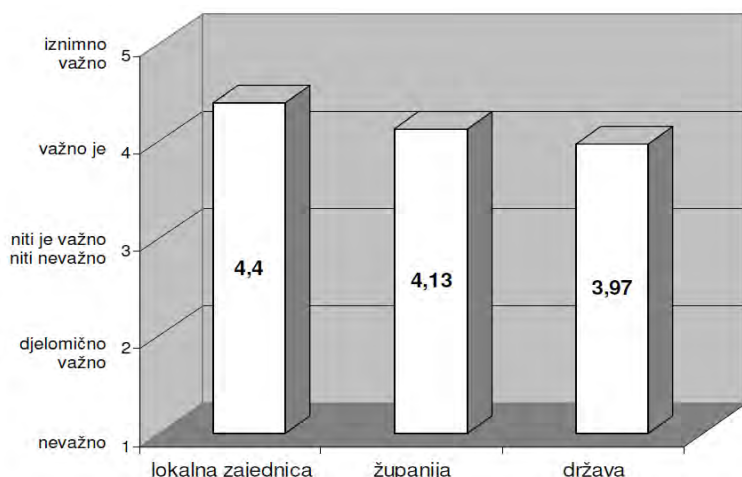
Ciljna skupina u istraživanju sastojala se od vlasnika agroturističkih gospodarstava u Istarskoj županiji. Rezultati su dobiveni anketom, na uzorku od 38 vlasnika agroturizama (od osnovnog skupa od 64 registriranih prema <http://www.hrvatski-farmer.hr>). Istraživanje je provedeno tijekom druge polovice 2009. godine. Upitnik se sastojao od 38 pitanja te je bio podijeljen u više tematskih cjelina. Prvi dio odnosio se na pitanja o kućanstvu, broju članova kućanstva, kapacitetu smještajnih jedinica i usluge prehrane, te godinama poslovanja. Drugi dio odnosio se na pitanja vezana uz pokretanje posla agroturizma, razlog ulaska anketiranih na ruralno turističko tržište kao poslovnih subjekata. Treći dio pitanja obradio je poljoprivrednu djelatnost anketiranih. Četvrti dio sadržavao je pitanja o budućem razvoju agroturizama, a posljednji dio odnosio se na pitanja o arhitekturi.

## Rezultati i rasprava

Jedan od ciljeva istraživanja bio je utvrditi stavove anketiranih o ulozi države, županije i lokalne zajednice u daljnjem razvoju agroturizma. Rezultati istraživanja pokazuju kako vlasnici agroturizma smatraju da najznačajniju ulogu u daljnjem razvoju agroturizma ima lokalna zajednica (ocjena 4.4; na ljestvici od 5 stupnjeva, gdje 5 znači jako važna uloga, a 1 potpuno nevažna uloga), a država je na posljednjem mjestu (Slika 1.). Prema mišljenju vlasnika agroturizama u Istri, mjere koje omogućuju daljnji razvoj agroturizma od strane države i županije su jednake na obje razine, a odnose se na uvođenje većeg broja poticaja i subvencija, te smanjivanje poreza i ostalih davanja.

Ako uzmemo u obzir da lokalne zajednice (općine i gradovi) i jesu u neposrednom kontaktu sa stanovnicima, i najbolje su upućeni u problematiku svog područja onda su i očekivanja pripadnog stanovništva i najveća, pa tako i očekivanja vlasnika agroturizama da lokalna zajednica najviše doprinese izgradnji infrastrukture, da održava urednim ruralni krajolik, održava kulturnu baštinu i povijesne znamenitosti, i prema mogućnostima investira u razvoj poljoprivrede i turizma (i drugih djelatnosti) i u njihovu promociju.

## Stavovi vlasnika o daljnjem razvoju agroturizama u Istarskoj županiji



**Slika 1. Važnost lokalne i državne samouprave u razvoju agroturizama**

Izvor: Istraživanje znanstvenog projekta "Agroturizam, element održivog ruralnog razvoja", Institut za poljoprivredu i turizam Poreč, 2009.

Ministarstva poljoprivrede, turizma i ruralnog razvoja nadležna za razvoj ruralnog turizma (a time i agroturizma) raspodjeljuju financijska sredstva kroz Programe i projekte za razvoj ruralnih područja (i turizma) na koji se mogu prijaviti lokalne zajednice (uz vlastito sufinanciranje). Agroturizmi (i drugi subjekti) nisu u mogućnosti se samostalno prijavljivati i na taj način unaprijediti i ruralno područje i turističku ili poljoprivrednu djelatnost, stoga su upućeni na lokalnu zajednicu i za prijavu projekata i za sufinanciranje, što doprinosi njihovoj značajki (slika 1.).

Rezultati istraživanja pokazuju da su za daljnji razvoj agroturizma na prvom mjestu po važnosti neekonomске mjere poput održavanja okoliša čistim i pristupačnim za turiste (ocjena 4.8), te valoriziranje kulturnih i povijesnih znamenitosti (ocjena 4.6) kao mjere koja utječe na poboljšanje dodatne ponude agroturizama i motiva privlačenja turista u ruralne krajeve (Tablica 1.). Na skali odgovora ove mjere su važne s ocjenom blizu 5 (pri čemu je 1 bilo nevažno, a 5 iznimno važno). Tek na trećem mjestu dolaze ekonomske mjere programa za agroturizam te iza njih potrebite subvencije (u rangu ocjene vrlo važno, 4.2). U vrijeme ispitivanja tek nekolicina vlasnika je imalo kreditna zaduženja prema županiji (kreditne linije sa subvencioniranim kamatama), a nisu znali za kredite Ministarstva turizma koji su subvencionirali kamatu (sa 6 na 2% za korisnika, putem HBOR-a, u 2009.). Premda postoje i programi i projekti od strane više ministarstava, po mišljenju vlasnika agroturizama nema pravovremenih informacija.

**Tablica 1. Potrebne mjere za razvoj agroturizma u Istri**

Mjere	N	Aritmetička sredina	Rang
Održati okoliš čistim i pristupačnim za turiste	36	4.8	1.
Valorizirati kulturne i povijesne znamenitosti	37	4.6	2.
Pravovremeno navesti programe za poticaje razvoja agroturizama	38	4.5	3.
U programe za poticanje poduzetništva bi trebalo uključiti i agroturizme	38	4.3	4.
Uvesti dodatne poticaje i subvencije za vlasnike agroturizama	38	4.2	5.
Izgradnja infrastrukture (ceste, tel/računalne instalacije, vodovod, kanalizacija)	38	4.1	6.
Umanjiti porezna davanja s obzirom na veličinu prometa	38	4.0	7.
Omogućiti zapošljavanje dodatne radne snage van obitelji	38	3.8	8.

Izvor: Istraživanje znanstvenog projekta "Agroturizam, element održivog ruralnog razvoja", Institut za poljoprivredu i turizam Poreč, 2009.

Za većinu vlasnika agroturizama smatra da su čimbenici koji predstavljaju najveće probleme prilikom obavljanja osnovne poljoprivredne djelatnosti nedostatak kapitala i neprimjereni zakoni i prostorni planovi (Tablica 2). U odnosu na 2007. intenzivirala se potreba za kapitalom na agroturističkim gospodarstvima (Rajko i sur., 2007.).

Prostorni planovi dinamički rijetko mogu pratiti potrebe stanovništva i privrede zbog mnogobrojnih administrativnih ograničenja i duge vremenske procedure za njihovo usvajanje. Vlasnici agroturizama su uočili probleme prostornih planova i zakona vezanih uz njih u slučaju izgradnje objekata (npr. podruma, skladišta, štala, objekata za strojeve i opremu). Problemi se svode na potrebu širenja građevinskih zona, na dostatnu kvadraturu za tražene objekte i sl. Uz to se nadovezuje opći nedostatak zemljišta rapoloživog za kupnju ili najam na kojem bi se odvijala poljoprivredna proizvodnja za potrebe turista. Kao posljedica javlja

se nedostatak poljoprivrednih proizvoda u ponudi agroturističkih gospodarstava i potreba da se proizvodi kupuju od gospodarstava u okruženju (što povlači dodatne administrativne poslove - ugovori o kupnji, knjiženje prometa i dr.).

**Tablica 2. Problemi prilikom obavljanja osnovne poljoprivredne djelatnosti**

Mjera	N	Aritmetička sredina	Rang
Nedostatak kapitala	36	3.7	1.
Neprimjereni zakoni i prostorni planovi	35	3.6	2.
Neorganiziranost županije i države	32	3.3	3.
Nedostatak radne snage	37	3.1	4.
Infrastruktura	35	3.0	5.
Nedostatak zemljišta	37	2.6	6.
Opseg ponude poljoprivr. proizvoda	34	2.3	7.

Izvor: Istraživanje znanstvenog projekta "Agroturizam, element održivog ruralnog razvoja", Institut za poljoprivredu i turizam Poreč, 2009.

U poljoprivrednoj proizvodnji na agroturističkim gospodarstvima svi vlasnici (osim jednog) naglasili su nedostatak radne snage kao važan problem te potrebu da se omogući zapošljavanje dodatne radne snage. Ovi rezultati potvrđuju nalaze prethodnog istraživanja iz 2007. na znanstvenom projektu "Agroturizam" u svezi ograničenja kapaciteta radne snage i problematike oko zapošljavanja (Ilak Peršurić i sur., 2010.).

**Tablica 3. Povezanost sociodemografskih obilježja ispitanika i stavova o razvoju agroturizma**

	Koeficijent korelacije	
	Spol	Obrazovanje
Održati okoliš čistim i pristupačnim za turiste	0.740	0.233
Valorizirati kulturne i povijesne znamenitosti	0.783	0.977
Pravovremeno navesti programe za poticaje razvoja agroturizma	0.769	0.756
U programe za poticanje poduzetništva uključiti agroturizme	0.679	0.152

Izvor: obrada autora

Stavovi vlasnika agroturizama po pojedinim pitanjima pokazala su značajne razlike u odnosu na pojedine sociodemografske osobine, a najjače korelacije bile su u odnosu na spol i obrazovanje. Stoga smo za pojedine stavove o razvoju agroturizma prikazali te razlike (tablica 3.). Najjača korelacija pokazala se u odnosu na valorizaciju kulturnih i povijesnih vrijednosti koju su isticali najobrazovaniji ispitanici. Vrlo visoku statističku povezanost imaju svi ostali stavovi s obzirom na obrazovanje.

## Zaključak

U stvaranju i razvoju prepoznatljive i atraktivne turističke destinacije, za što Istra ima sve pretpostavke potrebno je sustavnim, organiziranim i aktivnim pristupom razviti nove i poboljšati postojeće turističke usluge na ruralnom području. Primjenom odgovarajućih aktivnosti definiranja i repozicioniranja ruralnog turizma u Istri kroz potrebne zakonske promjene, edukacijom turističkih djelatnika, prilagodbom i implementacijom inozemnih iskustava (Italije, Austrije) i planiranjem održivog ruralnog razvoja, moguće je organizirati i predstaviti ruralnu Istru kao destinaciju uzbudljivog mjesta aktivnog odmora, opuštanja, promatranja prirode, uživanja u doživljavanju kulturno-povijesne baštine, odnosno kao modernu i atraktivnu turističku destinaciju.

Za daljnji razvoj agroturizma vlasnici imaju potrebu jačanje suradnje s lokalnom zajednicom zbog prijave na programe i projekte ruralnog razvoja, sudjelovanje u očuvanju ruralnog krajobraza radi povećanja njegove vrijednosti i atraktivnosti za turističke dolaske, te razvoja djelatnosti poljoprivrede i turizma, a očekuju od državne razine više subvencija, poticaja i programa za razvoj.

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# Golf kao dio ponude agroturizma u Istri

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## Sažetak

U radu se polazi od pretpostavke da golf odnosno cjelokupna ponuda u vezi boravka turista-golfera na pojedinom ruralnom području može doprinijeti razvoju i revitalizaciji tog područja. Postojanje sadržaja vezanih za golf pruža mogućnosti bolje popunjenosti ugostiteljskih kapaciteta i produženje sezone u agroturističkim domaćinstvima. Pretpostavke su: veliki broj golfera u neposrednoj blizini, blaga klima koja omogućava igranje golfa tijekom cijele godine, intima koju agroturistička domaćinstva mogu pružiti golferima, postojanje golferskih igrališta u blizini, specifična ugostiteljska ponuda agroturizama. U radu su prikazane mogućnosti integriranja golfa kao dijela ponude agroturizama u Istri.

Ključne riječi: agroturizam, golf, Istra, ponuda

## Golf as a part of the rural holiday homes offer in Istria

### Abstract

The assumption of this paper is that golf and the entire offer concerning golfer-tourists stay on a rural area can contribute its development and revitalization. The existence of golf-related content leads to better occupancy and season prolongation for agritourisms (rural holiday homes). Assumptions: large number of golfers in the vicinity, mild climate which enables golf playing throughout the entire year, the intimacy provided by rural holiday homes, existence of the golf courses in the vicinity and specific restaurants offer. This paper shows research results for integrating golf as part of rural holiday homes offer in Istria.

Key words: rural holiday homes, golf, Istria, offer

### Uvod

Ruralna područja pružaju velike mogućnosti za razvoj turizma (Ružić, 2005.). Na njima se mogu odvijati različite turističke aktivnosti, a golf kao jedan od najrazvijenijih oblika zabave i boravka u prirodi može u značajnoj mjeri doprinijeti razvoju agroturističke ponude nekog ruralnog područja. Zbog svoje rasprostranjenosti i veličine tržišta golf kao dio ponude agroturizama pruža brojne mogućnosti od kojih su poboljšanje popunjenosti kapaciteta i produženje sezone u agroturizmima najvažnije. Golf je danas jedan od najrazvijenijih i najpopularnijih sportova u svijetu (Bartoluci, 2007.). Agroturizmi u Istri pružaju gotovo idealne uvjete za prihvata i smještaj golfera-turista. Da bi se to ostvarilo potrebno je ostvariti određene pretpostavke, a to su blizina emitivnom tržišta, broj golfera u neposrednoj blizini, blaga klima koja omogućava igranje golfa tijekom cijele godine, intima koju agroturizmi u Istri mogu pružiti golferima, postojanje golferskih igrališta u blizini i specifična ugostiteljska ponuda agroturizama. Razvoj golfa i golferskog turizma u RH i Istri kao našoj najrazvijenijoj turističkoj regiji tek je u početnoj fazi. Kako se 2009. godine otvorilo prvo pravo golf igralište u Istri - golf klub "Adriatic" u Savudriji, počeli su se ostvarivati osnovni uvjeti za razvoj ovog oblika turizma Istre. Agroturizmi u Istri bi sa svojom specifičnom atmosferom i ponudom mogla pružiti kvalitetnu ponudu za boravak turista-golfera, te su u ovom radu prikazani rezultati istraživanja mogućnosti integriranja golfa kao dijela ponude agroturističkih domaćinstava u Istri.



### Argumenti za integriranje golf ponude u agroturizme Istre

Istra je jedna od najvažnijih hrvatskih turističkih regija, a ugošćuje goste iz cijeloga svijeta od kojih su najbrojniji oni iz zapadne i srednje Europe. Početkom devedesetih godina prošlog stoljeća počinje se u Istri sustavno i ozbiljnije promišljati o razvoju agroturizma u Istri, pa je Istra i u ovom segmentu turističke ponude jedna od najrazvijenija regija u RH. Razvoj golfa i ponude golfa kao djela turističke ponude Istre, moglo bi u značajnoj mjeri pridonijeti kvaliteti cjelokupnog turističkog proizvoda Istre. Sadašnjost i budućnost turističke ponude i potražnje sve više pripada takvom turizmu koji nudi kompletnu relaksaciju i rekreacije, a tu golf kao sport zauzima sve značajniju ulogu. Sve veći broj turista tražit će cjelovit oblik rekreacije, u potrazi za općom ravnotežom tijela, duše i uma (Moutinho, 2005.). Postupno se formira novi turizam, onaj po mjeri čovjeka, što zazire od masovnosti, glomaznih hotela spavaonica, punih prometnica, plaža i restorana, a teži individualizmu, spontanosti doživljaja i kreativnosti odmora (Kušen, 2002.). S tim u svezi i agroturizmi koji pružaju idealne uvjete za prihvat i smještaj turista-golfera mogli bi računati na ovaj segment turističke potražnje. Time bi se ostvarili pozitivni efekti u razvoju agroturizama Istre kao što su:

- poboljšanje kvalitete i ekskluzivnosti ponude
- povećanje prihoda
- privlačenje gostiju veće platežne moći
- produženje turističke sezone
- povećanje broja turista i noćenja
- cjelogodišnje turističko poslovanje
- povećanje broja vikend-gostiju

Osim ekonomskih, potrebno je sagledati društvene, ekološke i ostale elemente argumentacije za integriranje golfa u ponudu agroturizama u Istri, a to su:

- promocija i turistička valorizacija te zaštita ambijenta, stare arhitekture i tradicijskog i kulturnog nasljeđa
- sprečavanje osipanja sela i depopulacije ruralnih područja
- izravna potpora poljoprivredi

### Pretpostavke za integriranje golfa u ponudu agroturizama Istre

Da bi se ostvario takav razvoj agroturizama u Istri i omogućio prihvat gostiju turista-golfera u agroturizmima Istre potrebno je ispuniti određene pretpostavke. Našim radom obuhvatili smo one najvažnije:

1. Blizina golf igrališta: predstavlja najvažniji čimbenik u ovom segmentu. Kako je razvoj golfa i golferskog turizma u RH i Istri još u početnoj fazi može se konstatirati da je prvo golf igralište u Istri - golf klub "Adriatic" u Savudriji koje se otvorilo 2009. godine još nedovoljno da bi se moglo govoriti o Istri kao golferskoj destinaciji. Kako su i ostali golf projekti na pragu realizacije u bliskoj budućnosti, uskoro bi se mogla stvoriti dovoljna kritična masa golfera-turista, koji bi značajnije mogli popuniti turističke kapacitete agroturizama Istre.
2. Blaga klima koja omogućava igranje golfa tijekom cijele godine: Istra ima mediteransku klimu s prosječno 2 388 sunčanih sati na godinu što je jedan od važnih čimbenika za njezino tretiranje kao velikog potencijala za razvoj "golf turizma", te s tim u vezi boravka turista-golfera na agroturizmima.
3. Specifična ugostiteljska ponuda agroturizama: u našem radu smo podrobnije proučili golfere kao specifične turiste te smo došli do zaključka da su agroturizmi idealna mjesta za njihov prihvat. Golferi su turisti koji putuju u manjim ili većim skupinama, veliki su ljubitelji lokalnih gastronomskih specijaliteta, traže mir, a intima agroturizama je idealna za njihov smještaj.
4. Blizina emitivnom tržišta odnosno broj golfera u neposrednoj blizini: budući da je golf sport u velikoj ekspanziji, radi njegove integracije u turističku ponudu agroturizama izvršena je analiza golferskog tržišta. Analizirali smo broj igrača, odnosno broj potencijalnih turista-golfera u zemljama koje tradicionalno gravitiraju Istri.

Tablica 1.: Promjena broja igrača od 2006. do 2009. godine

Država	Broj igrača 2006.	Broj igrača 2010.	Promjena u %
Austrija	89.812	104.475	16,32
Italija	81.100	100.317	23,69
Njemačka	506.746	599.328	18,26
Slovenija	7.309	7.900	8,08

Izvor: European Golf Association, Eurostat, 2006. i 2010. godine, www.ega-golf.ch, 03.10.2010.

Iz navedene tablice 1. vidljivo je da se broj igrača u navedenim zemljama u promatranom razdoblju neprestano povećavao. Ako se uzme u obzir podatak da u južnoj Njemačkoj ima cca 150.000 golfera, dolazi se do podatka, da se u relativno bliskom emitivnom području Istre nalazi tržište od cca 300.000 golfera koji gravitiraju Istri. Pri tome je osobito važno naglasiti da su zbog oštrem klime gotovo sva igrališta u tim zemljama tijekom zime zatvorena.

5. Obim eventualnog ulaganja u golf: kao što je već prije navedeno agroturizmi kao takvi pružaju idealno mjesto za prihvata golfera-turista. Eventualne dodatne investicije vezano za golfere-turiste bi se odnosile na sljedeće:

- osiguranje prostorije za smještaj golf opreme
- uređenje putting greena za vježbanje završnog udarca
- uređenje vježbališta za golf sa opremom i lopticama
- u dogovoru sa pojedinim golf igralištima proglašavanje pojedinog agroturizma "golf agroturizmom"

Sve gore navedene investicije osim osiguranje prostorije za smještaj golf opreme nisu neophodne da bi pojedini agroturizam uspješno ugošćivao turiste-golfere.

### Zaključak

Mali broj domaćih autora bavio se temama vezanim uz povezivanje ekonomije, ruralnog turizma, razvoja agroturizama i golfa kao djela turističke ponude ruralnog područja. Osim toga, golf kao svjetski fenomen je malo istražen, a osobito nisu istražene relevantne značajke za mogućnost integracije golf ponude kao sastavnog dijela turističke ponude ruralnog područja. Golf zbog svoje rasprostranjenosti i veličine tržišta pruža brojne mogućnosti razvoja turizma na ruralnom području od kojih su poboljšanje popunjenosti kapaciteta, privlačenje gostiju veće platežne moći i produženje sezone agroturizama Istre najvažnije. Ovo je osobito važno naglasiti s toga što agroturizmi u Istri pružaju gotovo idealne uvijete za prihvata i smještaj golfera-turista. Osim ekonomskih tu su i neekonomski razlozi od kojih su promocija i turistička valorizacija te zaštita ambijenta, stare arhitekture i tradicijskog i kulturnog nasljeđa i sprečavanje osipanja sela i depopulacije ruralnih područja najvažniji. Uz relativno mala dodatna ulaganja u smislu uređenja eventualnog vježbališta za golfere i osiguranje prostorije za smještaj golf opreme, sva ostala ponuda kakvu ovakav tip gostiju traži se već nalazi kao dio ponude agroturizama u Istri. U istraživanju se došlo do spoznaje da od 2009. godine s otvaranjem prvog pravog golf igralište u Istri - golf klub "Adriatic" u Savudriji su se počeli ostvarivati i najosnovniji uvjeti za ovakav oblik razvoja turizma u Istri. Može se zaključiti da bi agroturizmi u Istri sa svojom specifičnom atmosferom i ponudom mogli pružiti vrlo kvalitetnu ponudu za boravak turista-golfera.

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# Branding of rural regions and autochthon agricultural products linked to their terroir

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## Abstract

Europe possesses a high diversity of rural areas with specific culinary traditions and production methods often resulting from local expertise or special ingredients. The image or reputation of rural regions may be used in marketing of products and services originating from these regions and vice versa. Sustainable rural tourism strategies may therefore be supplemented by the concept of (a) regional identity brands (b) quality certification schemes with designation of origin and (c) geographic indications according to the EU-Scheme on PDOs/PGIs. Geographic indications may support the generation of added value from tourism in rural areas, by establishing cultural events and improvement of the public image and reputation of the region after registration. Vice versa rural tourism may play a major role in supporting the collective promotion of geographic indications as a culinary ambassador of the rural region.

Key words: geographical indication, regional identity brand, quality certification scheme

## Introduction

Rural areas account for 80% of European territory and therefore represent an essential part of the European agricultural model. The rural development policy, corresponding to the 2<sup>nd</sup> pillar of the European Common Agricultural Policy aims to introduce a consistent and lasting framework for guaranteeing the future of rural areas and promoting the preservation of employment, the environment and the rural heritage. For over 15 years, foodstuffs and agricultural products originating in these territories where a given quality, reputation or other characteristic of the product is essentially attributable to its geographical origin, can be registered under the EU agricultural product quality scheme. A major aim according to the preamble of the scheme is to improve the incomes of farmers and to retain the rural population in these areas. Specific forms of rural tourism which combine marketing tools for products originating in these territories like geographical indications, in this perspective, represent a suitable approach to generate a regional added value with positive benefits for the whole community and enhance local development (FAO, 2009).

## Region of origin effects

The image or reputation of a rural region may be used in marketing of those products and services originating in the rural region and vice versa the image or reputation of those products may be used in marketing the region of origin (van Ittersum et al., 2003; Profeta, 2006; Profeta et al., 2008). According to von Alvensleben (2000) the relationship between the image of the region, the image of the product and the purchasing intention can be basically characterised by five processes (Figure1): 1<sup>st</sup> the *cognitive process* in which the reputation of the region affects the perception of the product characteristics. The origin of the product determines the perception of other product characteristics; 2<sup>nd</sup> the *abbreviated cognitive process* in which the origin of information plays the role of a *key information* ("cue") for the overall assessment of the product; 3<sup>rd</sup> the *affective process* in which the image of the region is straightforward - without the

intervention of cognitive processes - transferred to the regional product (*image transfer*); 4<sup>th</sup> the *enhanced affective process* in which the image of the region is directly transferred to the regional product and halo effects influence the perception of product characteristics; and 5<sup>th</sup> the *normative process* in which the purchasing intentions are dominated solely by personal or social norms relating to product origin (e.g. such as commitment to support the local economy) regardless of the product image.

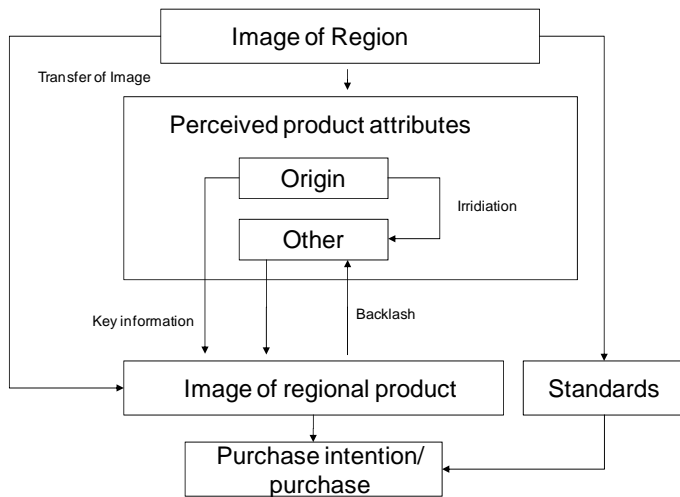


Figure 1. Relationship of image of region, image of product and purchasing intention. Source: von Alvensleben, 2000.

### Regional identity brands

Regional identity brands use the distinctive image or reputation of a region to promote it and differentiate it from those of others, whereby the region as a whole becomes a brand or a product and offers a “basket” of regional services and products (Messily et al., 2009). In the regional branding process a wide variety of attributes and qualities associated with the identity of the region and the regional identity such as cultural or natural landscapes, the culinary heritage, indigenous species, traditional or local knowledge e.g. are used to promote the region under a common brand. Functioning networks and close cooperation among the actors which involve local organizations and residents in the region are crucial for the success of regional identity brands (Messily et al., 2009). An evaluation of the objectives of various regional identity brands by Banik (2007) showed that global objectives between the initiatives may be very different and do not necessarily focus on economic objectives but rather on sustainability goals in agricultural production and processing of food in the region. Figure 2 illustrates exemplarily the objectives of the regional identity brand ‘Eifel’ from a rural region located in a low mountain range in Western Germany and its cross connections (Banik, 2007).

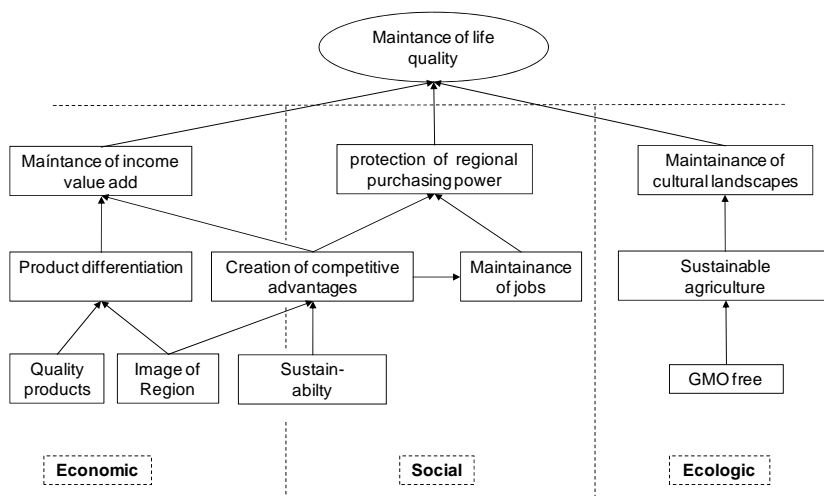


Figure 2: Economic, social and ecological objectives of the regional identity brand ‘Eifel’. Source: modified after Banik, 2007, p. 9.

### Protected geographical indications according to regulation (EC) no. 510/06

In Europe more than 900 traditional geographical indications for food and agricultural products are protected against misuse and imitation by regulation (EC) no. 510/06 (Profeta and Balling, 2007; Profeta et al., 2010). The goals of the EU-Scheme is to improve the incomes of farmers and to retain the rural population in these areas, to encourage diverse agricultural production, to protect names from misuse and imitation and to help consumers to understand the specific character of the products (c.f. regulation (EC) no. 510/06). According to estimates, a total annual sales volume of approximately 14 bn. Euro is generated with protected geographical indications (PGI) and protected designations of origin (PDO) (Profeta et al. 2009). There are three schemes (for wines, for spirit drinks, and for agricultural products and foodstuffs) and two instruments, the PDO (protected designation of origin) and the PGI (protected geographical indication) which are considered to bring together the three systems into a single regulatory structure, while preserving the specificities of each system (European Commission, 2009). The protection of geographical indications under regulation (EC) 510/06 offers food producers the possibility of maintaining traditional and regional food regulations and subsequently even food culture and customs (Williams and Penker, 2009). According to regulation (EC) no. 510/06 only those geographical indications of agricultural or processed food products can be protected that possess a long production tradition (minimum 20 years). The other main criterion is that these traditional products must have a tight quality or reputation connection with their region of production. This link can be climate or soil conditions as well as traditional production processes or indigenous breeds or seeds which have a proved impact on product quality or reputation (Thiedig, 2004; Wirsig et al., 2010).

### Implications for rural communities and regional rural initiatives

Rural tourism may be supplemented by the concept of (a) regional identity brands (b) quality certification schemes with designation of origin and (c) geographic indications according to the EU-Scheme on PDOs/PGIs (Figure 3). An example of a successful synergy between both measures to promote rural tourism and measures to promote autochthon agricultural products linked to geographical origin, is the case of the regional identity brand ‘*Südtirol*’ of the autonomous Italian province Bolzano-South Tyrol. Along the separate national food quality certification scheme with designation of origin ‘*Qualität Südtirol*’ autochthon agricultural products linked to geographical origin under the EU agricultural product quality schemes (e.g. ‘*Südtiroler Apfel PGI*’, ‘*Südtiroler Speck PGI*’) are communicated together as integral part of the regional branding strategy.

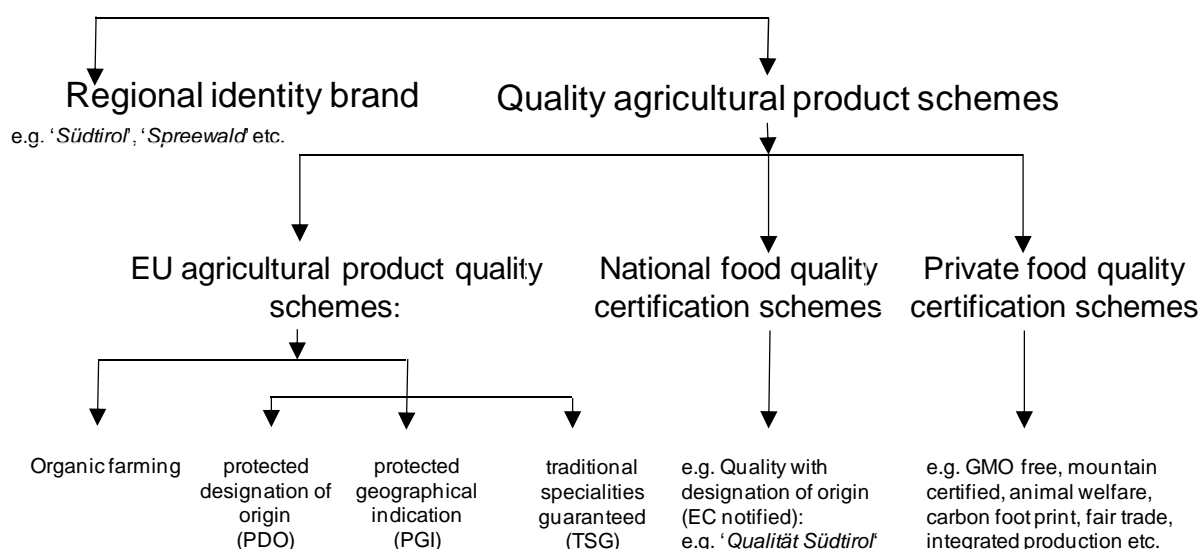


Figure 3: Geographical indications, quality certification schemes with designation of origin and regional identity brands. Source: own presentation.

Along the separate national food quality certification scheme with designation of origin 'Qualität Südtirol' autochthon agricultural products linked to geographical origin under the EU agricultural product quality schemes (e.g. 'Südtiroler Apfel PGI', 'Südtiroler Speck PGI') are communicated together as integral part of the regional branding strategy. Another example constitutes the PGI 'Spreewald gherkins' - a speciality produced in the German rural tourist region 'Spreewald' according to traditional recipes - the PGI contributes strongly to the image and identity of the region of origin. Apart from creating a significant number of jobs in the agricultural and food production sector, 'Spreewald gherkins' helped to maintain jobs in the tourism sector. The PGI contributes strongly to the popularity of the Spreewald region and constitute an essential element of the regional image due to its widespread popularity (Ecologic, 2006).

### Conclusions

The reputation of GIs and their specific local resources linked to them (production know-how and traditions, landscapes shaped by agricultural systems over time, specific native animal breeds or plant varieties, etc.) can be used as vehicles to attract consumers and tourists in the production area to important tourist locations and attractions (particular museums, archaeological sites, etc.) and to promote a differentiated basket of local products and services based on the use of local resources. Vice versa rural tourism can play a major role in supporting the collective promotion of GI product as a culinary ambassador of the rural region, by organizing itineraries for tourists and disseminating information such as gastronomic stopovers in restaurants or at production site and combination of scenic routes (FAO, 2009). GIs may support the generation of added value from tourism in rural areas, by establishing cultural events linked to GIs, integration of local associations linked to these products, and improvement of the public image and reputation of the region after registration (London Economics, 2008).

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# Sporazum CEFTA-2006 i vanjskotrgovinska razmjena poljoprivrednih proizvoda u Bosni i Hercegovini za razdoblje od 2007. do 2009. godine

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## Sažetak

Agrarna politika u Bosni i Hercegovini mora se uklapati u opće globalne procese liberalizacije trgovine koji se odvijaju u dva osnovna smjera: višestrana liberalizacija i dvostrani ugovori o liberalizaciji. Poljoprivreda ima posebno mjesto u tim procesima s obzirom na najčešće ograničene domete u liberalizaciji poljoprivrednim proizvodima. (Ćejvanović i sur. 2009). U prosincu 2006. godine u Bukureštu je potpisan sporazum o izmjeni i pristupanju Centralnoeuropskom sporazumu o slobodnoj trgovini (CEFTA). Sporazum je stupio na snagu u drugoj polovini 2007. godine. U radu su korištene, deskriptivna metoda, metoda analize uvoza i izvoza po jedinstvenoj carinskoj nomenklaturi, kao i komparativna metoda analize.

Osnovni cilj ovog rada je prezentirati i analizirati učinke CEFTA-2006 sporazuma na vanjskotrgovinsku razmjenu poljoprivrednih proizvoda u Bosni i Hercegovini s članicama CEFTA-2006 sporazuma za razdoblje od 2007. do 2009. godine.

Sporazum CEFTA-2006 je imao utjecaja na strukturu i obim vanjskotrgovinske razmjene BiH i ostalih članica unutar CEFTA-2006 sporazuma u razdoblju 2007.-2009. godina.

Ključne riječi: CEFTA, agrarna politika, trgovinska razmjena, Bosna i Hercegovina

## CEFTA-2006 and the foreign trade of agricultural products in Bosnia and Herzegovina for the period 2007th-2009th year

### Abstract

Agricultural policies in Bosnia and Herzegovina have to fit in overall global processes of trade liberalization which are going in two main directions: multilateral liberalization Agreements and bilateral Agreements on trade liberalization. Agricultural sector has specific position in these processes and is characterized with most often limited liberalization of the trade of the agricultural products (Ćejvanović and others, 2009). In December 2006 (Bucharest) Central European Free Trade Agreement (CEFTA) has been signed. The implementation of CEFTA started in the second half of 2007. The following methodologies have been used in this paper: descriptive method, import - export analysis using unique international tariff numbers and comparative analysis methodology. The main goal of this paper is to present and analyze the effects of CEFTA - 2006 Agreement on foreign exchange (with CEFTA - 2006 member countries) of the agricultural products in Bosnia and Herzegovina in the period 2007 - 2009. CEFTA - 2006 Agreement had an impact on structure and volume of the foreign exchange in



Bosnia and Herzegovina as well as in the other CEFTA - 2006 member countries during period 2007 - 2009.

Key words: CEFTA, Agricultural policy, Foreign exchange, Bosnia and Herzegovina

## Uvod

Poljoprivreda ima posebno mjesto u procesima slobodne trgovine s obzirom na najčešće ograničene domete u liberalizaciji poljoprivrednim proizvodima, za razliku od nepoljoprivrednih, gdje se u pravilu ukidaju sve carinske barijere. Kao dobar primjer je zona slobodne trgovine srednjoeuropskih zemalja, grupe CEFTA, gdje se većina osjetljivih poljoprivrednih proizvoda razvrstava u pojedine grupe i po uzajamno prihvaćenim pravilima. Zapravo je jedina prava zona slobodne trgovine u Europi na višestranom nivou Europska unija. Carinska unija je specifičan primjer institucionalnih trgovačkih veza kakve imaju pojedine zemlje, ili grupe zemalja s nekom zemljom. Radi se o usklađenoj vanjskotrgovinskoj politici (na razini carina) prema trećim zemljama i to za sve proizvode. Pri tome, uzajamna trgovina zemalja u carinskoj uniji ne mora biti u potpunosti liberalizirana.

## Metode i materijal

U radu je korištena literarna građa agrarne politike kao zajedničke politike EU i publicirani znanstveni i stručni radovi koji tretiraju ovu problematiku. Korišteni su i izvori podataka Ministarstva vanjske trgovine i ekonomskih odnosa BiH i podaci agencije za statistiku BiH. Na osnovu prikupljenih podataka korištena je deskriptivna metoda, metoda analize uvoza i izvoza po jedinstvenoj carinskoj nomenklaturi, kao i komparativna metoda analize. Kontrolnim uzorkom korištena su statistička izvješća drugih zemlja članica CEFTA-2006 sporazuma.

## Rezultati istraživanja

Republika Albanija, Bosna i Hercegovina, Republika Hrvatska, Republika Moldova, Republika Crna Gora, Makedonija, Republika Srbija i Misija privremene uprave Ujedinjenih naroda na Kosovu, u ime Kosova, sukladno s Rezolucijom 1244 Vijeća sigurnosti Ujedinjenih naroda, pristupile su Centralnoeuropskom sporazumu o slobodnoj trgovini (CEFTA).

U prosincu 2006. godine u Bukureštu je potpisan sporazum o izmjeni i pristupanju centralnoeuropskom sporazumu o slobodnoj trgovini (CEFTA-2006).

Sporazum je podlijegao ratifikaciji, prihvaćanju ili odobrenju sukladno s zahtjevima predviđenim domaćim zakonodavstvom. Instrumenti ratifikacije, prihvaćanja ili odobrenja su deponirani kod Depozitara. Sporazum je stupio na snagu u drugoj polovini 2007. godine. Bilateralni sporazumi koji su do tada potpisani otkazani su na dan stupanja na snagu ovog Sporazuma.

Kada je riječ o vanjskotrgovinskoj razmjeni poljoprivrednih proizvoda Bosne i Hercegovine i članica sporazuma CEFTA-2006 može se promatrati ukupan uvoz i izvoz poljoprivrednih proizvoda (Čejvanović, 2008).

U tablici 1. prikazan je uvoz poljoprivrednih proizvoda u BiH

Tablica 1. Uvoz poljoprivrednih proizvoda u BiH po regijama (u mil. €)

Regija	2007.		2008.			2009.		
	Uvoz	% učešća	Uvoz	% učešća	Rast/pad	Uvoz	% učešća	Rast/pad
EU	371,83	32,47%	473,66	35,34%	27,39%	397,99	32,57%	-15,98%
CEFTA	581,37	50,76%	634,29	47,33%	9,10%	612,78	50,15%	-3,39%
UoST*	25,41	2,22%	30,08	2,24%	18,40%	28,13	2,30%	-6,48%
Ostatak svijeta	166,65	14,55%	202,19	15,09%	21,33%	183,11	14,98%	-9,44%
<b>Ukupno</b>	<b>1.145,26</b>	<b>100,00%</b>	<b>1.340,22</b>	<b>100,00%</b>	<b>17,02%</b>	<b>1.222,01</b>	<b>100,00%</b>	<b>-8,82%</b>

Izvor: Agencija za statistiku BiH

\* Zemlje Ugovora o slobodnoj trgovini (Turska)

U 2009. godini u odnosu na 2008. godinu došlo je do pada uvoza poljoprivrednih proizvoda iz zemalja Europske unije za 15,98%, dok se bilježi rast uvoza poljoprivrednih proizvoda iz Evropske unije od 27,39% u 2008. god. u odnosu na 2007. godinu.

Kada se promatraju članice Sporazuma CEFTA-2006, došlo je do pada uvoza poljoprivrednih proizvoda iz zemalja potpisnica CEFTA-e za 3,39% u 2009. godini u odnosu na 2008., dok se bilježi rast uvoza poljoprivrednih proizvoda iz zemalja potpisnica CEFTA-e za 9,10% u 2008. u odnosu na 2007. godinu.

U tablici 2. prikazan je izvoz poljoprivrednih proizvoda iz BiH.

Tablica 2. Izvoz poljoprivrednih proizvoda iz BiH po regijama (u mil. €)

Regija	2007.		2008.			2009.		
	Izvoz	% učešća	Izvoz	% učešća	Rast/pad	Izvoz	% učešća	Rast/pad
EU	42,25	25,43%	45,93	21,90%	8,70%	54,82	23,67%	19,36%
CEFTA	117,19	70,52%	155,69	74,22%	32,86%	161,25	69,62%	3,57%
UoST*	1,55	0,93%	2,60	1,24%	68,19%	9,12	3,93%	249,71%
Ost. svijeta	5,19	3,12%	5,54	2,64%	6,72%	6,41	2,77%	15,82%
<b>Ukupno</b>	<b>166,18</b>	<b>100,00%</b>	<b>209,77</b>	<b>100,00%</b>	<b>26,23%</b>	<b>231,60</b>	<b>100,00%</b>	<b>10,40%</b>

Izvor: Agencija za statistiku BiH

\* Zemlje Ugovora o slobodnoj trgovini (Turska)

U 2009. godini u odnosu na 2008. godinu došlo je do značajnog rasta izvoza poljoprivrednih proizvoda u zemlje EU (19,36%), dok se također bilježi rast izvoza poljoprivrednih proizvoda u EU u 2008. u odnosu na 2007. godinu od 8,70%. Izvoz poljoprivrednih proizvoda u zemlje potpisnice CEFTA-e je porastao za 3,57% u 2009. u odnosu na 2008. godinu, što je znatno manji postotak rasta od onoga koji je zabilježen u 2008. godini u odnosu na 2007. godinu i iznosio je 32,86%.

Najznačajniji vanjskotrgovinski partneri BiH u okviru Sporazuma CEFTA-2006 su Republika Hrvatska i Republika Srbija.

Iz prezentiranih podataka u tablici 3. može se vidjeti da je Hrvatska glavni bosanskohercegovački vanjskotrgovinski partner, ne samo po uvozu, već i po izvozu. Tome u prilog govori podatak da izvoz poljoprivrednih proizvoda iz BiH u Hrvatsku u 2009. godini iznosi 34,53% od ukupnog izvoza poljoprivrednih proizvoda i 25,35% od ukupnog uvoza istih. Pokrivenost uvoza izvozom poljoprivrednih proizvoda u promatranom razdoblju sa Hrvatskom iznosi 25,81% i ima trend rasta od 2007. godine, kada je iznosila 20,69%. Došlo je do blagog pada uvoza iz Hrvatske poljoprivrednih proizvoda od 3,54%, u usporedbi 2009. i 2008. godine. Izvoz poljoprivrednih proizvoda iz BiH u Hrvatsku smanjio se za 0,78% u promatranom razdoblju.

(18,38%).

Tablica 3. Ukupna razmjena poljoprivrednim proizvodima sa Hrvatskom (Mil. €)

OPIS	2007.	Učešće u		2008.	Učešće u		2009.	Učešće u	
		ukupnom uvozu/izvozu			ukupnom uvozu/izvozu			ukupnom uvozu/izvozu	
Uvoz iz Hrvatske	309,11	26,99%		321,16	23,96%		309,80	25,35%	3,90%
Izvoz u Hrvatsku	63,94	38,49%		80,60	38,42%		79,97	34,53%	-0,78%
<b>Ukupno</b>	<b>373,07</b>	<b>/</b>	<b>/</b>	<b>401,76</b>	<b>/</b>	<b>/</b>	<b>389,77</b>	<b>/</b>	<b>7,69%</b>

Izvor: Agencija za statistiku BiH

Među vanjskotrgovinskim partnerima Bosne i Hercegovine, Republika Srbija zauzima visoko mjesto po vrijednosti ostvarene ukupne razmjene. Prema prezentiranim podacima u Tablici 4. uvoz poljoprivrednih proizvoda iz Srbije u ukupnom uvozu poljoprivrednih proizvoda u BiH sudjeluje s 21,29%, dok izvoz u Srbiju iz BiH sudjeluje s 41,53%.

Pokrivenost uvoza izvozom poljoprivrednih proizvoda sa Srbijom u 2009. godini iznosila je 17,84%, dok je u 2008. godini iznosila 15,97%. U 2009. godini je došlo do pada uvoza poljoprivrednih proizvoda od 5,51% i industrijskih proizvoda 34,81%. Na strani izvoza u Srbiju u promatranom periodu, došlo je do povećanja izvoza poljoprivrednih proizvoda od 5,55%.

Tablica 4. Ukupna razmjena poljoprivrednim proizvodima sa Srbijom (mil. €)

OPIS	2007.	Učešće u		2008.	Učešće u		2009.	Učešće u		Porast/Pad 2008/2007	Porast/Pad 2009/2008
		ukupnom uvozu/izvozu			ukupnom uvozu/izvozu			ukupnom uvozu/izvozu			
Uvoz iz Srbije	221,69	19,36%		275,27	20,54%		260,11	21,29%		24,17%	-5,51%
Izvoz u Srbiju	31,06	18,69%		43,96	20,96%		46,40	20,04%		41,53%	5,55%
Ukupno	252,75	/		319,23	/		306,51	/		26,30%	-3,98%

Izvor: Agencija za statistiku BiH

Zanimljivo je iznijeti usporedni pregled deficita po grupama, tj. industrijskih i poljoprivrednih proizvoda (tablica 5.)

Tablica 5. Usporedni pregled deficita po grupama proizvoda (industrijski i polj.) (u €)

Regija	2008.		2009.		Rast/Pad u%	
	Industrija	Poljoprivreda	Industrija	Poljoprivreda	Industrija	Poljoprivreda
EU	-1.680.184.976	-422.763.669	-1.225.311.256	-340.272.745	-27,07%	-19,51%
CEFTA	-644.124.528	-491.395.042	-162.278.832	-456.414.737	-74,81%	-7,12%
UoST*	-403.820.853	-27.147.506	-142.565.634	-18.526.125	-64,70%	-31,76%
Ostale zemlje	-1.039.648.082	-188.722.535	-972.021.385	-170.012.227	-6,50%	-9,68%
Ukupno	-3.767.778.439	-1.129.546.082	-2.502.177.107	-985.225.832	-33,59%	-12,78%

Izvor: Agencija za statistiku BiH

\* Zemlje Ugovora o slobodnoj trgovini (Turska)

U 2009. u odnosu na 2008. godinu, deficit bilježi pad i kod industrijskih i poljoprivrednih proizvoda u svim regijama. Najveća disproporcija u padu deficita je u vanjskotrgovinskoj razmjeni sa potpisnicama Sporazuma CEFTA-e, kod industrijskih proizvoda je pad 74,81% a kod poljoprivrednih 7,12%. Učešće u deficitu industrijskih i poljoprivrednih proizvoda prikazano je u tablici 6.

Tablica 6. Učešće u deficitu (industrijskih i poljoprivrednih proizvoda) (u €)

Regija	2008.				2009.			
	Industrija		Poljoprivreda		Industrija		Poljoprivreda	
	Deficit	Učešće (%)	Deficit	Učešće (%)	Deficit	Učešće (%)	Deficit	Učešće (%)
EU	-1.680.184.975	44,59	-422.763.669	37,43	-1.225.311.256	48,97	-340.272.745	34,54
CEFTA	-644.124.528	17,10	-491.395.042	43,50	-162.278.832	6,49	-456.414.737	46,33
UoST*	-403.820.853	10,72	-27.147.506	2,40%	-142.565.634	5,70	-18.526.125	1,88
Ostale zemlje	-1.039.648.081	27,59	-188.239.869	16,67	-972.021.385	38,85	-170.012.227	17,26
Ukupno	-3.767.778.437	100,00	-1.129.546.086	100,00	-2.502.177.107	100,00	-985.225.832	100,00

Izvor: Agencija za statistiku BiH

\* Zemlje Ugovora o slobodnoj trgovini (Turska)

U 2009. godini ukupan deficit industrijskih proizvoda iznosi 4,89 milijardi KM, a u okviru toga najveće učešće je zemalja EU od 48,97%. Ukupan deficit poljoprivrednih proizvoda je 1,93 milijarde KM, a u okviru toga je najveće učešće zemalja CEFTA-e od 46,33%.

## Zaključak

Svrha agrarne politike je da se mjerama trajno osigura određena politika gospodarskog položaja poljoprivrede u cjelokupnom poljoprivrednom sustavu, a zatim da osigura razvojne politike. Vanjskotrgovinska politika mora se voditi neovisno o utjecaju svjetskog tržišta s jedne strane, a s druge strane, utjecaja svjetskih cijena (Ćejvanović 2009).

Sporazum CEFTA-2006 je imao utjecaja na strukturu i obim vanjskotrgovinske razmjene BiH i ostalih članica unutar CEFTA-2006 sporazuma u razdoblju 2007.-2009. godina. Uvoz poljoprivrednih proizvoda u 2007. godini iznosio je 50,76% ukupne vanjskotrgovinske razmjene, a u 2008. godini došlo je do pada uvoza iz zone CEFTA-2006 na 47,33%, dok je uvoz u 2009. godini iznosio 50,15%. Izvoz poljoprivrednih proizvoda u 2007. godini iznosio je 70,52% ukupne vanjskotrgovinske razmjene, a u 2008. godini došlo je do porasta izvoza u zonu CEFTA-2006 na 74,22%, dok je izvoz u 2009. godini iznosio 69,62%. Može se zaključiti da je u

drugoj godini (2008) primjene CEFTA-2006 sporazuma došlo do pada uvoza i porasta izvoza. Međutim u 2009. godini uvoz je postigao skoro istu razinu kao u 2007. godini, a izvoz u istoj godini je pao ispod razine iz 2007. godine.

Iz prikazanih rezultata vidljivo je da se trgovina u razdoblju 2007. do 2009. godine obavljala najviše s Republikom Hrvatskom, zatim s Republikom Srbijom. Uvoz iz Republike Hrvatske u 2007. godini iznosio je 309.11 mil. €, dok je u 2008. godini porastao na 321.16 mil. €, a u 2009. godini uvoz je imao skoro istu vrijednost kao u 2007. godini 309.80 mil. €. Izvoz u Republiku Hrvatsku u 2007. godini iznosio je 63.94 mil. €, dok je u 2008. godini porastao na 80.60 mil. €, a u 2009. godini izvoz je imao vrijednost 79.97 mil. €. Uvoz iz Srbije u 2007. godini iznosio je 221.69 mil. €, dok je u 2008. godini porastao na 275.27 mil. €, a u 2009. godini uvoz je imao vrijednost 260.11 mil. €. Izvoz u Srbiju u 2007. godini iznosio je 31.06 mil. €, dok je u 2008. godini porastao na 43.96 mil. €, a u 2009. godini izvoz je imao vrijednost 46.40 mil. €. Općenito se može zaključiti da Sporazum je u određenim segmentima i pojedinim godinama pozitivno utjecao na trgovinsku bilancu poljoprivrednih proizvoda u BiH, a u nekim segmentima i godinama pomatranog razdoblja od 2007. do 2009. godine imao je negativan utjecaj.

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# Analiza hrvatskog tržišta jabuka

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## Sažetak

Nakon ulaska Hrvatske u Europsku uniju i ukidanja carinske zaštite, povećat će se konkurencija na domaćem tržištu jabuka, porast će ponuda i smanjit će se cijena jabuka. Da bi domaći proizvođači opstali morat će se prilagoditi novim uvjetima na tržištu. Cilj ovog rada je prikazati tržište jabuka u RH u razdoblju od 2000. - 2008. godine, te pomoću SWOT analize izdvojiti prednosti i slabosti sektora jabuka kao i izglede i ograničenja za daljnji razvoj tog sektora.

Ključne riječi: tržište jabuka, Hrvatska, proizvodno-potrošna bilanca, SWOT analiza

## Analyses of the Croatian apple market

### Abstract

Competition in the domestic apple market will increase after the Croatian accession to the European Union and the abolition of tariff protection and it will lead to increased supply and reduced prices of apples. To survive, domestic apple producers will have to adapt to new market conditions. The aim of this paper is to present the apple market in Croatia in the period 2000 - 2008, and to describe strengths and weaknesses of the sector as well as opportunities and constraints for further development of this sector using SWOT analysis.

Key words: apple market, Croatia, balance sheet, SWOT analysis

### Uvod

Jabuka zauzima treće mjesto prema ukupnoj svjetskoj proizvodnji voća, odmah iza banana i grožđa (Apple Industry Key Facts, 2009.). Ona je i tradicijska i najvažnija voćarska vrsta u Hrvatskoj; zauzima 22% ukupnih površina pod voćem, te 36% ukupne proizvodnje voća

Prije Domovinskog rata, glavnina proizvodnje jabuka se odvijala u velikim državnim poduzećima-kombinatima koji su tijekom Domovinskog rata i privatizacije doživjeli proizvodni krah. Sredinom devedesetih godina prošlog stoljeća došlo je do značajnijeg povećanja proizvodnje jabuka, posebice na obiteljskim poljoprivrednim gospodarstvima.

Današnja proizvodnja jabuka u Republici Hrvatskoj niti količinom niti kvalitetom ne zadovoljava domaću potražnju. Stoga se značajan dio domaće potrošnje namiruje iz uvoza, pri čemu se često uvozi jabuka niske kvalitete, koja ruši cijene domaćoj jabuci. Normalno funkcioniranje tržišta voća ograničava i neloyalna konkurencija, budući da se velik dio proizvodnje plasira na tzv. sivom tržištu, a nije dovoljno razvijena ni zakonska regulativa. Tržište voća, pa tako i jabuke u Hrvatskoj je neorganizirano i nedovoljno razvijeno, a poslovni subjekti uključeni u lanac trgovine nisu povezani (Par, 2009.).

Nakon ulaska Hrvatske u Europsku uniju i ukidanja carinske zaštite, povećat će se konkurencija na domaćem tržištu jabuka, porast će ponuda i smanjit će se cijena jabuka. Prema nekim procjenama, tek 30% hrvatskih voćara ima šansu za opstanak na tržištu nakon ulaske RH u Europsku uniju<sup>1</sup>.

Cilj ovog rada je dati pregled tržišta jabuka u Hrvatskoj od 2000. do 2008. godine, odnosno prikazati proizvodnju, uvoz i izvoz jabuka, kretanje cijena, prodaju i potrošnju jabuke te izraditi SWOT analizu hrvatskog tržišta jabuka. Na osnovu dobivenih podataka će se dati preporuke za daljnji razvoj sektora jabuka u RH.

## Materijal i metode

Za izradu ovog rada korišteni su sekundarni izvori podataka iz Ministarstva poljoprivrede, ribarstva i regionalnog razvoja (MPRRR) te Državnog zavoda za statistiku. Cijene jabuka u promatranom razdoblju su preuzete iz Tržišnog informacijskog sustava u poljoprivredi. U izradi rada su korištene metoda proizvodno-potrošne bilance (sukladno metodologiji EUROSTAT-a) i SWOT analiza.

## Rezultati i rasprava

### Proizvodnja i ponuda jabuka

Površine pod jabukom u promatranom razdoblju bilježe stalan rast zbog poticanja proizvodnje od strane MPRRR i iz pretprijetnih fondova Europske unije. Površine pod jabukom u 2008. godini su iznosile su 6.404 ha (52% više nego u 2000.).

Prinos jabuka po hektaru iz godine u godine varira pod utjecajem vremenskih uvjeta. Najveći prinos zabilježen je 2000. godine i iznosio je 19,4 tone po hektaru. Loši vremenski uvjeti su drastično smanjili prinos u 2001. da bi se nakon toga povećavao i uz godišnja kolebanja u 2008. godini dostigao 12,5 t/ha (tek 64% prinosa iz 2001.)

Ukupna proizvodnja jabuke u razdoblju od 2000. - 2008. godine se kretala između 60 i 80 tisuća tona, od čega oko 80% otpada na intenzivnu proizvodnju za tržište. Stabilnost domaće proizvodnje često je ograničena rizicima vremenskih nepogoda (tuča, mraz, velike količine oborina, suša) (Črep, 2010.).

Najzastupljenija sorta u domaćoj proizvodnji je Idared (cca. 65% ukupne proizvodnje jabuka), slijedi Jonagold i klonovi (svaki po cca 15%) i Zlatni Delišeš (cca. 10%). Preostalih cca. 10% sortimenta je: Gala, Elstar, Granny Smith, Melrose, Gloster i dr. (Kovačić i sur. 2007.). Ovakav sortni sastav uvelike odstupa od sortnog sastava u europskim zemljama, gdje dominiraju Golden Delicious, Golden Spur i Gala (posebice u starim članicama EU)<sup>2</sup>.

### Potpore domaćoj proizvodnji jabuka

Operativnim programom podizanja trajnih nasada u razdoblju od 2008. do 2012. godine je predviđena obnova postojećih i podizanje novih 8000 ha voćnjaka u cilju ostvarenja samodostatne proizvodnje voća. U sklopu modela poticanja proizvodnje propisani poticaji za podizanje 1 ha nasada jabuka do 2009. godine iznosio je 24000 kn odnosno 32400 kn za područja s težim uvjetima gospodarenja. Prema Zakonu o državnoj potpori poljoprivredi i ruralnom razvoju iz 2010. poticaji se isplaćuju po korištenoj površini, pri čemu se ukupna sredstva predviđena za izravna plaćanja utvrđuju na razini proizvodne godine, sukladno iznosima osiguranim u Državnom proračunu (NN 92/10).

Dodatne državne potpore odnose se na potpore osiguranju, potpore kapitalnim ulaganjima i sl. Potpore marketinškim programima su bile nedostatne ili su u potpunosti izostale. Pojedine jedinice lokalne i regionalne samouprave imale su i vlastite programe poticanja sadnje jabuka kroz plaćanje po posađenoj sadnici te dodatno sufinancirale kapitalna ulaganja (Črep, 2010.).

<sup>1</sup> <http://www.agroklub.com/vocarstvo/stare-uvozne-jabuke-zavadile-agrokor-i-vocare/2247/>; pristupljeno 15.10.2010.;

<sup>2</sup> EU Commission market report on apples, 2009., [http://www.wapa-association.org/docs/2010/Facts\\_and\\_Figures/EU\\_Commission\\_market\\_report\\_on\\_apples.pdf](http://www.wapa-association.org/docs/2010/Facts_and_Figures/EU_Commission_market_report_on_apples.pdf), pristupljeno 20. listopada 2010.

## Analiza hrvatskog tržišta jabuka

Konkurentnost hrvatske jabuke na domaćem tržištu je dijelom zaštićena razmjerno visokom carinom. Pri uvozu jabuka u Hrvatsku naplaćuje se carina od 15% na vrijednost uvezene robe te dodatno u razdoblju od 15. rujna do 20. veljače 13,5 eura na 100 kilograma uvezenih jabuka (NN, 145/2009). RH s nekim zemljama sklopila ugovor o povlaštenom trgovinskom režimu. Sporazum je potpisan s EU, BiH, Srbijom, Crnom Gorom i Makedonijom. Prema ugovoru s EU određene su dvije količinske kvote (7.800 t i 5.800 t) s preferencijalnim stopama carina (50% od osnovne stope i 0%), dok se uvoz iz BiH odvija bez naplat carine.

### Uvoz - izvoz jabuka

Proizvodnja i ponuda jabuka na domaćem tržištu je manja od potencijalnih mogućnosti i ne zadovoljava domaće potrebe, tako da se značajne količine jabuke uvoze. Ukupan uvoz jabuka u Hrvatsku je jako visok naspram proizvodnje i kreće se na razini od 30 do 40 tisuća tona (Tablica 1). U razdoblju od 2002. do 2006. uvoz je premašivao polovicu domaće proizvodnje jabuka, da bi se u posljednje dvije promatrane godine uvezlo oko 25% od domaće proizvodnje jabuka. Najveća količina jabuka iz uvoza dolazi u razdoblju od 21. veljače do 14. rujna. U tom razdoblju je ponuda jabuka iz domaće proizvodnje smanjena. Razlog tomu je ograničena mogućnost čuvanja (skladištenja) te sortiranja i pakiranja (Črep, 2010.). Jabuka se najviše uvozi iz Austrije, Italije i Slovenije.

Tablica 1. Proizvodno potrošna bilanca jabuka 2000.-2008. godine

	000 t								
	2000.	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.
POVRŠINE (1 000 ha)	4,192	4,826	5,366	6,220	5,253	5,625	5,863	5,993	6,404
PRINOS (100 kg/ha)	194,034	67,263	110,218	93,334	146,562	123,879	125,704	133,779	125,236
Intenzivna proizvodnja za tržište	64,077	22,405	44,160	46,340	63,092	57,298	57,571	62,991	57,341
Proizvodnja u ekstenzivnim voćnjacima (pretežno za vlastite potrebe)	17,262	10,056	14,983	11,714	13,897	12,384	16,129	17,183	22,860
<b>UKUPNA PROIZVODNJA</b>	<b>81,339</b>	<b>32,461</b>	<b>59,143</b>	<b>58,054</b>	<b>76,989</b>	<b>69,682</b>	<b>73,700</b>	<b>80,174</b>	<b>80,201</b>
UKUPAN UVOZ	8,687	47,020	42,169	34,371	37,621	45,421	41,450	28,487	27,073
- EU	4,536	13,898	15,339	13,981	12,844	39,266	32,939	18,985	16,609
UKUPNI RESURSI	90,026	79,481	101,312	92,425	114,610	115,103	115,150	108,661	107,274
UKUPAN IZVOZ	2,309	1,622	1,541	4,767	24,266	36,968	16,574	27,725	13,235
- EU	0,378	0,185	0,095	2,799	16,912	25,600	8,571	17,907	4,640
POČETNE ZALIHE	0,097	0,037	0,010	0,055	0,071	0,067	0,088	0,067	0,060
KONAČNE ZALIHE	0,262	0,010	0,055	0,071	0,067	0,088	0,067	0,058	0,030
PROMJENE ZALIHA	-0,165	0,028	-0,045	-0,015	0,004	-0,021	0,021	0,009	0,030
<b>DOMAĆA POTROŠNJA</b>	<b>87,455</b>	<b>77,849</b>	<b>99,715</b>	<b>87,587</b>	<b>90,277</b>	<b>78,047</b>	<b>98,509</b>	<b>80,878</b>	<b>94,009</b>
GUBICI	2,886	2,569	3,291	2,890	2,979	2,576	3,251	2,669	3,102
INDUSTRIJSKA POTROŠNJA - prehrambeni proizvod i alkoholna pića	2,624	2,335	2,991	2,628	2,708	2,341	2,955	2,426	2,820
INDUSTRIJSKA POTROŠNJA - prehrambenih proizvoda	17,146	2,337	4,305	4,100	8,967	6,937	6,501	6,537	6,614
LJUDSKA POTROŠNJA - po glavi stanovnika/kg	81,945	72,945	93,433	82,069	84,589	73,130	92,303	75,783	88,086
STUPANJ SAMODOSTATNOSTI	93,007	41,697	59,312	66,281	85,281	89,282	74,815	99,130	85,312

Izvor: Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja

Izvoz jabuka do 2003. godine je bio zanemariv, da bi se nakon toga povećao. U 2005. godini je izvezeno nešto više od polovice domaće proizvodnje jabuka, nakon čega taj udio opet opada te je u 2008. izvezeno 16% proizvedenih količina (13 tisuća tona). Glavna izvozna destinacija je Bosna i Hercegovina (oko dvije trećine ukupnog izvoza u 2008.).

Pokrivenost uvoza izvozom glede količine uvezenih jabuka u promatranom razdoblju je jako oscilirala od svega 3% u 2001. i 2002. do 81% odnosno 97% u 2005. i 2007. da bi 2008. ponovo pala na 49%.

Stupanj samodostatnosti jabuke u RH u promatranom razdoblju je varirao od 60% do 99% (u 2007. godini), da bi 2008. godine iznosio 85%.

### Prodaja i potrošnja

Jabuka se najvećim dijelom prodaje u trgovačkim lancima u kojima se nudi 8-10 standardnih sorata jabuke. Ponuda nije ujednačena, te se razlikuje kvalitetom, cijenom, načinom izlaganja i asortimanom. Drugi po važnosti prodajni kanal su tržnice na malo na kojima se nudi uži asortiman, ali su jabuke u većini slučajeva bolje kvalitete. Jabuka se prodaje i u specijaliziranim trgovinama - voćarnama, koje u pravilu imaju širi asortiman i vrlo dobru kvalitetu.

Domaća potrošnja jabuke u promatranom razdoblju se kretala između 77 i 99 tisuća tona (Tablica 1). Industrijska potrošnja jabuka je mala i iznosi u prosjeku oko 10% ukupne domaće potrošnje. Pri tome se značajno veće količine te jabuke troše za preradu u prehrambene proizvode nego za neprehrambene proizvode i alkoholna pića.

Prema podacima DZS (Statističke informacije, 2010.) jabuka je najzastupljenija voćna vrsta u našoj prehrani s prosječnom potrošnjom po članu kućanstva u 2008. godini od 14,1 kg, nešto manje nego u prethodnim godinama. Podaci iz proizvodno-potrošne bilance (Tablica 1) ukazuju na ipak nešto veću potrošnju i to 19,8 kg po stanovniku u 2008. godini, što je i dalje manje od EU prosjeka koji iznosi oko 25 kg po stanovniku<sup>3</sup>.

Jabuka se najviše troši u jesenskim (listopad - prosinac) i proljetnim mjesecima (ožujak - svibanj). Na potrošnju najviše utječe zamjenjivost s bananom i narančom, te drugim sezonskim voćem (Črep, 2010.).

### Zaključak

Provedena analiza ukazuje na pozitivne trendove na tržišta jabuke u promatranom razdoblju, ali i nedostatke vezane uz nedovoljnu samodostatnost domaće proizvodnje odnosno značajan uvoz jabuke. Iako je državna potpora dala određene rezultate (veće površine pod jabukom), strukturni problemi sektora jabuka nisu riješeni. Daljnji razvoj ovog sektora ovisit će o primjeni suvremenih metoda proizvodnje, te udruživanju proizvođača posebice radi zajedničkog plasmana svojih proizvoda. Važan zadatak u razvoju sektora jabuka je i daljnja edukacija proizvođača ne samo glede proizvodnje nego i marketinga jabuke. U svemu tome značajnu ulogu mogu odigrati Hrvatska voćarska zajednica, kao i pojedinačna udruženja proizvođača..

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<sup>3</sup> EU Commission market report on apples, 2009., [http://www.wapa-association.org/docs/2010/Facts\\_and\\_Figures/EU\\_Commission\\_market\\_report\\_on\\_apples.pdf](http://www.wapa-association.org/docs/2010/Facts_and_Figures/EU_Commission_market_report_on_apples.pdf), pristupljeno 20. listopada 2010.



# Sheep meat balance in Republic of Macedonia

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## Abstract

Sheep meat is a traditional product for the Republic of Macedonia, with a decreasing production trend in the last fifteen years. The aim of the paper is to analyze the changes in the sheep meat balance and to measure the declining tendency of this sub-sector. The results show that the number of sheep as well as the sheep meat production decreased by one-third in the research period (1995-2009), whereas the meat exports increased by one-third. There are many factors contributing to this situation, resulting into an increased cost of production and a decreased the farmers' return. In the conclusion of the article it is stated that governmental actions could have a significant role in order to avoid further deterioration of this sub-sector with huge social meaning for the Republic of Macedonia.

Key words: sheep meat, balance, Macedonia

## Introduction

Sheep production in Republic of Macedonia has a long tradition, supported by favorable natural conditions. The flocks are raised in ecologically clean zones, with pastures taking up more than half of the total agricultural land. In addition, the traditional markets where the Macedonian lamb is recognized for its quality further emphasize the potential of this sub-sector. However, this potential has not been fully utilized by all structures included in this production, since it is carried out in a traditional extensive manner, almost the same way as a century and a half ago (Dimitrievski, Ericson, in press; Dimitrievski et al., 2010).

The significance of the sheep meat sub-sector can be observed through the fact that this is the main export-orientated sub-sector within the livestock complex. Moreover, this sub-sector produces one-third of the meat in the country and engages about 20 thousand families (Dimitrievski, Kotevska, 2008). The fact that this production is mainly located in the mountainous and rural areas, it adds a social dimension to the deteriorating development of this sub-sector. Besides the declining number of animals and produced quantities, the economic significance of this sector is increasing, as seen from the increased participation in the agricultural output, from 1.6% in 1998 up to 1.9% in 2008, with a peak of 12.2% in 2006 (SSO, 2005-2010)

## Material and Methods

The official data from the State Statistical Office (SSO) for the period 1995-2009 were used for the analysis of the sheep meat sub-sector. These figures are further processed and structured into a balance of the sheep meat sub-sector, as a country model for its supply and demand of this commodity. The ending stocks are not included in the balance sheet, because there are no data available. Nevertheless, taking into consideration the seasonality of the production and the marketing of the sheep meat, which is taking place in the same calendar year, we assume that there are negligible amounts left as ending stocks.

Although most of the slaughtered heads are lambs, this analysis also covers other sheep categories, hence the term 'sheep meat' comprises both mutton and lamb meat.

## Results and discussion

### Production capacities for sheep production

The farm structure in the Republic of Macedonia is represented by farm enterprises (most originating from former state-owned holdings) and family farms. According to the agricultural census in 2007, most of the sheep production with 749 thousands heads (94.37%) is carried out in family farms; whereas the remaining 45 thousands heads (5.63%) are bred by agricultural enterprises and cooperatives. The portion of sheep raised at family farms shows an uptrend in the total sheep number, especially after 1998, increasing from 91% to 96.7% in the period 1998-2007 (Dimitrievski, Ericson, in press).

Sheep production is still based on indigenous, non-selected breeds such as Shar Mountain's and Ovce Pole's Pramenka and its-crossbreeds. Genetic improvements have been performed by cross-breeding with merino, resulting with expansion of the number of those cross-breeds, and in more recent years, with the breed Wurttemberg (Dimitrievski, Kotevska, 2008; Dzabirski & Andonov, 1998).

There has been a decreasing trend of sheep number in the last decade. The total number of sheep in the period of analysis has declined from 2320 thousands in 1995 to 755 thousands in 2009, or approximately 67% decrease compared to 1995. The sheep herd structure is steady in the whole period. Ewes take the largest share with about 70%, followed by lambs younger than 1 year with about 25%, while the remaining are rams and culled sheep (Tab. 1).

The downtrend of sheep numbers, and consequently the production, is a result of a number of factors: low prices of meat, milk and wool; reduction in the fodder base; and high prices of fodder and bulk food (Dimitrievski et al., 2010; Dimitrievski, Ericson, in press). Furthermore, there is reduced availability of labour force for the sheep-keeping in the mountain areas which subsequently increases the costs of labour force. Beside the economic reasons such as availability and price of feed and labor, another reason for the negative development of the sector is the high participation of the family farms in the total production with their low capacity to face the non-favorable economic and market environment. Disease outbreaks and trade embargos in the last two decades, as well as the inconsistent agricultural policy in terms of supporting the production or export of lambs, additionally worsened the situation.

### Production of lamb meat

The basic breeding orientations in the sheep breeding farms in the Republic of Macedonia are milk and meat production. Most lambs are born in January/February and are slaughtered in April/May. After weaning, the sheep are milked for cheese production.

While the number of sheep has decreased, the yields - the average lambs per sheep and the slaughter weight - have remained stable. Consequently, the decline of sheep numbers resulted into a proportional decrease of slaughtered heads and sheep meat production. The total number of slaughtered heads in the sheep sub-sector peaked in 1996 with 1591 thousand heads, decreasing by two-thirds with 537 thousands heads in 2008 (Tab.1).

The number of slaughtered lambs accounts for 80% of the total number of slaughtered heads. They are slaughtered at very small weight, corresponding to the age of 2.5-3 months old, thus the average gross weight of slaughtered heads is very low - about 18 kg for lambs, and 37 kg for culled sheep (Dimitrievski & Ericson, in press; Dzabirski & Andonov, 1998). The net-yield (ratio between gross and net weight) is accounted for approximately 50% for lambs and 44% for sheep (SSO, 1996-2010).

Sheep meat accounts for average production of 6357 tons for the period 1995-2009 (Tab. 1), *i.e.* 24% of the average production of all types of meat. The production of sheep meat for the same period showed a downtrend. In comparison, the quantities of 9976 tons in 1995 have been reduced to 5225 tons in 2009, thus decreasing the production of sheep meat by half in 2009 as compared to 1995.

## Sheep meat balance in Republic of Macedonia

**Table 1: Balance of sheep meat in Republic of Macedonia**

Year	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	M <sub>x</sub>
<b>Inventories (1000 heads)</b>																
Total number	2.32	1.81	1.63	1.32	1.29	1.25	1.29	1.23	1.24	1.43	1.24	1.25	0.82	0.82	0.00	1.26
Lambs up to 1 year	0.42	0.47	0.36	0.29	0.33	0.29	0.32	0.28	0.33	0.34	0.33	0.32	0.23	0.20	0.20	0.31
Breeding sheep	1.74	1.23	1.18	0.95	0.87	0.89	0.90	0.88	0.83	1.01	0.83	0.86	0.55	0.59	0.52	0.92
Rams and barren sheep	0.16	0.11	0.09	0.08	0.09	0.07	0.07	0.07	0.09	0.09	0.08	0.07	0.04	0.03	0.03	0.08
Lambs per ewe	1.0	0.9	1.2	1.0	1.0	1.0	1.0	0.9	1.0	1.0	0.6	0.9	1.0	1.0	n.a	1.0
Lamb crop	1.78	1.15	1.36	0.90	0.87	0.85	0.87	0.78	0.79	0.97	0.54	0.79	0.56	0.58	n.a	0.91
Slaughtered heads	1.24	1.59	1.48	1.16	0.84	0.83	0.79	0.78	0.74	0.73	0.68	0.75	0.96	0.54	n.a	0.94
<b>Supply-Demand Balance (1000 tons)</b>																
Total supply	10.0	9.5	6.6	5.6	4.4	4.9	5.8	4.6	5.9	7.0	6.9	7.2	6.5	5.2	5.2	6.4
Production	10.0	9.5	6.6	5.6	4.4	4.9	5.8	4.6	5.9	7.0	6.9	7.2	6.5	5.2	5.2	6.4
Import	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total demand	10.0	9.5	6.6	5.6	4.4	4.9	5.8	4.6	5.9	7.0	6.9	7.2	6.5	4.5	5.2	6.3
Consumption	8.1	7.5	4.7	3.7	2.4	2.9	2.9	1.7	3.1	4.0	4.1	4.3	3.7	1.8	2.3	3.8
Export	1.8	2.1	1.8	1.9	2.0	2.0	2.9	2.9	2.8	3.0	2.7	2.9	2.8	2.7	2.9	2.5
<b>Derived indicators (ratio)</b>																
Level of self-supply	1.2	1.3	1.4	1.5	1.8	1.7	2.0	2.7	1.9	1.8	1.7	1.7	1.8	2.9	2.3	1.8
Net-trade	1.8	2.1	1.8	1.9	2.0	2.0	2.9	2.9	2.8	3.0	2.7	2.9	2.8	2.7	2.9	2.5
Consumption per capita (kg)	4.1	3.8	2.4	1.8	1.2	1.4	1.4	0.9	1.5	2.0	2.0	2.1	1.8	0.9	1.2	1.9
<b>Prices (den/kg)</b>																
Producer price (lambs carcass)	85	83	71	82	73	116	130	150	137	147	141	146	147	154	n.a	119
Export price	80	84	120	136	125	231	252	233	239	257	301	288	286	320	276	215

Source: SSO (1996-2010), Dimitrievski, Ericson (in press)

### Consumption of lamb meat

Sheep meat is a delicacy nutritional product and is part of the diets of all religious groups in the Republic of Macedonia. On the other hand, the seasonal supply, and the high market price limit the consumption of sheep meat and it represents approximately a fifth (20%) of total meat consumption.

The consumption of sheep meat in the Macedonian households for the period 1995-2008 displays a downtrend, from 8,140 tons consumed in 1995 down to 1719 tons in 2002, *i.e.* 79% less than 1995. In 2008 the consumption per capita was just 1.2 kg, whereas, in 1995 it was 4.1 kg/capita. In other words, the consumption of sheep meat per capita has been reduced by approximately 70%. These variations are explained by the fact that, on one side, the decreasing production and at the same time increasing exported quantities resulted in smaller supply at the domestic market and thus a higher price. On the other side, the quantities of meat that have not been exported during the diseases outbreaks and trade embargos caused oversupply at the domestic market and decreased the price at the domestic market.

### Foreign trade of lamb meat

Lamb meat is the most important export-oriented commodity within the livestock complex. However, taking into consideration that the livestock complex participates with a slightly lower degree in the agri-food exports, and that the main export commodity group from the livestock complex - 'meat and edible meat offal' - is taking up 4.3% from the total agri-food exports (Dimitrievski et al., 2010), lamb meat as an exporting commodity does not have such a significant contribution for the whole agri-food trade.

Lamb meat takes the largest share in the total exports of this sub-sector. The exports for the period 1995-2009 show a gradual rise since the trough in 1997-2000, with an increasing level of stability after 2004 (Dimitrievski, Ericson, in press). The exported quantities of sheep meat for the period 1995-2009 vary from 1836 tons in 1995 to 3021 tons in 2004, while the average quantity of these products was 2491 tons. A significant increase in the export is registered in 2001 in comparison to 2000, with increase in export by

40.7%. The overall increase of the exported quantities in 2009 in comparison to 1995 was 59%, which is mostly a result of the overcoming the foot-and-mouth disease and increased agricultural support.

Due to its low price and high quality, the Macedonian lamb is competitive on the international market. Greece and Italy are the main export destinations of the Macedonian lamb, absorbing about 90% of the export. The remaining 10% of the export are assigned for the ex-Yugoslavian market.

Except for some very small negligible amounts in 2008 (16 tons in total), there is no import of lamb and mutton meat in the Republic of Macedonia.

#### Supply and demand balance of mutton and lamb meat

The production of sheep meat satisfies the needs of the Republic of Macedonia, making this product the only livestock commodity that has market surpluses intended for export. The coefficient of self-supply of these products is higher than 1 during the whole period. It varies from 1.23 in 1995 to 2.89 in 2008 showing the increasing market surpluses. Anyway, the production of lamb is still in decline. Taking into consideration that there is no import of mutton or lamb's meat, it can be concluded that the sheep meat supply consists of domestically produced quantities only. In average, 58% of the domestic production of sheep meat is consumed by the domestic market, while the remaining 42% is exported. Considering that no sheep meat is imported in the Republic of Macedonia, the net-trade is positive.

#### Prices

The analysis of the deflated sheep meat price displays an uptrend, with three distinct development phases. In the first phase (1995-1999) the price was on average 79 den/kg (1.43 €/kg). The second phase (2000-2002) is characterized by an increasing trend of the price due to the re-opening of the international markets (the economic embargo to Serbia, the foot-and-mouth disease outbreak and internal political conflict in Macedonia are left behind), as well as the introducing of governmental measures for minimal buy-out price of lambs as a condition for eligibility for export subsidies. In the third phase (period after 2002) the prices tend to stabilize again, at the level of 145 den/kg (2.38 €/kg), on average *i.e.* about 80% higher than in the price in the first phase. The producer prices of sheep production commodities are low, with commonly accepted conclusion that they do not cover the costs of working in that sub-sector. This is confirmed by the analysis showing that a break-even price for lamb meat for year 2009 was 151.6 den/kg (2.47 €/kg) (Milevska, 2010). Therefore, it can be concluded that these prices are not stimulating for the sheep-breeders to expand the flocks or to introduce more up-to-date equipment which would increase the income. The export price of sheep meat in the period 1995-2009 ranged from 80 den/kg (1.61 €/kg) in 1995 to 320 den/kg (5.27 €/kg) in 2008, *i.e.* at an average price for the period of question of 215 den/kg (3.57 €/kg). The analysis of the export price shows the same development pattern as at the producer price.

#### Conclusion

The long tradition and favorable natural conditions are not sufficient to maintain a positive development of the sheep sub-sector, nor is the recognition of the Macedonian lamb meat as a high-quality product at the traditional international market. The alarming signals of weakening of this sub-sector indicate that immediate actions must be taken, in order to avoid further deterioration of this sub-sector, especially since it plays an important social role in the less-favored and rural areas. The government could and should have a critical role in improving the situation in this sub-sector. The weak points of the sub-sector can be pointed out as focal points for improvement. For instance, the consistent and focused agricultural policy can contribute in stabilizing and increasing the herd size. The structural policy and measures can compensate the low financial capacity of the farmers and enhance farmers' knowledge and management techniques. For example, the genetic improvements, accelerated lambing, and better management practices can increase the lamb production. In addition, the social program can help in overcoming the employment issue in this sub-sector. Although this paper considers the sheep meat only, the revenue coming from milk should be noted as well, especially if processed into high quality cheese products.

Generally, the balance of the sheep meat shows that once this sub-sector was a very important for the Republic of Macedonia in the recent history. The markets for this product still exist, with increasing demand especially at international level. With elimination of most of the negative circumstances this sub-sector can easily regain its position in the Macedonian economy.

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# Analysis of Serbian beef marketing chain from the standpoint of primary producers

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## Abstract

Livestock production is an important part of agriculture of the Republic of Serbia. Besides supplying the domestic market, exports of live cattle and beef is important for foreign trade balance. The largest export was made during late 1980ies and afterwards there was a reduction of export. Although the EU has approved a preferential treatment for exports of Serbian beef, this possibility is only partially used. There are many facts, explanations and interpretations of reasons for export decline. However, very rarely analysis of live animals' trade, as the important element of marketing chain, has been carried out. Using surveys and interviews various aspects of trade with live animals were analyzed. The results show that primary producers do not always have positive attitudes towards traders, regardless of the volume of trade. This paper analyzes the trade of live animals from the standpoint of primary producers and their relation with customers, especially slaughterhouses and meat processors. The aim of this paper is, firstly, to examine the way of trade, secondly, to show views and opinions of the primary producers about buyers of live animals and thirdly, to present the effect of trade volume on the pricing of livestock. The aim of the research is also to find opportunities for improvement of the marketing chain in trade with live animals.

Key words: marketing, beef, primary producers, Serbia

## Introduction

For primary agricultural producers in Serbia a good marketing is essential for making a profit which is usually determined by the volume of trade.

According to the 2002 Census, farms were classified into seven groups according to size of agricultural land. In the largest group there are the farms with 15 or more hectares of agricultural land. This group is made of 1.96% farms and breed some 8.5% of the total number of cattle, while average family farm has less than one cattle.

Research on primary producers in marketing of their own products in Serbia is mostly focused on all farms in agriculture. Since there are differences in farm size measured in hectares and number of livestock, it is interesting to explore the position of the largest farms. Those farms could be classified as advanced and they are important for further competitiveness improvement of the livestock production in Serbia.

As a rule, farmers sell their products directly on the farm, where abattoirs, processors and traders appear as buyers, whose main activity is further trade. In this study, the basic characteristics of advanced farms in the Republic of Serbia are shown, as well as the general problems they are facing with when they are selling their products.

## Materials and methods

In order to obtain relevant information, a survey was conducted. In the group of the largest farms it was selected a random sample with a sample size of 52 family farms. Interviewers were persons familiar with the situation at local level and experienced in surveys. In addition to surveys, interviews were conducted with key stakeholders involved in animal husbandry in certain regions. This allowed getting precise picture of current

situation in the livestock production and trade. Questions in the survey were mostly in the closed form and consisted of several areas: general issues, regulations, production, contracts and standards; market - trends, volumes, buyers; prices of products, inputs and services; suppliers; professional development and perspectives; compliance with rules and standards, the basic characteristics of the farms. Collected data were analyzed mainly using descriptive statistics and for specific topic the method of variance analysis (ANOVA) was used.

## Results and discussion

**The basic characteristics of the farms:** Farmers have been asked about the predominant type of livestock production that exists on their farms. In case of the variety of production, farmers had a choice of multiple responses. The largest number of farmers, 48% of them indicated that they have production of milk and cattle fattening, 27% of them are specialized for cattle fattening, while the production of cow milk as predominant activity is characteristic for 11% of farmers. Sheep farming is the main activity of 11% farms. Poultry - broilers, eggs and day-old chicks are produced on approximately 3% of farms. None of the surveyed farms is engaged in goat production.

Based on the obtained data it can be concluded that there is no narrow specialization for particular type of livestock production. The largest portion of cattle breeders practices combined production of meat and milk. Such production orientation is probably due to the dispersion of risks and needs for cash on a monthly basis. The money usually comes from selling of raw milk.

**General issues:** The views of primary producers on the general issue are estimated on a scale from 1 to 5. The note 1 means that this problem is not important and 5 means that this problem is the most important one. For farmers the problem of drinking water and water for animals is of relatively low importance (score 2.37), and the biggest problem are low prices of agricultural products (score 4.38). The most important potential problem for farmers is respect of agreements by the buyers (score 4.38), followed by changes of prices of agricultural products (score 4.15) and, finally high costs of inputs (score 4.00). Based on these results it can be concluded that the biggest problem for farmers is marketing of their products and purchasing of inputs. Bearing in mind that the good supply of inputs is one of the basic prerequisites of successful business, farmers can significantly improve their position by improving skills and knowledge in trade and marketing.

The problem of the agreement respect by the buyers is an area where farmers can not have any influence. It is important to emphasize that the majority of farmers don't have written agreements, but just verbal ones. Research shows that farmers believe that even if written agreements were signed, it will not be a guarantee that it would be enforced (Zaric, 2008). It is obvious that institutions are responsible for this situation.

**Trade - trends, quantity, and buyers:** Surveyed farmers were asked to estimate trade trend during the period 2006-2009 compared to 2005. The following statements about the volume of trade were possible: reduced (1), remained the same (2), increased (3), I do not know (4). Volume of trade with live animals and animal products according to farmers' estimates does not change in the analysed period.

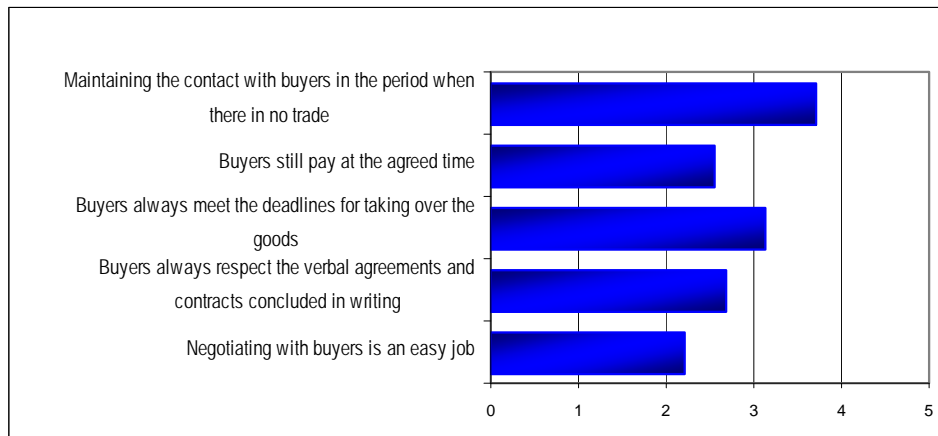
Producers were asked about the number of animals sold during the year, and the number of animals that are used on farms for consumption by farmers and members of their family. In the period 2007-2009 farm sold 60 heads of horned cattle, 52 fattening pigs and 38 lambs annually on average. For consumption on the farm, each year there seven heads of horned cattle, 3 fattened pigs and 3 lambs were used by farmers and their family members. The most important farm products for sale are fattened cattle (550 kg/head). In the period 2007-2009 the annual sales volume ranged between 36 and 42 animals. It is important to note that the maximum number of cattle sold was 120 pieces, but there are farms that sold only ten animals. This shows that producers have different capacities and different intensity of specialization. In addition to the fattening, the beef cattle producers are dealing with at least one more activity. In most cases it is fattening of pigs or sheep breeding. Data indicate that producers with a smaller number of sold cattle, have a larger number of sold fattened pigs and lambs.

The larger producers of beef cattle in Serbia tend to have contracted production for their products. In 70% of cases farmers are selling cattle to local abattoir and processors in the region, while in 30% of those are the cattle traders. Based on this finding it can be concluded that most of the trade is done at the local and regional level. The products retain the characteristics of the region since the production and processing are performed in the same area. Marketing chain is quite short, so the added value of primary producers is

smaller than the potential, which could be achieved if they would have a share in processing plants (Zaric, 2008).

On average, each farmer has two processors and three cattle traders as buyers. This relatively large number of the primary products buyers shows that farmers maybe not be satisfied with their buyers and that they are constantly looking for new ones. At the same time, this could mean that there is a lack of supply and surplus of processing capacity on the livestock market. Buyers try to provide enough animals for slaughter by purchasing animals from different producers (Zaric, 2008).

Farmers were asked to rate certain statements relating to the trade of agricultural products. There were five statements on which respondents could answer on a scale ranging from strongly disagree (score 1) to strongly agree (score 5).



Graf 1. Trade - attitudes of primary producers (survey research)

Most producers maintain relationships with buyers during periods when there is no trade (score 3.71). Farmers state that buyers do not meet the promised deadlines concerning payments (score 2.56). A similar assessment was given to the statement "Buyers always respect the verbal agreements and contracts concluded in written form" (score 2.69). The surveyed farmers do not agree with the statement "Negotiating with buyers is an easy job", since they usually gave the answer "disagree", and overall rate amounts to 2.21. The above results indicate that the position of farmers could be improved if they are skilled in negotiating process (Koester and Zaric, 2009). Adequate training on this subject would certainly be of benefit to primary producers.

In the next step the correlation between the relationships with buyers on one side and the sales volume of livestock on the other side was analysed. The basic hypothesis was that the sales volume of livestock, as an independent variable, has no influence on the attitudes of primary producers to retailers. The results confirmed this null hypothesis. The lowest value of F test was 0.327 ( $p > 0.05$ ). It can be concluded that the behaviour of the livestock buyers is equal with all producers. The prices that farmers realize in the sale of livestock don't depend on sales volume as well ( $F = 2.349$ ,  $p > 0.05$ ). Farm size and sales volume also have no effect on the purchasing prices of inputs.

These results suggest that farmers can not influence the creation of input prices, or prices of their products. It is important to emphasize that analyzed primary producers are relatively large (for the conditions in Serbia) and that they represent a minority of the total number of producers. It is obvious that these producers are relatively small "players" for abattoirs and processors.

Since there is an effort of Serbia to join the EU, we can expect changes in the structure of supply and in the vertical chain from primary producers to abattoirs, processors, wholesale and retail trade. The enforcement of regulations that allow the traceability of products is expected and consequently there will be a need for adaptation of primary producers (Gorton et al., 2009). Food safety is one of the basic requirements for the placement of products into the EU market (Nielsen, 2000). On this basis one can expect further structural changes in primary production.



## Conclusion

This research analyzes the position of the advanced livestock farms in Serbia in marketing of their products. The data show that there is no narrow specialization for particular types of production. The most important problems from the standpoint of the primary producers are related to the marketing of their products due to the non-compliance with agreements by buyers and changes in prices of inputs. Volume of live animals' trade over the past several years has not changed, which basically shows that there is no increase in production. Sales contracts have been made only by the largest producers from this group. The largest part of the trade is done at the local and regional level. Farm size measured as the volume of the live animals' trade per year, does not have a significant influence onto the prices of animals, or input prices, as well as onto the buyers' attitude toward primary producers. Although the analysed farms are relatively large for conditions in Serbia, their size is not sufficient to make them able to influence trade flows in the case of live animals. With the further liberalization of foreign trade, an adjustment of livestock farms will be even more needed. In the entire marketing chain primary producers are in a position to accept the rules, over which they do not have any influence.

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# Utjecaj obujma proizvodnje na izbor kanala prodaje meda

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## Sažetak

Cilj rada je bio ustanoviti na koje načine članovi Udruženja pčelara Trebinje prodaju med na području općine Trebinje i koji faktori imaju utjecaja na odluku o izboru kanala prodaje. Podaci dobiveni iz ankete obrađeni su jednovarijantnim analizama podataka (distribucije i frekvencije) i komparativne analize. Proizvođači meda u Trebinju koriste više načina prodaje meda. Manji proizvođači do 2.000 kg meda kao kanal prodaje koriste isključivo prodaju na gospodarstvu, dok oni s više od 3.000 kg koriste veći broj alternativnih načina prodaje. Najveći stupanj zadovoljstva je iskazan prodajom na imanju posrednicima (prekupcima), prosječna ocjena 4,7, dok prodaja putem zadruge i veleprodaja imaju nisku prosječnu ocjenu (3,0).

Ključne riječi: med, obim proizvodnje, kanali prodaje, Trebinje

## The influence of the production volume on the honey sales channels

### Abstract

The objective of this work was to determine the ways in which the members of the Trebinje Beekeepers Association sell their honey in the area of the municipality of Trebinje and which factors influence on decision on the selection of sales channels. Data obtained by the survey were processed by a single variant analyses of data (distribution and frequency) and comparative analyses. Honey producers in Trebinje use multiple ways of selling their honey. Smaller producer up to 2.000 kg of honey as a sales channel use exclusively sell on the household, while those with a more than 3.000 kg praxis a number of alternative sales channels. The highest level of satisfaction was expressed by on-farm sale to the traders (dealers), average rating 4.7, while sales through cooperatives and wholesalers have a love average rating (3.0).

Key words: honey, volume of production, sales channels, Trebinje.

### Uvod

Pčelarstvo predstavlja 1% od ukupne poljoprivredne proizvodnje u BiH. Ukupna proizvodnja meda ne zadovoljava potrebe domaćeg tržišta. U BiH se godišnje uvoze meda između 500 i 1000 tona. Procjena je da se manje od 30% od ukupne proizvodnje meda u BiH proda putem službenih kanala i prerađivača. Pčelari uglavnom prodaju med na tržnicama, rodbini, susjedima, prijateljima i poznanicima. U prosjeku jedan pčelar u BiH ima 50 košnica, mada ima i znatan broj onih koji posjeduju 100 i više košnica (FARMA, 2010.). Savez udruženja pčelara Republike Srpske predstavlja asocijaciju udruženja pčelara Republike Srpske, a registriran je 1994. godine. U savezu se nalazi 49 općinskih udruženja pčelara. Pčelarstvo u Republici Srpskoj

ima imponantan potencijal. Krajem 2007. godine pčelari u Republici Srpskoj su posjedovali preko 106.000 pčelinjih zajednica, a krajem 2010. godine 140.000. Broj pčelinjih zajednica iz godine u godinu se povećava. Njihova godišnja proizvodnja meda je oko 2.500 tona. Količina proizvedenog meda varira od godine do godine, a 2010. godina je bila nepovoljna u sjevernim dijelovima, gdje je bagrem dao slabe rezultate. Južni dio je imao dosta dobre rezultate s proizvodnjom meda od 25 kg po košnici.

Područje općine Trebinje je karakteristično po povoljnim klimatskim uvjetima za uzgoj pčela. Submediteranska klima zastupljena je u južnim predjelima općine, a umjereno kontinentalna klima zastupljena je u sjevernim dijelovima općine. Nadmorska visina općine Trebinje je od 210 do 1.900 metara. Navedeni faktori omogućuju idealne uvjete za bavljenje pčelarstvom. Blizina mora omogućava rani proljetni razvoj pčelinjih društava, što omogućava kvalitetno iskorištavanje ranih pčelinjih paša.

Na području općine Trebinje je registrirano jedno udruženje pčelara. Broj pčelara je 600, a broj pčelinjih društava (košnica) 15.000. Prosjek proizvedenog meda u posljednjih 5 godina je 15 kg meda po košnici. Na području općine Trebinje registrirana je i pčelarska zadruga "Žalfija", koja ima 51 zadrugara. Zadruga se bavi otkupom i pakiranjem meda, ali su navedene aktivnosti na samom početku jer ne postoje prostorni i drugi uvjeti za obavljanje ovih aktivnosti. Najveći problem za pčelare općine Trebinje je taj što za sada nema dobro organiziranog otkupa meda i pčelinjih proizvoda. Oblik prodaje uvjetovan je sljedećim faktorima: obujmom raspoložive radne snage, dinamikom i obujmom prispjeća proizvoda, te ponudom i tražnjom za proizvodima (Ilić i sur., 2006).

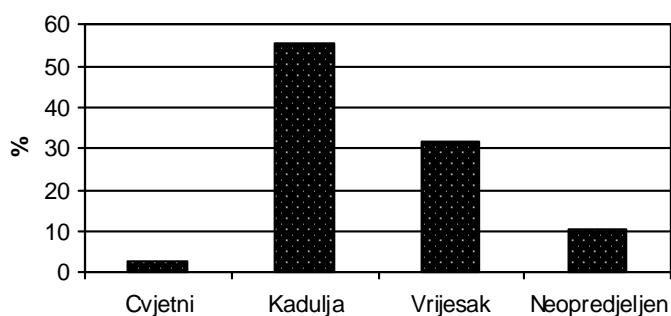
### Materijal i metode

Za potrebe ovog istraživanja izvršeno je anketno ispitivanje proizvođača meda na području općine Trebinje. Anketom je obuhvaćeno 30 proizvođača meda koji su članovi Udruženja pčelara Trebinje. Udruženje broji 300 članova, a uzorkovanje je obavljeno putem prostog slučajnog uzorka. Istraživanje je provedeno u rujnu 2010. godine. Kroz anketu, kao instrument prikupljanja podataka, prikupljeni su podaci o starosti i broju članova domaćinstva koja se bave pčelarstvom, veličini proizvodnje, načinima prodaje meda, stupnju zadovoljstva s korištenim kanalima prodaje kao i problemima koji se javljaju pri prodaji meda. Anketni upitnik je imao 12 pitanja. Pitanja u upitniku su bila otvorenog i zatvorenog tipa. Putem Likertove skale utvrđen je stupanj zadovoljstva korištenim kanalima prodaje. Podaci dobiveni iz ankete obrađeni su jednovarijantnim analizama podataka (distribucije i frekvencije) i komparativnom analizom.

### Rezultati i rasprava

#### Opći podaci

Prosječna starost ispitivanih pčelara Udruženja pčelara Trebinje je 49 godina. Veoma je mali broj pčelara koji su mlađi od trideset godina i u uzorku ih je bilo svega oko 7%. Najveći broj ispitanika je u starosnoj grupi od 40 - 55 godina i oni čine 47% ukupnog broja ispitanika. Pored toga što se radi o nepovoljnoj starosnoj strukturi proizvođača meda, također je evidentno da u jednom pčelarskom domaćinstvu živi veći broj generacija, na što ukazuje podatak da u domaćinstvu živi najčešće pet članova ( $Mo=5$ ). Najveći broj anketiranih pčelara raspolaže s 80 košnica. Na području općine se najviše proizvodi livadski, kaduljin i med od vrijeska. Na pitanje o potražnji meda na tržištu odnosno koja je vrsta meda najatraktivnija za kupce najveći broj ispitanika se izjasnio da je to med od kadulje (grafikon 1).



Grafikon 1. Stupanj potražnje meda na tržištu

Čak 55% ispitanika smatra da je najpogodniji med za prodaju od kadulje, dok skoro 32% smatra da je to med od vrieska. Gotovo  $\frac{3}{4}$  ispitanika je navelo da ostvaruje godišnji prihod od prodaje meda preko 5.000 KM, odnosno  $\frac{1}{3}$  ima prihode veće od 10.000 KM.

#### Načini prodaje meda, zadovoljstvo kanalima prodaje

U anketnom upitniku proizvođači su imali mogućnost višestrukog izbora kada je u pitanju način prodaje meda. Može se reći da najčešći način prodaje meda je na kućnom pragu, odnosno direktna prodaja potrošaču na gospodarstvu (tablica 1). Do sličnog zaključka (direktna prodaja meda 65%) je došao i Macura (2003.) prilikom istraživanja kanala distribucije meda na istom području. Direktna prodaja ima niz prednosti. Tako, Kovačić (2005.) navodi da su bitne prednosti izravne prodaje kvaliteta, svježih, prirodnih i ukusnih proizvoda, te uzajamno povjerenje kupaca i prodavača.

Tablica 1. Korišteni kanali prodaje u zavisnosti od ostvarene proizvodnje

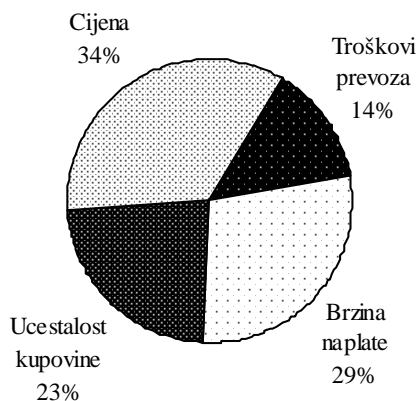
Obim proizvodnje meda (kg)	Korišteni kanali prodaje							
	I	II	III	IV	V	VI	VII	VIII
do 1.000	1	4	0	1	0	0	0	0
1.001-2.000	2	13	2	1	1	0	2	0
2.001-3.000	5	7	0	3	0	0	1	0
3.001-4.000	1	4	0	1	1	0	0	2
4.001-5.000	0	1	0	0	0	1	0	1
5.001-6.000	0	1	1	0	0	0	1	0

I- prodaja na imanju prekupcima, II- prodaja na imanju krajnjem potrošaču, III- prodaja zadruzi, IV- prodaja na tržnici, V- prodaja na štandu uz cestu, VI- prodaja "od vrata do vrata", VII- prodaja putem veleprodaje, VIII- drugi oblici prodaje (sajam i dr.)

Analizirajući prikazane podatke uočava se da što je niži obujam proizvodnje dominantnija je prodaja na gospodarstvu krajnjem potrošaču. Može se reći da proizvođači koja imaju proizvodnju do 2.000 kg prvenstveno koriste ovaj način prodaje, odnosno samo dva gospodarstva prodaju na imanju posrednicima ili preko zadruge, što se može smatrati zanemarivim u odnosu na njih 13 koji koriste ovaj vid prodaje. Kod proizvođača koji imaju proizvodnju veću od 3.000 kg evidentno je da se koristi veći broj alternativa u prodaji odnosno da neki od njih vode računa i o vlastitoj promociji jer vrše prodaju i putem specijaliziranih sajmova.

Uzimajući u obzir stupanj zadovoljstva korištenim kanalima prodaje, najveću prosječnu ocjenu je ostvario kanal prodaje na gospodarstvu prekupcima (I) - 4,7, a potom prodaja na gospodarstvu krajnjim potrošačima (II) - 4,4. Interesantno je da su proizvođači poprilično nezadovoljni prodajom preko zadruge (prosjek 3,3) i putem veleprodaje (prosjek 3,0).

Kao najbitniji faktor za izbor kanala prodaje proizvođači meda navode prodajnu cijenu koju mogu ostvariti pri određenom načinu prodaje (grafikon 2), a potom brzinu naplate. Prodajnu cijenu meda kao jedno od najbitnijih pitanja bavljena pčelarstvom prije nekoliko godina su potencirali i pčelari u Hrvatskoj (Stefanić i sur., 2004.).



Grafikon 2. Faktori od značaja za izbor kanala prodaje

Evidentno je da za proizvođače sami troškovi prodaje koji nastaju pri upotrebi pojedenih načina prodaje nemaju veliki značaj, odnosno oni su im u opredjeljenju za izbor kanala prodaje najmanje bitni.

### Zaključci

Anketirana gospodarstva koriste različite načine prodaje meda na području općine Trebinje. Najznačajniji oblik prodaje meda je direktna prodaja na imanju krajnjim potrošačima. Ovaj oblik prodaje je dominantan kod gospodarstava koja imaju proizvodnju na godišnjem nivou do 2.000 kg. Proizvođači s rastom proizvodnje pored prodaje na gospodarstvu koriste i druge kanale prodaje. Najveći stupanj zadovoljstva proizvođača je s prodajom posrednicima (prekupcima) koji dolaze na imanje. Prodaja meda na području općine Trebinje je neorganizirana i proizvođači se susreću sa znatnim problemima na tržištu od: patvorenog meda, meda sumnjive kvalitete i porijekla, do nerazvijenog marketinga meda. Bitni faktori za izbor kanala prodaje su cijena, brzina naplate i dr. Rezultati ankete pokazuju da su proizvođači najzadovoljniji prodajom na gospodarstvu posrednicima (prekupcima) jer u najvećoj mjeri i zadovoljavaju njihove kriterije u pogledu optimalnosti i isplativosti pojedinih kanala prodaje. Proizvođači meda koji koriste zadrugu za plasman vlastitog proizvoda pokazuju nizak stupanj zadovoljstva ovim kanalom prodaje.

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# Wheat balance of the markets in the Republic of Macedonia

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## Abstract

The aim of this article is to present the wheat market elements by deriving the wheat market balance during a ten-year period (1999-2008). The analysis showed that the country is not self-sufficient with wheat so in order to satisfy the domestic demand, wheat is imported. Conversely, the country is still being a wheat exporter due to the governance of open economic system. Furthermore, besides the contribution of the international trade to retain the wheat market balance, still the equilibrium is reached through storing and releasing wheat stocks on the market when necessary. Generally, the wheat supply suffices, and creates surplus that is stored. These stocks were released only during four years from the analyzed period (2001, 2003, 2006 and 2007), when the wheat demand increased and the production and imports were not sufficient to cover this demand.

Key words: wheat, market elements, market balance, Republic of Macedonia

## Introduction

Wheat is an important diet staple for the population in the Republic of Macedonia. However, the Macedonian wheat market is not self-sufficient and the wheat supply, from both domestic origin and imports, is characterized by a downward trend. The domestic demand for wheat remains more or less the same. Even though this condition at the wheat market is not yet considered as a threat, still it is a signal which should not be neglected. Therefore, it is necessary to track the developments that take place on the wheat market. For this reason, the aim of this article is to present the wheat market elements (production and yields, domestic consumption, international trade, and prices) during a ten-year period (from 1999 to 2008), and in addition to derive the wheat market balance.

## Material and methods

For the wheat market analysis, the main source of data was the official Macedonian statistical database. The changes within the wheat market are presented by applying descriptive statistics, time series and indices (Risteski and Tevdovski, 2008). Furthermore, the wheat market balance is represented by the difference in wheat quantities supplied and wheat quantities consumed. In this context, wheat supply (TS) represents a function of the total domestic wheat production (P), imports (IM) and beginning stocks (BS), and wheat demand (TD) is represented by the domestic consumption (DC)\*, exports (EX) and ending stocks (ES) (Scarth, 1988).

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\* The domestic wheat consumption was derived by applying the following conversion coefficients

The analysis is supported by applying a standard economic model. So, if we refer to the supply as only production and import, and demand as only domestic consumption and export, then the difference between the supply and demand will give the changes in the stocks. Hence, we may derive the following equation:

$$TS = P + IM + BS, \text{ and}$$

$$TD = DC + EX + ES,$$

If,  $TS = TD$ , follows,

$$P + IM - DC - EX = BS - ES, \text{ or}$$

$$P + IM - DC - EX = \Delta \text{ Stock.}$$

## Results and discussion

The harvested area under cereals is showing a downward trend which is mainly a result of the reduction in the cultivated area under wheat. Approximately one-half of the area under cereals belongs to wheat (SSO, 2009). Within the analyzed period, the average harvested wheat area is 103,854 ha or, 18% of the total cultivable area and 22% of the total arable land and gardens (SSO, 2000-2009). The main reduction in the harvested area is noted in 2008. However, wheat production was not affected during this year mainly because of the relatively high yields (3,414 kg/ha) (SSO, 2009). A year before, the production was at its minimum (218,076 tons) because of both the decrease of the harvested area and the relatively low yields (circa 30% lower than those in 2008) (SSO, 2008). The average wheat production accounts for 285,107 tons with an average yield of 2,765 kg/ha (SSO, 2000-2008). Generally, even though wheat yields have an upward trend, still the general production trend is down-slopping due to the reduction of the area under wheat.

Table 2. Descriptive statistics for wheat supply for the period 1999-2008 (SSO, 2000-2009)

<i>Measure</i>	Harvested area <i>'000 ha</i>	Yield <i>kg/ha</i>	Production <i>'000 t</i>	Value of production <i>mill. EUR</i>	Import <i>'000 t</i>	Value of imports <i>mill. EUR</i>	Total supply <i>000 t</i>
Mean	103.9	2,765.4	285.1	46.4	77.0	11.8	362.1
Standard Error	3.5	154.0	14.5	1.9	12.3	1.7	19.9
Median	102.4	2,722.0	292.5	48.1	75.2	12.4	351.0
Standard Deviation	11.2	487.1	45.9	6.1	39.0	5.4	62.9
Coefficient of Variation	0.11	0.18	0.16	0.13	0.51	0.45	0.17
Sample Variance	124.5	237,222.3	2,102.9	36.9	1,518.4	28.7	3,952.2
Kurtosis	-0.63	-1.14	-0.94	-1.22	-1.20	-1.17	-1.28
Skewness	-0.09	0.26	-0.07	-0.09	0.25	-0.29	0.20
Range	35.7	1,390.0	138.8	18.0	116.0	15.0	184.5
Minimum	85.5	2,132.0	218.1	37.4	26.0	3.6	278.4
Maximum	121.1	3,522.0	356.8	55.4	142.0	18.6	462.9
Sum	1,038.5	27,654.0	2,851.1	463.7	770.4	117.7	3,621.4
Count	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Even though cereals have the largest share in regard to the land use, still their share in the value of the agricultural output is low. The crop output takes up 68.8% of the agricultural output in 2008 (the largest share belonging to vegetables with 37.6%), and only 14.5% of the crop output belongs to cereals, out of which 43.6% is wheat output (SSO 2010). Concisely, the value of total crop output accounts for 842.8 million EUR, whereas the value of wheat production accounts for 53.5 million EUR in 2008 (SSO, 2010). However, cereals, moreover wheat, is still considered as a strategic, and accordingly, an important crop for the Macedonian agriculture.

Although the country is a traditional wheat producer, it is also a permanent wheat importer. The Republic of Macedonia imports 77 thousand tons wheat on annual average, but the variation from the average between years is very large (50%). Serbia is the main wheat exporter to the Republic of Macedonia, followed by Hungary, Bulgaria and Russia (www, SSO, 2010). The Macedonian average import value is 11.77 million EUR, which participates with only 3% in the total agro-food import value (SSO, 2000-2009; www, SSO, 2010).

The increase of the agricultural input prices affected the cereal production causing a break-even situation. Another reason for the reduced domestic supply of wheat is that the imported wheat can be found at even lower prices than the domestically produced wheat.

The domestic wheat demand is relatively stable during the analyzed period mainly because of the steady demand for bread. The domestic wheat consumption accounts for 316.5 thousand tons on average (SSO, 2000-2009) with only 6% variability between years. The wheat consumption reaches its peak in 2002 with 343.7 thousand tons (SSO, 2003). A significant drop in the wheat consumption was noted during 2008 (the domestic consumption accounted for 291 thousand tons) (SSO, 2009).

Table 3. Descriptive statistics for wheat consumption for the period 1999-2008 (SSO, 2000-2009)

	Domestic consump.	Bread consump.	Flour consump.	Pasta consump.	Export	Value of export	Total consump.
<i>Measure</i>	<i>000 t</i>	<i>kg/capita</i>	<i>kg/capita</i>	<i>kg/capita</i>	<i>000 t</i>	<i>mill EUR</i>	<i>000 t</i>
Mean	315.8	75.0	53.2	6.4	0.7	0.16	316.5
Standard Error	5.5	1.6	2.6	0.5	0.4	0.09	5.5
Median	314.6	76.2	52.9	7.2	0.3	0.04	317.0
Standard Deviation	17.5	5.2	8.2	1.7	1.1	0.28	17.5
Coefficient of Variation	0.06	0.07	0.15	0.26	1.57	1.75	0.06
Sample Variance	306.3	26.9	66.8	2.8	1.3	0.08	305.6
Kurtosis	-1.37	1.68	-0.27	-1.28	6.89	4.76	-1.30
Skewness	0.20	-1.33	-0.25	-0.8	2.53	2.04	0.14
Range	52.2	16.7	27.5	4.1	3.7	1.00	52.4
Minimum	291.2	63.4	38.6	4.0	0.1	-0.12	291.3
Maximum	343.3	80.1	66.1	8.1	3.8	0.88	343.7
Sum	3,157.8	749.9	532.4	64.4	7.2	1.65	3,165.0
Count	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Every household member consumes on average 75 kg wheat; 49% belongs to bread consumption, 45.5% to flour and 5.5% to pasta, respectively (SSO, 2000-2009). The flour consumption shows a gradual decrease (approx. with -1.66 kg/capita annually), while the consumption of pasta has a tendency to grow (approx. with 0.47 kg/capita annually). During this ten-year period, the consumption of wheat substitutes has grown as well. For instance, the consumption of rice is showing an upward trend with an average annual increase of 0.36 kg/capita (SSO, 2000-2009). The country is a very small wheat exporter. However, the existence of the relatively liberal market conditions contributes for an open trade. The country exports 0.72 thousand tons of wheat on average in the period 1998-2009 (or 0.16 million EUR), which is only 0.06% from the total agro-food exports (SSO, 2000-2009). The main export destinations are the neighboring countries.



Figure 1. Production versus consumption of wheat 2000-2008 (SSO, 2001-2009)



## Wheat balance of the markets in the Republic of Macedonia

The small volume of exported wheat is expected since the country cannot cover the domestic demand for wheat with its own production (see Figure 1). The data reveal that the country is self-sufficient with wheat only during the period 2004-2005 while during the remaining period of analysis there is not enough domestic wheat production to satisfy the consumption in the country.

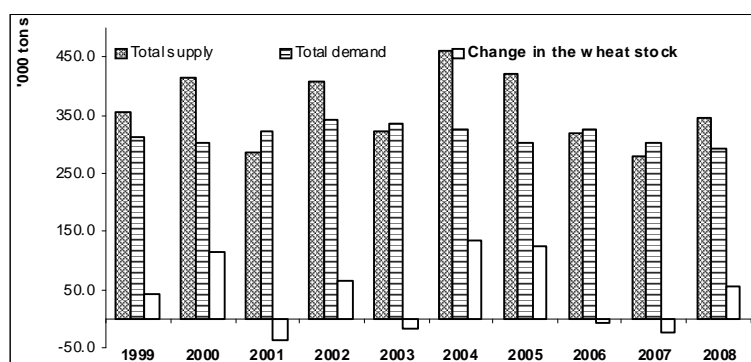


Figure 2. Market wheat balance during 1999-2008 (SSO, 2000-2009)

The data show that, on one hand, the supply of wheat is mainly covered by the domestic production (79% on average); while imported wheat covers on average 21% of the supply (see Figure 2). On the other hand, the total wheat consumption mainly results from the domestic consumption (taking up 99.8% from the total consumption on average).

The data also show that the total domestic supply supported with the wheat imports is exceeding the total consumption. The created surplus is stocked. There is a surplus mainly throughout the whole period of analysis with exception in 2001, 2003, 2006 and 2007, when it was necessary for the country to release the stored wheat stocks on the market in order to satisfy the demand. The average annual change in the wheat stocks amounts for 45.6 thousand tons (SSO, 2000-2009).

## Conclusions

If we recall to the main aim of this article, which is to present the wheat market elements by deriving a market balance, we may derive the following conclusions:

- Even though wheat is the main cereal crop in the Republic of Macedonia, with a relatively high share in the total agricultural utilized area, still there is a reduction in the wheat production mainly due to the decrease in the area under wheat.
- Generally, the wheat market in the country is not self-sufficient (except during 2004-2005). For that reason, it is necessary to satisfy the demand for wheat with imports. However, the country still exports neglectful quantities of wheat on foreign markets (mainly in neighboring countries). It is still not evident if it is a case of a re-export, or the stocks from the excess production are being offered on the external markets.
- Finally, the market balance of wheat in the country is obtained by storing and releasing wheat stocks when necessary. Generally, the difference in the stocks is positive, as the country mainly creates stocks, from both production and imports. However, during four years of the analyzed period (2001, 2003, 2006 and 2007), the country was forced to use the created stocks in order to satisfy the demand for wheat.

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# Zadrugarstvo - potencijal razvoja gospodarstva

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## Sažetak

U radu se polazi od spoznaje da zadrugarstvo ima značajnu ulogu u gospodarskom razvitku, te ovaj rad afirmira zadružnu filozofije i druge etičke vrijednosti. Obiteljska poljoprivredna gospodarstva identificiraju se kao ključni subjekti prilikom zadružnog organiziranja koja moraju prepoznati prednosti, prilagoditi se tržištu i prihvatiti promjene kao i nove spoznaje. Cilj je ovog rada prikazati stanje zadrugarstva u Republici Hrvatskoj kao i njegov gospodarski potencijal s osvrtom na provođenje programa potpora od strane Ministarstva gospodarstva, rada i poduzetništva. Novi prijedlozi zakonske regulative, kao i različite potpore ali i cjelokupni zadružni sustav na putu je ka sve većoj potpori i afirmaciji zadrugarstva što je u radu argumentirano kroz novi prijedlog Zakona o zadrugama.

Ključne riječi: poljoprivredno zadrugarstvo, razvoj, gospodarstvo, Republika Hrvatska

## Cooperatives - potential of economic development

### Abstract

Cooperatives have significant role in economic development and this paper affirming cooperative philosophy and other ethical cooperatives values. Family farms are identified as basic and key factors in agriculture cooperative organization. Those farms should recognize advantages, adjust to the market and accept changes and new knowledge. The aim of this paper is to present cooperative position in the Republic of Croatia and its potential in retrospective to the Ministry of Economy, Labor and Entrepreneurship program implementation. New preposition of law regulation, different kind of subvention as well as cooperative system in global in the Republic of Croatia is on the way to affirming and supporting this kind of business organization. The paper also represents new preposition of Cooperative legislation.

Key words: agricultural cooperatives, development, economy, Republic of Croatia

### Uvod

Ideja zadrugarstva stara je koliko i ljudsko društvo. Iako se često pogrešno započinje sa zadružnim poslovanjem ako je povezano isključivo uz profit (pa se vrlo brzo i odustaje), ono je naime vezano uz sve aspekte ljudskog ponašanja i djelovanja. Promatrano etimološki i zakonodavno zadrugarstvo u ekonomskom smislu nastoji svakog čovjeka učiniti vlasnikom, nastoji unaprijediti njegovo gospodarstvo, razviti štednju i osjećaj odgovornosti koji je povezan sa vlasništvom, nastoji ljude učiniti susjedima koji rade za svoje i za zajedničko dobro, nastoji ih osposobiti i obrazovati za upravljanje njihovom organizacijom (Poljoprivredni zadružni priručnik, 2006:12).

Obiteljska poljoprivredna gospodarstva koja su ključni subjekti prilikom zadružnog organiziranja moraju prepoznati prednosti, prilagoditi se tržištu i prihvatiti promjene kao i nove spoznaje. Posjedovna struktura poljoprivrednih gospodarstava, kvalitativna i kvantitativna obilježja poljoprivrednog stanovništva kao i

neodgovarajući kapital upućuju na činjenicu da oni ne mogu sami. Obiteljska poljoprivredna gospodarstva ne samo da “*ne mogu sami*” na globaliziranom tržištu Europske unije već oni ne mogu samostalno poslovati ni na nacionalnom pa čak ni na regionalnom tržištu. U procesu prestrukturiranja i razvoja bitno je pristupiti udruživanju poljoprivrednih gospodarstava i njihovom poslovnom povezivanju, naročito iste proizvodnje, bilo da se udruže u zajedničku proizvodnju na više povezanih parcela i/ili da imaju zajednički proizvod namijenjen prodaji. Strateški se treba opredijeliti za zadrugarstvo kao poduzetnički sustav (Tratnik i sur., 2007:69). Upravo iz tog razloga u radu će se dati pregled trenutnog stanja hrvatskog zadrugarstva ali sa prijedlozima i mogućnostima za razvoj.

U zemljama Europske unije zadružne organizacije se razvijaju i jačaju. Iako se broj zadruga u Europi i u svijetu smanjuje u najrazvijenijim zemljama njihova ekonomska moć raste. Na otvorenom i globaliziranom tržištu zadruge uspijevaju održati konkurentsku sposobnost primjenjujući strategiju koncentracije i specijalizacije na državnoj, pa i međunarodnoj razini (Mataga, Papeš, Petak; 2009:215). Zadruga je poslovni model koji ostvaruje gospodarske i društvene čimbenike razvoja što je prepoznato u Europi i svijetu gdje polovina svjetskog stanovništva ostvaruje prihode od zadruga.

### Materijal i metode

Cilj je ovog rada prikazati stanje zadrugarstva u Republici Hrvatskoj kao i njegov gospodarski potencijal. Zadruge se pojavljuju kao djelotvoran odgovor na recesiju i cjelokupnu ekonomsku krizu. U ovom preglednom radu koristile su se sekundarne baze podataka od internet stranica ([www.zadruga.hr](http://www.zadruga.hr)) pa do značajnih domaćih i inozemnih publikacija. Zadrugarstvo se kao pokret razvija kroz znanost ali isto tako i kroz praksu. Stoga su u radu korišteni i podaci Hrvatskog saveza zadruga, Ministarstva poljoprivrede, ribarstva i ruralnog razvoja kao i podaci Ministarstva gospodarstva rada i poduzetništva. Državni sustav sve više prepoznaje zadruge kao mogućnost novog zapošljavanja, stvaranja novog dohotka i tržišta, što je važno za rješavanje postojeće krize. U radu se osim navedenih materijala koristila i komparativna analiza zadružnog zakonodavstva gdje se koristio Prijedlog Zakona o zadrugama usvojen na 86. sjednici Vlade Republike Hrvatske.

### Rezultati i rasprava

Posljednjih desetak godina stvaranja zadružnog okruženja uz istodoban edukativan proces imao je svoje pozitivne i učinkovite pomake. Zadruge se dugi niz godina uspoređuju s trgovačkim društvima. Istina je da ima elemenata po kojima ih se može usporediti ali važnije ih je razlikovati i na taj način im pristupiti. Naime, radi se o međusobno ravnopravnim tržišnim subjektima ali je njihova unutrašnja organizacija različita, odnosno njihov vrijednosni sustav koji se treba naglašavati. Specifičnosti zadruga ogledaju se u demokratskom odlučivanju, raspodjeli dobiti koja se dijeli razmjerno isporučenoj količini i kvaliteti i što je najvažnije “zadruga je društvo osoba u kojoj je svaki član subjekt odlučivanja”.

Prema registru poslovnih subjekata u Republici Hrvatskoj registrirano je čak 3.058 zadruga od čega je aktivno svega 47%, odnosno njih 1.454 je prijavljeno u Hrvatski zadružni savez. Poljoprivredne zadruge su najznačajnije kako po broju zadruga tako i prema poslovnom obuhvatu. One su podjednako važne u cijeloj Republici Hrvatskoj. Prema Hrvatskom zadružnom savezu 49% aktivnih zadruga pripada poljoprivrednom zadrugarstvu (Sudarić, i sur., 2010:319).

U vrijeme recesije i krize zadruge se nalaze između države i tržišta koje se ogleda u demokratskom poduzetništvu gdje svaki član “*vrijedi*”, ne gomila se kapital, nije primarna okrenutost novcu, već čovjeku. Činjenica je da “*čovjek rijetko uspijeva u poslu ako ga ne radi sa užitkom*”, a upravo te moralne i etičke vrijednosti nalaže zadrugarstvo. Svatko želi pomoći sebi i svom okruženju u kojem živi. Podupirući zadruge, lokalna vlast najviše doprinosi eliminaciji siive ekonomije, nelojalne konkurencije i siromaštva i što je najvažnije, podupire zapošljavanje, rast i razvoj regije ili lokalne sredine.

Naime, identitet poljoprivredne i ruralne regije transformirao se u identitet nerazvijene i depopulacijske regije. Tradicija sela i seljaštva umjesto da bude polazišna točka daljnjeg razvitka, ona postaj teret koji usporava razvitak regije svojom tradicijskom netržišnošću, niskoprofitabilnošću osnovne djelatnosti, sporošću promjena i sličnim odrednicama. Često se u tradiciji vidi otpor modernizaciji s jedne strane, dok se na drugoj strani, modernizaciju gleda kao pokapanje tradicije i razaranje tradicijske seoske kulture (Šundalić, 2010:21).

Upravo iz navedenog potrebno je jače utjecati na razvoj na Strukovne i regionalne zadrugne saveze (kao što su Zadružni savez Dalmacije, Hrvatski poljoprivredni zadružni savez, Hrvatski savez obrtničkih zadruga i slično).

Tablica 1. Operativni plan poticanja zadrugarstva

Mjere potpora zadrugarstvu			
Početna ulaganja	Ulaganja u materijalnu i nematerijalnu imovinu	Savjetodavne usluge	Potpore razvoju socijalnih zadruga
- pokrīće dijela rashoda i izdataka za osnivanje zadruge	- ulaganje u građevinsko zemljište, zgrade i opremu - nabava patenata, licenci, posebnih znanja i vještina	- intelektualne usluge koje obavljaju vanjski savjetnici, a koje nisu povezane s redovitim tekućim troškovima te nemaju stalni ili periodični karakter troška zadruge	- za pokrīće dijela rashoda i izdataka za osnivanje zadruge
- sudske takse, javnobilježničke i odvjetničke usluge, objavu oglasa o registraciji i slično	- potpora iznosi najviše do 200.000,00 kn od čega za troškove početnog kapitala najviše do 5.000,00kn		- sudske takse, javnobilježničke i odvjetničke usluge, objavu oglasa o registraciji i slično - jednogodišnji rashodi za jednog zaposlenika
- do 5.000,00 kn	- do 200.000,00 kn	- do 50.000,00 kn	- do 200.000,00 kn

Izvor: WWW.MINGORP, 2010

U tablici 1. prikazan je Operativni plan poticanja zadrugarstva za 2009. i 2010. godinu. Navedene su osnovne mjere potpora u zadrugarstvu: potpore za početna ulaganja, ulaganje u materijalnu i nematerijalnu imovinu, potpore u sklopu mjera za savjetodavne usluge i posebne potpore za razvoj socijalnih zadruga.

U 2009. godini prema Registru potpora MINGORP-a ostvareno je 56 potpora u zadrugarstvu u ukupnom iznosu od 3.500.000,00 kn što iznosi 1,9% od ukupno dodijeljenih sredstava.

Za stanje u zadrugarstvu i provođenje programa potpora u Republici Hrvatskoj vezanih uz zadrugarstvo nadležno je Ministarstvo gospodarstva, rada i poduzetništva. U posljednjih desetak godina sustav poticanja zadrugarstva imao je svoj put. Naime, početkom 90-ih godina novonastala vlast ne afirmira odnos prema zadrugarstvu, sredinom 90-ih pokušava se stvoriti osnova za opstanak i razvitak (kroz Zakon od zadrugama, 1995), međutim Zakon ne pokazuje određenu učinkovitost što krajem 90-ih godina rezultira slabom poslovnom aktivnošću zadruga i stečajem. Od 2005. godine broj zadruga, zadrugara i kooperanata je u stalnom porastu. Ministarstvo gospodarstva, rada i poduzetništva podupire proizvodno-uslužne zadruge koje pretežno obavljaju primarnu poljoprivrednu proizvodnju i ribarstvo, a koje ispunjavaju slijedeće uvjete:

- ostvaruju pozitivne poslovne rezultate u 2009. i 2010. godini
- imaju najmanje sedam zadrugara i jednog zaposlenog
- upisane su u evidenciju zadruga pri Hrvatskom savezu zadruga
- nemaju nepodmirenih obveza prema državi i zaposlenicima
- namjenski su koristile potpore po projektima Ministarstva gospodarstva, rada i poduzetništva iz prethodnih godina.

U razvijenijim europskim zemljama zadrugarstvo je nezamjenljiv gospodarski sustav u poljoprivredi, ali i u razvitku ostalih gospodarskih i uslužnih djelatnosti. Upravo te zemlje najviše potiču razvitak zadrugarstva konkretnim mjerama kreditne i porezne politike.

Zemlje Europske unije reguliraju položaj zadruga svojim zakonodavstvom koje je u skladu sa pravnim propisima ICA (*International Cooperative Association*), dok se u Republici Hrvatskoj primjena ovih načela osigurava kroz novi prijedlog Zakona o zadrugama. Pojedina pitanja zakonom treba urediti tako da se omogućiti ostvarivanje potreba i interesa članova, individualnih i zajedničkih, poslovanjem člana putem zadruge ili drugim aktivnostima članova.

Prijedlog Zakona je da se definiraju zadrugne specifičnosti, zadrugna načela, pojednostavi osnivanje zadruge, poveća broj osnivača (na 7 osoba), regulira kontrola i revizija rada, definira članski ulog i slično. Novim uvjetima moraju se prilagoditi ne samo zadruge i njihovi članovi nego i društvo, koje još uvijek u dovoljnoj mjeri ne prepoznaje razliku između zadruga i drugih gospodarskih subjekata, ni posebnost zadruge kao

društva sa svojim specifičnostima. Novi prijedlozi zakonske regulative, kao i različite potpore Ministarstava ali i cjelokupni zadružni sustav na putu su ka sve većoj potpori i afirmaciji zadrugarstva.

Prema Zakonu o državnoj potpori poljoprivredi i ruralnom razvoju (N.N. 83/09) u sklopu mjera za ruralni razvoj potiče se osnivanje i razvoj proizvođačkih grupa i proizvođačkih organizacija putem potpora o uspostavi, funkcioniranju i umrežavanju proizvođačkih grupa i proizvođačkih organizacija kao i potpore u sklopu izrade i provođenja programa proizvođačkih grupa, proizvođačkih organizacija i udruga proizvođača.

### Zaključak

Polazeći od spoznaje da zadrugarstvo ima značajnu ulogu u gospodarskom razvitku, ovaj rad se fokusira na afirmaciji zadružne filozofije i drugih etičkih vrijednosti. Naime, zadrugarstvo je cjeloviti gospodarski i socijalni sustav koji treba olakšati put od ideje do primjene u praksi. Iz svega navedenog može se zaključiti kako cjelokupni zadružni sustav kroz nove prijedloge zakonske regulative ima pozitivne pomake u sve većoj potpori i afirmaciji zadrugarstva. Informiranost, edukacija i reakcija na promjene polako stižu na određite. U posljednjem desetogodišnjem razdoblju uočavaju se pozitivni pomaci jer zadrugarstvo sve više pokazuje da je živo, vitalno i prilagodljivo. Međutim, u zadružnom organiziranju i zadružnoj legislativi još uvijek je mnogo nedorečenosti i ne riješenih problema koji će se morati sustavno i dugoročno rješavati. Neka od pitanja (definiranje zadružnih specifičnosti i načela, osnivanje zadruga, povećanje broja osnivača, kontrola i revizija, visina članskog uloga i slično) rješava novi prijedlog Zakona o zadrugama koji je usvojen na 86. sjednici Vlade Republike Hrvatske. Ovaj pozitivan iskorak omogućiti će bolju suradnju s europskim zadrugama jer se kroz novi Zakon uvode ista pravila organiziranja, implementacija zadružnih vrijednosti i načela, čija primjena znatno utječe na razvoj zadrugarstva i čini ga bitnim čimbenikom gospodarstva europskih zemalja. Donošenjem novog Zakona o zadrugama u Republici Hrvatskoj uređuje se zadrugarstvo u cjelini i stvaraju uvjeti za njegov dugoročni razvoj. Nalazimo se na pragu ulaska u Europsku uniju u kojoj su zadruga poticane u svim sektorima (poljoprivredne, uslužne, obrtničke, radničke, socijalne i ostalo). Prilagodnom europskim standardima, hrvatsko zadrugarstvo postaje komplementarno europskom i osposobljeno za ulazak u mrežu europskog zadrugarstva.

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# Hrvatski zadružni pokret - Pozadina i poveznice s europskim zadružnim pokretom

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## Sažetak

U radu je napravljena komparacija hrvatskog i europskog zadružnog pokreta, te su prikazane poveznice ali i razlike ova dva pokreta. Podaci pokazuju na dosta sličnosti ali i razlike kojima su prethodile politička, društvena i povijesna iskustva pojedinih zemalja. Nedostatak pravnih temelja, neadekvatna podrška vlade, nedostatak informacija i znanja, te način razmišljanja i ostavština stvorena u zadnjih 50 godina samo su neki od pokazatelja postojećeg nepovoljnog stanja zadružnog sustava RH. Rezultati analize ukazuju na potrebu daljnjeg posvećivanja pažnje ovome pokretu, koji poprima sve veći zamah u svijetu, te primjenu suvremenih zadružnih metoda i načela.

Ključne riječi: zadružni pokret, Republika Hrvatska, EU

## Croatian Cooperative Movement - Background and common denominators with the European cooperative movement

### Abstract

The paper made a comparison of Croatian and European co-operative movement, and presents the links and differences of these two movements. Data show the many similarities and differences which preceded as the result of political, social and historical experiences of individual countries. The lack of legal basis, inadequate government support, the lack of information and knowledge, the way of thinking and historical legacy created in the last 50 years are just some of the indicators of the current condition of the cooperative system in RH. The analysis results indicate the need for the further attention to this movement, who gets much more attention in the world and the application of modern cooperatives methods and principles.

Key words: cooperative movement, Republic of Croatia, EU

### Uvod

Ljudske su zajednice pod različitim vidovima motiva svoga utemeljenja i organizacije, oduvijek predstavljale sastavni dio ljudske kulture u zemljama Europe, ali i u Hrvatskoj, poboljšavajući društveni i ekonomski život ruralnih krajeva. Zadruge, bez obzira jesu li organizirane na obiteljskoj tradiciji ili suvremenim združnim načelima poslovanja, bile su "afirmacija minornih pojedinaca kroz zajednicu-zadrugu."

Hrvatska nije bila, bez obzira na sadašnji stupanj razvijenosti i afirmaciju zadružnog organiziranja, na marginama povjesne zadružne tradicije<sup>1</sup> ali i slijedila suvremeno zadružno organiziranje, raspadom kućnih zadruga. O toj poveznici sa suvremenim zadružnim organiziranjem u Europi, nedugo nakon osnivanja prve suvremene zadruge (The Rochdale Society of Equitable Pioneers, 1844.g.) i njezinih pravila, i danas u nas aktualnoj pozadini, progovara u svojoj knjizi dr. Dragutin Pavličević<sup>2</sup>.

Položaj i poslovanje poljoprivrednih zadruga ključni su za sveukupno zadrugarstvo, jer je ukupan prihod tih zadruga, primjerice, 7 puta veći od ukupnog prihoda obrtničkih, 10 puta veći od ukupnih prihoda stambenih zadruga, a vrijednost aktive 7 puta veća (HSZ, 2007.). Na tom tragu dr. D. Pavličević piše<sup>3</sup> u nastavku svoje knjige "Hrvatske kućne zadruge I" i o nekim prepoznatljivim, današnjim pojavama u gospodarstvu i neprolaznoj ulozi zadruge sela i ruralne zajednice kroz današnje aktualne trendove ruralnog razvitka. Političke i društvene promjene koje su zahvatile RH u 90-im godinama prošloga stoljeća pridonjele su kreiranju prvog hrvatskog Zakona o zadrugama (1995). Iako je zakon naširoko otvorio vrata njihovom daljnjem razvoju; ovaj nejasno preciziran zakon, te neriješena imovinsko-pravna pitanja, kao i naslijeđena loša povijesna iskustva s društvenim poduzećima-kombinatima rezultirala su nerazumijevanjem i neprepoznavanjem zadruga kao gospodarskog sustava koji obogaćuje.

Ulaskom RH u EU povećati će se konkurentnost na domaćem tržištu i hrvatsko gospodarstvo naći će se u nezavidnoj situaciji. U takvoj situaciji, mali i neprofitabilni hrvatski proizvođači, teško će preživjeti i dolazi u pitanje njihov opstanak. S druge pak strane, ulaskom u EU hrvatski Zakon o zadrugama biti će nužno mijenjati i uskladiti ga s modernim europskim zadružnim stečevinama.

Stoga je cilj ovoga rada prikazati osnovne značajke hrvatskoga zadružnoga pokreta, nakon osamostaljenja, i pronaći poveznice s zemljama EU, koje su prepoznale njegov značaj i ulogu u ukupnom gospodarskom rastu zemlje.

### Materijal i metode

Za izradu ovoga rada korišteni su sekundarni izvori podataka iz Hrvatskog saveza zadruga (HSZ), Financijske agencije (FINA), te podatke koje o zadrugama objavljuje Državni zavod za statistiku (broj registriranih i aktivnih zadruga te broj zaposlenih). Uočena su velika odstupanja u podacima od izvora do izvora, što je značajno otežalo interpretaciju i usklađivanje podataka, s ciljem stvaranje slike aktualnog stanja hrvatskog zadružnog pokreta. U izradi rada korišteni su i sekundarni podaci COGECA, ICA-e i drugih europskih zadružnih organizacija. U nastavku su izneseni i komentirani podaci zadružnih završnih računa u Republici Hrvatskoj.

### Rezultati i rasprava

Prema podacima FINA-e u razdoblju od 2000-2007. broj zadruga se povećao za 61%, odnosno osnovano je 571 nova zadruga (nisu uključene štedno-kreditne zadruge). Iako danas točan broj zadrugara nije poznat, on

<sup>1</sup> Poznate kao "hrvatske kućne zadruge"

<sup>2</sup> Od 1861. do 1867. Hrvatski je sabor nastojao autonomno i odozdo riješiti zadružno pitanje ustavnim putem, pa je to i sadržaj četvrtog dijela. U razrešenju ovog problema, koji se pokazao izuzetno kompliciran i slojevit, uključila su se najistaknutija imena političkog i gospodarskog života Hrvatske. I dok su se jedni zalagali za ubranu slobodnu diobu zadruga radi što hitnijeg uključivanja građanske Hrvatske u svjetsku trgovinu kroz akumulaciju kapitala (barun Lazar Hellenbach, ali i sisački gradonačelnik Franjo Lovrić pored ostalih), drugi su zastupali usporeno dijeljenje. Međutim iz posebnog "Iskaza o zadrugah" iz 1861. - koji je Pavličević objavio u okviru ovog dijela - vidi se, da je proces podjele kućnih zadruga već silno uznapredovao. Međutim do razrešenja zadružnog pitanja usprkos četiri nacrtane Osnove zakona za uređenje zadruga nije tada došlo, jer su sporna pitanja, kako su to pokazale diskusije u Saboru i napisi u štampi, bila suviše krupna, pa je Utješenović kao dvorski savjetnik ukinuo 1862. saborsku osnovu "o uređenju zadrugah" iz 1861., jer se radi o predmetu "koi duboko zadire u blagostanje i u budućnost seoskog pučanstva", a osobito se je bojati da u slučaju prodaje zadružnog imanja na dražbama ne dođe do nemira na selu. Pavličević ispravno zaključuje da se dubinski radilo o očuvanju hrvatske autonomije i posebnosti, budući da drugi narodi Habsburške monarhije nisu imali zadružnih ustanova.

<sup>3</sup> Selo je bilo, a i danas je, najsigurnije mjesto generacijskog preživljavanja a i čuvanja tradicija. Na našim prostorima, pošto se je već pred desetak godina pokazalo, da je naša industrijalizacija strukturno promašena, ponovno su se istraživači, zbog zanimanja javnosti, počeli okretati selu i njegovim očuvanim, ali i iščezlim vrijednostima



se drastično smanjio s tendencijom daljnjeg smanjivanja. Na početku promjena koje su zahvatile RH početkom 90-ih godina u poljoprivrednom zadrugarstvu bilo je 19.579 zadrugara, 2000. godine 11.900, da bi u 2007. taj broj iznosio 7.320 (svega 37% broja zadrugara s početka tranzicije). Slična situacija aktualna je i u drugim oblicima zadruga. Posljedice takvih kretanja je i smanjivanje prosječnog broja zadrugara po zadruzi koji je u 2007. godini iznosio 28 (HSZ, 2007). U međuvremenu su zadruge prestale biti instrument zapošljavanja. Broj zaposlenih se od 1999-2007 u svim zadrugama smanjio za 17%, što je uzrokovalo odlazak stručnjaka, eroziju stručnih kriterija i stanoviti oblik deprofesionalizacije (Mataga, 2009:221).

Razlozi tome mogu se pronaći i u Zakonu o izmjenama i dopunama Zakona o zadrugama (2002) koji je poticao i dopuštao osnivanje novih zadruga, a da uopće nisu poslovale, što je dovelo do povećavanja broja (pseudo)zadruga. Isto tako brisanjem odredbi o zajedničkom vlasništvu zadruga, omogućilo se prebacivanje imovine u ruke malih interesnih grupa, što je rezultiralo drastičnim smanjenjem članstva u navedenom razdoblju.

Tablica 1. Socioekonomski pokazatelji hrvatskog poljoprivrednog zadrugarstva u razdoblju od 1999. do 2007.

Pokazatelji/Godine	2000	2001	2002	2003	2004	2005	2006	2007
Ukupan broj zadruga	126	122	165	177	186	191	218	220
Ukupna broj članova	11.900	...	...	...	...	...	...	7.320
Ukupan broj zaposlenih	1.696	1.494	1.672	1.772	1.496	1.518	1.506	1.429
Aktiva zadruga (u mil. kn)	1.049	1.066	1.279	1.220	1.217	1.204	1.179	1.209
Prihodi zadruga (u mil. kn)	768	802	1.067	953	1.038	890	986	1.107
Rashodi zadruga (u mil. kn)	783	812	1.080	966	1.039	892	1.006	1.074
Dobit zadruga (u tisućama kn)	13.226	20.629	18.676	16.380	18.676	18.626	15.938	41.963
Gubitak zadruga (u tisućama kn)	28.482	31.282	33.382	29.924	17.413	22.987	38.774	12.340

Izvor: FINA

Promatrajući ekonomske pokazatelje, hrvatski zadružni pokret bilježi rast u svim segmentima. Tako je u razdoblju od 2005 do 2007. aktiva zadruga narasla 31%, a prihodi i rashodi 33%. U istom razdoblju dobit zadruga narasla je 57% uz istovremeni pad gubitaka za 38% (HSZ, 2007.). Svi ovi podaci idu u prilog zadrugama kao obliku poslovnog organiziranja koje može osigurati opstanak i bolji život svojim članovima.

Sektorska struktura zadruga ima drugačiju sliku. Ona je stabilna i poljoprivredne zadruge čine predominantnu grupaciju (60% ukupnoga broja zadruga), a slijede ih redom uslužne (16%), obrtničke (11%), štedno-kreditne (9%) i stambene zadruge (4%). O veličini poljoprivrednih zadruga u ukupnom zadružnom pokretu svjedoče i slijedeći podaci. Vrijednost aktive je 47%, prihodi i rashodi čine 70%, dobit 55%, gubitak 72%, a zaposlenost 69% ukupne vrijednosti svih zadruga. (HSZ, 2007.).

O značaju i važnosti poljoprivrednoga zadrugarstva u zemljama EU svjedoče mnoge zemlje. Tako primjerice, danska Danish Crown zadruga (meso i preradevine) s tržišnim udjelom od 90% ima godišnji promet 5,420 milijuna €, finska Osuuskunta Metsäliitto (šumarski sektor) s 33% udjela na tržištu ima 8,300 milijuna € godišnjega prometa (Chloupková, 2005). U TOP 5 najvećih poljoprivrednih zadruga spadaju i Bay Wa (Njemačka), Arla Foods (Švedska-Danska) i Friesland Coberco Dairy Foods (Nizozemska) s ukupnim godišnjim prometom od 15,926 milijuna prometa godišnje (COGECA, 2005).

Iz ovih podataka vidljivo je da zadruga može biti ekonomski isplativ poslovni subjekt u poljoprivrednom sektoru i time omogućiti opstanak i prosperitet ionako malom i nekonkurentnom hrvatskom poljoprivredniku. Ovome u prilog idu i podaci o europskom zadrugarstvu, te možemo reći da pratimo njene trendove. I u njihovom sektorskom zadružnom pokretu poljoprivredno zadrugarstvo igra važnu ulogu. Najveći broj članova zaposleno je u bankarskom i uslužnom sektoru, a prati ih poljoprivreda. Lagan pad broja zadruga zabilježen je u razdoblju od 2005-2009, što može biti objašnjeno nestankom pojedinih sektora u zadružnom organiziranju. Kao posljedica toga došlo je i do laganog pada broj članova. Za razliku od toga, podaci o zaposlenosti, koji su glavni ekonomski pokazatelji, daju ideju o velikoj elastičnosti zadružnoga poslovanja koja je dokazana za vrijeme ekonomske i financijske krize, te govori o njenoj mogućnosti da sačuva ali i otvori nova radna mjesta (Scribd, 2010).

Tablica 2. Socioekonomski podaci o poljoprivrednim zadrugama pojedinih zemljama EU i Hrvatske, 2003.

	EU-15	Danska	Njemačka	Grčka	Španjolska	Francuska	Italija	Hrvatska
Ukupni promet (u mil. €)	251.360	18.850	37.000	1.040	14.190	67.000	27.070	165,8
Broj zadruga	25.036	14	3.286	6.370	4.175	3.500	5.164	359
Broj članova	6.809.480	81.500	2.385.000	714.000	932.100	580.000	783.800	9.950
Broj zaposlenih	679.540	35.000	120.000	...	78.400	150.000	86.100	2.064
								Prosjek:
Promet/zadruzi (u tisućama €)	10.040	1.346.430	11.260	160	3.398	19.140	5.240	650
Broj članova/zadruzi	272	5.821	726	112	223	166	152	28
Promet/članu (u €)	36.913	231.288,3	15.513,62	1.460	15.223,6	115.520	34.540	16.664
Broj zaposlenih/zadruzi	27,14	2.500	36,5	...	18,8	42,9	16,7	5,7
Broj zaposlenih/članu	0,10	0,42	0,1	...	0,10	0,26	0,11	0,21

Izvor: Agricultural Cooperatives in Europe, COGECA, studeni 2005; te interni podaci Hrvatskog saveza zadruga (HSZ) za 2005., 2006. i 2007

Tablica 3. Komparativne razlike u prosječnoj veličini članstva, uposlenosti i prometu zadruga odabranih zemalja EU-15 i Hrvatske

	Danska	Njemačka	Grčka	Španjolska	Francuska	Italija	Hrvatska	Prosjek
Ukupni promet (u 000.000 €)	-40.651	-22.501	-58.461	-45.311	7.499	-32.431	-59.336	59.501
Broj članova/zadruzi (u 000 €)	4698	-397	-1011	-900	-957	-971	-1095	1.123
Promet/zadruzi (u 000 €)	1.147.049	-188.121	-199.221	-195.983	-180.241	-194.141	-198.731	199.381
Promet/članu (u €)	166.937	-48.838	-62.891	-49.128	51.169	-29.811	-47.687	64.351
Broj uposlenih na 100 članova	26	-12	-17	-9	9	-6	4	17

### Zaključak

Provedena analiza podataka pokazuje na pozitivne pomake u zadružnome organiziranju, ali i na nedostatke vezane uz nedovoljno definirane zakone o zadrugama. Iako je državna potpora dala određene rezultate (veći broj zadruga i rast ekonomskih pokazatelja); veličina zadruga, njihova konkurentnost i strukturni problemi unutar organiziranja zadruga, i dalje nisu riješeni.

Tako je ukupni promet kroz zadružni sustav Hrvatske niži za 99% od prosjeka analiziranih zemalja EU-15-ice i pojedinih zemalja članica te čini tek 0,3% toga prosjeka. Dok promet po jednom članu zadruge u Hrvatskoj čini 27% prosječnog prometa po članu, analiziranih zemljama i EU-15-ice.

Broj uposlenih u zadruzi na 100 članova zadruge premašuje 26% prosjeka uposlenih u EU-15 i zemljama članicama.

Iako, ovi pokazatelji oslikavaju, nezavidno poslovno stanje u zadružnom sustavu Hrvatske, oni ne trebaju biti obehtrabrenje i odustajanje od zadružnog sustava i njegovih dokazanih prednosti u zemljama tržišnog gospodarstva, u onim dijelovima usitnjene gospodarske strukture, kakva je posebice u poljoprivredi Hrvatska.

Daljnji razvoj zadruga u RH prvenstveno će ovisiti o novom zakonu koji je u planu i provedbi, primjeni suvremenih zadružnih načela i revizije unutar zadruga, te o rješavanju imovinsko-pravnih odnosa nastalih za vrijeme društvenih i političkih promjena u RH početkom devedesetih.

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# Održivost i diverzifikacija ruralne ekonomije

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## Sažetak

Dosadašnje iskustvo velikog broja zemalja pokazuje da glavni oslonac ruralnoj ekonomiji više ne može biti poljoprivreda, već širok spektar aktivnosti zasnovanih upravo na neaktiviranim potencijalima ruralnih područja. Stoga se u radu identificiraju i analiziraju ključni socio-ekonomski indikatori ruralnih gospodarstava sa aspekta mogućnosti unapređenja njihovih performansi u pravcu diversifikacije ruralne ekonomije. Mala i srednja poljoprivredna gospodarstva bi trebala odigrati ključnu ulogu u obnovi, očuvanju i integralnom, multifunkcionalnom razvoju ruralnih područja, a time i ublažavanju cjelokupne tranzicije.

Ključne riječi: održivost, multifunkcionalnost, diverzifikacija, ruralna ekonomija

## Sustainability and rural economy diversification

### Abstract

Previous experience of many countries shows that the backbone of rural economies can no longer be farming, but a wide range of activities, based precisely on the inactivated potential of rural areas. This paper identifies and analyzes key socio-economy indicators in rural areas in order to improve performance of rural diversification. Small and medium farms should be key factors in revitalization, sustainability and multifunctional development of rural areas concerning transition in the whole.

Zbog toga se kao jedan je od prioritarnih zadataka u promatranim županijama istočne Hrvatske može smatrati definiranje adekvatne politike (ne samo agrarne) kojom bi se zaustavili negativni demografski i ekonomski trendovi i kako bi se osigurao očuvanje prirodnog i kulturnog nasljeđa ruralnih područja.

Key words: sustainability, multifunctional, diversification, rural economy

### Uvod

Jedno od centralnih pitanja europske poljoprivredne politike i regionalnog razvoja odnosi se na vitalnost ruralnih područja i poljoprivrednih gospodarstava. Starenje ruralne populacije i devastacija ruralnog okoliša značajno utječu na ukupne promjene u gospodarskoj strukturi europskih zemalja. Zemlje u tranziciji, čiji je gospodarski sustav desetljećima bio zasnovan na marginalizaciji poljoprivrednog stanovništva i iscrpljivanju ruralnog prostora, suočene su sa istim problemom: kako dugoročno osigurati održivost resursa ruralnih područja i osigurati jednake uvjete za njihovo uključivanje u gospodarski razvoj. Nove politike ruralnog razvoja fokusirane su na definiranje učinkovitih mehanizama kojima bi se osigurala koordinacija razvoja poljoprivrede i drugih djelatnosti u ruralnim područjima u skladu sa principima održivog razvoja, a u cilju poboljšanja životnog standarda i kvalitete života stanovništva. Tijekom tranzicijskog razdoblja primarna pažnja državne politike bila je usmjerena na organizacijske, institucionalne i probleme strukturnog prilagođavanja poljoprivrednog sektora. Rješavanje jednako složenih ekonomskih i socijalnih problema

ruralnih područja potisnuto je u drugi plan. Uslijed toga su permanentno izostajali cjeloviti i sveobuhvatni naponi na stvaranju učinkovitih mehanizama za aktiviranje samorganizacijskih potencijala ruralnih područja. Zbog toga se kao jedan od prioritarnih zadataka može smatrati definiranje ruralne i okolišne politike (Zmaić, Petrač, Sudarić, 2007.) kojom bi se zaustavili negativni demografski i ekonomski trendovi i kako bi se osigurao očuvanje prirodnog i kulturnog nasljeđa ruralnih područja.

Koncept multifunkcionalnosti predstavlja model ostvarivanja rastuće održivosti ruralne ekonomije poticanjem tržišnih i netržišnih javnih dobara u poljoprivredi i ruralnom području. Multifunkcionalnu poljoprivredu od kraja 90-tih godina obilježava europski model poljoprivrede uz očuvanje prirode i ruralnog prostora što doprinosi vitalnosti ruralnog stanovništva i odgovara zahtjevima potrošača u pogledu kvalitete i zdravstvene sigurnosti hrane, zaštite okoline i dobrobiti životinja" (EC, 2005.). Multifunkcionalnost u poljoprivredi doprinosi širenju i razvoju koncepta multisektorskog ruralnog gospodarstva. Nova politika ruralnog razvoja Europske unije temelji se na četiri osovine: 1) povećanje poljoprivredne konkurentnosti, 2) poljoprivredno-okolišni program, 3) unapređenje kvalitete života u ruralnim područjima i diverzifikacija ruralnih aktivnosti 4) LEADER pristup (IPARD plan, 2007). Novi razvojni koncepti, posebno multifunkcionalna poljoprivreda i multisektorski ruralni razvoj osnova su održivog razvoja, s naglaskom na očuvanje okoliša, bioraznolikosti i etno-ambijenta. U tom kontekstu mala poljoprivredna gospodarstva postaju značajni subjekti održivosti i razvoja ruralnih područja, neovisno od stupnja ekonomskog potencijala komercijalizacije proizvoda i usluga. Ovo je novi pristup ruralnom razvoju koji je potican programima europskih ruralnih politika kroz LEADER pristup.

### Materijali i metode

Utvrđivanje specifičnih razvojnih ograničenja malih ruralnih gospodarstava i objektivno sagledavanje njihovih potreba i mogućnosti razvoja, treba doprinijeti kreiranju vjerodostojnih mehanizama i strategija za pokretanje revitalizacijskih procesa u ruralnim područjima. Stoga, se u radu identificiraju i analiziraju ključni socio-ekonomski indikatori ruralnih gospodarstava sa aspekta mogućnosti unapređenja njihovih obilježja u pravcu diverzifikacije ruralne ekonomije. Socio-ekonomskih indikatora, a koji se odnose na kvantitativna i kvalitativna obilježja ruralnog stanovništva, posjedovnu strukturu, diverzifikaciju aktivnosti u poljoprivrednim domaćinstvima, izvore financiranja su analizirani na osnovu podataka dobivenih u sklopu IPA prekogranične suradnje Mađarska-Hrvatska "Regional Universities as Generators of Transnational Knowledge Region" i doktorske disertacije "Diverzifikacija gospodarskih aktivnosti u funkciji ruralnog razvoja". Realizacija postavljenih ciljeva istraživanja se odvijala primjenom različitih metodoloških postupaka kojima su analizirani dostupni (publicirani i interni) statističkih podataka vezanih za značaj i položaj ruralnih gospodarstava u ukupnim potencijalima i osnovnim demografskim nacionalnim i/ili regionalnim agregatima. Analiza osnovnih prostornih, demografskih, gospodarskih i infrastrukturnih indikatora vezanih za istraživano ruralno područje omogućilo je komparaciju i interpretaciju makroekonomskog okruženja pojedinih tipova ruralnih područja. Sekundarna analiza obuhvatila je studije sa sličnom ili relevantnom problematikom, kao i analizu državnih strategija vezanih za problematiku istraživanja.

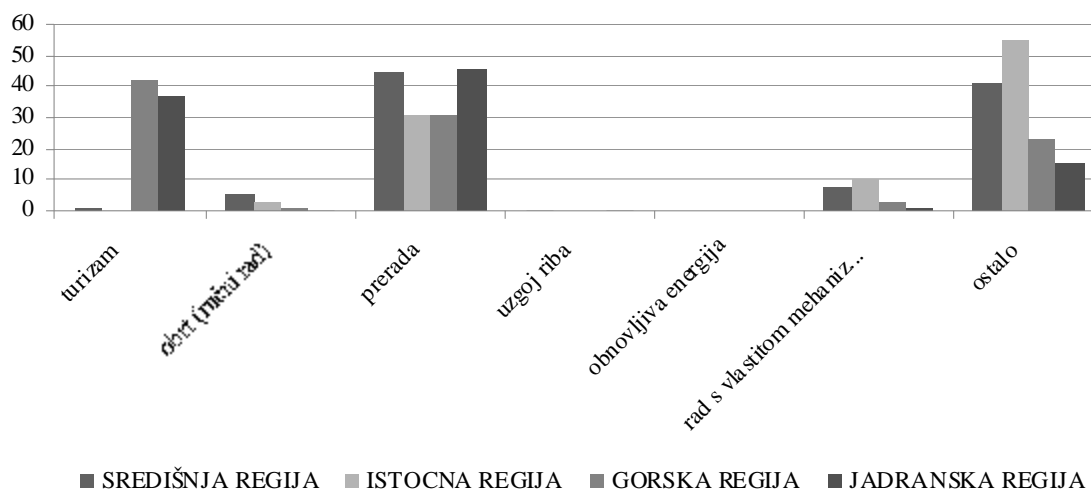
### Rezultati i rasprava

Poljoprivredna tranzicija je dugoročan i važan strateški zadatak koji se sastoji u razumijevanju kako se i zašto mijenja situacija u grani i gospodarstvu uopće i formiranje vizije o revitalizaciji subjekata. Dosadašnji tijek tranzicijskih procesa hrvatske poljoprivrede nije riješio goruće agrarne probleme. Ruralni prostor zahvaćen je ekonomskim osiromašenjem, nedostatnom komunalnom i društvenom infrastrukturom. Usitnjeni i neracionalno raspoređeni posjedi nerentabilni su i ne pružaju mogućnost za razvoj komercijalne poljoprivrede, a gospodarstva koja su tržišno orijentirana prema kvantiteti i imaju potrebne preduvjete, suočavaju se s velikom konkurencijom na tržištu. Razvoj i ulazak novih, nepoljoprivrednih djelatnosti u ruralni prostor često nije planiran proces, već posljedica nemogućnosti osiguravanja egzistencije u djelatnostima primarnog sektora, odnosno nemogućnosti zapošljavanja izvan vlastitoga gospodarstva. Hrvatska je danas suočena s općom neravnotežom između razvoja sela i grada; industrijske proizvodnje i poljoprivrede. Treba znati da se višedesetljevano forsiranje industrijalizacije i urbanizacije događalo na štetu razvoja hrvatskog sela. Posljedice prisilne nacionalizacije i kolektivizacije bile su tek početak repulzivnih utjecaja koji su ubrzali proces deagrarizacije - napuštanje poljoprivrede kao djelatnosti, odnosno ruralni egzodus. Ovi procesi teku izuzetno selektivno s naglaskom na iseljavanje pretežito mladih osoba.

Usporedba procesa deagrarizacije i deruralizacije u Republici Hrvatskoj ukazuje na znatno brži proces deagrarizacije gdje je veliki broj stanovnika koji živi na ruralnom području, a ne bavi se poljoprivrednim djelatnostima. Nedostatni razvoj nepoljoprivrednih djelatnosti ili nepoljoprivrednim djelatnostima, zapravo predstavlja kočnicu razvoja ruralne sredine što je utjecalo da 77% ruralnih područja ima karakteristiku izrazitog zaostajanja u pogledu demografskih, socio-kulturnih i prostorno planskih indikatora. Nadalje, 11% ruralnih područja nalazi se u stagnaciji, odnosno takvom načinu razvoja kojega karakterizira niz povoljnih pretpostavki za brže, lakše i racionalnije usmjeravanje procesa i odnosa, ali uz kontinuiranu intervenciju mjera i instrumenata za daljnji razvitak ovih područja. Također, 8% ruralnih područja se nalazi u okvirima uravnoteženog razvoja, a 4% bilježi ekspanziju i upravo uravnotežena i ruralna područja u ekspanziji trebaju biti u fokusu oživljavanja ruralnog prostora.<sup>1</sup> Ruralni prostor Republike Hrvatske formiran je na paradigmi suprotstavljanja grada i sela, industrijalizacije i deagrarizacije, društvenog i privatnog vlasništva, velikih poljoprivrednih dobara/kombinata i sitnih neznčajnih individualnih gospodarstava što je utjecalo na osiromašenje ruralnih potencijala koji otežavaju primjenu novoga modela ruralnog razvitka. Udio poljoprivrednog u ukupnom stanovništvu je u zadnjih pedeset godina smanjen sa 56,1% na 5,5%, što je na razini visoko razvijenih zemalja. Međutim, to je obilježje koje nas izjednačuje s visoko razvijenim industrijskim zemljama, a ima za posljedicu neodrživ razvitak zbog preniske akumulacije znanja i kapitala hrvatskog stanovništva, posebno ruralnog. Većina ruralnog stanovništva upućena je na procese zapošljavanja umjesto samozapošljavanje, čije posljedice posebno dolaze do izražaja u razdobljima recesije, odnosno visokih stopa nezaposlenosti. Revitalizacija sela je stoga nužna u smislu održivog i cjelovitog razvoja koji će paralelno osigurati ujednačene uvjete za daljnji razvoj komercijalnih gospodarstava s jedne strane, ali i samoodrživih i diversificiranih gospodarstava s druge.

Politika ruralnog razvitka ne smije se promatrati kao dio politike agrara. Politika agrara samo je jedan od elemenata integralne politike ruralnog razvitka, a potpore poljoprivrednoj proizvodnji su dio te politike. Međutim, razvitak konkurentnosti u poljoprivredi potiče koncentracijske procese (individualna korisnost) s negativnim posljedicama na okoliš, ali i na ukupne mogućnosti zapošljavanja u sektoru poljoprivrede, što je u novije vrijeme dovelo u pitanje održivost industrijske paradigme. U tom kontekstu događaju se promjene u konceptu i primjeni mjera zajedničke agrarne politike Europske unije (Tolić, Zmaić, Pušić, 2010.) koja se okreće u pravcu financiranja zajedničkog dobra, odnosno prema poticanju razvitka društvenog kapitala: ukupnog znanja, inovativnosti, suradnje i umrežavanja na razini lokalnih ruralnih područja, podržavanjem multifunkcionalnih i multisektorskih modela. U Republici Hrvatskoj pretežiti dio ruralnih područja ima sve preduvjete za promoviranje i uspješnu primjenu koncepta multifunkcionalne poljoprivrede i integralnog ruralnog razvoja obzirom na raznolikost ruralnog područja, prirodnih resursa, očuvanog ruralnog krajobraza i tradicije uz neiskorištene potencijale za razvoj nepoljoprivrednih aktivnosti u ruralnom području. S druge strane, prisutna su ograničenja i slabosti koja se ogledaju u nepovoljnoj proizvodnoj i posjedovnoj strukturi, neiskorištenom ljudskom potencijalu i mehanizaciji, nerazvijenom infrastrukturom, nedostatkom poduzetničke inicijative, suradnje i motivacije u ekonomiji lokalnog stanovništva (Zmaić, 2004.). Uravnoteženje razvoja krupnog i sitnog sektora poljoprivrede, mora biti usmjereno i na povećanje multifunkcionalnosti, odnosno samoodrživost brojnih obiteljskih gospodarstava, uz već postojeći sektor krupnih poljoprivrednih gospodarstava, farmerskog tipa, orijentiranih isključivo na specijaliziranu tržišnu proizvodnju. Opstanak navedenih poljoprivrednih gospodarstava uvjetovan je daljnjom diverzifikacijom, pri čemu se trebaju međusobno nadopunjavati poljoprivredne i nepoljoprivredne aktivnosti, koje povećavaju ukupnu zaposlenost i dohodak u ruralnoj prostoru. Poljoprivredu i/ili poljoprivredu sa još nekom dodatnom aktivnošću, kao svoju perspektivu prvenstveno vide gospodarstva koja su i sada isključivo vezana za poljoprivredne prihode (Sudarić, 2009.). Gospodarstva koja imaju dohodak iz drugih izvora ne pokazuju spremnost u angažiranju u poljoprivredi ili investiranju u neke poslove vezane za farmu (Grafikon 1.)

<sup>1</sup> Navedeni podaci su preuzeti i komentirani iz „Strategije prostornog uređenja Republike Hrvatske“



Grafikon 1. Obilježja dopunskih aktivnosti po regijama

Izvor: Sudarić, 2009:227

Raspoloživi potencijali malih ruralnih gospodarstava su skromni po opsegu, neadekvatni po strukturi, i kao takvi nedovoljno atraktivni za ulaganja. Istraživanje ključnih socio-ekonomskih indikatora ruralnih gospodarstava sa aspekta mogućnosti unapređenja njihovih ekonomskih performansi u pravcu diverzifikacije ruralne ekonomije, ukazalo je kako ruralna gospodarstva nisko ocjenjuju značaj radne snage kao resursa i ne prepoznaju dodatne vještine i sposobnosti svojih članova (Sudarić, 2009.). Raspoloživo zemljište za poljoprivredna gospodarstva čini samo garanciju za njihovo opstojanje i prehranu, a samo za mali broj navedenih gospodarstava zemljište ima funkciju kapitala. Većina nije spremna na prodaju zemljišnih resursa jer u njima vide svoju egzistenciju. Fizički kapital (oprema, objekti, mehanizacija) je skroman po strukturi, prosječnog ili ispodprosječnog stanja i malo se koristi za ostvarivanje dodatnog dohotka (iznajmljuje/renta, ili koristi za vršenje usluge drugim osobama). Realno je pretpostaviti kako će se vremenom postojeće “svaštarsko” poljoprivredno gospodarstvo osposobiti za veći stupanj samoodrživosti, a tek manji broj će se transformirati u farmersko, moderno i tržišno orijentirano poljoprivredno gospodarstvo. To se podjednako odnosi na “punu” ili “djelomičnu” poljoprivredu na kojima će se organizirati organska proizvodnja zdrave hrane, visokih nutritivnih kvaliteta, trženje proizvoda, kao i turističko-rekreativne usluge.

### Zaključak

Svako društvo u svom urbano-ruralnom kontekstu, suočava se sa problemima održivog i ujednačenog prostornog, socio-ekonomskog i demografskog razvoja. Prostorna, socioekonomska, demografska i svaka druga ravnomjernost u razvoju određenog društva, neophodan je uvjet njegovog napretka. Ruralna područja imaju sve preduvjete za promoviranje i uspješnu primjenu koncepta multifunkcionalne poljoprivrede i integriranog ruralnog razvoja obzirom na raznolikost ruralnog područja, prirodnih resursa, očuvanog ruralnog krajobraza i tradicije uz neiskorištene potencijale za razvoj nepoljoprivrednih aktivnosti u ruralnom području. Revitalizacija sela je stoga nužna u smislu održivog i cjelovitog razvoja koji će paralelno osigurati ujednačene uvjete za daljnji razvoj komercijalnih gospodarstava s jedne strane, ali i samoodrživih i diversificiranih gospodarstava s druge. Ekonomske performanse u pravcu diverzifikacije ruralne ekonomije, ukazalo je kako ruralna gospodarstva nisko ocjenjuju značaj radne snage kao resursa i ne prepoznaju dodatne vještine i sposobnosti svojih članova. Stoga, većina ruralnog stanovništva upućena je na procese zapošljavanja umjesto samozapošljavanje, čije posljedice posebno dolaze do izražaja u razdobljima recesije, odnosno visokih stopa nezaposlenosti. Politika poticanja multifunkcionalnog pristupa pomaže u razvijanju partnerstava, a samim tim snaženju društvenog potencijala za poslovnu i ukupnu suradnju.

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# Oblici nasljeđivanja obiteljskih poljoprivrednih gospodarstava u Hrvatskoj

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## Sažetak

U radu se iznose rezultati terenskog istraživanja sociodemografske reprodukcije obiteljskih poljoprivrednih gospodarstava u pet hrvatskih županija. Cilj istraživanja je bio ustanoviti oblike nasljeđivanja i mogućnosti reprodukcije obiteljskih gospodarstava u idućoj generaciji te povezanost između socioekonomskih karakteristika gospodarstva i oblika nasljeđivanja. Analiza realnih mogućnosti nasljeđivanja ispitanih 252 gospodarstva pokazuje da njih 53,1% ima izgleda da se reproducira u idućoj generaciji. Mogućnost nasljeđivanja i oblik socijalne reprodukcije ispitanih gospodarstava povezan je s veličinom posjeda i proizvodnom orijentacijom gospodarstva.

Ključne riječi: obiteljsko poljoprivredno gospodarstvo, nasljeđivanje, nasljednik, Hrvatska

## Patterns of family farm inheritance in Croatia

### Abstract

In the article the authors present the results of the survey about sociodemographic reproduction of family farms in five Croatian counties. The aim of the study was to determine the patterns and chances of family farms for social reproduction in the next generation and the connection between socioeconomic characteristics of farm and patterns of inheritance. An analysis of actually existing potential successors shows that 53.1% of farms have prospect of being reproduced in the next generation. The existence of potential inheritance and the form of social reproduction depend on the size of the farm and the type of farm production.

Key words: family farm, inheritance, successor, Croatia

### Uvod

Brojna istraživanja u svijetu potkrepljuju tezu da održivost obiteljskih gospodarstava umnogome ovisi o pravodobnom prijenosu upravljačkih i vlasničkih funkcija na sljedeću generaciju (Gamble i sur. 1995; Potter and Lobley, 1996; Kaine i sur. 1997; Barker i sur. 2001; Barclay i sur. 2007). Međugeneracijski prijenos obiteljskog gospodarstva višeslojan je proces na koji utječu brojni i vrlo različiti čimbenici - od objektivnih društveno-ekonomskih prilika u društvu, lokalnoj zajednici ili na gospodarstvu, do sociokulturnih i psiholoških karakteristika obitelji (Dunemann i Barrett, 2004, Pardo-del-val, 2009). Te okolnosti određuju obrasce nasljeđivanja i sukcesije, odnosno da li će se gospodarstvo u cijelosti prenijeti na jednog ili će se dijeliti između više nasljednika, ili će se "ugasiti" kao proizvodno-ekonomska jedinica, zatim, preferira li se nasljeđivanje po muškoj liniji ili postoji ravnopravni tretman sve djece, planira li se pravodobno umirovljenje vlasnika i prijenos upravljačkih funkcija gospodarstva na nasljednika i sl.

Razmatranje sociodemografske reprodukcije obiteljskih gospodarstava naročito je važno za hrvatsku poljoprivredu koju obilježava prosječno mala veličina i velika rasparceliranost zemljišnog posjeda, te



nepovoljna starosna struktura poljoprivrednika. Gotovo 35% vlasnika obiteljskih gospodarstava stariji su od 60 godina, a svega 13.4% je u vlasništvu poljoprivrednika mlađih od 40 godina (Žutinić, Grgić, 2010). To znatno sužava reprodukciju sektora obiteljske poljoprivrede.

### Materijal i metode

Predmet našeg istraživanja jest sociodemografska reprodukcija obiteljskih poljoprivrednih gospodarstava u pet hrvatskih županija. Ciljevi rada su: (a) ustanoviti oblike nasljeđivanja i procijeniti mogućnosti reprodukcije obiteljskih gospodarstava u idućoj generaciji i (b) ustanoviti postoji li povezanost između socioekonomskih karakteristika gospodarstva i oblika nasljeđivanja.

Osnovna metoda za prikupljanje podataka bila je anketa koja je provedena među voditeljima obiteljskih poljoprivrednih gospodarstava, prostorno raspoređenih u pet hrvatskih županija: Vukovarsko-srijemskoj, Osječko-baranjskoj, Međimurskoj, Istarskoj i Brodsko-posavskoj. Uzorak je bio namjeran, a osnovni kriteriji za izbor gospodarstva bili su: (a) kućedomaćin/ca u dobi 45 i više godina, i (b) važnost poljoprivrede kao izvora prihoda i zaposlenosti članova kućanstva. Od svakog voditelja/ice gospodarstva na temelju pismenog upitnika, prikupljeni su sociodemografski podaci o članovima kućanstva, o osnovnim proizvodnim karakteristikama gospodarstva, te odgovori na pitanja o planovima o predaji i nasljeđivanju gospodarstva. Istraživanje je provedeno u prvoj polovici 2009. godine, a uzorkom je obuhvaćeno 252 obiteljska gospodarstva.<sup>1</sup>

Obrada podataka obavljena je standardnim statističkim tehnikama kojima su analizirane distribucije frekvencija i postoci. Postojanje razlika između socioekonomskih obilježja gospodarstava i oblika nasljeđivanja ustanovili smo pomoću  $hi^2$ -testa uz toleranciju moguće pogreške od 5% ( $p < 0,05$ ). U obradi se koristio programski paket SPSS-13.

### Rezultati i rasprava

#### Obilježja ispitanika, kućanstva i gospodarstva

Obiteljskim gospodarstvom u pravilu upravlja vlasnik posjeda i po tradiciji to je najstariji muškarac u obitelji, što je pokazalo i ovo istraživanje. Većinu anketiranih gospodarstava vode muškarci, a žene na čelu gospodarstva nalazimo samo u 11,5% slučajeva. Istodobno, kućedomaćina kao jedinog zakonskog vlasnika zemljišta i ostalih fizičkih resursa, evidentirali smo na 59,9% gospodarstava, ženu kao jedinog vlasnika na 6,3%, dok na preostalim gospodarstvima (33,8%) vlasništvo dijele supružnici. Podrobniji opis socioekonomskih obilježja anketiranih gospodarstava prikazujemo u tablici 1.

Kućanstva naših ispitanika su mnogoljudnija u odnosu na prosječno seosko kućanstvo u Hrvatskoj (3,3 člana). Većinom (62,3%) su to kućanstva s četiri do šest članova, i nerijetko obitelji s višegeneracijskim obilježjima. Gotovo sva kućanstva ispitanika/ca (94,5%) ima jedno ili više djece, pa time i veće izgleda da se njihova gospodarstva reproduciraju u idućoj generaciji. U prilog tome idu i dobivene informacije o veličini gospodarstva s kojih ispitanici dolaze. Prevladavaju gospodarstva koja rabe više od 10 hektara poljoprivrednog zemljišta. Ranija istraživanja u Hrvatskoj su potvrdila da su znatno povoljnije mogućnosti za socijalnu reprodukciju imala obiteljska gospodarstva koja su bila većih zemljišnih površina. (Brkić i Žutinić, 1993; Ilak Peršurić, 2003).

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<sup>1</sup> Istraživanje je sastavni dio znanstveno-istraživačkog projekta "Sociodemografska reprodukcija obiteljskih gospodarstava" kojeg financira Ministarstvo znanosti, obrazovanja i športa RH.

Tablica 1. Osnovna socioekonomska obilježja obiteljskih gospodarstava

Obilježje	N = 252
Voditelj/ica gospodarstva prema spolu (u%)	
muškarci	88,5
žene	11,5
Prosječna dob voditelja/ice (god.)	53,2
Formalno obrazovanje voditelja/ice (u%)	
1-7 razreda i osnovna škola	35,3
srednja škola	54,8
viša škola i fakultet	9,9
Radni status (u%)	
poljoprivrednik/ca	67,3
zaposlenik/ca	13,1
nezaposlen/a	4,0
umirovljenik/ca	15,6
Prosječni broj članova u kućanstvu	4,5
Tip obitelji prema spolu djece (u%)	
samo sin/sinovi	25,8
samo kći/kćerke	17,9
djeca oba spola	50,7
bez djece	5,6
Prosječni broj djece u obitelji	2,3
Gospodarstva prema veličini korištenog polj. zemljišta (u%)*	
do 5 ha	19,4
5,1-10 ha	15,9
10,1 -20 ha	18,7
20,1 ha i više	46,0
Prosječna veličina korištenog polj. zemljišta (u ha)*	32,4
Prevladavajuća proizvodnja na gospodarstvu (u%)	
stočarska proizvodnja	35,7
biljna proizvodnja	35,3
mješovita	29,0

\* vlastito i zakupljeno poljoprivredno zemljište

Izvor: Anketa

### Zadržavanje nasljednika i oblici nasljeđivanja

Na temelju sociodemografskih podataka o članovima kućanstva ustanovili smo da gotovo sva (94,4%) gospodarstva imaju potencijalnu mogućnost reproducirati se u idućoj generaciji. Međutim, postojanje djeteta ili djece u obitelji ne jamči da će se gospodarstvo održati u budućnosti jer često postoji raskorak između želja i očekivanja voditelja/ice gospodarstva i motiviranosti nasljednika za preuzimanje gospodarstva i bavljenje poljoprivredom. S druge strane, u planiranju sukcesije često nisu uključeni potencijalni nasljednici i čest je slučaj da voditelji gospodarstva, iako su u visokoj životnoj dobi, ne namjeravaju prepustiti upravljanje gospodarstvom sve dok su psihofizički sposobni obavljati tu funkciju. To slabi motiviranost potencijalnog nasljednika za preuzimanje posjeda.

U procjeni mogućnosti reprodukcije anketiranih gospodarstava vodili smo se iskazima ispitanika na dva pitanja. Prvo je bilo "tko će od srodnika naslijediti gospodarstvo?", a drugo "je li se nasljednik/ca obvezao/la na preuzimanje gospodarstva?".

Tablica 2. Oblici (tipovi) nasljeđivanja obiteljskih gospodarstava

Oblici nasljeđivanja	Srodnik/ci	n	%
I - Samo jedan nasljednik	Sin	106	42,0
	Kći	22	8,7
	Unuk	4	1,6
	Zet	2	0,8
II - Više nasljednika	Sinovi s istim udjelom	10	4,0
	Kćeri s istim udjelom	12	4,8
	Sin/ovi i kći/kćeri s istim udjelom	25	9,9
III - Bez identificiranog nasljednika	Kućedomačin nije odlučio tko će od djece naslijediti gospodarstvo	61	24,2
	Kućedomačin nema djece/nasljednika	10	4,0
Ukupno		252	100,0

Izvor: Anketa

Drugim smo pitanjem nastojali dobiti potvrdu da su želje i očekivanja voditelja/ice gospodarstva i obitelji glede potencijalnog nasljednika opravdane, odnosno da će odabrani srodnik prihvatiti da u doglednoj budućnosti preuzme gospodarstvo. Ukrštavanjem tih dvaju pitanja razlučili smo tri osnovna oblika nasljeđivanja (Tablica 2).

Podaci o zadržavanju nasljednika pokazuju da realne izgleda da se održe kao cjelovite proizvodno-ekonomske jedinice ima 53,1% obiteljskih gospodarstava, s obzirom da je na tim gospodarstvima identificiran samo jedan nasljednik. Kod 18,7% gospodarstava zemljište i ostalu imovinu podijelit će više nasljednika, što može rezultirati marginalizacijom gospodarstva kao proizvodne jedinice. Za 24,2% gospodarstva sukcesija je neizvjesna jer kućedomaćini/ce nisu odlučili tko će preuzeti imanje, a 4% gospodarstava će se najvjerojatnije “ugasiti” jer obitelj nema djece.

#### Utjecaj socioekonomskih obilježja gospodarstva na oblike (tipove) nasljeđivanja

Cilj istraživanja bio je i utvrditi postoji li povezanost između socioekonomskih karakteristika gospodarstva i tipova nasljeđivanja. Kontingencijskom analizom ustanovili smo da nema povezanosti između demografskih obilježja kućedomaćina/ce (spol, dob, formalna naobrazba i radni status) te veličine kućanstva i tipova nasljeđivanja ( $p > 0.05$ ). Uočene su statistički značajne razlike između tipova nasljeđivanja i veličine zemljišnog posjeda ( $hi^2 = 13,248$ ,  $p = 0.003$ ) i proizvodne orijentacije gospodarstva ( $hi^2 = 37,027$ ,  $p = 0.012$ ). Drugim riječima preferiranje jednog nasljednika (tip I) je prisutnije na gospodarstvima koja koriste veće poljoprivredne površine, pa je time i izglednije njihovo reproduciranje. Također, isti obrazac je prisutniji na gospodarstvima koja su proizvodno više usmjerena na biljnu proizvodnju. Nadalje, postoje razlike među gospodarstvima s obzirom na teritorijalnu pripadnost i tipova nasljeđivanja ( $hi^2 = 54,005$ ,  $p = 0.000$ ). U Istarskoj županiji je najveći udio (76,0%) gospodarstva s prvim tipom nasljeđivanja, u Osječko-baranjskoj prevladavaju (56,0%) gospodarstva s nesigurnom sukcesijom-tip III, a u Vukovarsko-srijemskoj je u odnosu na ostale istraživane županije, najviše gospodarstava koja će naslijediti više sukcesora (38%) -tip II.

#### Zaključci

S obzirom na karakter korištenog namjernog uzorka, navedeni rezultati nisu reprezentativni za RH i odnose se na istražena gospodarstva. Ipak, pružaju indikacije za eventualna uopćavanja i smjer daljnjih istraživanja.

Rezultate istraživanja o nasljeđivanju obiteljskih gospodarstava u pet hrvatskih županija možemo ukratko svesti na sljedeće:

1. Izgleda da se u idućoj generaciji održe kao cjelovite proizvodno-ekonomske jedinice ima 53,1% obiteljskih poljoprivrednih gospodarstava (gospodarstvo nasljeđuje jedan sukcesor koji se obvezao na preuzimanje imanja - “uspješna socijalna reprodukcija”).
2. Kod 18,7% obiteljskih poljoprivrednih gospodarstava izvjesna je marginalizacija gospodarstva u proizvodnom pogledu jer će se zemljišni posjed i gospodarski resursi podijeliti među više nasljednika.
3. Socijalna reprodukcija za 24,2% obiteljskih poljoprivrednih gospodarstava je neizvjesna jer kućedomaćini/ce iako imaju potomke i u prosjeku su stari 57 godina nisu odlučili o sukcesoru.
4. Među anketiranim gospodarstvima 4% će se najvjerojatnije “ugasiti” jer na gospodarstvu nema djece.

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# Rural women: employment and micro finance plans

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## Abstract

One of the fundamental development debates is correct and improved utilization of human resources capabilities and talents. Rural women position as a half of rural community's work force has particular importance and requisite which up to date has not received its deserved attention in managerial and legal systems.

The default belief is that rural women play outstanding community roles in spite of their not fully understood economical, social and cultural status and their high participation rate in many economical, production- and service-based activities. They also play an important role in production of various products such as agricultural, horticultural, live stock, hand craft and transformational industries. Their presence in other activities such as decision making, management, ownership, employment and income making, however, is challenging and unfortunately less than their deserved attention is devoted by officials and planners of rural development field due to variety of reasons. One of the approaches to help rural women and to lessen their poverty is taking advantages from their work force in small businesses and micro economical operations. This policy needs financial resources to be spent in developing such occupations.

Key words: rural women, micro finance plans, women employment

## Introduction

The "Work Principles and Programs" declaration of Land Reform and Development International Conference, July 1979, declares that "women must equally participate in socio-economical and political processes of rural development efforts and play their full roles in improving rural dwellers' life environment" (Women Affairs Bureau of the Presidential, 1997).

One of the most effective practical approaches in the field is designing and implementing micro finance program focusing on women efficient presence and participation with the aim of poverty reduction; this approach is able to resolve most of the social, economical and cultural barriers and problems which are appeared in the course of achievement to develop objectives especially rural development and in determination of rural and tribal women activities (Rahmani Andebili, 1993).

The situation dominated on the Iran's villages is such that it promotes rural poverty especially for rural women due to various reasons including small agricultural farms and production units i.e. agricultural and live stock units, water shortage and drought, unavailability of protection facilities such as cool rooms, improper rural roads, lack of transportation infrastructures, high load of sponsorship among rural families, low price of agricultural products and limited governmental investments in rural areas, lack of public investment from other sectors in the agriculture sector and low level of capital and savings in rural areas (Asefirad, 2002).

In spite of global attempts to bring up rural women into developmental endeavors, lots of countries are facing with various difficulties for involving rural women in development processes including economical development. These difficulties are mainly limiting with respect to single parent families. The other challenge

for rural women is unavailability of financial institutes' services particularly credit banks. In most parts of the world countries, credit payments are based on farm size, so rural women are mostly deprived of such rights due to their small sized farms or even because of ownership problems (Harighi, 2002).

Micro finance is one of the most effective tools against poverty which most of the countries in five continents of the world have accepted such provisions. Based on available statistics, micro finance plans have succeeded to include 8 million of poorest people in developing countries under their support (World Bank, 1999).

### **Rural women and employment**

Most of the rural women especially their poorest one are working in economical production sectors along with their house keeping responsibilities. It is obvious that in most of the societies, women's work and activity levels are higher than men but their roles are ignored in economical calculations and national auditing and the problem is more serious in rural communities of developing economics.

The ignorance of women work importance has caused some deprivations from their own real rights so they mostly receive very little share from planning, credit distribution and income. Women with their exhausting works and responsibilities receive very little credit and more importantly, their work's formality is mostly disregarded (Lahsaeizadeh, 1990).

For a rural woman, involvement in planting, cultivation and harvest activities beside other family members is seen as one of her house keeping responsibilities and not as a separate job or occupation. Neglectfully, house keeping is not included as a job in census reports so it has caused a large portion of rural economical activities to be considered as an inactive area. Based on economic view, it is unreasonable to pay credits to unemployed communities. This careless account of reality thus has resulted in a large population of producers to be excluded from bank credit programs (Women Research Group, 1995).

Various statistics reveal that our country's rural women have a wide involvement rate in economical activities. They are involved in 70% of rice planting, up to 90% of carpet knitting in some areas, 90% of vegetable planting and also silkworm rearing in Mazandaran Province (Nasari, 1996).

With respect to rural women population which includes 20% of total country's population, on the average they are engaged in 40% of agricultural activities, the value does not include their house keeping activities. According to estimates, women are active in 70% of rice planting, 90% of vegetable and cash crops production, 50% of cotton and oil seed crops production and 30% of horticultural activities of the country. The other heavy duty activity of rural women is rural hand craft in which women's share is 80% of the community (First Advisor Research Group, 1996).

### **Rural women and micro finance**

The nature of "micro finance" is based on human beings requirements and capabilities and it origins from the fact that no one knows poverty except poor persons and it is necessary to provide them with desired environment and needed working tools. Totally speaking, micro finance programs aim at increasing poor person's income through self-employment and providing training services to improve resources utilization (Rasouloff, 2002)

Micro finance plans play an important role in poor people access to social primary services. According to planning for micro finance granting, it was estimated that 100 million of poorest families all around the world would be under the cover of micro finances until 2005 and women in such families received especial attention in the program. Based on experience, women income has tremendous impact on improvement of family welfare especially for children and girls. Moreover, this class of women will find their appropriate status (International Affairs Office of Agriculture Bank, 1999).

An interesting point here is the level of credits repayment. Based on statistics of the World Bank, micro finances repayment rate has been very successful and mostly 98% of loans have been repaid by loan receivers. Poor families have demonstrated that although they have not any security for safekeeping the micro finances, but they are bank-friendly and try to increase their savings as well as in time repayments (Ledgerwood, 1999).

In views of classic economists, the word "micro" indicates development inefficiency. In the classic economic view, human beings as consumers try to maximize their satisfaction and as producers, their efforts are

focused on minimizing production costs. In the production field, average cost will be decreased by higher production rate and higher capacity for a product is associated with higher exclusive profit and pricing possibilities (Rahimi, 1999).

### Finances and finance programs

In order to create technical changes in production activity, credits are needed from one hand and proper application of such credits with desired output requires appropriate training and technology on the other hand. Thus, credits beside technology and production technical skills are depended on each other. Predetermined condition for effectiveness of injected credit in production activities and its acceptable output is providing proper technology based on rural areas' social and economical environment. This shows why in development view point credit is considered alongside with "credit planning". The credit plan is not only dealt with giving and receiving money but also has various steps during which all training, marketing services, product entry, input supplying and loan services are considered simultaneously (Rahimi Andebili, 1993). The objectives of micro finance plans can be cited as:

- Increasing low-income rural woman accessibility to credit facilities
- Paying attention and focusing on low income rural women
- Raising women income level through small projects
- Empowering rural women with needed job skills (training)
- Empowering rural women with group work and participation
- Equipping unproductive savings of rural women with productive and efficient investments
- Planning of projects based on regional capacity, facilities and environment
- Breaking the poverty cycle and relieving rural families from poverty
- Developing employment and stabilization of jobs in financial crisis events (Moazzami, 1999).

### The necessity of micro finances for rural woman

Regarding what was presented at the beginning of present paper with respect to rural woman positions and roles, and based on the nature and objectives of micro finance programs, these credits and programs have some important and necessary aspects in service and production activities for rural woman which briefly are as follows:

- The role of rural woman as productive work force in agricultural and rural development
- Unavailability of credit resources for rural woman
- Satisfactory investment output at micro and small scales
- Importance and role of rural families' income increase with respect to family economic statute
- The role of rural woman financial power in improving all of the family development indexes and consequently in rural community as a whole (for example, researches show that environmental movements in most part of the world are created or leaded by women (Momsen, 1991)).
- Limitation of formal (governmental) credit resources and its bureaucratic barriers

Rural woman self-reliance, as a main outcome of the micro finance plans, has several individual (psychological), economical, social and collective impacts. The individual impacts of rural woman self-reliance are women self-esteem, equality of men and women and authorizing women. The most economical ones are self-sufficiency and financial independency, changing economical behavior, autonomy, improving economical growth and job creation among families. Social impacts can also be mentioned as improving women social base and role, family strengthening, changing family relations, weakening patriarchy thinking and population regulation. Finally, the collective impacts of rural woman self-reliance are also:

- Application of financial capabilities in improvement of social, economical and cultural conditions of villages;
- Struggling and fighting with contamination, rural poverty as well as rural environment protection;
- Utilization of available resources for environmental development.

## Conclusion

If the micro finances are provided in the form of coherent and comprehensive programs based on women and rural families economical and social conditions and with respect to their capabilities and skill levels, it will be possible to achieve the predetermined objectives and to provide them with production technology and needed activities as well as necessary credit. In this manner, the injected credit will have satisfactory output and also operational and production productivity will be increased. This systematic and comprehensive view is able to rescue rural families and women from null cycle of poverty and indigence.

If such credits are granted without due attention to individuals' skill requirements, it will be failed to achieve such objectives. Some results of credit granting cases without coherent and regular programs are: failing to achieve the satisfactory level of production productivity by the credit receivers, inability to repay in due times, instability of activities and spending much of the credit out of production activity cycle due to failure and lack of necessary skills. But if the credit has a planning framework, its receivers will improve their technical and job related skills and will spend it timely in their activities and production operations and so they will achieve improved production, income and life style.

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# Nepoljoprivredne djelatnosti ruralnog područja Zagrebačke županije

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## Sažetak

Ekonomska i demografska devastacija ruralnog prostora može se zaustaviti poticanjem razvitka nepoljoprivrednih djelatnosti. Očekuje se da su to djelatnosti koje uvažavaju ekonomske, socijalne, tradicijske i ekološke zahtjeve prostora odnosno domicilnog stanovništva. Ruralni prostor Zagrebačke županije nije kompaktan. Postoje značajne razlike u ekonomskoj razvijenosti, demografskim obilježjima, prirodnim resursima, očekivanjima i mogućim pravcima budućeg razvitka. U radu se, na temelju ankete lokalne samouprave, istražuju mogućnosti i ograničenja (potencijalnih) budućih nepoljoprivrednih djelatnosti ruralnog prostora Županije. Kao najvažniji čimbenik kod izbora odnosno poticanja pojedine djelatnosti ističe se zainteresiranost stanovništva za dotičnu djelatnost, a kao najmanje značajnim da je tradicijski već prisutna. Najpoželjnije djelatnosti su obrt, mali prerađivački pogoni i seoski turizam koji po mišljenju ispitanika najbolje koriste raspoložive resurse i čuvaju prostor. Najmanje su poželjni metalska te tekstilna industrija.

Kao najvažniji razlog nepoželjnosti određene djelatnosti ispitanici navode onečišćenje prostora, nedostatak radne snage, nedostatak tradicije i neprofitabilnost.

Ključne riječi: nepoljoprivredne djelatnosti, ruralni prostor, Zagrebačka županija, lokalna samouprava

## Non-agricultural rural activities in Zagreb County

### Abstract

Economic and demographic devastation of rural areas can be stopped by encouraging the development of non-agricultural activities. It is expected that these activities take into account economic, social, traditional and environmental requirements of space and the inhabitants. The rural area of Zagreb County is not compact. There are significant differences in economic development, demographic characteristics, natural resources, expectations and possible directions for future development. This paper is based on surveys of local government and explores the possibilities and limitations of (potential) future of non-agricultural rural activities of the County. As the most important factor in selecting or promoting certain activities highlights the interest of the population for that activity, and as the least important to the traditional already present. The most preferred activities are crafts, small processing plants and rural tourism, in the opinion of the respondents use the best available resources and preserve the area. The least desirable are the metal and textile industries. The most important reason for non-desiring specific activities, respondents mention pollution, labor shortages, lack of tradition and non-profitability.

Key words: non-agricultural activities, rural area, Zagreb County, local government.

## Uvod

Ruralni prostor razvijenih zemalja sve manje je poljoprivredni proizvodni prostor i mjesto življenja, a sve više je prostor ponude raznovrsnih sadržaja i proizvoda od poljoprivredno-prehrambenih do proizvoda kućne radinosti, obrta i slično (Marsden i Sonnino, 2008.; Bateman i Ray, 1994.).

U ruralnim područjima tradicionalni i najčešći izvori dohotka su djelatnosti primarnog sektora (poljoprivreda, šumarstvo i sl.) (Grgić i sur. 2007). Međutim, od sredine prošlog stoljeća gospodarski razvijene države u suradnji s lokalnim zajednicama sve više počinju tražiti mogućnost diversificiranja zaposlenosti i dohotka pri čemu se kao jedna od mogućnosti često naglašava agroturizam (Reichel i sur., 2000.; Polovitz i sur., 2001.; Bott-Alama, 2004.).

Diversifikacija djelatnosti u ruralnim područjima jedan je od ključnih nastojanja za unaprjeđenjem, održivošću i revitalizacijom ruralnih prostora (Županac 2010). Različiti ruralni prostori imaju različite potrebe za djelatnostima koje su pogodne za obavljanje baš u tom području (Grgić 2008).

Neusklađenosti između urbanih i ruralnih područja onemogućava stabilan društveno-gospodarski i regionalni razvitak čega je rezultat cjelokupni neravnomjeran razvitak zemlje.

## Materijal i metode

Ruralni prostor Zagrebačke županije nije kompaktan i postoje značajne razlike u ekonomskoj razvijenosti, demografskim obilježjima, prirodnim resursima i očekivanim i mogućim pravcima budućeg razvitka (Juraćak, Grgić i sur. 2004).

Za potrebe istraživanja mogućnosti i ograničenja (potencijalnih) budućih nepoljoprivrednih djelatnosti ruralnog prostora Županije provedena je anketa lokalne samouprave<sup>1</sup>. Anketno ispitivanje je provedeno tijekom svibnja 2009. godine i obuhvaćene su sve županijske jedinice lokalne samouprave, odnosno anketirane su osobe zadužene za ekonomski razvoj jedinica lokalne samouprave (članovi poglavarstva, pročelnici ureda za gospodarstvo i sl.). Ukupno je anketirano 34 osobe, a anketa se sastojala od 27 pitanja. Korištena je Likertova skala procjene od 5 stupnjeva. Zbog relativno malog broja anketa nije istraživana jakost veze između pojedinih varijabli. *Obrada je obavljena pomoću SPSS paketa (Statistical Package for Social Sciences).*

## Rezultati i rasprava

Najveći dio zaposlenih osoba Zagrebačke županije radi u Gradu Zagrebu (36,5%), manji dio na području vlastite općine/grada (29,1%), u drugoj općini/gradu u Zagrebačkoj županiji (26,5%) te najmanji dio u drugim mjestima druge županije (7,9%)<sup>2</sup>.

Nezaposlenost na istraživanom području je u odnosu na prosjek Županije približno ista, manja u odnosu na Grad Zagreb te još manja u odnosu na prosjek Republike Hrvatske što potvrđuje tezu da blizina Zagreba bez promjene prebivališta pogoduje relativno povoljnijoj slici (ne)zaposlenosti.

Prosječna plaća stanovnika ruralnog područja je na razini prosjeka Hrvatske ali je značajno niža u odnosu na prosjek Grada Zagreba.

Zaposlenost i plaća, uz ostale čimbenike, određuju životni standard. Pokazatelji životnog standarda su različiti i to od materijalnih (stanovanje, opremljenost i i sl.) do nematerijalnih (kulturna ponuda i potražnja, odmor i razonoda).

Nešto iznad polovice ispitanika mišljenja su da je standard na ruralnom području na razini prosjeka Županije što je i očekivano s obzirom na naglašenu ruralnost Zagrebačke županije. Isto kao i kod procjene zarade, sličan postotak ispitanika životni standard u odnosu na Grad Zagreb procjenjuju nižim. Nasuprot tome, veći dio (43,5%) ih je mišljenja da je veći od prosjeka Hrvatske, trećina (30,4%) da je manji te njih 26,1% da je isti kao u Republici Hrvatskoj.

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<sup>2</sup> Za pojedine društveno ekonomske fenomene ne postoje statistička praćenja te se radi o procjeni ispitanika.

## Nepoljoprivredne djelatnosti ruralnog područja Zagrebačke županije

Poljoprivreda je još uvijek značajna djelatnost ruralnog područja te je prema procjeni ispitanikama, od ukupnog broja zaposlenih, trećina (31,8%) zaposlena u poljoprivredi, ribarstvu, lovu i šumarstvu. Jedna petina (20,3%) ih radi u trgovini i ugostiteljstvu, nešto manje (18,7%) u prerađivačkoj industriji, te skoro podjednako u građevinarstvu (14,8%) i ostalim djelatnostima (14,4%).

Postojeća ekonomska struktura područja osnovica je za promišljanje budućeg gospodarskog razvitka, ali vrlo bitan je i razlog za izbor razvoja pojedinih djelatnosti.

Tablica 1 Najvažniji razlozi za izbor pojedinih djelatnosti ruralnog prostora

(1= Potpuno nevažno; 2= Nevažno; 3= Važno; 4= Vrlo važno i 5= Iznimno važno)

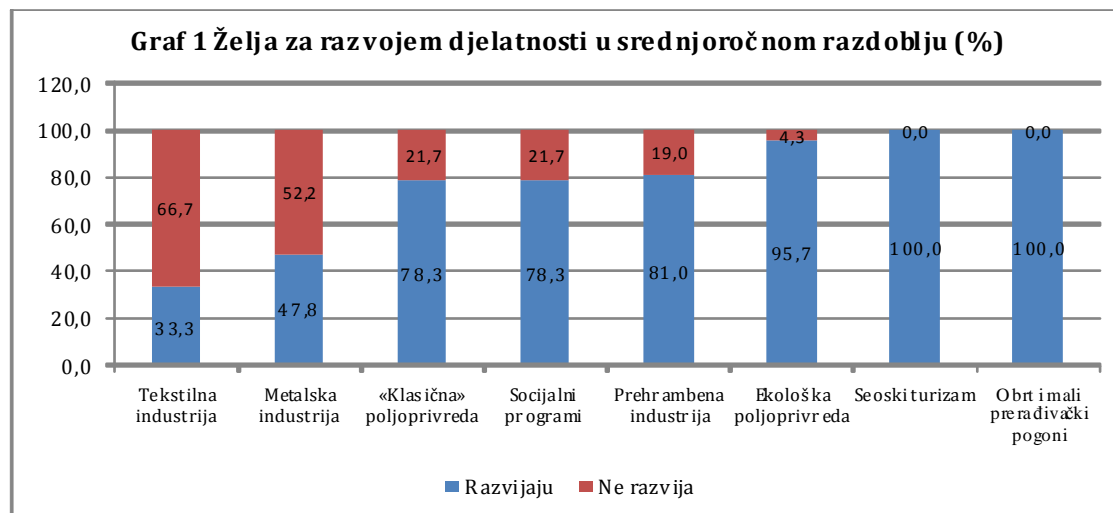
Razlog	Važnost (%)				Prosječna ocjena
	Nevažno	Važno	Vrlo važno	Jako važno	
Zainteresiranost stanovništva za dotičnu djelatnost	-	13,0	34,8	52,2	4,39
Zainteresiranost regionalnih poduzetnika i ulagača	-	17,4	56,5	26,1	4,09
Ekološki prihvatljive djelatnosti	4,3	30,4	17,4	47,8	4,09
Mogućnost dodatnog zapošljavanja domicilnog stanovništva	8,7	21,7	34,8	34,8	3,96
Zainteresiranost regionalne uprave i samouprave	4,3	43,5	26,1	26,1	3,74
Djelatnosti koje su tradicijski prisutne	13,0	34,8	34,8	17,4	3,57

Izvor: Anketa

Kao najvažniji razlog za izbor pojedine djelatnosti ispitanici navode zainteresiranost lokalnog stanovništva za dotičnu djelatnost. Njihov interes mora biti prepoznat od regionalnih poduzetnika i ulagača koji bolje poznaju cjelokupno okruženje od nekoga sa strane. Poduzetnici koji dolaze u ruralni prostor, u njihove poduzetničke zone često se ponašaju podcjenjivački, raspoloživu radnu snagu plaćaju manje nego u urbanim sredinama.

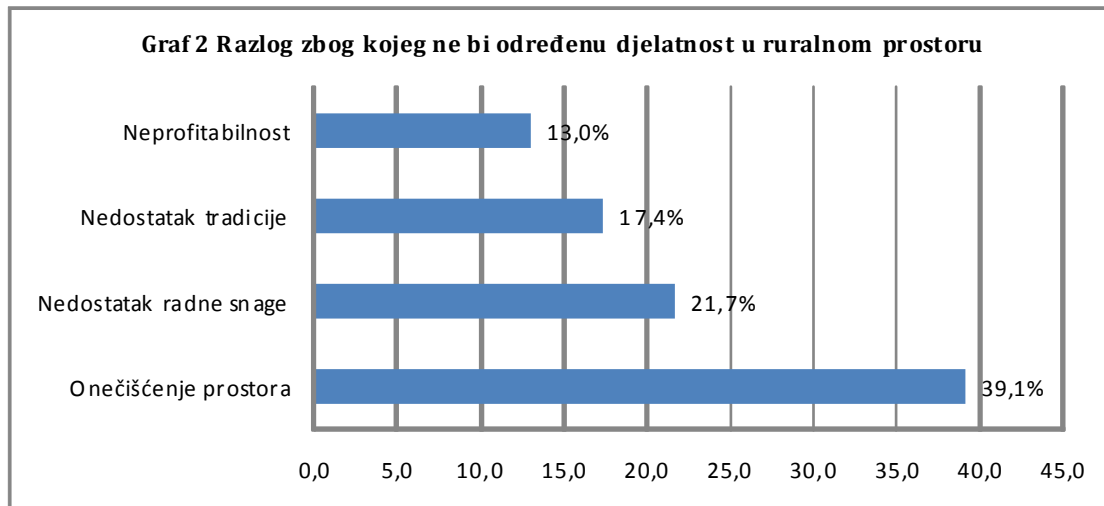
Za izbor pojedine djelatnosti važna je i njena ekološka prihvatljivost. Manje važnim smatraju mogućnost dodatnog zapošljavanja poljoprivrednih i drugih kućanstava, zainteresiranost regionalne uprave i samouprave te da su to djelatnosti koje su tradicijski prisutne na određenom prostoru.

U svome ruralnom prostoru svi ispitanici žele obrt i mali prerađivački pogon koji po njihovom mišljenju najbolje koriste raspoložive resurse i čuvaju prostor. Isti je odnos prema seoskom turizmu koji osim agroturizma uključuje i druge vidove turizma kao što je izletnički, sportski, vjerski, avanturistički itd.



Visoki postotak prihvatljivosti su projekti u okviru prehrambene industrije (81%), socijalnih programa (78,3%) te "klasične" poljoprivrede (78,3%). Blizina Zagreba može biti poticaj za poljoprivredu zbog blizine tržišta, ali se poljoprivreda uglavnom odnosi na vlastite potrebe. Manje je prihvatljiva metalska (52,2%) te tekstilna industrija (33,3%).

Razlozi zbog kojih se ne žele određene djelatnosti u ruralnom prostoru su različiti. Kao najvažniji razlog neprihvatanja određene djelatnosti ispitanici navode onečišćenje prostora, zatim nedostatak radne snage, nedostatak tradicije i neprofitabilnost.



Ostali razlozi za neprihvatanje su da se ne uklapa u razvojnu viziju Općine, da su već prisutne, da ne postoji prostor i uvjeti za navedenu djelatnost i sl.

Kod razloga prihvaćanja ispitanici (njih 47,8%) na prvo mjesto ističu iracionalni ili iskustveni razlog (osjećaj) da postoje potencijali za određenu djelatnost (sa strane resursa ali i sa strane tržišne potražnje za proizvodom/uslugom). Isti postotak ispitanika vjeruju da odabrana djelatnost doprinosi zapošljavanju, manji ali značajni dio (39,1%) da će ona povećati dohodak područja. Iznad trećine ispitanika misli da bi povećale odnosno potakle ukupni gospodarski razvoj (34,8%) te pomogle odnosno ne bi onečistile prirodu i kulturno naslijeđe.

Ispitanici kao razloge zbog kojih bi razvijali određene djelatnosti navode i tradiciju kod pojedinih djelatnosti ili proizvodnji, kvalificiranu radnu snagu, sprečavanje iseljavanja i mogućnost doseljavanja iz drugih dijelova Hrvatske, relativno mala ulaganja te veću turističku potražnju.

### Zaključci

Ruralni prostor Zagrebačke županije značajno se razlikuje od ostalog hrvatskog ruralnog prostora. Njegova budućnost u značajnoj mjeri ovisiti će o dobro osmišljenoj introdukciji nepoljoprivrednih djelatnosti.

Najvažniji čimbenik kod izbora odnosno poticanja pojedine djelatnosti je zainteresiranost domicilnog stanovništva, zatim zainteresiranost regionalnih poduzetnika i ulagača, da su ekološki prihvatljive, potiču zapošljavanje domicilnog stanovništva, da za njih postoji potpora regionalne uprave i samouprave te na kraju da su te djelatnosti već tradicijski prisutne.

Najpoželjnije djelatnosti su obrt, mali prerađivački pogoni i seoski turizam koji po mišljenju ispitanika najbolje koriste raspoložive resurse i čuvaju prostor. Najmanje su poželjni metalska te tekstilna industrija.

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# Correlation between agriculture and rural development in a disadvantageous sub-region

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## Abstract

The paper first negotiates the concept of multifunctionality, then the main steps of the development of the connection between agriculture and rural development are discussed. It presents the situation of a most disadvantageous sub-region that is aided by a complex program. The local rural resources are estimated by the multifunctional rural resource analysis method considering threefold function of the rural areas. It is concluded, that the land use systems and labour-intensive cropping systems have specific missions in multifunctional agriculture and rural development in the sub-region.

Key words: multifunctional agriculture, rural development, sub-region, land use systems

## Introduction

In order to overcome the harmful effects of intensive agricultural production, the concept of multifunctional agriculture has come in the forefront in scientific and political debates in the European Union. There are growing demands on healthy food, protection of environment, preserving country lifestyle and rural cultural heritage. No doubt, that the situation of rural regions can not be studied realistically without thorough considerations of agricultural situation. As a consequence agriculture has to be evaluated in a broad context, beyond the classical agricultural activities, the manufacturing of special products of the given region, the local utilization of these products, the development of tourism built on the local conditions and specialities should be involved in modern agriculture, which are present in recent development policy of EU countries. The objective of this paper is to give answers for the present disadvantageous conditions in some sub-regions of Hungary and through the example of a sub-region to present the possibilities for multifunctional agriculture and rural development.

## Material and methods

Key international references are cited to clarify the scientific background for the study. Multifunctional rural resource analyzes method (Nagy, 2007) is referred to determine the rural resource potential of land use system in the given sub-region. Statistical data used are derived from national statistical database (KSH). Personal experiences (first author is a resident of the given sub-region) are also utilized to reveal the potential of agriculture in multifunctional rural development in one of the most disadvantageous sub-regions investigated.

## Results and discussion

### Multifunctionality

Studying the relationship between agriculture and rural development, nowadays, it is necessary to identify the context of multifunctional agriculture. The term appeared first in the protocol of the United Nations Environment and Development conference in Rio de Janeiro in 1992: „...the multifunctional aspect of agriculture is primarily in relation to food safety and sustainable development (DeVries, 2002).” According

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to Rizov (2004) rural developmental policy - in the present Common Agricultural Policy - is closely tied to two concepts: "multicolor" (that is multifunctionality), and sustainability. These concepts are key in rural development. Renting et al. (2009) interpret the term similarly. According to them, considering future agriculture and rural development, multifunctional aspect is unavoidable. Besides food production, traditional agriculture has to provide such functions as manufacturing renewable energy sources, preserving the region and biodiversity, and contributing to the social-economy of the rural areas as well.

### Main stages of reinforcing the connection between agriculture and rural development

One of the goals of The Common Agricultural Policy (CAP) was to provide reasonable incomes for farmers, which was carried out by the support of the farmers, because of the low profitability of agriculture. Since in rural areas main source for living was agriculture, it became more and more intensive leading to overproduction of some commodities and to severe environmental damages in the resources of rural areas. In 1992, within the framework of the CAP reform, quotas tried to slow down overproduction and protect the environment by introducing set aside, extensive farming, and as an additional step, early retiring, forestation and aiding agro-environmental programs as well. In 1995, the European Council passed the European Charter for Regional Areas, in which rural functions (economic, ecological, social-cultural) in modern societies were declared. This document was an answer to the trends that had been generated by the depopulation of agricultural areas, overproduction and its consequence, the destruction of environment (CAP, 2002). The Declaration of Cork drafted the general principles of rural development in 10 principles. The supporters of this European document - those, who were present at the Cork conference - put into shape the importance of implanting rural developmental policy into the general development strategies (Cork Declaration, 1996). The conception of AGENDA 2000 agricultural policy gave a general idea of a new European agricultural model. Its main characteristics was a competitive agricultural sector, using environmental friendly methods, producing quality goods, which meets the demands of people. The model included the multi-colored agriculture, which had rich traditions, and more simple, understandable agricultural policy. The AGENDA 2000 supported the development of a truly multifunctional, sustainable, and competitive agriculture, which contributes to the support the future of those regions' that were straggling behind (Agenda, 1999). This was supported by the philosophy of the Common Agricultural and Rural Policy for Europe (CARPE), in which agricultural and rural policies were connected, and rural policy had a growing role. In the budget planned for 2000-2006, rural policy had its own budget in the chapter of Common Agricultural Policy (Saraceno, 2002). According to the traditional definition, the primary aim of agriculture was food production, agriculture needed various resources and its primary stage was rural life. The next step on the way was formulated on the basis of the multifunctional model of Ploeg and Roep (2003). They interpreted multifunctionality and suggested that the traditional concept of agriculture has to be broadened horizontally as well as vertically. Local innovations, the industry, small and medium-size enterprises, fostering traditions and culture all contribute to the broadening of the region's economic activities, and the role of communities and people who maintain these activities are essential. The environmentally conscious agriculture (ecological, organic farming) and the direct marketing of the goods produced locally, as well as the conformity to the changed consumer demands (environmentally conscious and healthy alimentation) is a deepening activity. Deepening and broadening makes the region such a complex economy, which leads into more markets and new services. Re-establishment is also necessary on the level of resources, which can mean more effective utilization of the already owned resources, and use of alternative raw materials. In these cases farmers have other jobs as well to establish a safe living (Ploeg and Roep, 2003; Bálint et al., 2007).

### Disadvantageous sub-regions and multifunctional agriculture

In Hungary distributions of disadvantageous sub-regions (Local administrative unit 1) were introduced by Faluvégi and Tipold (2007), who developed five index groups (economic, social, infrastructural, employment and welfare) and evaluated sub-regions considering 31 indexes. Based on these indexes 33 sub-regions got into the most disadvantageous category, which had to be aided by complex programs. These are rural regions and therefore have strong agricultural nature, so it is unavoidable to study the connection between rural development and agriculture. This study shows this connection by presenting the case study of an East-Hungarian sub-region, namely the sub-region of Sarkad. The disadvantageous situation of the sub-region of Sarkad is the result of a long process, which has been developed by the unfavorable outcomes of the change

of economic system in the region. The first element of the process happened when the big cooperative farms, which provided employment at a large scale, were eliminated, and most of the employees became unemployed. Unfortunately, most of these ex-agricultural workers could not become agricultural entrepreneurs, because of the lack of entrepreneur skills. Before the political transformation, natural conditions were not really considered when agricultural structures were developed, moreover this development usually damaged nature (intensive grain-program, turning up grasslands, terminating wetland habitat, simplified cropping structure, etc.). In spite of these past developments land use remained a real development alternative in the sub-region, because it is the biggest local resource. The productive land is considered as the base for rural life. Therefore land use systems still have strong effects on rural economy, society and culture. A recent study evaluated the potential of different land use systems in rural development by the multifunctional rural resource analysis method (Table 1).

**Table 1. The potentials of different land use systems in meeting different expectations from society for multifunctional agriculture and rural development**

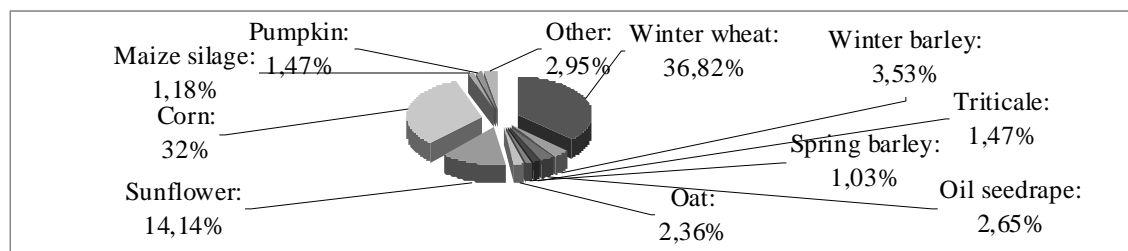
Land use system	% in productive land Hungary <sup>1</sup>	% in productive land Sarkad sub-region <sup>1</sup>	Potential in meeting different functions		
			Economical	Ecological	Social-cultural
Arable	58,3	69,5	*****	*/**	*
Garden	1,3	0,46	***	*	***
Fruit	1,3	0,11	***	*	**
Grape	1,2	0,07	***	*	****
Grassland	13,7	17,3	****	*****	****
Forrest	23,0	9,0	**	*****	***
Reed	0,8	0,65	*	***	*
Fishpond	0,4	2,98	***	***	***

Indications for potential: \* = low, \*\* = below average, \*\*\* = average, \*\*\*\* = above average, \*\*\*\*\* = outstanding  
Source: Nagy, 2007, <sup>1</sup>KSH, 2009

The results of this study may be applied for the Sarkad sub-region. The outstanding economic potential of arable lands in this disadvantageous sub-region is out of question for some reasons. The proportion of the arable lands among the existing land use systems is the biggest in the sub-region, crop farming has great tradition and relatively high technical level. However the potential for the ecological function in rural development is negligible due to the relatively intensive technologies applied. Year by year and mid-season soil cultivations, grains centered cropping structures, use of chemicals are clearly against biodiversity and habitat-protection. The socio-cultural potential of arable lands in rural development is below average as well. Due to mechanization in the past decade the employment capacity of arable farming is very moderate, and by now we can hardly find any cultural heritage or traditions that are connected to arable farming. According to the last statistical data the proportion of arable land in the sub-region is almost 70%, higher than the national average. Unfortunately the employment capacity of arable lands is very limited, due to the agricultural mechanization. The proportions of more labour intensive land use systems (vegetables, fruits and vineyards) unfortunately are below the national averages. The increase in these land use systems seem reasonable, mainly because of their social (employment) role and secondly of their cultural role (maintaining of cultural heritage connected to these land use systems). Labour-intensive land use systems provide better family incomes, in this way their economic function could become stronger as well. The proportion of grasslands in the sub-region is relatively high compared to the national average. Their economic potential is obvious, since they produce harvestable forage without any inputs. Their ecological potential is the highest due to the extensive farming practices. Their social potential in multifunctional rural development, regarding employment capacity, are limited, but we cannot disregard cultural values (ethnographic values, shepherd culture, welfare services), so their final evaluation in this respect is above average. Regarding forests, their regional proportion should be increased, both from ecological and social points of view, responding to the European forestation strategy. The fish-ponds have great traditions in the sub-region. Their proportion in land use is much higher than the national average. They belong to the wetland habitats, which have important ecological functions. Their economic potential in rural development may be increased by establishing primary processing facilities in the sweet water fish farms and the potential of social functions of fishponds could also be increased by making available fishing for a larger number of local people and tourists. The cropping structure of arable lands in the sub-region is shown in Graph 1. Crops represented are totally mechanized. Their employment capacity is very limited. An other problem in the sub-region that



processing industry for these products is missing from the sub-region, which has negative effects both on the employment and on the value added incomes of the sub-regional industry.



Graph 1. Cropping structure of the arable lands in the sub-region of Sarkad

Source: own research, 2010

Agriculture has got great attention in the mid-term development strategies of the sub-region for some reasons: to utilize social capabilities connected to agriculture, to improve the employment situation, to harden the local industry, to preserve the existing ecological values and to maintain the socio-cultural heritage from the past. To meet these objectives, measures that have to be taken include some key agricultural steps: to modify the cereal-centered cropping structure on arable lands, to enhance the labour intensive land use systems, to focus more intensively on local conditions in the development work. For this latter the Irish case study may be an international reference. The “Celtic tiger” went through an unbelievable development in the 1990s, which was based on local characteristics and traditions. The latter included sub-regional thinking, primarily tourism, local processing industry, local services, through the programmed development of agriculture.

## Conclusion

The relationship between agriculture and rural development can be described by the term multifunctionality. In the European Union this aspect is more and more prominent. In Hungary, however, instead of multifunctionality the production-centered traditions of agriculture still dominate. It is especially true for the most disadvantaged sub-regions in the country. Mid-term strategies of rural development in most sub-regions require more complex way of thinking. This new context include: more environment friendly and social centered land use and economic systems. The economic, ecological, and social-cultural functions of the sub-region investigated, can be strengthened in the future by changing the cropping structure of arable lands, by introducing more labour intensive agricultural crops and by enhancing the added value processing industry of the local commodities. Multifunctional agriculture and rural development will be successful if measures are based on existing local resources.

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# Defining primary selection criteria by the factor model

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## Abstract

One of important issues in plant breeding is a determination of interrelationships of traits for which selection is done. The trial was set up with 15 maize hybrids, in six locations, two sowing densities and during two years. The aim of the study was to establish if the same yield components had the crucial effect on the yield in different sowing densities. Two main factors belonging to the set of correlated yield components were extracted by the factor analysis in both sowing densities and they encompassed 60.6 and 60.9% of variability. They were in the highly significant correlation ( $p < 0.01$ ) with yield in both sowing densities (0.81 and 0.70 first factor and 0.28 and 0.44 second factor, respectively).

In the trial with a lower sowing density, the first factor (47.87% of the variance) was in the greatest correlation with plant height, ear height, ear length and number of kernels per row. In the trial with a higher sowing density, the first factor (47.91%), was in the greatest correlation with ear and cob diameters and grain moisture. Low estimates of the correlation for the number of kernel rows, concerning both factors and both sowing densities, point out that this trait does not share the same structure with the other yield components, and cannot be explained by the factor model. These results point out to the different selection criteria that should be favoured in breeding maize hybrids for various sowing densities.

Key words: factor analysis, correlation, selection criteria, yield components.

## Introduction

One of the most important issues in plant breeding is the determination of the interrelationships of traits for which selection is done. The form of the regression analysis that provides an introspective of direct and indirect effects, as well as, a proportion of co-effects (determination) of the independent variables ( $x_1, x_2, \dots, x_n$ ) on the dependent variable ( $y$ ) is a method of path coefficients (Wright, 1934). In the majority of studies including the path analysis, the researchers investigate the possibility of the variables of the first order to predict the effect of the dependent variable such as yield (Ivanović, 1983; Bekavac et al., 2002). The basic assumption while carrying out multiple regression is that yield components, i.e. traits used as predictor variables, are independent of each other. In reality, yield components are intricately interrelated, often leading to high multicollinearity. The conventional path analysis does not consider multicollinearity of independent variables (Samonte et al., 1998). Therefore, difficulties in the interpretation of results of actual participation of each variable can occur (Hair et al., 1995). Samonte et al. (1998) adapted the sequential path analysis for determining the interrelationships among grain yield and yield components in rice by organising and analysing various predictor variables in the first, second and the third order paths. Different factors can affect associations among yield components, including the germplasm used, various environments and the statistical analysis employed to define associations among observed variables. Mohammadi et al. (2003) considered that this sequential path model showed advantages over the conventional path model in analysing the associations between yield and yield components, with special attention on the analysis of collinearity of various predictor variables and analysing their predictive value of the model.

Peterson and Pfeiffer (1989) stated that the factor analysis can be used with the aim to better understand the background of the yield structure and relationships between yield components and morphological traits of

plants. The objective of the study was to define several basic, important factors that mostly determine the yield by the application of the factor model. The trials were set up in two different densities in order to establish whether the same yield components had the same effects in different densities. By the identification of components that affect yield to a greater extent, their importance, as breeding criteria in the process of breeding and selection of superior genotypes, is emphasised.

### Materials and methods

The following 15 commercial maize hybrids of different FAO maturity (FAO 400-700) were included into trials: ZP-42a, ZP-480, check-500, ZP-533, ZP-599, ZP-570, ZP-580, ZP-633, ZP-677, ZP-704, ZP-701, ZP-753, ZP-732, ZP-735 and check-600. The two-year four-replicate trials were set up according to the randomised-complete block design in two densities (D1=54.9000 plants ha<sup>-1</sup> and D2=64.900 plants ha<sup>-1</sup>) and six locations.

The following traits were analysed in the present study:

- Grain yield (kg ha<sup>-1</sup>)
- Yield components: number of kernel rows, number of kernels per row, ear length (cm), ear diameter (cm), cob diameter (mm), moisture content at harvest (%).
- Morphological traits: plant height (cm), ear height (cm).

Ten plants of each replication were used for the analysis of morphological traits, while 10 ears per replication were used for determining yield components.

The degree of compatibility between two traits was determined by simple correlations, and the factor analysis was applied to yield components and measured morphological traits, in order to establish their common structure.

### Results and discussion

Results of simple correlations point out that plant height, ear height, ear length, ear diameter, cob diameter, number of kernel rows and number of kernels per row are statistically highly significantly correlated with yield ( $p < 0.01$ ), while grain moisture is statistically significantly correlated with yield ( $p < 0.05$ ) (Tab. 1).

Table 1. Pearson's correlations of observed traits

	Plant height	Ear height	Ear length	Ear diameter	Cob diameter	No. of kernel rows	No. of kernels per row	Grain yield	Moisture
Plant height	1.00								
Ear height	0.94**	1.00							
Ear length	0.63**	0.58**	1.00						
Ear diameter	0.82**	0.68**	0.62**	1.00					
Cob diameter	0.67**	0.52**	0.48**	0.83**	1.00				
No. of kernel rows	0.42**	0.47**	0.22**	0.25**	0.39**	1.00			
No. of kernels per row	0.46**	0.50**	0.60**	0.32**	0.24**	0.33**	1.00		
Yield	0.82**	0.76**	0.62**	0.77**	0.52**	0.21**	0.48**	1.00	
Moisture	0.36**	0.18**	0.07	0.50**	0.61**	0.19**	-0.17**	0.12*	1.00

Since observed traits are interrelated, the factor analysis was applied in order to reduce data, remove the effect of multicollinearity and by that to make a result interpretation easier. This analysis provides defining a lower number of hidden factors that reflect a common structure of observed traits. Prior to the application of the factor analysis it is necessary to test the adequacy of data set for a given analysis. The values of Kaiser-Meyer-Olkin (KMO) (0.749) and Bartlett's test of sphericity ( $p < 0.01$ ) indicate that the factor model can be applied.

Two main factors were extracted out of eight observed traits and they encompassed 60.65% and 60.92% of total variability for the first and the second density, respectively. In such a way a problem of multicollinearity

## Defining primary selection criteria by the factor model

with a great number of yield components was avoided and this number was minimised to two main factors that were not correlated. (Tab. 2).

**Table 2. Total variance explained by the factor model**

D1			D2		
Extraction of sum of squared loadings			Extraction of sum of squared loadings		
Eigenvalues	% of variance	Cumulative%	Eigenvalues	% of variance	Cumulative%
3.83	47.87	47.87	3.833	47.91	47.91
1.02	12.77	60.65	1.041	13.01	60.92

Due to the existence of the common structure of yield components, variability of each component individually can be partially explained with remaining variables. For instance, the plant height can be explained with 90.6% and 92.1% of other yield components, while the explanation of the number of kernel rows with other traits is small (32.5% and 30.9%). Variability of traits plant height and ear height, as well as, of observed yield components was to a satisfactory extent encompassed by two extracted factors (52.3-81.6% of their variance) except for the number of kernel rows whose variability was encompassed with only 19.6% and 16.9%, which explicitly indicate that this trait does not share a common structure with remaining yield components (Tab. 3).

**Table 3. Common structure of the observed traits**

Yield components	D1		D2	
	Initial	Extraction	Initial	Extraction
Plant height	0.906	0.816	0.921	0.786
Ear height	0.865	0.628	0.895	0.622
Ear length	0.583	0.561	0.635	0.645
Ear diameter	0.753	0.755	0.816	0.805
Cob diameter	0.712	0.740	0.719	0.681
Number of kernel rows	0.325	0.196	0.309	0.169
Number of kernels per row	0.464	0.528	0.546	0.658
Moisture	0.493	0.627	0.428	0.508

**Table 4. Rotated factor matrix**

Yield components	D1		D2	
	Factor 1	Factor 2	Factor 1	Factor 2
Plant height	0.724	0.540	0.691	0.556
Ear height	0.729	0.311	0.554	0.562
Ear length	0.719	0.210	0.210	0.775
Ear diameter	0.530	0.688	0.765	0.469
Cob diameter	0.428	0.746	0.778	0.274
Number of kernel rows	0.385	0.219	0.321	0.256
Number of kernels per row	0.713	-0.141	0.023	0.811
Moisture	-0.076	0.788	0.681	-0.211

It is observable that the results of the factor analysis over densities are very similar to already presented parameters. Behind eight observed yield components there are two main factors determining the yield of studied maize hybrids. In the lower density trial, the yield is statistically significantly correlated ( $p < 0.01$ ) with the first two factors (0.81 and 0.28). On the other hand, in the higher density trial, correlations between the yield and factor scores of the first two factors are 0.70 and 0.44, respectively, and they are statistically significant ( $p < 0.01$ ).

Since two main factors are extracted, the key issue is to what extent certain components of yield are included into their formation. In order to easily interpret correlations between yield components and extracted factors, the rotation of factor axes was done after method Varimax with Kaiser Normalisation. In the first density, the first factor that encompasses 47.87% (Tab. 3) of the variability is in the greatest correlation with the plant height, ear height, ear length and the number of kernels per row (0.724, 0.729, 0.719 and 0.713, respectively). The second factor encompassing 12.77% of the variability is in the greatest correlation with ear

diameter, cob diameter and grain moisture (0.688, 0.746 and 0.788, respectively). In the trial with a higher density, the first factor encompassing 47.91% of the variability is in the greatest correlation with ear diameter, cob diameter and grain moisture (0.765, 0.778 and 0.681, respectively), while the second factor encompassing 13.01% of the variability is in the greatest correlation with ear length and the number of kernels per row (0.775 and 0.811, respectively) (Tab. 4).

The effect of various yield components on achieved yields over different sowing densities is especially expressed in this part of the analysis. Although applied densities are not extreme ones, but those usually recommended (54 900 and 64 900 plants ha<sup>-1</sup>) for sowing of studied maize hybrids it is observable that plant height, ear height, ear length and the number of kernels per row had a greater effect in the trial with a lower sowing density, while ear and cob diameter, as well as, grain moisture had a crucial effect in the trial with a higher sowing density. In this case, plant height and ear height equally participate in the formation of both factors and therefore their significance as a breeding criterion for the selection of genotypes to be grown in higher densities is reduced. The number of kernel rows is in small correlations with both factors over both densities and it points out that this trait does not share the common structure with the remaining yield components.

### Conclusion

Multicollinearity of independent variables can provide false performance and can mask the actual significance of a certain variable or can overvalue some other variable. The factor analysis solves the problem of multicollinearity of observed yield components, hence two main factors determining yields of studied maize hybrids are extracted.

Different yield components affect the formation of factor axes in various sowing densities. Such a result point out to different breeding criteria that should be applied in the selection process of hybrids intended for diverse sowing densities. Ear length, number of kernels per row and robustness-plant height are more important for smaller sowing densities, while ear and cob diameters, as well as, grain moisture are more important for greater sowing densities. Plant height is not crucial trait for greater sowing densities.

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# Rank correlation coefficients among agronomic traits of maize

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## Abstract

The Spearman's rank correlation coefficient among agronomic traits of maize hybrids of different FAO maturity groups was calculated. The performance index (PI) in hybrids of all FAO maturity groups was highly significantly positively, i.e. negatively correlated with yield ( $t\ ha^{-1}$ ), i.e. moisture% at harvest, respectively. The yield of hybrids belonging to FAO 100-200 and 700-800 positively correlated with the plant height and the ear height at the 0.05 probability level, while the yield of tropical hybrids (belonging to the latest FAO maturity group) highly positively correlated with the plant height ( $P=0.001$ ). The yield of white-kernel tropical hybrids highly significantly correlated with the ear height, while this was not a case with yellow-kernel hybrids of this type.

Key words: agronomic traits, maize (*Zea mays* L.), Spearman's rank correlation coefficient

## Introduction

The correlation coefficient is a measure of interdependence of two random variables, while the Spearman's rank correlation coefficient is a non-parametric measure of statistical dependence between two variables. It assesses how well the relationship between two variables can be described using a monotonic function. The Spearman's correlation coefficient is often thought of as being the Pearson's correlation coefficient between the ranked variables, and is used instead of Pearson's coefficient when observed data that did not have normal distribution.

Knowing about correlations among different traits of maize hybrids is one of the prerequisites for efficient selection aimed at high and stable yield. Selection based on grain yield alone proved to be incomplete and insufficiently efficient. Namely, selection for yield components in maize proved to be a reliable criterion for selection (Muhammad et al., 2003). The development of desirable genotypes should be carefully planned and be based on the type of impacts that each of observed traits has on the yield.

Many researchers studied the correlation between the yield and agronomic traits. Arias et al. (1999) concluded that the direct and the indirect correlation between the ear weight and the plant/ear height varied in relation to the observed progeny. The plant height and ear height are strongly correlated with the yield (Martin and Russell, 1984; Burak and Magoya, 1991; Singh and Dash, 2000; Umakanth et al, 2000; Mohammad et al, 2003). On the other hand, Rather et al. (1999) did not establish a statistically significant correlation between the plant height and the grain yield. The ear height, length and diameter are positively correlated with the grain yield (Burak and Magoja, 1990; Malvar et al., 1994; Khatun et al., 1999; Singha and Prodhan, 2000), but they are negatively correlated with the kernel weight (Martin and Russell, 1984). Orlyian et al. (1999) and Gautam et al. (1999) found out that the number of kernels per row, number of kernels per ear and the ear height were the most important traits in maize grain yield improving, while according to Mohammad et al. (2003) in addition to these traits, the ear diameter and the 1000-kernel weight are also important traits for the yield improvement. Neto and Filho (2001) established that the correlation between the plant height and the ear height was the strongest correlation.

The objective of the present study was to determine the interrelationship among six maize traits (plant height, ear height, grain moisture (%) at harvest, cob%, yield ( $t\ ha^{-1}$  at 14% moisture) and performance index

(PI) in 524 genotypes that belong to different FAO maturity groups (100-900). By the obtained correlation among observed traits, it is possible to establish the traits that, if selection is carried out for them, could result in the increase of grain yield.

### Materials and methods

The trial was set up in the experimental field of the Maize Research Institute, Zemun Polje in 2010 with 524 maize genotypes, 453 single crosses and 71 three way cross hybrids, out of which 128 genotypes had been developed by crossing lines of tropical and moderate germplasm (the latest FAO maturity group). The trial was mechanically sown and standard cropping practices were applied in order to phenotypically evaluate derived combinations. The plot length was 3.4 m, plant spacing between plants in a row was 0.2 m, while row spacing amounted to 0.75 m. In order to obtain the optimum number of plants, they were sown in a higher density and then thinned to 18 plants per plot.

The following traits were measured: plant height, ear height, moisture percentage at harvest, cob percentage, grain yield (t ha<sup>-1</sup> at 14% moisture) and performance index (PI) of the observed hybrids. The sample of six ears was drawn from each of studied hybrids and they were used for measuring moisture and cob percentages. These traits were analysed in a laboratory on a harvest day. The grain yield in t ha<sup>-1</sup> at 14% moisture was calculated according to the following formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{10}{Pa} \times Pw \times \frac{Sw - Cw}{Sw} \times \frac{100 - Sm}{86}$$

Where Pa=plot area (m<sup>2</sup>), Pw=grain yield from a plot (kg), Sw=sample weight (kg), Cw=cob weight of ear samples (kg) and Sm=grain sample moisture at harvest (%).

The performance index is a very useful parameter in hybrid selection and it was estimated according to the following formula:

$$PI = \frac{HY \times \text{St. moist.}}{\text{StY} \times H. \text{moist.}}$$

Where HY=hybrid yield (t ha<sup>-1</sup>), StY=standard hybrid yield (t ha<sup>-1</sup>) (check hybrid of desirable traits), H. moist.=hybrid grain moisture at harvest (%) and St. moist.=standard grain moisture at harvest (%).

The Spearman's rank correlation coefficient is used instead of the Pearson's correlation coefficient because there were no genetic relationships among hybrids. The rank correlation coefficients ( $r_s$ ), as well as, the t value of the correlation significance were estimated in the following manner:

$$r_s = 1 - \frac{6 \sum_{i=1}^N d_i^2}{N^3 - N} \quad t = r_s \times \sqrt{\frac{N-2}{1-r_s^2}}$$

Where N is a number of paired variables X and Y;  $d_i=r(x_i)-r(y_i)$  is a difference between the ranks of variables X and Y (traits X and Y for a particular hybrid).

The Spearman's rank correlation coefficient can have values in the following interval:  $-1 \leq |r_s| \leq 1$ ; when  $|r_s| < 0.3$  correlation is weak;  $0.3 < |r_s| < 0.6$  correlation is medium strong and when  $|r_s| > 0.6$  correlation is strong.

Complete statistical calculations were performed by the Microsoft Office Excel 2003.

According to obtained results the plant height and the ear height for all observed FAO maturity groups were highly positively correlated ( $P_{0.001}$ ), which was in accordance with results gained by Neto et al. (2001). According to Singha and Prodan (2000), Burak and Magoja (1990), as well as, Umakanth et al. (2000), the grain yield and the plant height were significantly correlated. This was also a case with our observed hybrids of FAO 100-200, 700-800 and tropical hybrids in which these two traits positively correlated at the  $P_{0.001}$ , while these correlation was positive but not significant in hybrids of FAO 300-400 and FAO 500-600, which was in accordance with results obtained by Rather et al. (1999). The ear height and the grain yield were positively significantly correlated in hybrids of FAO 100-200, FAO 700-800 (significantly at the  $P_{0.05}$ ), and in tropical white kernel hybrids ( $P_{0.001}$ ), which confirmed results gained by Burak and Magoja (1991), Malvar et al. (1994), Khatun et al. (1999) and Singha and Prodan (2000). This correlation was positively insignificant for hybrids of FAO 300-600 and negative, but insignificant in tropical yellow-kernel hybrids. This is an aggravating circumstance in maize hybrid selection, because these hybrids are selected for a high plant height and a low ear height (in order to mitigate a risk of stalk lodging), hence these two correlations (plant

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height/ear height, i.e. grain yield/ear height) should be broken in the process of selection. The relationship between the grain yield and moisture at harvest is also interesting. Sotchenko (2000) established a positive, but insignificant, correlation between these two traits. However, our results differed in relation to the observed FAO maturity group. The rank correlation coefficient of these two traits in hybrids of FAO 100-200, FAO 300-400, FAO 500-600 and tropical yellow-kernel hybrids was in accordance with results obtained by Sotchenko et al. (2000), but this correlation was negative in hybrids of FAO 700-800 and white-kernel tropical hybrids. Furthermore, this correlation in hybrids of FAO 700-800 was at the  $P_{0.05}$ , where  $r_s$  was 0.553 (Tab. 2). This is of particular interest for the applied breeding programmes, because it shows possibility to create hybrids with high yield and low grain moisture at harvest (high dry down). Since the used plant material for this research are highly selected hybrids, obtained correlation is not an unexpected one, because selection of this hybrids was for years based on a performance index (PI) calculated considering these two traits. All this goes in favour of selection based on some kind of indexes. The moisture percentage at harvest and the cob percentage had a positive correlation in hybrids of all FAO maturity groups, but this correlation was not significant only in hybrids belonging to FAO 300-400 and 700-800. Based on obtained data it cannot be affirmed that the cob percentage and the grain yield were correlated. As expected, the performance index was significantly positively, i.e. highly negatively correlated with the grain yield, i.e. the moisture percentage, respectively, in hybrids of all observed FAO maturity groups, though this correlation was a somewhat less significant in tropical genotypes. Although the grain yield did not correlated with the cob percentage, the PI was negatively correlated with the cob percentage, and this correlation was significant in hybrids of FAO 300-400 ( $P_{0.05}$ ) and FAO 500-600 ( $P_{0.01}$ ). According to the formula for the PI estimation, this index was inversely proportional to hybrid moisture at harvest, which, on the other hand, was positively correlated with the cob percentage, hence that was the source of this interrelationship.

## Results and discussion

**Table 1. Spearman's rank correlation coefficients among observed traits of hybrids belonging to FAO maturity group 100-200 (above diagonal) and FAO maturity group 300-400 (below diagonal) (PH=plant height, EH=ear height, C%=cob% at harvest, M%=grain moisture% at harvest, GY=grain yield t ha<sup>-1</sup>, PI=performance index)**

100-200	PH	EH	C%	M%	GY	PI
PH	1	0.483***	-0.095ns	0.098ns	0.468***	0.255*
EH	0.462***	1	-0.055ns	0.122ns	0.248*	0.098ns
C%	0.039ns	0.141ns	1	0.447***	0.181ns	-0.179ns
M%	0.052ns	-0.025ns	0.143ns	1	0.233ns	-0.619***
GY	0.215ns	0.086ns	-0.191ns	0.155ns	1	0.523***
PI	0.117ns	0.097ns	-0.275*	-0.52***	0.706***	300-400

\*\*\* - significant at the 0.001 probability level; \* - significant at the 0.05 probability level; ns - insignificant.

**Table 2. Spearman's rank correlation coefficients among observed traits of hybrids belonging to FAO maturity group 500-600 (above diagonal) and FAO maturity group 700-800 (below diagonal) (PH=plant height, EH=ear height, C%=cob% at harvest, M%=grain moisture% at harvest, GY=grain yield t ha<sup>-1</sup>, PI=performance index)**

500-600	PH	EH	C%	M%	GY	PI
PH	1	0.635***	0.226***	0.165*	0.075ns	-0.085ns
EH	0.604***	1	0.165*	0.225***	-0.011ns	-0.165*
C%	-0.041ns	0.164ns	1	0.418***	0.034ns	-0.249**
M%	0.027ns	0.027ns	0.027ns	1	0.051ns	-0.598***
GY	0.586**	0.421*	-0.228ns	-0.553**	1	0.732***
PI	0.475*	0.307ns	-0.258ns	-0.744***	0.954***	700-800

\*\*\* - significant at the 0.001 probability level; \*\* - significant at the 0.01 probability level; \* - significant at the 0.05 probability level; ns - insignificant.

**Table 3. Spearman's rank correlation coefficients among observed traits of hybrids developed from crosses of tropical and moderate germplasm with yellow [Tr×Te.y. (above diagonal)] and white (Tr×Te.w. (below diagonal)] kernels (PH=plant height, EH=ear height, C%=cob% at harvest, M%=grain moisture% at harvest, GY=grain yield t ha<sup>-1</sup>, PI=performance index)**

Tr×Te.y.	PH	EH	C%	M%	GY	PI
PH	1	0,729***	0.15ns	0.255*	0.379***	0.042ns
EH	0.73***	1	0.253*	0.387***	0.159ns	-0.149ns
C%	-0.014ns	0.121ns	1	0.32**	0.06ns	-0.069ns
M%	0.065ns	0.161ns	0.308*	1	0.037ns	-0.294*
GY	0.588***	0.471***	-0.026ns	-0.021ns	1	0,277*
PI	0.51***	0.407***	-0.08ns	-0.283*	0.929***	Tr×Te.w.

\*\*\* - significant at the 0.001 probability level; \*\* - significant at the 0.01 probability level; \* - significant at the 0.05 probability level; ns - insignificant.

### Conclusions

The development of desirable genotypes with high and stable yields is the aim of the selection programme of any crop. Knowledge about interrelationships of different agronomic traits, especially the grain yield, is essential for successful selection of maize hybrids. In such a way, traits whose selection can indirectly affect the yield increase can be determined, since selection based on grain yield alone proved insufficient. Also, correlation shows how selection on some traits influences other, correlated traits (i.e. correlated response on selection).

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# Comparative analysis of maize hybrids based on chemical quality and grain yield

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## Abstract

The aim of this study was comparison of chemical composition and grain yield of 15 maize hybrids. One year field research at two locations in Serbia were conducted. Hybrids differed in grain yield and grain quality. The protein content ranged from 9.37 (ZP362) to 11.5%, (ZP666), averaged 10.10%. The starch content was between 79.26% (ZP341) and 81.22% (ZP677), averaged 80.31%. The oil content varied from 3.98% (ZP600) to 5.12% (ZP505), averaged 4.51%. Hybrids ZP666 had the highest protein content and in same time the second lowest starch content. The hybrids from FAO600 had the highest grain yield, high starch content and the low oil content. The grain yield was significant positive correlated with starch content ( $r=0.51^*$ ), and negatively correlated with oil content ( $r=-0.29$ ).

Key words: maize, hybrids, oil, protein, starch, yield

## Introduction

The majority of maize production is used for animal feed but an important fraction is used for food, seed, and industrial purposes, which are functions of grain quality. The three major components of a grain of maize are starch, protein, and oil. On dry weight basis, a typical hybrid contains approximately 4% oil, 9% protein, 73% starch, and 14% of other constituents (Clark et al., 2006). Kernels quality depends on outward factors influenced by the environment, weather, soils, temperature, rainfall as well as the management technology used during crop growth and development aimed to obtain economically sustainable yielding (Thomison et al., 2004, Fabijanac et al., 2006, Zeidan et al., 2006, Radosavljević and Milašinović, 2008, Harrelson et al., 2007, Idikut et al., 2009, Raymond et al., 2009). The genetic background undoubtedly influence chemical quality of maize hybrids and may be modified in profit of the chemical constitution and so achieve new germplasm with excellent attributes related to industrialization and nutritional value. Development of maize with unique grain quality traits, however, has not received the same emphasis in genetics, breeding, and economics as higher yield and agronomic performance (Hallauer, 2001, Scott et al., 2006). The aim of this study was comparison of chemical composition and grain yield of ZP maize hybrids and identification of hybrids that can be used for specific purpose.

## Materials and methods

Fifteen hybrids from Maize Research Institute Zemun Polje, belonged to the various maturity groups from FAO 300 (ZP341, ZP362), FAO 400 (ZP427, ZP471), FAO 500 (ZP505, ZP555, ZP560), FAO 600 (ZP600, ZP606, ZP666, ZP677, ZP684), FAO700 (ZP718b, ZP730 ZP789) was studied. An experiment was set up in randomized block design with two replications at two experimental locations of MRI in Serbia, Zemun Polje and Krnjesevci, during 2010. Both locations were sowed in the first half of April (12.4 and 13.4, respectively), plant density was 67000 plant ha<sup>-1</sup> and applied mineral fertilization: 90 kg P and K in fall, 120 kg N in spring. Each experimental plot was 4 m long by 3 m wide (four rows). Each row consisted of 20 plants. All ears were harvested from the two center rows of each plot, and grain yield (kg ha<sup>-1</sup> adjusted to 14% grain moisture) was measured. A two sub-sample of 100 g of grain collected from every plot in all environments was used to

measure grain quality and their results were averaged to obtain the final values. Grain oil, protein, and starch concentrations were measured as percentage using Infratec 1241 Grain analyzer, (Foss Tecator, Sweden) and reported on a zero percent moisture basis (% d.m). The simple correlation coefficient among the different chemical components and grain yield was estimated.

## Results and discussion

The Tab. 1 summarizes the chemical composition of 15 ZP hybrids. Maize as the other cereal crops is relatively poor in grain protein content as usually varies from 8.0 to 11.0% according to FAO reports. In general, maize protein content varies according to genotype (Lorenz et al., 2007, Drinic Mladenovic et al., 2009). The protein content of 15 ZP hybrids across locations ranged from 9.37 (ZP362) to 11.5% d.m, (ZP666) (Tab. 1.). The average protein content was 10.10% d.m, compared to typical hybrid protein contain of approximately 9% (Clark et al., 2006). Hybrid ZP666 (FAO600) had the highest protein content in both location, 10.87% and 11.44%, respectively. The lowest protein content in both locations had hybrid ZP362 (FAO300), 9.26% and 9.45%, respectively. The avaraged protein content were different between location, 9.84 and 10.36% d.m, respectively. Obtained results is agreement with findings of Corcuera et al. (2004), that protein content of 72 maize hybrids varied form 8.2 to 12.6%, average 10.5%. Seven hybrids had higer protein content than average. Hybrids from FAO 600 had the highest average protein content, 10.50% d.m and from FAO 400 the lowest one 9.68% d.m. Kernal protein content is affected by rainfall distribution and mineral nutrition. In this study all hybrids were under the same mineral nutrition conditions, but hybrids from midle-late group (FAO 500 and 600) showed higher protein content related to hybrids from another FAO groups due to favorable rainfall distribution during kernal filling.

The starch is the largest single components in maize grain and the primary energy source. The starch content of ZP hybrids ranged from 79.26% d.m (ZP341) to 81.22% d.m (ZP677), averaged 80.31% d.m (Tab. 1). This result is in agreement with findings of Drinic Mladenovic et al. (2009). Eight ZP hybrids had starch content higher than average. Hybrid ZP341 had the lowest starch content 77.17% d.m and hybrid ZP606 the highest one, 79.25% d.m at location 1. The starch content in location 2 averanging 82.24% compared to 78.38% in location 1. All hybrids had higer starch content in location 2. The highest starch content had hybrids from FAO700, average 80.79% d.m Hybrids of FAO 600 and 700 have a longer vegetation period and more intense carbohydrate accumulation. Hybrids ZP 789, ZP 606 and ZP 600, with high starch content, are with one common parent from Lancaster germplasm, which is also genetically similar to the male component of hybrid ZP 677.

Hybrids had oil content between 3.98% (ZP600) and 5.12% (ZP505) (Tab. 1). The average oil content of ZP hybrids (4.51% d.m), represent somewhat higher oil content compared to typical maize hybrids (Clark et al., 2006.) The averaged oil content was higher in location 1, 4.55% compared to location 2, 4.47% d.m. Hybrid ZP600 had the second lowest oil content in location 1 and the lowest in location 2, as well in both location. Hybrid ZP505 had the higher oil content in both locations. This result is consistent with findings of Radosavljevic and Milašinović (2008). Corcuera et al. (2004), obtained little higher values for oil content in maize hybrids, from 3.52 to 6.41%, average 5.24%. Two genetically similar FAO 500 hybrids parental lines from Lancaster germplasm, have high oil content and as such are donors of benefitial alleles.

The grain yield ranged from 7730 kg ha<sup>-1</sup> to 12970 kg ha<sup>-1</sup>, averaged 11570 kg ha<sup>-1</sup> at location 1. At location 2 grain yield varied from 8930 kg ha<sup>-1</sup> to 13580 kg ha<sup>-1</sup>, averaged 11780 kg ha<sup>-1</sup>. The grain yield across locations varied between 8330 kg ha<sup>-1</sup> (ZP471, FAO400) to 13010 kg ha<sup>-1</sup> (ZP600, FAO600), averaged 11670 kg ha<sup>-1</sup> (Tab. 2.). This result is in agreement with findings of Raymond et al. (2009) who found that grain yield for maize ranged from 7001-16134 kg ha<sup>-1</sup>. The highest grain yield had hybrids from FAO 600, 12520 kg ha<sup>-1</sup> and the lowest hybrids from FAO 400, 9350 kg ha<sup>-1</sup>. Nine hybrids had higher grain yield than average. Enviroment had significant effect on all traits except oil content but GxE interactions were not significant for any of the studied traits (data not presented).

The starch yield ranged from 6606.03 kg ha<sup>-1</sup> to 10538.42 kg ha<sup>-1</sup> (Tab. 2). The protein yield ranged from 826.11 to 1407.31 kg ha<sup>-1</sup> and oil yield from 374.56 to 619.28 kg ha<sup>-1</sup>.

Table 1. Average protein, oil and starch content of ZP hybrids from two location

Hybrids	Protein content,% d.m	Oil content,% d.m	Starch content,% d.m
ZP341	10.21 bcde	4.50 cde	79.26 f
ZP362	9.37 f	4.07 fg	80.02 bcdef
ZP427	9.44 f	4.54 bcde	79.79 def
ZP471	9.92 cdef	4.50 cde	79.30 f
ZP505	9.76 def	5.12 a	79.88 cdef
ZP555	10.47 abcd	4.88 abc	80.14 abcdef
ZP560	10.47 abcd	4.57 bcde	80.40 abcdef
ZP600	10.07 cdef	3.98 g	81.02 abc
ZP606	10.80 ab	4.08 fg	81.04 ab
ZP666	11.15 a	4.91 ab	79.47 ef
ZP677	10.56 abc	4.41 def	81.22 a
ZP684	9.89 cdef	4.21 efg	80.71 abc
ZP718b	9.78 def	4.82 abc	80.52 abcde
ZP730	10.05 cdef	4.78 abcd	80.85 abcd
ZP789	9.54 ef	4.27 efg	81.00 abc
SEM	0.1110	0.0340	0.2850
LSD	0.715	0.395	1.145

<sup>a-g</sup> column means with common superscripts do not differs ( $p>0.05$ ), SEM standard error mean

Table 2. Average grain yield, protein, oil and starch yield of maize hybrids from two location

Hybrids	Grain yield, kg ha <sup>-1</sup>	Protein yield, kg ha <sup>-1</sup>	Oil yield, kg ha <sup>-1</sup>	Starch yield, kg ha <sup>-1</sup>
ZP341	11450 ab	1168.94 bcde	514.73 ab	9075.99 abcd
ZP362	12240 ab	1146.26 bcde	497.48 ab	9791.59 abcd
ZP427	10360 b	978.22 ef	470.25 bc	8267.77 d
ZP471	8330 c	826.10 f	374.56 c	6606.02 e
ZP505	11260 ab	1099.39 de	576.58 ab	8994.94 bcde
ZP555	12060 ab	1262.32 abcd	587.99 a	9661.28 abcd
ZP560	12190 ab	1276.56 abc	556.70 ab	9802.50 abc
ZP600	13010 a	1310.10 abc	517.20 ab	10538.42 a
ZP606	11700 ab	1263.20 abcd	477.42 abc	9481.55 abc
ZP666	12620 a	1407.31 a	619.27 ab	10027.02 abc
ZP677	12670 a	1338.18 ab	558.34 ab	10291.04 ab
ZP684	12600 a	1246.81 abcd	530.75 ab	10172.40 b
ZP718b	11360 ab	1111.64 cde	548.11 ab	9149.43 abcd
ZP730	10560 b	1061.57 de	504.91 ab	8541.62 bcd
ZP789	12700 a	1211.08 abcd	542.26 ab	10283.57 ab
SEM	7830	9888	2774	5044
LSD	1898	213.3	113.0	1523

<sup>a-e</sup> column means with common superscripts do not differs ( $p>0.05$ ), SEM standard error mean

The correlation coefficients among oil, starch, protein content and grain yield were calculated. There is not a significant association between oil and protein content ( $r=0.17$ ) although negative and middle correlation were found between oil and starch content ( $r= -0.42$ ) similarly to reported by Wassoma et al. (2008). No correlation was observed between protein and starch ( $r=0.04$ ). The correlation between grain yield and protein content was middle and positive ( $r=0.27$ ) and with protien yield significant ( $r=0.63^{**}$ ). The grain yield was significant positive correlated with starch content ( $r=0.51^{*}$ ), and negatively correlated with oil content ( $r=-0.29$ ). The positive significant correlations between grain yield and starch are in agreement with findings of Dorsey-Redding et al. (1991) and White and Johnson (2003).

### Conclusion

Our results indicate the importance of testing corn hybrids in terms of chemical composition on the basis of which hybrids can be used for a particular purpose. Many of hybrids tested show good grain quality based on their oil, protein and starch content, which makes them more than suitable to be used for animal and human feed or as industrial staples. The starch content is important criterion in the maize based alcohol production

so, hybrids ZP 789, ZP 606 and ZP600 will be further tested for that purpose, as well as the hybrids with high protein (ZP666) and oil content (ZP505) for animal nutrition.

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# Varijabilnost svojstava klipa kod domaćih populacija kukuruza

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## Sažetak

Uvođenjem hibridnog kukuruza u poljoprivrednu proizvodnju nakon II. Svjetskog rata došlo je do zanemarivanja lokalnih populacija i stranooplođnih kultivara kukuruza. Današnji visokoprinosni hibridi kukuruza nastali po inbred linija-hibrid konceptu često su genetski vrlo slični jer se u oplemenjivačkom postupku u pravilu koristi isti ili vrlo sličan početni elitni materijal. Zanemarene lokalne populacije kukuruza su zbog široke genetske varijabilnosti često bolje prilagođene biotskim ili abiotskim stresovima, ili manje intenzivnim uvjetima proizvodnje od hibrida. Iz tog razloga sakupljanje i proučavanje populacija kukuruza kao potencijalno vrijedne germplazme može biti od koristi u oplemenjivanju kukuruza. Cilj ovog rada je usporediti varijabilnost svojstava klipa unutar i između domaćih populacija kukuruza sakupljenih na više lokacija širom Hrvatske. Od svojstava analizirani su duljina i promjer klipa, broj redova zrna na klipu, masa klipa i masa okrunjenog zrna po klipu, postotak krunjenja te omjer duljine i širine klipa. Između populacija sakupljenih sa područja Dalmacije i kontinentalne Hrvatske uočeno je variranje svojstava u širokom rasponu. Najveću varijabilnost u obje regije imale su masa klipa i masa zrna, a najmanju postotak krunjenja. Rezultati rada upućuju da domaće populacije kukuruza predstavljaju važnu zalihu genetske varijabilnosti. Neke od proučavanih populacija mogle bi biti zanimljiv materijal za oplemenjivački razvoj hibrida prilagođenih lokalnim proizvodnim uvjetima.

Ključne riječi: kukuruz, domaće populacije, genetska varijabilnost, svojstva klipa

## Ear traits variability of Croatian maize landraces

### Abstract

After the World War II, release and spread of maize hybrids led to loss of many maize local landraces and cross-pollinated varieties. Presently grown maize hybrids developed under the inbred line-hybrid concept are genetically very similar because of the utilization of common parental elite material in breeding procedures. Local maize landraces are because of their high genetic variability well adapted to biotic and abiotic stresses and extensive production conditions. Therefore, collecting and characterization of local maize landraces as potentially valuable germplasm for maize breeding is important. The purpose of this paper is to compare ear trait variability among and within Croatian maize landraces collected at several locations thorough Croatia. Analyzed traits were ear length and diameter, kernel row number, ear weight, grain weight per ear, percent of shelled grain and ear length-diameter ratio. Between the landraces from Dalmatia and continental region of Croatia, high trait variation was observed. At both regions the largest variability was observed for ear and grain weight and lowest for percentage of shelled grain. Results indicate that domestic maize landraces represent important

maize gene pool. Some of the studied landraces could be interesting material for production of hybrids adapted to local production conditions.

Key words: maize, domestic populations, genetic variability, cob traits

## Uvod

Stranooplodni kultivari i udomaćene populacije te međusortni križanci kukuruza uzgajani su na području Hrvatske sve do perioda nakon Drugog svjetskog rata. U to vrijeme dolazi do uvođenja američkih hibrida u poljoprivrednu proizvodnju i do korištenja američkih inbred linija u domaćim oplemenjivačkim programima kukuruza (Rojc i Kozumplik, 1996).

Proširenjem hibrida u proizvodnji, domaće stranooplodne sorte i populacije kukuruza koje su prošle dug period prilagodbe našim agroekološkim uvjetima, kao i proces selekcije od strane proizvođača bivaju zanemarene. Stranooplodne sorte kukuruza su u prosjeku manjeg prinosa od hibrida, ali zbog bolje adaptiranosti stresnim uvjetima okoliša i ekstenzivnim uvjetima proizvodnje imaju izraženo važno svojstvo stabilnosti prinosa (Zeven, 1998), te mogu poslužiti kao važan izvor alela za otpornosti na različite izvore biotskog i abiotskog stresa. Iz tih razloga javlja se interes za sakupljanje, proučavanje i očuvanje starih stranooplodnih populacija, sorata i ekotipova kukuruza te za njihovo uključivanje u suvremene oplemenjivačke programe (Hallauer i Sears 1972; Stuber 1978; Dudley 1988; Ragot i sur., 1995; Šimić 1999). Interes za njihovo očuvanje povećan je i zbog uske genetske osnove većine današnjeg hibridnog sortimenta (Goodman 1985; Smith i sur., 1992). Važan preduvjet uvođenja egzotičnog biljnog materijala u moderne oplemenjivačke programe je temeljita karakterizacija sakupljenog biljnog materijala (Ruiz de Galaretta i Alvarez, 2001). Taksonomska deskripcija, multivarijatne analize za mjerenje divergentnosti između populacija, kao i morfološka karakterizacija proučavanih populacija pokazale su se učinkovitima za postizanje saznanja o većini važnih svojstava. Od morfoloških svojstava, svojstva klipa su redovito proučavana kod morfološke karakterizacije domaćih populacija kukuruza (Azar i sur., 1997; Pressoir i Berthaud 2004, Harda i sur. 2009), kao i oplemenjivačkih populacija (Šarčević i sur. 2004).

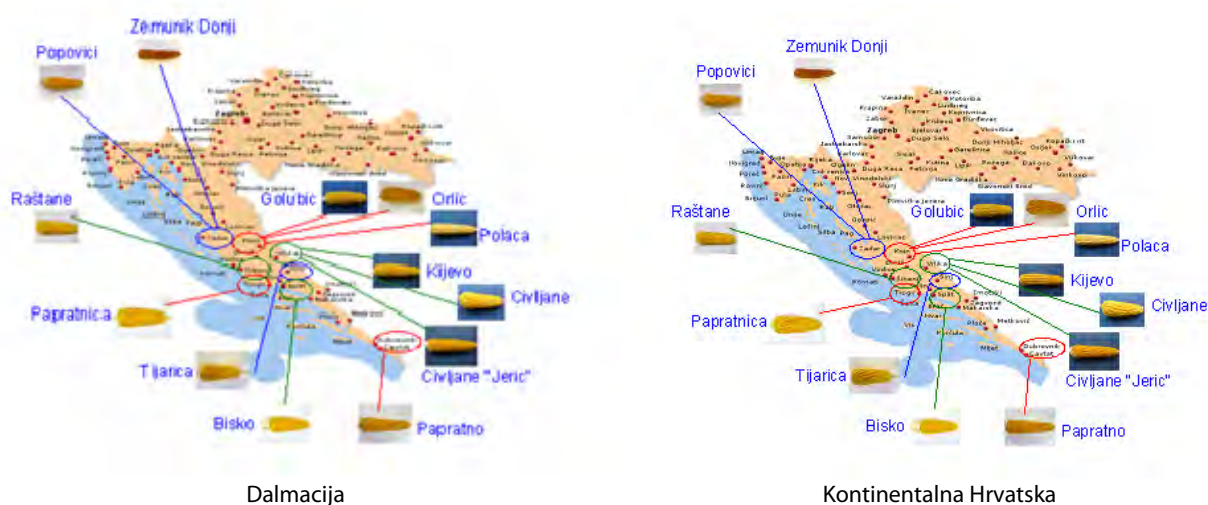
Varijabilnost tipova i stranooplodnih sorata kukuruza sa područja jugoistočne Europe su među prvima detaljnije opisali Leng i sur. (1962). Od vrijednih svojstava domaće germplazme kukuruza isti autori ističu otpornost na sušu, rani vigor i otpornost na kasne proljetne mrazove, visoku kvalitetu zrna, visok% krunjenja i ranozrelost. Cilj ovoga rada je usporediti varijabilnost svojstava klipa unutar i između domaćih populacija kukuruza prikupljenih u različitim područjima Hrvatske.

## Materijali i metode

Uzorci klipova domaćih populacija kukuruza sakupljeni su tijekom 2008. g. na veće broju lokacija u Dalmaciji i kontinentalnoj Hrvatskoj. Za analizu morfoloških svojstava klipa izabrano je po 13 populacija iz Dalmacije i 13 populacija iz kontinentalne Hrvatske (Graf 1.). Po tipu endosperma sve proučavane populacije sa područja Dalmacije bile su u tipu tvrduca. Sa područja kontinentalne Hrvatske, populacije iz Kutjeva, Ribnika, Draganjeg Sela, Gornje Bebrine i Lupoglava bile su u tipu tvrduca, a sve ostale u tipu polutvrduca.

Broj sakupljenih klipova po populaciji varirao je od 6 do 36. Na pojedinačnim klipovima analizirana su sljedeća morfološka svojstva: duljina klipa, promjer klipa, broj redova zrna, masa klipa i masa okrunjenog zrna po klipu. Svojstva izvedena iz mjerenih su postotak krunjenja (omjer mase zrna i mase klipa) i omjer duljine i promjera klipa. Za sve populacije su ovisno o regiji sakupljanja prikazane srednje vrijednosti i koeficijenti varijabilnosti svojstava. Za testiranje značajnih razlika srednjih vrijednosti i koeficijenata varijabilnosti svojstava populacija iz dvije regije korišten je t-test. Između duljine klipa, promjer klipa i broja redova zrna na klipu i prinosa zrna po klipu izračunati su Pearsonovi koeficijenti korelacije ( $p < 0,05$ ). Statističke analize napravljene su pomoću Microsoft Office Excel 2003 kompjuterskog programa.

## Varijabilnost svojstava klipa kod domaćih populacija kukuruza



Graf 1. Sakupljačke lokacije domaćih populacija kukuruza

### Rezultati i rasprava

U tablici 1. su prikazane srednje vrijednosti i koeficijenti varijabilnosti domaćih populacija kukuruza ovisno o regiji sakupljanja. Populacije iz kontinentalne Hrvatske imale su veće srednje vrijednosti duljine klipa, mase klipa i mase zrna po klipu od populacija sa područja Dalmacije. Za ista svojstva koeficijenti varijabilnosti nisu se značajno razlikovali između dvije regije sakupljanja. Populacije dviju regija nisu se značajno razlikovale u promjeru klipa i% krunjenja, ali je varijabilnost promjera klipa bila signifikantno veća kod populacija sa područja Dalmacije. Broj redova zrna na klipu bio je značajnije veći također kod populacija sa područja Dalmacije, dok je omjer duljine i promjera klipa bio signifikantno veći kod populacija sa područja kontinentalne Hrvatske. Za ista svojstva koeficijenti varijabilnosti bili su signifikantno veći kod populacija sa područja Dalmacije.

Tablica 1. Srednje vrijednosti i koeficijenti varijabilnosti svojstava domaćih populacija kukuruza ovisno o regiji sakupljanja

Svojstvo	DK, (cm)	PK, (mm)	BRZ	MK, (g)	MZ, (g)	Krunjenje (%)	D/P
Prosjek Dalmacija	15,00	43,90	13,70	121,20	98,40	81,40	3,40
Prosjek kont. Hrvatska	20,50	42,30	10,80	196,80	158,50	81,00	4,90
Signifikantnost	**	n.s.	**	**	**	n.s.	**
C.V. Dalmacija	13,70	9,40	14,80	21,80	21,80	4,50	16,00
C.V. kont. Hrvatska	10,90	6,20	8,90	17,80	18,50	4,30	11,90
Signifikantnost	n.s.	**	**	n.s.	n.s.	n.s.	*

DK- duljina klipa; PK- promjer klipa; BRZ- broj redova zrna; MK- masa klipa; MZ- masa zrna po klipu; D/P- omjer duljine i promjera klipa

\*\*- signifikantno pri  $p < 0,01$ ; \*- signifikantno pri  $p < 0,05$ ; n.s.- nije signifikantno

U tablici 2. prikazani su koeficijenti korelacije između duljine klipa, promjera klipa i broja redova zrna sa prinosom zrna po klipu unutar populacija sa područja Dalmacije, odnosno kontinentalne Hrvatske. Kod sedam populacija sa područja Dalmacije najveća pozitivna korelacija s prinosom zrna po klipu uočena između za duljinu klipa, kod pet populacija za promjer klipa, te kod dvije populacije za broj redova zrna na klipu. Populacija iz Polače imala je podjednako visoke korelacije prinosa zrna s duljinom klipa (0,84) i promjerom klipa (0,83). Kod populacija sa područja kontinentalne Hrvatske najveća pozitivna korelacija s prinosom zrna po klipu opažena je kod osam populacija za duljinu klipa, kod četiri populacije za promjer klipa te kod jedne populacije za broj redova zrna na klipu.

## Zaključci

Lokalne populacije kukuruza prilagođene različitim uvjetima okoline i ekstenzivnim proizvodnim uvjetima mogu biti potencijalno vrijedan oplemenjivački materijal. Kod opisivanja i morfološke karakterizacije sakupljenih populacija kukuruza, kao i oplemenjivačkih populacija svojstva klipa su redovito proučavana. Sva proučavana svojstva varirala su u širokom rasponu između populacija u obje regije, Dalmaciji i kontinentalnoj Hrvatskoj. Najveću varijabilnost u obje regije imale su masa klipa i masa zrna, a najmanju postotak krunjenja. U obje regije je duljina klipa unutar populacija varirala više od promjera klipa. Svojstva klipa bila su međusobno u pozitivnoj ili negativnoj korelaciji (povezanosti) ovisno o populaciji. Duljina klipa je kod najvećeg broja populacija u obje regije bila u najvećoj korelaciji s masom zrna po klipcu. Rezultati rada upućuju da domaće populacije kukuruza predstavljaju važnu zalihu genetske varijabilnosti. Neke od proučavanih populacija mogle bi biti zanimljiv materijal za oplemenjivački razvoj hibrida prilagođenih lokalnim proizvodnim uvjetima.

**Tablica 2. Koeficijenti korelacije nekih svojstava klipa sa prinosom zrna po klipcu unutar populacija određene regije**

Populacija	Svojstva klipa - prinos zrna			Populacija	Svojstva klipa - prinos zrna		
	Duljina	Promjer	Br. redova		Duljina	Promjer	Br. redova
Tijarica	0,40	0,59	0,41	Kutjevo	0,80	0,37	-0,33
Popovići	0,02	0,92	0,73	Mirkovci	0,69	0,73	-
Papratno	0,55	0,27	0,82	Ciglenik	0,71	0,78	0,55
Bisko	0,42	0,62	0,41	Bušetine	0,65	0,82	-
Papratnica	0,70	0,63	0,66	Staro P. Selo	0,63	0,62	0,01
Orlić	0,76	0,48	0,26	Ribnik	0,66	0,28	0,15
Zemunik Donji	0,60	0,57	0,13	Paljevina	0,70	0,89	0,41
Civljane	0,89	0,23	0,35	Slobodnica	0,85	0,32	-0,29
Polača	0,84	0,83	0,22	Kula	0,62	-0,02	0,29
Civljane "Jerić"	0,74	0,39	0,37	Kr. Vidovec	0,82	0,10	0,71
Golubić	0,74	0,89	0,37	Draganje Selo	0,90	0,63	0,09
Kijevo	0,84	0,13	0,13	Gornja Bebrina	0,77	0,50	-0,17
Raštane	0,45	0,67	0,84	Lupoglav	0,34	0,50	-

## Zahvala

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# Tassel morphology and pollen productivity in some maize (*Zea mays* L.) local populations

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## Abstract

Maize (*Zea mays* L.) is the most important staple crop in Kosovo with the small holder farming systems accounting about 32% of the total production. A field experiment was conducted at the location in Prishtina (Kosovo) to test ten maize local populations for tassel morphology and pollen productivity. The experiment was set up in randomized complete block design (RCBD) with three replicates. Data about productive elements have been gathered from counting and measurements from ten plants, which were taken from each plot. Pollen was collected in pollen bags in each plot from plants were randomly selected from the two middle rows. The collection of pollen was started on the day when the first anthers appeared on the tassels main branches. Population analyses have revealed a large amount of variability for tassel morphology, pollen productivity (PP) and tassel area index (TAI). Pollen productivity (PP) was significantly affected by genotype, while the total genetic variation between maize local populations was higher (90%). TAI approach is well-suited for distinguishing genetic variation in pollen productivity and relative responses to treatments under field conditions. We supplement our results with data of those traits in maize local populations which were significantly higher at LSD<sub>p</sub>=0.01, except main stem diameter (MSD), that was non significant.

Key words: maize local populations, pollen productivity, tassel area index (TAI)

## Introduction

Maize (*Zea mays* L.) is a monoecious species, which has separate staminate and pistillate flowers on the same plant. The male inflorescence (tassel) arises from the shoot apical meristem, while the female inflorescences (ears) originate from the axillary bud apices (Maiskomitee, 2003). During development, spikelets transition from bisexual due to the selective elimination of male or female developmental processes, resulting in two morphologically distinct inflorescences; the male tassel and female ear (Wei Li, 2009). Pollination in maize can occur only if pollen shed by the tassel is captured by the stigmas (silks) on the ear. Pollen is produced in the anthers of the tassel at the top of the plant. When mature, the anthers suspend on filaments that emerge from the tassel and pollen is released from an opening at the tip of the anther. Branches start to shed one or two days after the beginning of the pollen shed of central rachis and follow the same pattern. An individual tassel may shed pollen for 2 to 10 days, depending on genotype and environmental conditions (Fonesca and Westgate, 2003). Morphology of tassel components primarily influencing pollen amount can be a significant factor of successful seed production and selection. There are only few studies reporting tassel characteristics and pollen producing ability of maize. Inheritance of tassel features has not been fully clarified yet (Berke and Rocheford, 1999), cited by Bodi and Pepo (2007). The majority of maize varieties are able to produce adequate quantity of viable pollen under various ecological circumstance, and pollen production cannot be considered as a limiting factor as far as yield is concerned (Duvick, 1997). Managing pollen dispersion is an important consideration in seed production, too. The male tassel can produce considerably more pollen grains than required for pollination of a single plant (Schoper et al., 1987). A single tassel from a normal plant may produce up to 25 million pollen grains or an average of 25000 pollen grains for each female flower on an ear of 750 to 1000 kernels (Poehlman and Sleper, 1995), cited by Bannert (2006). Environmental conditions can affect pollen availability by modifying the synchrony between pollen shedding and silk

emergence, by affecting how long pollen remains viable, or by changing the amount of pollen produced per tassel (Bolanos and Edmeades, 1993). However, extreme abiotic stress factors may cause flowering asynchronism, reducing the chance of fertilization or may generate the production of less viable pollens in lower quantity. Though pollen production does not limit kernel set, the amount of pollen produced per plant could become a limiting factor for kernel number if the reduction in tassel size persists (Basseti and Westgate, 1994). Our study was undertaken to obtain information for tassel morphology, pollen productivity per plant and tassel area index for ten maize local populations in agro ecological conditions of Kosovo.

### Materials and methods

#### Plant material and experimental design

A field experiment with ten maize local populations (MLP) was conducted 5 km southwest of the capital Prishtina at Latitude N 42°38'97", Longitude E 21°08'45" and an altitude 570 m.a.s.l. with an average rainfall of 720 mm per year and the mean annual temperature of about 10.27°C. This site is in the region where summer temperatures sometimes exceed 35°C, resulting in higher evapotranspiration (HMIK, 2009). The ten MLPs collected from traditional farmers in different regions of Kosovo were designated as: FAGB-02, FAGB-04, FAGB-06, FAGB-08, FAGB-12, FAGB-14, FAGB-16, FAGB-26, FAGB-28, and FAGB-30 (Tab. 1). The experimental design was a randomized complete block design (RCBD) with three replicates. Experimental unit (plot) consisted of four rows 5m long and 70 cm apart, with plant to plant distance of 25 cm or 57000 plants ha<sup>-1</sup>. Different parameters for tassel morphology were estimated from measurements of 10 random plants per plot. Pollen was collected in pollen bags from the two middle rows per plot. The collection of pollen was started on the day when the first anthers appeared on the tassels main branches. Measurements were carried out until there was no measurable quantity of pollen in the bags any more. Pollen was cleaned of impurities (anthers, insects, etc) using fine-meshed screen. Main stem length (MSL), main stem diameter (MSD), number of tassel branches (NTB), and total branches length (TBL), were recorded when tassels reached maximum pollen shed. Main stem length (MSL) was measured from the insertion of the first branch on the stem to the main tassel branch. Total branch length (TBL) was calculated as the sum of the lengths of all branches. Tassel area index (TAI) was calculated according to Fonesca et al., 2003 using the following formula:

$$TAI = \pi \times MSD \text{ (mm)} \times MSL \text{ (cm)} + \pi \times 0.5 \times MSD \text{ (mm)} \times TBL \text{ (cm)}$$

This calculation provides an estimate of the effective area of pollen production (PP) per tassel by assuming a uniform distribution of flowers on the main tassel branch, and uniform, but lower density of flowers on the lateral branches. A coefficient of 0.5 for the lateral branches provided the best fit between TAI and pollen per tassel.

#### Statistical analysis

The data for all traits were analyzed using analysis of variance (ANOVA) and Duncan's multiple range test. Statistical analyses were conducted using program MINITAB-14, SASS-JMP-IN 5.1.2 (2004) and Excel program.

### Results and discussion

Mean values for pollen production (PP) and tassel morphological characteristics of ten maize local populations are given in Tab. 1. Genotype (MLP) had significant effect on pollen production per tassel (PP) which varied from 0.83 g tassel<sup>-1</sup> in FAGB-12 to 2.00 g tassel<sup>-1</sup> in FAGB-08. The differences between two genotypes were +1.17 g tassel<sup>-1</sup> or genetic variation was significantly on higher value 90%. Tassel morphology changes dramatically as it emerges from the whorl, sheds pollen and senesces. Thus, attempts to relate tassel morphology with pollen production must consider this phenology and document the stage at which tassels are sampled (Fonesca and Westgate, 2003). Pollen represents a critical stage in the life cycle of plants, as viable pollen is crucial for efficient sexual plant reproduction. Maize pollen grains are one of the heaviest and largest (about 90-100 µm) among the wind-dispersed pollen grains, thus limiting the distance maize pollen can travel (Raynor et al., 1972).

**Table 1. Mean values for pollen production and tassel morphological characteristics of ten maize local populations**

Maize local Populations (MLP)	Pollen Production (PP) (g tassel <sup>-1</sup> )	Main Stem length (MSL) (cm)	Number of Tassel branches (NTB)	Total branch length (TBL) (cm)	Main stem diameter (MSD) (mm)	Tassel Area Index (TAI)
FAGB-02	1.10 bc	30.34 bc	14.52 ab	242.11 ab	3.86 a	1865.03 bc
FAGB-04	1.02 bc	29.11 cd	16.22 a	261.44 a	4.02 a	2095.93 ab
FAGB-06	0.95 c	29.33 bcd	16.77 bcd	224.11 bc	4.01 a	1800.51 bc
FAGB-08	2.00 a	31.66 ab	14.99 bcd	256.89 a	4.15 a	2366.50 a
FAGB-12	0.83 c	28.66 cd	15.11 cd	194.11 d	4.34 a	1777.41 bcd
FAGB-14	1.24 abc	29.77 bcd	8.89 e	135.77 e	3.40 a	806.04 e
FAGB-16	1.58 abc	30.50 bcd	13.11 d	207.75 cd	4.02 a	1738.77 bcd
FAGB-26	1.78 ab	27.73 d	15.78 abc	226.55 bc	4.09 a	1795.38 bc
FAGB-28	1.38 abc	28.22 cd	13.88 cd	210.66 cd	3.77 a	1451.23 cd
FAGB-30	1.11 bc	31.72 a	17.00 ab	255.22 a	3.83 a	2017.89 ab
Mean	1.29	29.70	14.62	221.46	3.94	1771.46

\*means followed by the same letter are not significantly different at  $p=0.05$  according to Duncan's multiple range test

A study by Racz et al. (2006), conducted in Martonvasar showed different results for Pollen Productivity (PP) which varied from 7.5 till 2.12. Main stem length (MSL) was the most consistent and robust parameter in tassel morphology in maize (Fonesca and Westgate, 2003). There were significant differences among MLPs for MSL in our study.

Mean of MSL was 29.70 cm and ranged from 27.73 cm (FAGB-26) to 31.72 cm (FAGB-30). Differences for these two genotypes were +3.99 cm or expressed in relative value was 13.42%. Similar findings range of MSL in six different maize genotypes (25.35 to 32.75 cm) was reported by Fonesca and Westgate (2003). The Significantly higher value for NTB was characterised genotype FAGB-30 on value 17 branches per tassel, while with lower was recorded at FAGB-14 (8.89 branches per tassel.). Differences between them were +8.11 branches per tassel or 55.43%. Total branch length (TBL) in our investigation had also significant effect on value which varied from 135.77 cm in FAGB-14 to 261.44 cm in FAGB-04. The differences among two genotypes were +125.67 cm or 56.74%. The results for MSD were non significant, in this case genotype FAGB-08 had 4.15 mm, while FAGB-14 gave the smallest diameter 3.40 mm. The results are close to reseraches of Fonesca and Westagate (2003), that showed results from 2.46 till 4.95 mm. Tassel area Index (TAI) as an indicator of pollen productivity (PP) per plant emerged as an interesting alternative to tassel weight loss due primarily to its speed and simplicity (Fonesca and Westgate, 2003). The variation in TAI among maize local populations (MLPs) shows little correspondence to observed levels of PP. The experimental mean for TAI was 1771.46. Our results showed large range of variability which varied from 2366.5 till 806.04, which had significant differences among genotypes + 156.46 or 88.08%. Our results according to the differences of Pearson's correlation coefficients (PCC) exhibited different values. Results are present in Tab. 2. However, TAI exhibited positive correlation coefficients at all other parameters except with TBL had higher correlation ( $r=0.92$ ).

**Table 2. Pearson's correlation among investigate quantitative parameters**

Traits	Pollen productivity (PP) $X_1$	Main stem length (MSL) $X_2$	Number of branches (NTB) $X_3$	Total branch length (TBL) $X_4$	Main stem diameter (MSD) $X_5$	Tassel area index (TAI) $X_6$
$X_1$	-					
$X_2$	0.17	-				
$X_3$	-0.14	0.01	-			
$X_4$	0.13	0.31*	0.83**	-		
$X_5$	0.07	-0.11	0.03	0.48*	-	
$X_6$	0.19	0.36*	0.81**	0.92**	0.73**	-

Significant at the \* $p=0.05$  and \*\* $p=0.01$  level of probability

## Conclusions

The results presented in this paper indicate that the maize local populations collected in different parts of Kosovo are an important genetic reservoir of variability. Some of these maize local populations had higher



pollen productivity. In general, tassel morphology characteristics were poorly correlated with pollen productivity. The variation in TAI among maize local populations shows little correspondence to observed levels of pollen production.

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# Genetic variability among maize hybrids for yield and yield components

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## Abstract

Sixteen hybrids of different genetic background were tested under field conditions at Zemun Polje in the vicinity of Belgrade, Serbia. The aim of the study was to observe genetic variability of yields and yield components of the stated hybrids under our agroecological conditions. Hybrids belong to different FAO maturity groups and have different kernel type. The obtained yield significantly varied over hybrids at the probability level of  $P=0.05$ . Yield components (ear length, kernel row number, number of kernels per row and ear diameter) also differed at the probability level of  $P=0.05$ . The strongest positive correlation (0.755) was recorded between the ear length and the kernel row number, while the weakest positive correlation (0.183) was detected between the yield and the kernel row number.

Key words: maize, genetic variability, yield

## Introduction

Maize (*Zea mays* L.) is one of the most important agricultural products of the Republic of Serbia. This crop is cultivated on approximately 1.2 million ha. The grain yield increase per area unit is a principal task in maize breeding. Maize grain yield is a complex trait and a result of interrelationships of different yield components (Grafius, 1960). Therefore, it is important to determine yield components, which include traits such as plant height, top ear height, number of leaves above the ear, ear length, ear diameter, 1000-kernel weight, kernel row number, number of kernels per row, etc. In order to establish in which way and which of the stated traits affect the yield, it is necessary to observe traits, to determine their values and to find out the associations and interrelationships between both, yield components themselves and yield components and the yield as an end result.

A genetic correlation is a useful tool that facilitates the detection of the degree of association among important quantitative traits (Malik et al., 2005). Previous studies showed that the top ear height, ear length and diameter are positively correlated with the grain yield (Burak and Magoja, 1991; Khatun et al., 1999). According to Arias et al. (1999) number of kernel rows showed only a small positive indirect effect on ear weight via ear diameter and the number of kernels per row showed high positive direct effect. Number of kernels per row and kernel rows per ear have positive genetic correlation with grain yield (Shalygina, 1990; Altenbas and Algan, 1993; Gyanendra and Singh, 1993; Khakim et al., 1998 and Khatun et al., 1999). The aim of the present study was to establish genetic variability among maize hybrids and to determine the correlation between the yield and certain yield components.

## Materials and methods

The following 16 maize hybrids of FAO maturity groups, ranging from 300 to 700, developed at the Maize Research Institute, Zemun Polje, were used in this study: ZP 1 and ZP 2 (FAO 350), ZP 3 and ZP 4 (FAO 400), ZP 5, ZP 6, ZP 7 and ZP 16 (FAO 500), ZP 8, ZP 9, ZP 10, ZP 11 and ZP 12 (FAO 600), ZP 13, ZP 14 and ZP 15 (FAO 700). All these hybrids are yellow-seeded dent hybrids, except ZP 13 that is a white-seeded hybrid and ZP 16 that is a sweet maize hybrid. The hybrids were tested in 2010 in the experimental fields of

the Maize Research Institute, Zemun Polje, at two locations. The trial was set up as complete randomised block design (RCBD) with two replications. Four rows were sown for each hybrid, and there were 20 plants per row, which resulted in a sowing density of 67,000 plants ha<sup>-1</sup>. The inter-row distance amounted to 0.75 m, while the elementary plot size was 12 m<sup>2</sup> (4 x 3 m). Two inner rows within the plot were used for calculations. The identical cropping practices were applied for all hybrids in both locations.

A yield measured in the plot was used to compute to grain yield per hectare (t ha<sup>-1</sup>) with 14% moisture. Ten ears from the total number of ears were drawn from each plot for the analysis of the ear length, kernel row number, number of kernels per row and the ear diameter.

The program MSTAT-C (MSTAT Development Team, 1989) was used for the data processing. Two-factorial analysis ANOVA, FACTOR option of the program MSTAT-C was applied to data on yield and yield components. Means of ANOVA were tested to the least significant difference test (LSD test,  $\alpha=0.05$ ), which is within the RANGE option of the program MSTAT-C. Correlation coefficients and values of the t-test for means of yield and yield components were computed in the option CORR of the program MSTAT-C.

### Results and discussion

Yields of ZP hybrids significantly varied at the probability level of  $P=0.05$  (Tab. 1). These variations ranged from 5.52 to 13.01 t ha<sup>-1</sup>. The differences in yields of different hybrids are possible in hybrids of various genetic backgrounds (Ali et al., 2007), which is confirmed by our results. ZP 8 was the most yielding hybrid with 13.01 t ha<sup>-1</sup>, while the lowest yield of 5.52 t ha<sup>-1</sup> was recorded in ZP 16, but that was expected because it was the only sweet corn among investigated hybrids.

Table 1. ANOVA for yield performance and yield components of evaluated maize (*Zea mays* L.) hybrids

Hybrid	Y	EL	KRN	NKPR	ED
ZP 1	11.45 ab	20.30 abcde	15.05 ef	42.75 def	4.74 efg
ZP 2	12.24 ab	18.75 ef	15.15 def	38.40 g	4.85 cde
ZP 3	10.36 b	18.54 f	14.20 gh	43.31 cdef	4.84 cde
ZP 4	8.33 c	20.19 bcde	13.98 h	44.46 cde	4.46 h
ZP 5	11.26 ab	21.03 abc	15.90 cd	47.38 b	4.73 efg
ZP 6	12.06 ab	19.90 cdef	17.50 a	41.78 ef	4.93 bcd
ZP 7	12.19 ab	21.75 ab	16.01 bc	44.90 bcd	4.82 de
ZP 8	13.01 a	20.90 abc	13.93 h	42.60 def	4.93 bcd
ZP 9	11.70 ab	21.80 a	14.40 fgh	44.10 cdef	4.94 bcd
ZP 10	12.62 a	19.10 def	16.70 b	43.59 cdef	4.78 ef
ZP 11	12.67 a	20.30 abcde	15.56 cde	41.40 f	5.04 b
ZP 12	12.60 a	21.48 abc	15.25 de	45.63 bc	4.95 bc
ZP 13	11.36 ab	20.68 abcd	15.45 cde	43.45 cdef	4.73 efg
ZP 14	10.56 b	21.10 abc	15.25 de	50.48 a	5.28 a
ZP 15	12.70 a	21.41 abc	14.88 efg	44.68 bcd	4.66 fg
ZP 16	5.52 d	15.95 g	15.48 cde	35.36 h	4.62 g
LSD (0.05)	1.976	1.594	0.7594	2.841	0.1288

[Y=yield (t ha<sup>-1</sup>), EL=ear length (cm), ED=ear diameter (cm), KRN=kernel row number, NKPR=number of kernels per row]

Furthermore, yield components also varied at the probability level of  $P=0.05$ . The ear length varied from 15.95 cm in ZP 16 to 21.8 cm in ZP 9. The kernel row number varied from 13.93 in ZP 8 to 17.5 in ZP 6. The number of kernels per row ranged from 35.36 in ZP 16 to 50.48 in ZP 14. The ear diameter varied from 4.46 cm in ZP 4 to 5.28 cm in ZP 14 (Tab. 1).

The simple correlation coefficients of yield and yield components varied from -0.097 to 0.755 (Tab. 2). The strongest positive correlation was obtained between grain yield and ear length ( $P=0.01$ ) and ear length and number of kernels per row ( $P=0.001$ ). Gauntam et al. (1999) also found highest correlation between grain yield and ear length i.e. number of kernels per row. It can be concluded that most important traits for improving grain yield are these two. Also positive strong, but not significant relationship was obtained between grain yield and ear diameter, i.e. number of kernels per row. These results were in accordance with those obtained by Shalygina (1990), Altenbas and Algan (1993), Gyanendra and Singh (1993), Khakim et al. (1998), Khatun et al. (1999) and Burak and Magoja (1991). Correlation between grain yield and kernel row number was positive, but small.

A small negative and insignificant correlation was recorded between the ear length and the kernel row number and between the kernel row number and the number of kernels per row.

**Table 2. Simple correlation coefficients between the yield and the yield components**

	Y	EL	ED	KRN
Y	-			
EL	0.663**	-		
ED	0.438	0.313	-	
KRN	0.183	-0.097	0.146	-
NKPR	0.348	0.755***	0.361	-0.051

[Y=yield, EL=ear length, ED=ear diameter, KRN=kernel row number, NKPR=number of kernels per row]

\*\*-significant at P=0.01, \*\*\* -significant at P=0.001

### Conclusions

According to obtained results on yield and yield components it can be concluded that genetic variance existed among observed hybrids, which was expected concerning their different genetic background. The highest, i.e. lowest yield was recorded in the hybrid ZP 8, i.e. the hybrid ZP 16, respectively. Estimations of correlation coefficients showed a strong positive correlation between the yield and the ear length at the probability level of P=0.01, and also between ear length and number of kernels per row (P=0.001). Therefore, it is shown that maize selection for ear length can result in the yield increase per area unit.

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# Inheritance of ear yield and technological traits in sweet corn (*Zea mays L. saccharata*)

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## Abstract

Sweet corn as speciality corn is consumed in the milky stage of endosperm, when its kernel is tender, succulent and sweet. Therefore its quality is important as well as yield. In this paper we analyzed the mode of inheritance of ear yield and some technological traits in sweet corn, such as percentage of dry matter, shelling percentage and percentage of glucose in the kernel at harvest maturity of sweet corn, by the method of diallel crosses of six sweet corn inbred lines. ANOVA of combining ability indicated that non-additive gene effects were more significant in ear yield, while additive gene effects were more important for the expression of shelling percentage, percentage of dry matter and glucose in the kernel.

Key words: sweet corn, combining ability, ear yield, technological traits

## Introduction

Sweet corn differs from field corn by the mutation at the sugary (*Su*) locus on chromosome 4, so sweet corn has the *su* gene at this locus (Pajić et al., 1994). This mutation affects the endosperm composition by causing it to accumulate twice as much sugar and eight to ten times more water-soluble polysaccharides, than normal field corn at the milky stage of the endosperm development (Creech, 1968). Sweet corn also, has 25% less dry matter in the kernel 28 days after pollination than field corn (Creech and McArdle, 1966). Sucrose is the major sugar component of the sweet corn kernel, which provides its sweetness, but also simple sugars such as glucose, fructose and maltose are present (Cobb and Hannah, 1981). This kernel composition provides sweet taste and creamy texture of sweet corn.

Breeding of sweet corn has several equally important aims that are directed by the market demands and different mode of consumption than field corn. The ear yield, in sweet corn is not the only and main goal of breeding. Morphological traits of the plant, ear and kernel and chemical composition of the kernel are also very important. Favorable traits for the hybrids that are used in industrial processing are uniformity of ear size, length and shape, proper kernel row configuration, depth, width and color of kernels, as well as quality of the taste such as sweetness, pericarp tenderness and creamy texture of the endosperm (Pajić et al., 2005). Shelling percentage is also very important technological trait in sweet corn and it depends on the kernel properties, such as its weight and depth, and it represents the share of the kernel's weight in the weight of the whole ear. The method of diallel crosses has been widely used in genetic research to investigate the inheritance of important traits among a set of genotypes (Yan and Hunt, 2002). It was devised especially to investigate combining ability of the inbred lines for the purpose of identification of superior parents for use in hybrid breeding. This diallel study was undertaken with the objective to determine genetic nature and inheritance of ear yield and some technological traits in sweet corn—percentage of dry matter, shelling percentage and percentage of sugars in sweet corn kernel, and to evaluate breeding potential of six sweet corn inbred lines of different origin selected and adapted in the midcontinental environment of Serbia.

## Materials and methods

For this study six sweet corn inbred lines were chosen. All of them were selected in Maize Research Institute

“Zemun Polje”, but they originated from different varieties introduced from Mexico (L<sub>1</sub>- ZPL 620/121 and L<sub>2</sub>- ZPL ZPL 1/12), Iran (L<sub>4</sub>- ZPKŠ 8/1-161 and L<sub>5</sub>- ZPKŠ 8/1-153), synthetic populations of sweet corn derived in Maize Research Institute (L<sub>3</sub>- ZPL 620/121-25), and F<sub>2</sub> population of hybrid Jubilee (L<sub>5</sub>- Jub I-5).

Six sweet corn inbred lines were crossed in a diallel fashion without reciprocal combinations [ $n(n-1)/2$ ] (n-number of parental lines), which produced 15 F<sub>1</sub> combinations. The 15 hybrid combinations and 6 parental lines were included in a randomized block design with three replications in three treatments. The treatments were: 1. no irrigation, 2. with irrigation, 3. late sowing. Hybrids and inbreds were sown at the same time in separate plots with two border rows for each plot. The experimental unity was one row for each entry, with 20 plants and the final density of approximately 50.000 plants ha<sup>-1</sup>. Inheritance and genetic control for ear yield and percentage of dry matter, shelling percentage and percentage of glucose in the kernel at harvest maturity of sweet corn was determined.

Processing of data obtained from diallel analysis was done by PC program Genetic Analysis (Dick, 1987). General (GCA) and specific (SCA) combining ability were analyzed according to the Griffing (1956) mathematical model I, method 2.

### Results and Discussion

The analysis of variance of diallel crosses showed significant estimates ( $p < 0.05$ ) of GCA for all observed traits and SCA for all traits except glucose percentage. The non-additive gene effects were predominant in the expression of ear yield, which is indicated by GCA to SCA ratio lower than unity (Tab. 1). Significance of non-additive effects was also found in the research of Voichita (2001) both for sweet corn ear yield with or without husk and ear length. On the other hand Bordallo et al. (2005) observed the same significance of the GCA and SCA in the inheritance of the ear yield in sweet corn. For three technological traits of sweet corn GCA/SCA ratio was  $> 1$ , which pointed to the higher influence of the additive gene effect to the expression of these traits. The additive gene effect in the inheritance of percentage of dry matter in sweet corn kernel was also found in the research of Falconer (1960), and Peterović (1973). Although we examined ANOVA of combining ability for three main sugars in sweet corn-sucrose, fructose and glucose, significance was found only for glucose. In the expression of this sugar additive gene effects were significant, which is in accordance with the literature data (Rosenbrook and Andrew, 1971; Peterović, 1973).

Table 1. ANOVA of combining ability

Sources of Var.	D.F.	ear yield	Mean Square		
			% of dry matter	shelling percentage	% of glucose
GCA	5	3.629**	3.75**	19.50**	0.98**
SCA	15	10.692**	1.26*	11.46**	0.27
Error	40	0.375**	0.40	2.22	0.22
GCA/SCA		0.34	3.41	1.70	3.58

\*,\*\* - significant at the 0.05 and 0.01 probability level

According to the GCA, L<sub>4</sub> is the only inbred with significant estimate of GCA for ear yield. Concerning % of dry matter only L<sub>5</sub> had significant estimate of GCA, but for this trait it is important that the percentage of dry matter is low so, also the inbred L<sub>4</sub> which was ranked 6 is the most desirable (Tab. 2). For shelling percentage inbreds L<sub>1</sub> and L<sub>2</sub> had significant estimates of GCA, but for the % of glucose no inbred had positive significant GCA effect. In this case also L<sub>4</sub> was among the best ranked inbreds. Following the presumption that parental lines with significant GCA can be used to improve the trait of interest, inbred L<sub>4</sub> is probably the most desirable one in sweet corn breeding, because it had highly significant estimates of GCA for ear yield and according to GCA of % of dry matter and glucose it was ranked among the best.

Table 2. GCA for six sweet corn inbred lines

Inbred lines	ear yield		% of dry matter		shelling percentage		% of glucose	
	GCA	rank	GCA	rank	GCA	rank	GCA	rank
L <sub>1</sub>	-0.445	5	0.51	2	1.90*	1	-0.04	5
L <sub>2</sub>	0.347	2	-0.29	4	1.85*	2	-0.04	4
L <sub>3</sub>	-0.551	6	0.35	3	-0.27	3	-0.65*	6
L <sub>4</sub>	1.212**	1	-0.74	6	-0.85	5	0.23	2
L <sub>5</sub>	-0.183	3	0.76*	1	-1.97*	6	0.32	1
L <sub>6</sub>	-0.379	4	-0.60	5	-0.71	4	0.18	3
SE	-0.445		0.31		0.74		0.23	

\*,\*\* -significant at the 0.05 and 0.01 probability level

SCA estimates were high and significant for ear yield, as the result of non-additive gene action (dominance and epistasis). Inbred L<sub>4</sub> with significant GCA estimate was component of four out of eleven hybrid combinations with significant SCA for this trait. On the other hand only two hybrid combinations had significant SCA estimates for % of dry matter (L<sub>3</sub>xL<sub>2</sub> and L<sub>5</sub>xL<sub>2</sub>) and shelling percentage (L<sub>2</sub> x L<sub>1</sub> and L<sub>5</sub>xL<sub>2</sub>), and none of them had significant estimates for % of glucose, which was caused by the additive gene action in the inheritance of these traits (Tab. 3).

Table 3. SCA estimates for ear yield, % of dry matter, shelling percentage and % of glucose in kernel of sweet corn

Hybrid combinations	ear yield	% of dry matter	shelling percentage	% of glucose
L <sub>2</sub> x L <sub>1</sub>	2.47**	-0.63	4.30*	-0.03
L <sub>3</sub> x L <sub>1</sub>	0.19	0.62	0.20	-0.91
L <sub>4</sub> x L <sub>1</sub>	2.29**	-0.16	0.86	0.80
L <sub>5</sub> x L <sub>1</sub>	0.85	-0.6	0.97	0.51
L <sub>6</sub> x L <sub>1</sub>	2.01*	-1.28	0.14	-0.51
L <sub>3</sub> x L <sub>2</sub>	1.90*	2.27*	3.15	-0.27
L <sub>4</sub> x L <sub>2</sub>	3.03**	-1.64*	3.10	0.56
L <sub>5</sub> x L <sub>2</sub>	2.92**	1.91*	4.51*	-0.02
L <sub>6</sub> x L <sub>2</sub>	2.62**	-0.76	1.48	0.23
L <sub>4</sub> x L <sub>3</sub>	1.71*	-0.15	0.05	-0.50
L <sub>5</sub> x L <sub>3</sub>	2.24*	-0.16	-3.76*	0.17
L <sub>6</sub> x L <sub>3</sub>	1.67*	0.60	-0.24	0.64
L <sub>5</sub> x L <sub>4</sub>	-0.73	0.38	1.72	-0.14
L <sub>6</sub> x L <sub>4</sub>	1.67*	-0.63	-0.77	-0.63
L <sub>6</sub> x L <sub>5</sub>	0.80	1.56	1.01	-0.46
SE	0.75	0.80	1.82	0.57

\*,\*\* -significant at the 0.05 and 0.01 probability level respectively

### Conclusions

Diallel analysis of six sweet corn inbred lines resulted in following:

Estimates of GCA and SCA were significant for all traits except glucose percentage, showing the importance of both additive and non-additive gene effect. Based on the higher estimates of the SCA and GCA/SCA ratio <1 non-additive gene effect played more significant role in the inheritance of ear yield. On the other hand additive gene effect was more important for expression of shelling percentage, percentage of dry matter and glucose in sweet corn kernel. ANOVA of combining ability was performed for the percentage of all three main sugars in sweet corn kernel- sucrose, fructose and glucose, but significance was found only for glucose.

Significant GCA effects for the inbred L<sub>4</sub> concerning ear yield and its high not significant estimates of GCA for % of dry matter and glucose, indicated its potential usefulness in sweet corn breeding programs. This was confirmed by the ear yield performances of the hybrids in which one of the components was this inbred, according to SCA estimates. The more significant additive gene effect in the expression of examined technological traits in sweet corn caused that only few hybrid combinations had significant estimates of SCA for percentage of dry matter and shelling percentage and none of the F<sub>1</sub> had significant SCA estimate for the percentage of glucose in the sweet corn kernel.

### Acknowledgment

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# Grain yield of ZP maize hybrids in the maize growing areas in Serbia

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## Abstract

Five commercial ZP-maize hybrids were tested at 10 locations in Serbia over a three-year period to assess their yield potential and stability. Average grain yield of hybrids in three-year trial ranged from 7.439 t ha<sup>-1</sup> (ZP-5) to 8.332 t ha<sup>-1</sup> (ZP-3). Values of regression coefficient *bi* indicate better adaption of early to medium maturity hybrids to poor environments and good adaption of medium to late maturity hybrids to better environments. Hybrid ZP-3, which was highest yielding was not most stable, according to values of regression coefficient. According to the results gathered applying Lin & Binns model, hybrid ZP-3 is considered as a most stable genotype. By obtaining results of Spearman rank correlation coefficient we found positive correlation between values of *Pi* and grain yield and didn't find correlation between grain yield and regression coefficient *bi*.

Key words: maize hybrids, grain yield, yield stability

## Introduction

The development of maize hybrids with high grain yielding potential is one of the most important tasks of breeding. Grain yield depends on the genetic constitution of hybrids, i.e. on the frequency of favourable alleles controlling the yield that are not accumulated in hybrids and even more on the capacity of hybrids to resist limiting environmental factors (Stojaković et al (2002).

It is very important to create hybrids with high yielding potential, but new created hybrids should have some other desirable morphological and physiological characteristics.

In recent times in Serbia maize has been grown on the area of approximately 1,250,000 ha. Maize is one of the most important field crops and since it is sown on almost 60% of arable areas it has various purposes in nutrition of humans and animals and is a very important factor in the export of agricultural products. Due to favourable and very favourable conditions

(Vojvodina) of the majority of macroecological regions maize is successfully grown in our country (Jovanović, 2007). Early maturity hybrids have a shorter growing season and significantly lower grain moisture content at harvest (16-18%), which is a great advantage in maize storing. On the other side, late maturity hybrids have higher grain yield potential, but they need better agroecological conditions to release their high potential. Currently, hybrids from FAO 600 maturity group are most distributed in Serbia. The selection of locations, different soil and climatic conditions and long-term studies completely provide the adequate regional distribution of hybrids for different agroecological areas in Serbia.

The biological basis of the regional distribution of hybrids is established on the specific genotype × environment interaction, which is complex and has been an object of interest of science and practice for many decades (Ivanović et al., 2007).

In order to make maize production more stable and to improve it, it is necessary to adequately select maize hybrids of certain locations (Jovin et al., 2002).

## Materials and method

Five maize hybrids from different FAO maturity groups were used in this study (ZP-1: FAO 350, ZP-2: FAO 400, ZP-3: FAO 500, ZP-4: FAO 550, ZP-5: FAO 650). All of this hybrids are commercial and widely grown in Serbia.

Macro trials were set up on 10 locations, over a three-year period. Selected locations represent main maize production areas in Serbia. Plot size was 0.1 ha. Planting and harvesting were mechanized. During the harvesting samples for moisture content were taken. Hybrids were sown at different densities: FAO 300-400: 70000 plants per hectare, FAO 500: 65000 plants per hectare and FAO 600: 60000 plants per hectare. Grain yield data converted to t ha<sup>-1</sup> at 14% moisture level are shown in this work.

Stability parameters were estimated by models of Eberhart and Russel (1966) and Lin and Binns (1988). Correlation coefficients between both investigated stability parameters and grain yield were computed.

As described by Eberhart and Russell (1966), the behavior of the cultivars was assessed by the model  $Y_{ij}=m+b_iI_j+d_{ij}+e_{ij}$ , where  $Y_{ij}$  = observation of the  $i$ -th ( $i=1,2,\dots, g$ ) cultivar in the  $j$ -th ( $j=1,2,\dots,n$ ) environment,  $m$ =general mean,  $b_i$ =regression coefficient,  $I_j$ =environmental index obtained by the difference among the mean of each environment and the general mean  $d_{ij}$  the regression deviation of the  $i$ -th cultivar in the  $j$ -th environment and  $e_{ij}$ =effect of the mean experimental error (Scapim et al., 2000).

Regression coefficient ( $b_i$ ) measures the response of genotypes to environments. When  $b_i=1$  there is average stability and adaptability to both poor and good environments, when  $b_i>1$  genotypes give above average stability only in good environment. Whereas, when  $b_i<1$ , it indicates genotypes adaptation to poor environment (Aremu et al, 2009).

The Lin and Binns' (1988) model uses the  $P_i$  parameters obtained by the expression  $P_i = \sum_{j=1}^n (X_{ij} - M_j)^2 / 2n$  to

assess the superiority of the cultivar, where  $P_i$ =superiority index of the  $i$ -th cultivar,  $X_{ij}$ =yield of the  $i$ -th cultivar in the  $j$ -th environment,  $M_j$ =maximum response obtained among all the cultivars in the  $j$ -th environment, and  $n$ =number of environments. This expression was further partitioned into

$P_i = [n(\bar{X}_i - \bar{M})^2 + \sum_{j=1}^n (X_{ij} - M_j + \bar{M})^2] / 2n$ , where  $\bar{X}_i = \sum_{j=1}^n X_{ij} / n$  and  $\bar{M} = \sum_{j=1}^n M_j / n$ ,  $\bar{X}_i$  = yield mean of the  $i$ -th cultivar in the  $n$

environments and  $\bar{M}$  = mean of the maximum response in the  $n$  environments.

According to Lin and Binns (1988), the first part of the  $P_i$  expression quantifies the genetic deviation and the second quantifies the G x E interaction. It characterizes the genotypes with a single parameter ( $P_i$ ) by associating stability and productivity, and defines a superior cultivar as one with a performance near the maximum in various environments

Estimation of the relationship between stability parameters, and between investigated stability parameters and grain yield was calculated using Spearman rank correlation coefficient.

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}$$

where  $d_i$  is the difference in the ranks given to the two variable values for each item of data, and  $n$  is the number of subjects.

## Results and discussion

According to the results of three-year period, we can conclude that 2007. had unfavourable conditions for maize production because of extremely high temperatures during the july. Other two years characterized better conditions for maize production and grain yield was higher.

Average grain yield per year ranged from 6.920 t ha<sup>-1</sup> in 2007. to 8.717 t ha<sup>-1</sup> in 2009. It is interesting that all hybrids obtained yields close to average in 2008.

Table 1. Grain yield (t ha<sup>-1</sup>) of investigated hybrids during the three-year period

Hybrid	2007	Rank	2008	Rank	2009	Rank
ZP-1	7.285	2	8.020	2	8.706	3
ZP-2	6.829	3	8.187	1	8.944	2
ZP-3	7.758	1	8.016	3	9.223	1
ZP-4	6.667	4	7.882	4	8.439	4
ZP-5	6.063	5	7.979	5	8.275	5
Average	6.920		8.016		8.717	

The main grain yield of hybrids in three-year period ranged from 7.439 t ha<sup>-1</sup> (ZP-5) to 8.332 t ha<sup>-1</sup> (ZP-3). Early to medium maturity hybrids ZP-1 and ZP-2 had very good grain yields, better than late maturity hybrids ZP-4 and ZP-5 (Tab. 2).

Table 2. Average grain yield for period 2007-2009. and stability parameters for investigated hybrids

Hybrid	Grain yield	Rank	bi	Rank	Pi	Rank
ZP-1	8.004	2	0.959	2	2.101	4
ZP-2	7.986	3	0.879	5	1.912	3
ZP-3	8.332	1	1.062	3	1.111	1
ZP-4	7.663	4	1.069	4	1.604	2
ZP-5	7.439	5	1.031	1	2.117	5
Average	7.884		1.000		1.769	

The values of regression coefficient *bi* indicate better adaption of early to medium maturity hybrids to poor environments and good adaption of medium to late maturity hybrids to better environments (Tab. 2). These results are in concordance with results obtained by Madić et al., (2010).

Furthermore, maize hybrids ZP-1 and ZP-5 showed the best stability among investigated hybrids, but at the same hybrid ZP-5 had lowest grain yield in the trail. Delić et al. (2009) also found that hybrid with low grain yield showed good stability.

Regarding the method proposed by Lin and Binns' (1988) it was observed that hybrid ZP-3 showed lowest value of *Pi* measure and is considered as a most desirable genotype. Similar results were obtained by Alberts, 2004 who concluded that the highest yielding genotype had lowest *Pi* value.

By obtaining results of Spearman rank correlation coefficient we found positive correlation between values of *Pi* and grain yield and didn't find correlation between grain yield and regression coefficient *bi* (Tab. 3).

Table 3. Spearman's coefficients of rank correlation for grain yield and stability parameters

	Grain yield	bi	Pi
Grain yield	x	0.000	0.667
bi		x	-0,333
Pi			x

## Conclusion

Based on results obtained in this study, we can conclude that early to medium maturity hybrids produced higher yielding than medium to late maturity.

Maize hybrid ZP-3 had highest average yield during the three-year period.

Early to medium maturity hybrids are recommendable for growing in poor environments and medium to late maturity hybrids are recommendable for better environments.

Regarding the values of regression coefficients, hybrid ZP-5 showed the best stability between investigated genotypes, but at the same time lowest grain yield.

According to the results gathered applying Lin and Binns model, hybrid ZP-3 is considered as a most stable genotype.

There is no correlation between grain yield and regression coefficients, so some hybrids can have good stability but low grain yield and some hybrids with high grain yield is not always considered as a stable

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# Učinak gnojidbe dušikom na dormantnost zrna kod pšenice

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## Sažetak

Deset kultivara ozime pšenice raširenih u proizvodnji u Republici Hrvatskoj sijano je u vegetacijskoj godini 2008/2009. na dvije lokacije, Botinec i Rugvica u poljskom pokusu postavljenom prema latiniziranom redno stupčastom dizajnu u dva ponavljanja s dvije razine gnojidbe dušikom. Kod niske razine gnojidbe dušikom (N0) dodano je 100 kgNha<sup>-1</sup>, dok je kod visoke razine gnojidbe dušikom (N1) dodano 185 kgN ha<sup>-1</sup>. Cilj rada je bio utvrditi utjecaj kultivara i doze dušika (N) na stupanj dormantnosti zrna u dva roka: žetvenoj zriobi (ŽŽ) i 10 dana nakon žetvene zriobe (post-žetvena zrioba, PŽŽ). Dormantnost zrna je procijenjena u testovima klijavosti i izražena indeksom klijanja (GI). Indeksi klijanja su u oba roka bili veći u Botincu nego u Rugvici ukazujući na izraženiju dormantnost zrna na lokaciji Rugvica. U žetvenoj zriobi na lokaciji Botinec doza N nije imala signifikantan učinak na razinu dormantnosti zrna dok je na lokaciji Rugvica došlo do povećanja razine dormantnosti zrna povećanjem doze N. Deset dana nakon žetvene zriobe povećana doza dušika u Botincu nije utjecala na razinu dormantnosti ili je smanjila razinu dormantnosti, ovisno o kultivaru, dok je u Rugvici povećala razinu dormantnosti kod većine kultivara.

Ključne riječi: pšenica, gnojidba dušikom, dormantnost

## Nitrogen fertilizer effect on expression of grain dormancy in wheat

### Abstract

Ten cultivars of winter wheat used for commercial production in Croatia were sown in growing season 2008/2009 at two locations, Botinec and Rugvica in a field trial in two replications in two rates of nitrogen fertilizers. At the low level of nitrogen fertilization (N0) 100 kgN ha<sup>-1</sup> was applied, while at high level of nitrogen fertilization (N1) 185 kgN ha<sup>-1</sup> was applied. The objective of the present study was to determine the effect of cultivar and nitrogen rate (N) on expression of grain dormancy at two times: harvest ripeness (HR) and 10 days after harvest (post-harvest ripeness, PHR). Grain dormancy was determined in germination tests and expressed as germination index (GI). Germination indexes at both HR and PHR had higher values at Botinec compared to Rugvica indicating higher level of grain dormancy at Rugvica. The effect of N rate on grain dormancy at harvest ripeness was not significant at Botinec at Rugvica the higher N rate increased grain dormancy. Ten days after harvest ripeness increased N rate increased grain dormancy at Rugvica but at Botinec increased N rate had no effect on the level of grain dormancy or decreased grain dormancy, depending on cultivar.

Key words: wheat, nitrogen fertilization, dormancy

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## Uvod

Priježetveno proklijavanje kod pšenice izazvano prekomjernim oborinama u vrijeme žetve smanjuje prinos po jedinici površine, hektolitarsku masu kao i kvalitetu zrna donoseći financijske gubitke poljoprivrednim proizvođačima (Derera, 1989). Proklijala zrna i brašno dobiveno iz njih imaju povećanu aktivnost  $\alpha$ -amilaze, što ima negativni učinak na proizvodnju kruha. Razina dormantnosti zrna u žetvenoj zriobi kao i brzina gubitka dormantnosti tijekom posliježetvenog dozrijevanja su glavne komponente otpornosti na priježetveno proklijavanje kod pšenice (Derera, 1989), ali i drugi čimbenici kao što su morfologija klasa (King i Richards, 1984) kao i sadržaj u vodi topljivih inhibitora klijanja u vegetativnim dijelovima cvijeta (Šarčević i sur., 1999; Šarčević i sur., 2010) mogu utjecati na razinu otpornosti. Iako je dormantnost pod genetičkom kontrolom (Derera, 1989; Šarčević i sur., 2000) njezina razina i trajanje je pod velikim utjecajem okolinskih faktora posebno temperature. Općenito niže temperature tijekom dozrijevanja zrna induciraju duboku i produljenu dormantnost dok kod zrelog zrna u kombinaciji s upijanjem vode smanjuju razinu dormantnosti (Derera, 1989). Osim temperature i gnojidba dušikom (Kettlewell, 1999; Kindred i sur., 2005) imale su signifikantan učinak na variranje razine  $\alpha$ -amilaze, Hagbergovog padajućeg broja (HFN) i razinu dormantnosti zrna.

Cilj rada je bio utvrditi utjecaj kultivara i doze dušika (N) na stupanj dormantnosti zrna u dva roka: žetvenoj zriobi (ŽZ) i 10 dana nakon žetvene zriobe (post-žetvena zrioba, PŽZ).

## Materijali i metode

U istraživanje je bilo uključeno 10 kultivara ozime pšenice raširenih u proizvodnji u Republici Hrvatskoj od kojih je sedam kultivara stvoreno u Bc Institutu Zagreb (Sana, Tina, Prima, Zdenka, Aura, Liberta, Bc Elvira), jedan kultivar (Golubica) stvoren u Poljoprivrednom institutu Osijek te dva francuska kultivara (Soissons i Renan). Kultivari su sijani u vegetacijskoj godini 2008/2009. na dvije lokacije, Botinec i Rugvica u poljskom pokusu postavljenom prema latiniziranom redno stupčastom dizajnu u dva ponavljanja s dvije razine gnojidbe dušikom. Kod niske razine gnojidbe dušikom (N0) dodano je 100 kgN ha<sup>-1</sup>, dok je kod visoke razine gnojidbe dušikom (N1) dodano 185 kgN ha<sup>-1</sup>. Ostali agrotehnički postupci bili su jednaki za obje razine gnojidbe. U žetvenoj zriobi (zrna oko 14% vlage) su iz svake pokusne parcele uzeti uzorci od 30 slučajnih klasova, koji su ručno ovršeni i zrna čuvana na -20°C do početka pokusa klijavosti. Test klijavosti za procjenu dormantnosti zrna proveden je u dva roka: žetvena zrioba (ŽZ) i nakon 10 dana posliježetvenog dozrijevanja zrna na temperaturi 20°C (PŽZ). Klijavost je ispitivana u petrijevim zdjelicama u koje je postavljeno po 30 zrna na filter papiru namočenom s 5ml ddH<sub>2</sub>O. Zrna su prethodno sterilizirana s 13% Na-hipokloritom i dva puta isprana s ddH<sub>2</sub>O. Petrijevke su inkubirane u tami u klima komori pri konstantnoj temperaturi od 20°C. Proklijala zrna brojana su nakon tri i nakon šest dana. Kao kriterij za proklijalo zrno uzet je probijen perikarp iznad embrija. Na osnovi postotka proklijalih zrna izračunat je indeks klijanja prema formuli:

$$GI = [(br. prokl. zrna 3. dan \times 6) + (br. prokl. zrna 6. dan \times 3)] / (uk. br. zrna \times 6).$$

Manji indeks klijanja ukazuje na veću dormantnost zrna. Analiza varijance (PROC GLM) kao i Fisherov LSD test (kod P<0,05) za usporedbu između srednjih vrijednosti provedeni su korištenjem programskog paketa SAS (SAS Institute, 2007).

## Rezultati i rasprava

Kombinirane analiza varijance kroz lokacije (rezultati nisu prikazani) pokazala je signifikantni učinak lokacije (L), kultivar (K) kao i interakcija LxK, LxN i KxN na GI u oba roka, dok je doza N imala signifikantan učinak za GI samo u prvom roku (ŽZ). Interakcija KxNxL nije bila signifikantna niti u jednom roku. Rezultati analize varijance po lokacijama prikazani su u tablici 2. Kultivar je imao signifikantan učinak na GI u oba roka na obje lokacije, dušik je imao signifikantan učinak na GI u prvom roku (ŽZ) samo u Rugvici, a u drugom roku (PŽZ) na obje lokacije. Interakcija KxN bila je signifikantna samo u Rugvici za GI u oba roka.

Učinak gnojidbe dušikom na dormantnost zrna kod pšenice

Tablica 1. ANOVA (F vrijednost) za indeks klijanja (GI) u žetvenoj zriobi (ŽZ) i 10 dana nakon žetvene zriobe (PŽZ) za lokacije Botinec i Rugvica

Izvor varijabilnosti	Stupnjevi slobode	GI-ŽZ			GI-PŽZ				
		Botinec		Rugvica	Botinec		Rugvica		
Kultivar (K)	9	101,90	**	64,38	**	27,33	**	112,47	**
Dušik (N)	1	0,88	ns	28,95	**	5,95	*	22,83	**
K x N	9	1,24	ns	4,17	**	1,31	ns	5,59	**

U tablici 2. je prikazan indeks klijanja (GI) u žetvenoj zriobi (ŽZ) za 10 kultivara pšenice kod dvije razine dušične gnojidbe u Botincu i Rugvici 2008. Prosječni GI u Botincu kod N0 i N1 nisu se signifikantno razlikovali. Prosječni GI za sve genotipove u Rugvici bio je za 0,12 manji kod N1 u usporedbi s N0. Kultivari Sana, Tina, Zdenka i Golubica reagirale su najvećim smanjenjem GI s povećanom dozom N.

U tablici 3. je prikazan indeks klijanja (GI) 10 dana nakon žetvene zriobe (PŽZ) za 10 kultivara pšenice kod dvije razine dušične gnojidbe u Botincu i Rugvici 2008. Prosječni GI za sve kultivare u Botincu je bio signifikantno viši kod N1, dok je u Rugvici bio signifikantno niži kod N1. Izraženije povećanje GI u Botincu pokazivali su kultivari Liberta, Soisson i Renan. U Rugvici su kod N1 kultivari Zdenka, Aura, Golubica i Renan pokazali najveće smanjenje GI (izraženija dormantnost) s povećanjem doze N. Kultivar Renan imao je izraženu reakciju na povećanu gnojidbu s N na obje lokacije ali sa suprotnim predznakom.

Tablica 2. Indeks klijanja (GI) u žetvenoj zriobi (ŽZ) za 10 kultivara pšenice kod dvije razine dušične gnojidbe (N0 i N1) u Botincu i Rugvici 2008

Kultivar	GI-ŽZ					
	Botinec			Rugvica		
	N0	N1	N1-N0	N0	N1	N1-N0
Sana	0,86	0,87	0,01	0,82	0,59	-0,22
Tina	0,98	0,87	-0,12	0,82	0,53	-0,28
Prima	0,93	0,98	0,05	0,73	0,81	0,08
Zdenka	0,71	0,68	-0,03	0,41	0,23	-0,18
Aura	0,68	0,78	0,10	0,38	0,34	-0,04
Liberta	0,54	0,58	0,03	0,20	0,09	-0,10
Bc Elvira	0,82	0,84	0,02	0,73	0,68	-0,05
Golubica	0,63	0,65	0,02	0,56	0,21	-0,35
Soisson	0,19	0,2	0,01	0,04	0,05	0,01
Renan	0,23	0,29	0,06	0,13	0,11	-0,02
Prosjek	0,66	0,67	0,02	0,48	0,36	-0,12
LSD(P<0,05)	0,13	0,13		0,15	0,16	

Tablica 3. Indeks klijanja (GI) 10 dana nakon žetvene zriobe (PŽZ) za 10 kultivara pšenice kod dvije razine dušične gnojidbe (N0 i N1) u Botincu i Rugvici 2008

Kultivar	GI-PŽZ					
	Botinec			Rugvica		
	N0	N1	N1-N0	N0	N1	N1-N0
Sana	0,97	0,98	0,02	0,98	0,96	-0,03
Tina	0,98	0,98	0,00	0,98	0,96	-0,03
Prima	0,98	0,99	0,01	0,98	0,98	0,00
Zdenka	0,99	0,98	-0,01	0,98	0,68	-0,30
Aura	0,98	0,97	-0,01	0,86	0,64	-0,22
Liberta	0,81	0,93	0,12	0,66	0,72	0,07
Bc Elvira	0,93	0,97	0,03	0,98	0,9	-0,08
Golubica	0,99	0,99	0,00	0,98	0,87	-0,11
Soisson	0,48	0,68	0,19	0,23	0,29	0,06
Renan	0,55	0,67	0,11	0,41	0,29	-0,12
Prosjek	0,87	0,91	0,05	0,80	0,73	-0,07
LSD (P<0,05)	0,13	0,07		0,11	0,13	

Različita reakcija kultivara na gnojidbu dušikom na dvjema lokacijama kao i u različitim rokovima utvrđena u ovome radu u skladu je s rezultatima drugih studija. Tako je povećana opskrba usjeva s dušikom smanjila aktivnost  $\alpha$ -amilaze u zrnu u ispitivanjima Pushmana i Bingham (1976). Međutim u pokusu, koji su proveli Bhatt i sur. (1981), povećana gnojidba dušikom nije imala signifikantni učinak na aktivnost  $\alpha$ -amilaze niti na Hagbergov padajući broj (HFN), dok je u ispitivanjima Morrissa i Paulsena (1985) povećala razinu  $\alpha$ -amilaze kod genotipova osjetljivih na proklijavanje.

Gooding i sur. (1986) su dobili linearno povećavanje HFN s povećavanjem doze dušika kod dva od triju ispitivanih kultivara ozime pšenice, a u pokusu Svenssona (1990.) s jarim pšenicama povećana doza dušika povećavala je broj padanja sve do točke, kada je jače polijeganje rezultiralo u jačem proklijavanju. Povećanje doze dušika u dvogodišnjem pokusu Kettlewella (1999) samo je u jednoj godini imalo učinak na smanjenje aktivnosti  $\alpha$ -amilaze u neprokljalim zrnima. Kindred i sur (2005) su utvrdili utjecaj povećane doze dušika na povećanje HFN i dormantnosti zrna pšenice. Učinak dušika rastao je s porastom stupnja dormantnosti kultivara. Nasuprot tome, u ispitivanjima Morrissa i Paulsena (1985) povećana doza dušične gnojidbe je povećala proklijavanje samo kod genotipova osjetljivih na priježetveno proklijavanje. Za razliku od rezultata prethodnih istraživanja, rezultati ovoga rada ne upućuju na povezanost učinka N gnojidbe sa stupnjem dormantnosti kultivara. Rezultati ovoga rada kao i rezultati drugih autora ukazuju na različitu ekspresiju otpornosti na priježetveno proklijavanje kod pšenice u različitim okolinama. Stoga postoji potreba za testiranjem većeg broja genotipova kod više razina gnojidbe dušikom radi dobivanjem boljeg uvida u ulogu dušika u ekspresiji aktivnosti  $\alpha$ -amilaze u zrnu, dormantnosti zrna kao i priježetvenog proklijavanja.

### Zaključci

Doza dušika imala je nekonzistentan učinak na ekspresiju dormantnosti na dvjema lokacijama kao i u dva roka nakon žetve. U žetvenoj zriobi na lokaciji Botinec doza N nije imala signifikantan učinak na razinu dormantnosti zrna dok je na lokaciji Rugvica došlo do povećanja razine dormantnosti zrna povećanjem doze N. Deset dana nakon žetvene zriobe povećana doza dušika u Botincu nije utjecala na razinu dormantnosti ili je smanjila razinu dormantnosti, ovisno o kultivaru, dok je u Rugvici povećala razinu dormantnosti kod većine kultivara. Nova istraživanja su potrebna za dobivanje boljeg uvida u učinak dušika na ekspresiju dormantnosti zrna kod pšenice.

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# The components of variability of nitrogen status indicators in wheat

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## Abstract

The aim of this study was to estimate components of phenotypic variability of some nitrogen status indicators in wheat. A field trial included 30 wheat genotypes. The N content at flowering in aboveground parts of the plants, grain, straw and whole matured plants, N harvest index, N reutilization, N post-anthesis accumulation and physiological efficiency of N were studied. Higher genotypic than environmental variance for all traits was found out by analysis of phenotypic variance. The genetic variation ranged from 60% (N content in plant in flowering) to 86% (N post-anthesis accumulation) of phenotypic one. Tested materials represent a desirable variability source and have beneficial relationship between variability components.

Key words: breeding, genetic variance, nitrogen, variability, wheat

## Introduction

Increasing nitrogen accumulation in plants is one of the most important preconditions for improvement productive potential of new wheat cultivars and grain quality at the same time and overcome negative correlation between the most important traits (Austin et al., 1977; Djokic et al., 1998). The increase of N content in plants can be achieved by fertilization, but the excessive use of fertilizers, nowadays, is not desirable from the viewpoint of economy of plant production and, especially, environmental protection (Powelson et al., 2006-2007; Carman et al., 2007). So, the question of nitrogen nutrition efficiency is becoming very actually nowadays.

The nitrogen nutrition efficiency of some genotype can be assessed, easily and reliably, on the basis of nitrogen content at flowering in aboveground part of plant, grain, straw and whole matured plant, nitrogen harvest index, nitrogen reutilization, post-anthesis accumulation and nitrogen physiological efficiency (Djokic et al., 1998). The nitrogen content at flowering in aboveground parts of the plant, grain, straw and whole matured plant are indicators of genotype efficiency in absorption and accumulation nitrogen from soil reserves and applied fertilizers, also post-anthesis accumulation. Nitrogen harvest index is considered as indicator of efficiency of N translocation from vegetative to generative organs and its utilization to grain filling and protein synthesis. Nitrogen reutilization and nitrogen physiological efficiency are indicators of N utilization efficiency. Nitrogen reutilization point at genotype ability to move nitrogen, accumulated in the plant during the flowering and pollination, from vegetative parts to the grain. It is very important physiological trait because of the fact that in the event of adverse weather conditions in the reproductive period, all the grain actually provides nitrogen reutilization (Cox et al., 1986; Djokic et al., 1998; Przulj et al., 2004)

Some researchers emphasized importance of including some adequate physiological indicators related to nitrogen nutrition efficiency in breeding programs as criteria for selecting parents and evaluating progeny (Fisher, 1975; van Ginkel et al., 2001; Baker et al., 2004; Pathak et al., 2008). According to Tollenar (1991), some physiological traits can be useful as selection criterion if we know its genetic variability and genetic control. Furthermore, existing correlations of a physiological trait with some desirable traits (yield, quality)

are very important. Finally, that physiological trait must be measurable through trials. Mahon (1983) pointed at difficulties with including physiological traits in breeding processes, because of their sensitivity to environmental conditions, complex physiological interactions and absence of adequate methods for their genetical dissection studying and definition of their clear connection with genotype productivity.

The aim of this study was to estimate components of phenotypic variability of some nitrogen status indicators.

### Materials and methods

The investigation included 30 varieties and perspective lines of winter wheat, developed at the Small Grains Research Center in Kragujevac and the Institute of Field and Vegetable Crops in Novi Sad, Serbia, in various stages of selection. The following genotypes were examined: Morava, Lepenica, Studenica, Takovcanka, Toplica, Srbijanka, KG 100, Lazarica, Bujna, Matica, Vizija, Pobeda, Rana 5, Evropa 90, Renesansa, Tiha, Mina, Prima, Kremna, Rusija, Pesma, KG - 200/31, KG - 253/4 - 1, KG - 115/4, KG - 165/2, KG - 56/1, KG - 100/97, Perla, KG - 224/98 and KG - 10.

The experiment was set up as a randomized complete block system, design with five replications. The sowing was done manually, by "genotype - row" way. The sowing rate was 200 grain per row. The row length was 1.5m and the distance between rows 0.20 m. NPK fertilizer (8:24:16) was used for basic fertilization (300 kg ha<sup>-1</sup>) and KAN in tillering stage (7,5 - 8 g per row i.e. 250 - 260 kg ha<sup>-1</sup>).

The plant samples (above ground parts) were taken at flowering (five plants per genotype from each replication) and full maturity stage (ten plants per genotype from each replication). The airdried plant material was then processed. The mass of above ground part of plants at flowering, grain and straw was done separately. The nitrogen concentration in them was determined by Kjeldahl method (Krajovan et al., 1972), respectively.

The indicators of nitrogen nutrition efficiency were counted as follows:

- nitrogen accumulation (AN) or nitrogen content in above ground plant part in flowering, grain and straw as product of nitrogen concentration and dry mass (DM) of plant or appropriate plant part, based on the formulas:

$$AN_{\text{flowering}} (\text{g m}^{-2}) = DM_{\text{plant fl.}} (\text{g}) \times N_{\text{plant}} (\%)$$

$$AN_{\text{grain}} (\text{g m}^{-2}) = DM_{\text{grain}} (\text{g}) \times N_{\text{grain}} (\%)$$

$$AN_{\text{straw}} (\text{g m}^{-2}) = DM_{\text{straw}} (\text{g}) \times N_{\text{straw}} (\%)$$

- total N accumulation (AN<sub>t</sub>) or content in matured plant as sum of AN<sub>grain</sub> and AN<sub>straw</sub>, converted, across the number of plants per row, to area unit and expressed by g m<sup>-2</sup>, like above mentioned indicators
- nitrogen harvest index (NHI) as ratio between AN<sub>grain</sub> and AN<sub>t</sub>, expressed by%
- nitrogen reutilization (N<sub>re</sub>), calculated by taking AN<sub>straw</sub> from AN<sub>flowering</sub>, converted, across the number of plants per row, to area unit and expressed by g m<sup>-2</sup>
- N postanthesis accumulation (N<sub>pa</sub>) calculated by taking AN<sub>flowering</sub> from AN<sub>t</sub>, converted, across the number of plants per row, to area unit and expressed by g m<sup>-2</sup>
- physiological efficiency of nitrogen (PEN) as ratio between grain yield and AN<sub>t</sub>, expressed by g<sub>grain</sub> gN<sub>t</sub><sup>-1</sup>
- Obtained dates were statistically processed. The components of variability as well as their coefficients were determined according to Chaudhary et al. (1999).

### Results and discussion

The absolute values of variability components of indicators of nitrogen accumulation, utilization and distribution efficiency, their relative share in entire phenotypic variation and their coefficients of variation are presented in Tab. 1.

The statistically analysis of variability components of investigated indicators showed the lowest phenotypic variation (6.63%) of NHI in the first year, but the highest (92.42%) of nitrogen post anthesis accumulation

(N<sub>pa</sub>) in the second year of experiment. The coefficients of variation of genetic variance ranged from 4.51% (NHI, the first year) to 87.01% (nitrogen postanthesis accumulation, the second experimental year). High coefficients of variation traits mean a wide possibility to select genotypes in the tested varieties, according to the desired criteria (Surlan-Momirovic et al., 1996). It may therefore be considered the varieties selected for this test are the significant source of variability for breeding programs for wheat, which would include the test indicators of plant nitrogen status as criterions.

Genetic variation ranged from 60% (AN<sub>flowering</sub>, Tab. 1) up to 86% (nitrogen postanthesis accumulation, Tab. 1), as already intimated the coefficient of variation. From a practical point of selection is not desirable that the total variation has a greater share of environmental variance compared to genetic (Zivanovic, 1997). Significantly larger share of the total variation of genetic variance to the environment means less influence of environmental factors on the realized variation of these traits, which in terms of selection and breeding is considered a very favorable ratio. The obtained results are in accordance with the results Pavlovic (1997) and they also share genetic variance to phenotypic significantly higher compared with environmental indicators in the case of nitrogen status of plants, ranging from 52% to 74%.

**Table 1. Components of variability, relative share of V<sub>p</sub> and coefficients of variation of wheat plants nitrogen status indicators**

Trait	Year	V <sub>p</sub>	V <sub>e</sub>	V <sub>g</sub>	Relative share of V <sub>p</sub> (%)		CV <sub>p</sub>	CV <sub>g</sub>
					V <sub>e</sub>	V <sub>g</sub>		
AN <sub>flowering</sub>	1	13.24	3.64	9.60	40	60	37.07	31.56
	2	1.58	0.77	0.81			34.68	24.79
	3	7.06	4.42	2.64			21.23	12.99
$\bar{X}$		7.29	2.94	4.35			-	-
AN <sub>grain</sub>	1	12.04	2.55	9.49	28	72	39.96	35.47
	2	1.10	0.50	0.60			22.45	21.75
	3	10.21	3.41	6.81			26.79	21.87
$\bar{X}$		7.78	2.15	5.63			-	-
AN <sub>straw</sub>	1	2.43	0.36	2.06	21	79	45.74	42.16
	2	0.12	0.05	0.07			31.71	24.72
	3	1.90	0.53	1.37			33.29	28.23
$\bar{X}$		1.48	0.31	1.17			-	-
AN <sub>t</sub>	1	23.81	5.02	18.79	26	74	42.16	40.45
	2	1.51	0.72	0.78			26.46	24.72
	3	17.58	5.53	12.04			28.23	28.09
$\bar{X}$		14.30	3.76	10.54			-	-
NHI	1	22.63	12.19	10.44	24	76	6.63	4.51
	2	52.10	2.70	22.40			9.19	6.03
	3	25.76	8.87	16.89			6.81	5.52
$\bar{X}$		33.50	7.92	25.58			-	-
N <sub>re</sub>	1	6.30	1.13	5.17	35	65	40.09	36.32
	2	1.09	0.36	0.73			40.98	33.58
	3	4.17	2.56	1.61			24.59	15.27
$\bar{X}$		3.85	1.35	2.50			-	-
N <sub>pa</sub>	1	5.20	0.62	4.58	14	86	89.05	83.57
	2	1.31	0.15	1.16			92.42	87.01
	3	6.96	1.08	5.88			74.79	68.73
$\bar{X}$		4.49	0.62	3.87			-	-
PEN	1	11.73	3.91	7.81	30	70	8.10	6.61
	2	16.12	4.51	11.61			12.05	10.23
	3	11.05	3.38	7.67			7.55	6.29
$\bar{X}$		12.97	3.93	9.04			-	-

## Conclusion

Considering obtained results, it can be concluded that investigated materials represents a desirable variability source and has beneficial relationship between variability components. Therefore, it can be considered as important material for future breeding programs of wheat. Judging by obtained results, tested physiological indicators could meet requirements to the wheat selection and breeding in terms of the nature of their variability.

Noting objective difficulties about including physiological parameters as criteria in wheat breeding, further testing this material by other aspects (correlations with yield and quality, heritability) is necessary to more complete and more reliable assessment and conclusion.

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# Oplemenjivanje krušne pšenice na tolerantnost na stresne uvjete halomorfni tala

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## Sažetak

U F<sub>2</sub> potomstvima križanja krušne pšenice procijenjeni su genotipovi koji bolje toleriraju abiotički stres u uvjetima uzgoja na solonjecu uz popravak sa 25 t ha<sup>-1</sup> fosfogipsa i dreniranje tla. Broj i masa zrna po klasu su odabrane kao fenotipski markeri prinosa. Pokus je postavljen na černozemu i solonjecu. Sorte Partizanka i Pema su iskazale visoki nivo toleriranja alkaliziranog tla za broj zrna po klasu, a Partizanka i za masu zrna po klasu. Potomstva križanja Pobeda x Renesansa su se iskazala kao perspektivnim za odabir poželjnih genotipova po kriteriju povećane tolerancije na abiotičke stresne uvjete alkaliziranog tla sa popravkom. Način nasljeđivanja je ovisio o uvjetima okoline.

Ključne riječi: pšenica, abiotički stres, solonjec, oplemenjivanje

## Bread wheat breeding for tolerance to stressful conditions on halomorphic soils

### Abstract

The aim of this study was to evaluate promising F<sub>2</sub> progenies of bread wheat crosses for selection of genotypes that are more tolerant to abiotic stress caused by solonetz soil ameliorated by 25t/ha phosphogypsum and soil drainage. The number and weight of grains per spike were selected yield components as phenotypic markers. The experiment was set up on chernozem (control) and solonetz (alkaline soil). Varieties Partizanka and Pema expressed high level of tolerance to alkaline soil for number of grains per spike, and Partizanka for grain weight per spike, as well. The offspring of the cross Pobeda x Renesansa appeared to be a promising population for selection of desirable genotypes in the breeding process according to the criterion of increased tolerance to abiotic stress conditions caused by ameliorated solonetz soil. The mode of inheritance was largely dependent on environmental conditions.

Key words: wheat, abiotic stress, solonetz, breeding

### Uvod

Abiotički stresni uvjeti su često kritična točka u dobivanju stabilnog i visokog uroda krušne pšenice u Vojvodini, a i šire. Stresni uvjeti izazvani lošom raspodjelom ili količinom padalina, te temperaturnim kolebanjima i ekstremima, pa ponekad i uvjetima tala u stepskom, ravničarskom regionu su posljednjih decenija pojačani globalnim klimatskim promjenama. Alkaliziranost tala često nastaje degradiranjem kao posljedica navodnjavanja, a javlja se i kao tip tla solonjec ili solončak u aridnim ravničarskim krajevima stepskog klimata. Solonjec, kao natrijem bogato tlo, zauzima oko 20 milijuna hektara u Europi (Szabolcs,

1971). U Vojvodini se nalazi oko 80 000 hektara ovog tipa tla, najviše u Banatu (Belić, 1999). Solonjec je najčešće podloga za ekstenzivno ispašište, no pojedine poljoprivredne kulture i mjere popravka mogu podići uporabnu vrijednost ovog tla. Žitarice su umjereno tolerantne kulture na povećanu alkaliziranost tla (Maas i Hoffman, 1977). Kao takve one ne zahtijevaju prevelika ulaganja u proizvodnju, te su pogodne za uzgoj na solonjecu (Carter, 1983; Royo i Abió; 2003, Sabir i Ashraf; 2008, Zheng i sur., 2008). Kemijske mjere popravka solonjeca uz drenažu su raznolike i zasnivaju se na kalcijevim tvarima (gips, kalcijev klorid, kalcijev nitrat, fosfogips) ili kiselinama -  $H_2SO_4$ ,  $HCl$ ,  $HNO_3$  (Helgason, 2000; Oad i sur., 2002; Sadiq i sur., 2003). Ghafoor i sur. (2001) navode da popravak fosfogipsom uz uzgoj riže ili pšenice se pokazao najekonomičnijim na alkaliziranim tlima u Pendžabu. Pored stalne procjene uporabne vrijednosti sorti unutar postojeće genetske varijabilnosti pšenice sa stanovišta tolerantnosti na abiotski stres, u programima oplemenjivanja se kreira i nova genetska varijabilnost (Cseuz i sur., 2002, Araus i sur., 2008). Kriteriji izbora u ranim potomstvima križanja se često formiraju na bazi komponenti uroda zrna (Dashti i sur., 2010). Ovo se posebno odnosi na one komponente koje značajnije pozitivno koreliraju sa urodom.

Cilj ovog rada je da se uporedno genetski analiziraju komponente uroda u roditelja i  $F_2$  potomstvima križanja sorti pšenice na solonjecu i černozeu.

### Materijali i metode

Za pokus je odabrano pet sorata (Pobeda, Renesansa, Sara, Partizanka, Pesma) koje su poslužile kao roditelji i devet kombinacija njihovih križanja ( $F_2$  generacija): Pobeda x Renesansa, Pobeda x Sara, Pobeda x Pesma, Renesansa x Sara, Renesansa x Partizanka, Renesansa x Pesma, Sara x Partizanka, Sara x Pesma i Partizanka x Pesma. Pokus je postavljen jednovremeno na tlu tipa černozeu (kontrola), na pokusnom polju Instituta za ratarstvo i povrtarstvo Rimski Šančevi (45,322° sjeverno i 19,839° istočno) i na tlu tipa solonjec (abiotski stres), na pokusnom polju na lokaciji Kumane u Banatu (45,539° sjeverno i 20,228° istočno), tijekom vegetacijske sezone 2009/2010. Pokus na solonjecu je postavljen uz primjenu fosfogipsa za kemijsku popravku tla u količini 25 t ha<sup>-1</sup> i dreniranje u razmaku od 20 cm.

Sjetva pokusnog materijala je obavljena u redove duljine 1 m i razmakom između redova 20 cm. Pri tome je svaki roditelj posijan u šest redova sa 10 zrna po redu, dok je svako križanje sijano u 12 reda sa 10 zrna u redu. Analizirana je masa zrna po klasu (g) te broj zrna po klasu. Značajnosti razlika aritmetičkih sredina procijenjena je t-testom, te su utvrđeni načini naslijeđivanja u  $F_2$  potomstvima križanja.

### Rezultati i rasprava

U svrhu prikaza u ovom radu su iz ukupnog rezultata pokusa i izdvojena svojstva broj i masa zrna po klasu. Broj zrna po klasu ima značajan doprinos formiranju uroda zrna, posebno u uvjetima abiotskog stresa (García del Moral i sur., 2003). Slično je i sa masom zrna po klasu koja nema izraženu pozitivnu korelaciju sa urodom zrna pšenice u normalnim uvjetima, ali u uvjetima stresa javlja se pozitivna korelacija ova dva svojstva (Denčić i sur., 2000). Ovo upućuje na ova dva svojstva kao na fenotipske markere perspektivnih genotipova glede uroda zrna u generaciji razdvajanja ( $F_2$ ) križanja odabranih roditeljskih parova pšenice.

Broj zrna po klasu je u skladu sa očekivanjima bio veći na černozeu ( $\bar{X}_{Er} = 43,97$ ) nego na solonjecu ( $\bar{X}_{Er} = 33,53$ ). Najveću toleranciju na uvjete abiotskog stresa za promatrano svojstvo iskazale su sorte Partizanka i Pesma ( $\bar{x}_{Ch} - \bar{x}_{So} = 4,84$  i  $\bar{x}_{Ch} - \bar{x}_{So} = 7,43$ , redosljedom). Pri tomu, sorta Pesma je posjedovala i visoke srednje vrijednosti svojstva ( $\bar{x}_{Ch} = 46,31$  i  $\bar{x}_{So} = 38,70$ ).  $F_2$  potomstva su, kao populacije genetskog razdvajanja, iskazala isti nivo srednjih vrijednosti na kontroli na černozeu ( $\bar{X}_{Er} = 44,15$ ) nego na solonjecu ( $\bar{X}_{Er} = 3,00$ ). Potomstva križanja Pobeda x Renesansa su se iskazala kao perspektivna populacija ( $\bar{x}_{So} = 48,60$ ) za odabir poželjnih genotipova u postupku oplemenjivanja po kriteriju povećane tolerancije na abiotske stresne uvjete alkaliziranog tla sa popravkom. Slično se može ustvrditi za sve  $F_2$  populacije koje su iskazale superdominantni tip naslijeđa (+h), sa prosjekom broja zrna po klasu na nivou, ili iznad prosjeka pokusa (križanja Pobeda x Sara, Renesansa x Partizanka, Renesansa x Pesma, te Sara x Partizanka). Kombinacije Pobeda x Renesansa i Renesansa x Partizanka su u prosjeku zadržale isti nivo broja zrna po klasu na černozeu i solonjecu ( $\bar{x}_{Ch} - \bar{x}_{So} = 0,92$  i  $\bar{x}_{Ch} - \bar{x}_{So} = 0,15$ , redosljedom), pri većim srednjim vrijednostima svojstva.  $F_2$  potomstva križanja Pobeda x Sara, Pobeda x Pesma i Sara x Partizanka su iskazale trend reagiranja povećanjem broja zrna po klasu na solonjecu ( $\bar{x}_{Ch} - \bar{x}_{So} = -2,32$ ,  $\bar{x}_{Ch} - \bar{x}_{So} = -4,46$  i  $\bar{x}_{Ch} - \bar{x}_{So} = -3,44$ , redosljedom), što treba biti posebice praćeno u nastavku programa oplemenjivanja *in situ*. Uvjeti okoline su utjecali na ispoljen način naslijeđivanja. Na kontroli (černozeu), prosjek potomstva je bio na nivou roditelja

(-) u većini slučajeva, izuzev u F<sub>2</sub> križanja Pobjeda x Renesansa (+d, pozitivna dominantnost), Pobjeda x Pesma (-h, negativna superdominantnost) i Renesansa x Partizanka (+pd, pozitivna parcijalna dominantnost). Stresni abiotski uslovi na solonjecu su uvjetovali da je velika većina F<sub>2</sub> potomstava značajno prevazilazila (+h) boljeg roditelja, a u dva slučaja je bila na nivou roditelja sa većim prosjekom promatranog svojstva (+d) (Tablica 1.)

Tablica 1. Prosječne vrijednosti broja zrna po klasu na černozeu ( $\bar{x}_{Ch}$ ) i solonjecu ( $\bar{x}_{So}$ ), te genotipski ( $\bar{x}_G$ ) i ekološki prosjeci ( $\bar{x}_E$ ), kao i razlike prosjeka svojstva na tipovima tla ( $\bar{x}_{Ch} - \bar{x}_{So}$ ).

Genotip	$\bar{x}_{Ch}$	$\bar{x}_{So}$	$\bar{x}_G$	$\bar{x}_{Ch} - \bar{x}_{So}$
<i>Roditelji</i>				
Pobjeda	42,87	29,17	36,02	13,70
Renesansa	47,20	31,70	39,45	15,50
Sara	45,17	34,47	39,82	10,70
Partizanka	38,47	33,63	36,05	4,84
Pesma	46,13	38,70	42,42	7,43
$\bar{x}_{Er}$	43,97	33,53	38,75	10,43
<i>Križanja (F<sub>2</sub> potomstva)</i>				
Pobjeda x Renesansa	<sup>+d</sup> 49,52	<sup>+h</sup> 48,60	49,06	0,92
Pobjeda x Sara	41,50	<sup>+h</sup> 43,82	42,66	-2,32
Pobjeda x Pesma	<sup>-h</sup> 35,70	<sup>+d</sup> 40,16	37,93	-4,46
Renesansa x Sara	44,10	<sup>+d</sup> 40,40	42,25	3,70
Renesansa x Partizanka	<sup>+pd</sup> 45,02	<sup>+h</sup> 44,87	44,95	0,15
Renesansa x Pesma	50,08	<sup>+h</sup> 47,10	48,59	2,98
Sara x Partizanka	41,63	<sup>+h</sup> 45,07	43,35	-3,44
Sara x Pesma	47,23	40,27	43,75	6,96
Partizanka x Pesma	42,57	36,73	39,65	5,84
$\bar{x}_{Ek}$	44,15	43,00	43,58	1,15
$\bar{x}_E$	44,09	39,62	41,85	5,74
$\sigma_E^2$	41,40	131,50		
IPCA1 <sub>E</sub>	3,484	-3,484		
		LSD 0,05=5,354		LSD 0,01=7,121

Masa zrna po klasu je, slično broju zrna po klasu, imala trend većih prosjeka na černozeu ( $\bar{x}_{Er} = 1,66g$ ) nego na solonjecu ( $\bar{x}_{Er} = 1,27g$ ). Značajniju toleranciju uvjeta uzgoja na solonjecu za ovo svojstvo je iskazala sorta Partizanka ( $\bar{x}_{Ch} - \bar{x}_{So} = 0,10g$ ). F<sub>2</sub> potomstva su, slično kao kod broja zrna po klasu, iskazala isti nivo prosjeka na černozeu ( $\bar{x}_{Er} = 1,67g$ ) i solonjecu ( $\bar{x}_{Er} = 1,69g$ ). F<sub>2</sub> križanja Pobjeda x Renesansa se i za masu zrna po klasu pokazala kao perspektivna selekcijska populacija ( $\bar{x}_{So} = 2,07g$ ). Populacije potomstava koje su iskazale potencijalno upotrebljivim su Pobjeda x Sara ( $\bar{x}_{So} = 1,75g$ , pri  $\bar{x}_{Ch} - \bar{x}_{So} = -0,17$ ), Renesansa x Pesma ( $\bar{x}_{So} = 1,90g$ , pri  $\bar{x}_{Ch} - \bar{x}_{So} = -0,04$ ) i Sara x Partizanka ( $\bar{x}_{So} = 1,75g$ , pri  $\bar{x}_{Ch} - \bar{x}_{So} = 0,03$ ). Način nasljeđivanja se mjenjao zavisno od uvjeta okoline. Prosjek potomstva na černozeu je u većini slučajeva bio na nivou roditelja (-), odnosno način nasljeđivanja nije bilo moguće utvrditi. Izuzetak su potomstva Pobjeda x Pesma (-h, negativna superdominantnost) i Pobjeda x Pesma (-d, negativna dominantnost). Pozitivna superdominantnost (+h) je karakterizirala veliku većinu F<sub>2</sub> potomstava na solonjecu (Tablica 2.). Za oba promatrana svojstva u većini slučajeva se iskazala pozitivna superdominacija. Dobivanje prosječnih vrijednosti broja i mase zrna po klasu značajno većih od srednje vrijednosti boljeg roditelja u F<sub>2</sub> potomstvima upućuje na mogućnost selektriranja poželjnih genotipova pšenice za dalji postupak oplemenjivanja u cilju dobivanja sorti koje što bolje toleriraju uvjete uzgoja na solonjecu.



Tablica 2. Prosječne vrijednosti mase zrna po klasu na černozeu ( $\bar{X}_{Ch}$ ) i solonjecu ( $\bar{X}_{So}$ ), te genotipski ( $\bar{X}_G$ ) i ekološki prosjeci ( $\bar{X}_E$ ), kao i razlike prosjeka svojstva na tipovima tla ( $\bar{X}_{Ch} - \bar{X}_{So}$ ).

Genotip	$\bar{X}_{Ch}$	$\bar{X}_{So}$	$\bar{X}_G$	$\bar{X}_{Ch} - \bar{X}_{So}$
<i>Roditelji</i>				
Pobeda	1,70	1,22	1,46	0,48
Renesansa	1,83	1,37	1,60	0,46
Sara	1,65	1,13	1,39	0,52
Partizanka	1,42	1,33	1,38	0,10
Pesma	1,68	1,32	1,50	0,36
$\bar{X}_{Er}$	1,66	1,27	1,46	0,38
<i>Križanja (F<sub>2</sub> potomstva)</i>				
Pobeda x Renesansa	<sup>-</sup> 1,84	<sup>+h</sup> 2,07	1,96	-0,22
Pobeda x Sara	<sup>-</sup> 1,58	<sup>+h</sup> 1,75	1,66	-0,17
Pobeda x Pesma	<sup>-h</sup> 1,33	<sup>-</sup> 1,56	1,44	-0,23
Renesansa x Sara	<sup>-</sup> 1,70	<sup>-</sup> 1,49	1,60	0,21
Renesansa x Partizanka	<sup>-</sup> 1,65	<sup>-</sup> 1,48	1,57	0,17
Renesansa x Pesma	<sup>-</sup> 1,86	<sup>+h</sup> 1,90	1,88	-0,04
Sara x Partizanka	<sup>-d</sup> 1,78	<sup>+h</sup> 1,75	1,77	0,03
Sara x Pesma	<sup>-</sup> 1,84	<sup>+h</sup> 1,71	1,78	0,12
Partizanka x Pesma	<sup>-</sup> 1,44	<sup>-</sup> 1,47	1,45	-0,03
$\bar{X}_{Ek}$	1,67	1,69	1,68	-0,02
$\bar{X}_E$	1,66	1,54	1,60	0,18
$\sigma_E^2$	0,05	0,10		
IPCA1 <sub>E</sub>	-0,571	0,571		
			LSD 0,05=2,256	LSD 0,01=3,000

## Zaključci

Imajući u vidu da će uvjeti abiotskog stresa u budućnosti biti sve prisutniji u poljoprivredi, što će zasigurno utjecati na gospodarstveni rezultat, te izmjenu proizvodne prakse, iskustva u proizvodnji i oplemenjivanju pšenice u nepovoljnoj okolini poprimaju na važnosti. Rezultati komentirani u radu ukazuju na mogućnost kreiranja poželjne genetske varijacije križanjem roditeljskih sorti iz postojećeg sortimenta pšenice, te rekombinacijom roditeljskih genoma dobivanje genotipova poboljšane tolerancije na abiotski stres, što je u ovom pokusu solonjec sa mjerama popravka fosfogipsom te dreniranjem tla. Sve ovo je dio projekta u cilju kreiranja sorti većeg nivoa toleriranja stresnih uvjeta uzgoja na alkalnom tlu u programu oplemenjivanju pšenice *in situ*.

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# Toxic influence of nickel (Ni) on germination of two cultivars of wheat (*Triticum aestivum* L.)

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## Abstract

The paper presents results of researches of the effect of several doses of NiCl<sub>2</sub> (0.00195, 0.00391, 0.0078, 0.0156, 0.0313, 0.0625, 0.125, 0.25, 0.5 and 1M) on % of germination, the length of root and shoot of two wheat *Triticum aestivum* L. cultivars - Kruna and Toplica. The results indicated that % of germination, root and shoot length of investigated cultivars were remarkably reduced with the rise of NiCl<sub>2</sub> concentration after 3. and 5. days of incubation. The average values of germinated seeds illustrated higher % of germination of cultivar Kruna than Toplica in both measurements by about 20%. The analysis of the average length of root and shoot showed remarkable differences in their length between cultivars and also between measurements after 3. and 5. incubation days of each cultivar. Results obtained by analysis of variance present high statistic differences ( $p \leq 0.01$ ) among concentrations of % of germination after 3. and 5. days, as both root and shoot length after 3. days of incubation. Our results also illustrate statistical significant differences ( $p \leq 0.05$ ) of % germination between cultivars after 3. days and of the shoot length after 5. days of incubation.

Key words: wheat cultivars, germination, nickel

## Introduction

Some toxic metals at low doses are essential micronutrients for higher plants, among them is nickel (Ni). In higher doses heavy metals may cause metabolic disorder and growth inhibition for most of the plant species (Fernandes and Henriques, 1991; Claire et al., 1991). High levels of Ni in plants growth media are phytotoxic. Slight increases in the growth of a number of plants species were attributed to low levels of Ni, but its function is not known. Possible beneficial effects of Ni on plant growth are poorly defined and not understood. Some studies have confirmed that the nickel is essential for activation of urease, an enzyme involved with nitrogen metabolism that is required to process urea. Possibly urease and, therefore, Ni might be required for the mobilization of stored seed-nitrogen through ureides or arginin during early stage of seedling growth. Without Ni, toxic levels of urea accumulate, leading to the formation of necrotic lesions (Welch, 1981; Barker and Pilbeam, 2007). The present manuscript reports results of the percentage of germinated seeds, the root and shoot length of two cultivars Kruna and Toplica of wheat (*Triticum aestivum* L.) which were treated with different concentration of NiCl<sub>2</sub>.

## Materials and methods

In order to research effects of nickel to germination of wheat seeds NiCl<sub>2</sub> (6H<sub>2</sub>O) which was obtained from Merck, Germany was used. The effect of several doses of NiCl<sub>2</sub> (0.00195, 0.00391, 0.0078, 0.0156, 0.0313, 0.0625, 0.125, 0.25, 0.5 and 1M) on % of germination, the length of root and shoot of two cultivars Kruna and Toplica of wheat (*Triticum aestivum* L.) was studied. For the nickel treatment of seed, the initial solution of NiCl<sub>2</sub> in distilled water at the concentration of 1M was prepared. From the initial solution, 10 dilutions with descending gradients of concentration were prepared up to the concentration of 0.00195M NiCl<sub>2</sub>. The seeds were germinated in Petri dishes with double layer of filter paper soaked in distilled water (control) and 1M -

0.00195M NiCl<sub>2</sub> solutions. Petri dishes were kept under standard laboratory conditions (light/darkness - 16/8h, temperature 22/18°C and humidity 55/65%). Data are the results from three separate analysis with 100 seeds in each Petri dishes. Statistical analysis was performed based by STATISTICA. The data were analyzed by analysis of variance (ANOVA) to determine the effect of treatments. The percentage of germinated seed and the length of root and shoot were recorded for each sample three and then five days after seeding in the same experiment.

### Results and discussion

The analysis data of the percentage of germination showed that the number of germinated seeds depended on the concentration of NiCl<sub>2</sub> in the medium. In comparison with control, (sample without NiCl<sub>2</sub>), % of germination, root and shoot length of investigated cultivars were considerably reduced with the rise of NiCl<sub>2</sub> concentration in both measurements (Tab. 1 and 2). The average values of germinated seeds illustrated higher % of germination of cultivar Kruna than Toplica in both investigated days by about 20%. Cultivar Kruna showed the biggest average value of germinated seeds after 3. days (63.4%). The germination wasn't found in the samples of 1 M solution of NiCl<sub>2</sub> (except at cultivar Toplica after 5. days of incubation). The average value of percentage of germinated seeds of both cultivars didn't remarkably change between first and second measurements. Seed germination and seedling growth inhibition by heavy metals has also been reported by (Eskew et al., 1984; Prasad, 1995; Lee et al., 1999; Reeves and Baker, 2000; Liu et al., 2004; Jun et al., 2009; Stanković et al., 2010).

**Table 1. Percentage of germination, root and shoot length after three days of incubation**

Concentration of NiCl <sub>2</sub> (M)	% of germination <sup>1</sup>		root length <sup>1</sup> (mm)		shoot length <sup>1</sup> (mm)	
	Kruna	Toplica	Kruna	Toplica	Kruna	Toplica
1	0	0	0	0	0	0
0.5	3.33±2.31	1.33±2.31	0	0	0.01±0	0.003±0.006
0.25	10±3.46	5.33±3.01	0	0	0.01±0	0.01±0
0.125	9.33±1.15	0	0.007±0.011	0	0.015±0.003	0
0.0625	81.33±7.6	9.33±9.01	0.01±0.01	0.003±0.005	0.010±0.001	0.008±0.007
0.0313	96±3.46	13.33±2.3	0.022±0.025	0.007±0.011	0.011±0.001	0.012±0.004
0.0156	97.33±1.1	41.3±18	0.059±0.026	0.017±0.02	0.012±0.002	0.011±0.002
0.0078	100±0	92.67±2.3	0.034±0.005	0.018±0.017	0.017±0.005	0.011±0.002
0.00391	100±0	98±0	0.039±0.009	0.045±0.007	0.037±0.003	0.033±0.009
0.00195	100±0	99.33±1.2	0.038±0.009	0.125±0.091	0.037±0.036	0.272±0.20
0	100±0	96±1	0.096±0.01	0.135±0.01	0.22±0.01	0.278±0.10
$\bar{x}$	63.4±44.7	41.15±43	0.028±0.031	0.032±0.055	0.04±0.06	0.058±0.11

<sup>1</sup> Values expressed as mean ± standard error (n=3)

The analysis of the average length of root and shoot showed remarkable differences in their length between cultivars and also between measurements after 3. and 5. incubation days of each cultivar. Considering, root and shoot length of cultivar Toplica showed higher average values in both of investigated days than of cultivar Kruna. After the first measurement, the average values of root length of cultivar Toplica was 0.032 mm, and second measurement showed remarkable difference in value and was 2.26 mm. Significant reduction in root and shoot growth of both cultivars with the increase in concentration of Ni treatment were also observed as compared to control. Only in the sample with 0.00195 M of NiCl<sub>2</sub> the length of root and shoot was higher than control sample which is in accordance with earlier researches (Welch, 1981). The root didn't develop at both cultivars in the samples with 1 M till 0.25 M solution of NiCl<sub>2</sub> in both studies days.

On the other hand, the shoot didn't develop with both cultivars in the sample with 1 M solution of NiCl<sub>2</sub> in both study days (except at cultivar Toplica after 5. days of incubation). The average shoot length of cultivar Toplica was 0.58 mm after 3. days, and 5.28 mm, nearly 10 times bigger, after 5. days of incubation. Nickel in high concentration affects many plant metabolic processes. As a consequence of the Ni<sup>2+</sup> toxicity, reduction in root and shoot size were evident. This is due to reduction in both new cell formation and cell elongation in the extension region of the root and shoot (Prasad, 1995; Liu et al., 2004).

**Table 2. Percentage of germination, root and shoot length after five days of incubation**

concentration of NiCl <sub>2</sub> (M)	% of germination <sup>1</sup>		root length <sup>1</sup> (mm)		shoot length <sup>1</sup> (mm)	
	Kruna	Toplica	Kruna	Toplica	Kruna	Toplica
1	0	1.33±0	0	0	0	0.033±0.03
0.5	4.67±4.61	2.67±1.15	0	0	0.047±0.046	0.027±0.011
0.25	10±4	6.67±1.15	0	0	0.10±0.04	0.067±0.011
0.125	7.33±3.1	1.33±1.15	0	0	0.073±0.031	0.013±0.011
0.0625	86.67±7.6	9.33±9.01	0.027±0.046	0	0.90±0.11	0.093±0.09
0.0313	85.33±5	31.33±8.1	0.087±0.11	0	0.90±0.12	0.313±0.08
0.0156	96±0	60±22.71	0.14±0.11	0.02±0.034	1.15±0.197	0.68±0.09
0.0078	98.67±2.3	95.33±2.3	0.58±0.158	0.36±0.06	2.18±0.39	1.5±0.35
0.00391	100±0	96.67±1.1	2.57±0.29	1.81±0.53	4.95±0.83	8.07±1.83
0.00195	100±0	97±1	2.35±1.89	15.83±0.03	5.22±5.92	28.35±0.03
0	94±1	99±1	4.68±0.02	6.81±0.099	19.04±0.02	18.88±0.02
$\bar{x}$	62.1±43.8	45.7±43.2	0.95±1.59	2.26±4.79	3.14±5.62	5.28±9.31

<sup>1</sup>Values expressed as mean ± standard error (n=3)

**Table 3. ANOVA for% of germination, root and shoot length after three and five days of incubation**

F - calculated value	Cultivars		Concentration of NiCl <sub>2</sub>	
	after 3. days	after 5. days	after 3. days	after 5. days
% germination	5.226*	4.407	7.261**	10.261**
The lenght of root	0.145	1.1217	5.060**	2.1972
The lenght of shoot	1.154	1.012	9.566**	3.978*

$F_{1,10;0.005} = 4.96$ ,  $F_{1,10;0.001} = 10.04$ ,  $F_{10,10;0.05} = 2.94$ ,  $F_{10,10;0.001} = 4.85$

F-test of significance level: \*  $p \leq 0.05$ ; \*\*  $p \leq 0.01$

Results obtained by analysis of variance (ANOVA) present high statistic differences ( $p \leq 0.01$ ) among concentrations of% of germination after 3. and 5. days, like both root and shoot length after 3.days of incubation (Tab. 3). Our results also illustrate statistical significant differences ( $p \leq 0.05$ ) of% germination between cultivars after 3. days and of shoot length after 5. days of incubation.

### Conclusion

The results show that increasing concentration of NiCl<sub>2</sub> significantly inhibited seed germination and early growth of wheat root and shoots. Cultivar Kruna showed higher average value of% of germination after 3. and 5. days of incubation than cultivar Toplica. On the other hand cultivar Tolica had higher average value of root and shoot length after 3. and 5. days of incubation than cultivar Kruna. Results obtained by analysis of variance (ANOVA) show high statistic differences among concentrations of% germination after 3. and 5. days, like both root and shoot length after 3. days of incubation. Our results also illustrate statistical significant differences of germination between cultivars after 3. days and of shoot length after 5. days of incubation.

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# Stabilnost parametara translokacije hranjivih tvari kod krušne pšenice

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## Sažetak

U radu su prikazani rezultati pokusa sa 22 genotipa pšenice podrijetlom iz različitih svjetskih programa oplemenjivanja. Sa ciljem ispitivanja varijabilnosti i stabilnosti translociranja hranjivih tvari iz vegetativnih u generativne dijelove biljke, korišteni su omjer klas/stabljika i žetveni indeks. Stabilnost genotipova je procijenjena metodom regresijske analize prema Eberhart and Russell, a interakcija genotip x okolina PCA analizom. Na osnovi dobivenih rezultata zapaženo je da je sorta Rana niska ispoljila najveću stabilnost, a prva PCA os ima najvećeg udjela u objašnjenju ukupnoj varijanci pokusa.

Gljučne riječi: pšenica, omjer klas/stabljika, žetveni indeks, stabilnost, PCA

## Stability parameters of nutrients translocation in bread wheat

### Abstract

This paper presents the results of the experiment with 22 wheat genotypes originating from various international breeding programs. In order to examine the variability and stability of nutrient translocation from the vegetative to the reproductive parts of plant, the spike/stem ratio and harvest index were used. Stability has been estimated by the Eberhart and Russell regression analysis and a genotype/environment interaction by PCA analysis. Based on these results it is noticed that the variety Rana niska exhibited the greatest stability, and the first PCA axis has the largest share in the total variance explained of the experiment.

Key words: wheat, spike/stem ratio, harvest index, stability, PCA

### Uvod

Osnovni cilj oplemenjivanja pšenice je stvaranje sorata sa visokim genetskim potencijalom za prinos, koje bi najbolje reagirale na različite agroekološke uvjete, heterogene u pogledu klime i tla. Obzirom da je prinos vrlo kompleksno svojstvo, rezultat niza kvantitativnih svojstava, za uspješan učinak oplemenjivanja, potrebno je poznavati svojstva genotipova, kao i interakciju između genotipova i okoline.

Prelomni moment u oplemenjivanju pšenice je učinjen skraćivanjem visine stabljike, čime je uspostavljen optimalniji omjer između vegetativnih i generativnih dijelova biljke. Ova promjena je poboljšala translociranje hranjivih tvari u klas, a time povećala genetski potencijal za prinos. Današnje polupatuljaste visokoprinosne sorte su kraće skoro za polovicu od ranije selekcioniranih. Posljedica ove genetske promjene je i povećanje žetvenog indeksa. Borojević (1990) naglašava da se daljnje povećanje genetskog potencijala za prinos pšenice može ostvariti povećanjem žetvenog indeksa na 50% i više.

Omjer klas/stabljika je parametar koji se određuje u ranijem stadiju životnog ciklusa biljke u fazi cvatnje. Pored žetvenog indeksa, Siddique i sur. (1989) ga navode kao potencijalnog indikatora prinosa.

Pojava polupatuljastih genotipova pšenice se odrazila i na interakciju genotip x okolina (Braun, 1992). Pojavom intenzivnih genotipova, ova interakcija se povećava, odnosno povećava se stupanj reagiranja genotipova na vanjske uvjete. Ovi izvori varijabilnosti su važni za utvrđivanje područja uzgoja u kojima bi neki genotip dao svoj maksimum (Dimitrijević i Petrović, 2005).

Cilj rada je ispitati varijabilnost i stabilnost parametara translociranja hranjivih tvari-omjera klas/stabljika i žetvenog indeksa kod krušne pšenice.

### Materijali i metode

Za pokus su odabrana 22 genotipa pšenice, različite visine stabljike i porijekla. Prvoj grupi visokih genotipova pripadaju: Bankut 1205 (Mađarska), Bersee (Francuska), Mironovska 808 i Stepnjačka 30 (SSSR), Perdue 3912 i Atlas 66 (SAD) i Compair (Velika Britanija). Drugoj grupi polupatuljastih genotipova pripadaju: Sava, Sremica, Pobeda, Italija (Srbija), Caldwell (Kanada), Talent i Concordia (Francuska) te Florida (Australija). Treću grupu patuljastih genotipova čine: Rana niska i Kratka (Srbija), Ana (Hrvatska), UPI 301 (Indija), Tom Thumb (Tibet), Mexico 120 (Australija) i Aibian (Japan).

Pokus je postavljen po slučajnom bloknom rasporedu u tri ponavljanja, u dvije vegetacijske sezone, na pokusnom polju Instituta za ratarstvo i povrtarstvo u Novom Sadu. Sjetva je obavljena u redove duljine 1 m, sa razmakom između redova 20 cm i između biljaka u redu 10 cm.

U fazi cvatnje odrijeđen je omjer klas/stabljika (Siddique i sur., 1989). Izmjerena je masa klasa i masa primarne vlasi, sa koje je odstranjen lisni rukavac, prije i poslije sušenja. Biljni materijal je sušen 24 sata na temperaturi 70°C. Omjer klas/stabljika je odrijeđen kao omjer suhe tvari klasa i suhe tvari stabljike za svaku biljku posebno. U fazi pune zrelosti je odrijeđen žetveni indeks, kao omjer između mase zrna po biljci i mase cijele biljke bez korjena, za svaku biljku posebno (White and Wilson, 2006).

Ekološki indeks je računat kao razlika prosjeka svih genotipova u svakoj agroekološkoj sredini i ukupnog prosjeka u svim ispitivanim agroekološkim uvjetima (opći prosjek). Stabilnost genotipova je procjenjena metodom regresijske analize (Eberhart and Russell, 1966). Prema danom modelu, stabilnim genotipom se smatra onaj koji ima željenu prosječnu vrijednost i regresijski koeficijent  $b_i=1$ . Za utvrđivanje interakcije genotip x okolina, primjenjena je metoda glavnih komponenti (PCA, *Principal Component Analysis*), pri čemu broj faktora odgovara broju promatranih varijabli, a u daljoj analizi se koriste samo one koje objašnjavaju značajan dio ukupne varijance (Zobel i sur., 1988).

### Rezultati i rasprava

Prosječne vrijednosti omjera klas/stabljika široko variraju. Najniže vrijednosti ovog parametra (Tablica 1.) ispoljavaju visoki genotipovi Perdue 3912 ( $\bar{x}=0,36$ ), Stepnjačka 30 i Compair ( $\bar{x}=0,40$ ), a najviše Rana niska ( $\bar{x}=0,56$ ), Ana i Aibian ( $\bar{x}=0,54$ ).

Prosječne vrijednosti žetvenog indeksa se kreću od  $\bar{x}=0,36$  kod genotipova Tom Thumb i Perdue 3912, do  $\bar{x}=0,58$  kod genotipa Rana niska i  $\bar{x}=0,57$  kod genotipova Ana i Aibian (Tablica 1.). Niska prosječna vrijednost žetvenog indeksa visokog genotipa Perdue 3912 upravo potvrđuje težnju da se smanjenjem visine stabljike povećava vrijednost žetvenog indeksa. Niski genotip Tom Thumb je lokalna populacija sa Tibeta, pa je niska prosječna vrijednost žetvenog indeksa za očekivati.

Kao najstabilniji genotip za omjer klas/stabljika (Tablica 1.) izdvaja se Rana niska sa vrijednošću regresijskog koeficijenta  $b_i=1,60$ . Najnestabilniji su genotipovi Concordia ( $b_i=6,40$ ) i UPI 301 ( $b_i=5,20$ ).

Srednje visoki genotipovi Florida i Italija, kao i niski genotip Rana niska (Tablica 1.) ispoljavaju najveću stabilnost žetvenog indeksa ( $b_i=0,85$ ), dok su najmanje stabilni genotipovi Atlas 66 i UPI 301 ( $b_i=4,23$ ).

Nestabilnom reakcijom analiziranih svojstava uglavnom su se odlikovale sorte sa višom stabljikom. Izuzetak čini visoki genotip Bankut 1205 (Tablica 1.) koji ima visoke prosječne vrijednosti omjera klas/stabljika ( $\bar{x}=0,47$ ) i žetvenog indeksa ( $\bar{x}=0,49$ ) i ispoljava stabilnu reakciju ( $b_i=0,56$ ). Dobiveni rezultat ukazuje na činjenicu da su sorte pokazale različitu divergentnost u korištenju raspoloživih potencijala za formiranje uroda i u skladu je sa rezultatima koje navode Takanashi i sur. (2002) i Royo i sur. (2007).



## Stabilnost parametara translokacije hranjivih tvari kod krušne pšenice

Genotip Rana niska ima stabilnu reakciju za omjer klas/stabljika i za žetveni indeks, pri visokoj prosječnoj vrijednosti, što je u skladu sa težnjom da se smanjenjem visine stabljike omogući bolja translokacija hranjivih tvari iz vegetativnih u generativne dijelove biljke.

Značajne korelacijske veze omjera klas/stabljika između genotipova i prve PCA-osi su ustanovljene kod genotipova Compair, Atlas 66, Stepnjačka 30, Mironovska 808, Italija, Sava, Concordia, Mexico 120, Krataka, Ana, Tom Thumb i UPI 301. Značajna korelacijska povezanost je ustanovljena između druge PCA-osi i genotipova Bankut 1205, kao i između treće PCA-osi i genotipa Bersee (Tablica 2.).

Tablica 1. Prosječne vrijednosti ( $\bar{x}$ ), ekološki indeks (EI), koeficijenti regresije ( $b_i$ ) i koeficijenti varijacije (V%) za omjer klas/stabljika i žetveni indeks 22 ispitana genotipa pšenice

Genotipovi	Omjer klas/stabljika				Žetveni indeks			
	$\bar{x}$	EI	$b_i$	V	$\bar{x}$	EI	$b_i$	V
Bankut 1205	0,47	-0,01	$7 \times 10^{-5}$	6,4	0,49	$4 \times 10^{-3}$	0,56	8,6
Compair	0,40	-0,06	3,20	12,6	0,41	-0,07	3,95	18,1
Atlas 66	0,50	0,03	4,80	13,6	0,53	0,04	4,23	17,6
Perdue 3912	0,36	-0,11	2,80	13,0	0,36	-0,12	2,26	14,6
Bersee	0,44	-0,03	$6 \times 10^{-5}$	6,1	0,45	-0,04	0,00	9,7
Stepnjačka 30	0,40	-0,07	-4,00	14,9	0,41	-0,07	-2,82	19,3
Mironovska 808	0,45	-0,03	-2,40	8,1	0,45	-0,04	-1,41	12,3
Sremica	0,47	-0,01	-2,00	7,4	0,49	0,01	-0,28	12,6
Florida	0,45	-0,03	$6 \times 10^{-5}$	5,7	0,48	$-4 \times 10^{-3}$	0,85	6,7
Caldwel	0,49	0,01	-1,60	6,9	0,50	0,02	-1,41	7,8
Italija	0,49	0,01	1,60	5,8	0,50	0,01	0,85	10,4
Talent	0,48	$4 \times 10^{-3}$	$7 \times 10^{-5}$	5,8	0,46	-0,03	-1,13	10,6
Sava	0,53	0,06	3,20	9,1	0,54	0,06	3,10	12,2
Pobeda	0,48	$3 \times 10^{-3}$	-4,00	7,5	0,48	$-2 \times 10^{-3}$	-0,28	7,7
Concordia	0,48	0,01	6,40	18,1	0,48	$-9 \times 10^{-4}$	6,21	24,7
Mexico 120	0,53	0,06	-2,00	6,7	0,53	0,05	-2,26	13,3
Rana niska	0,56	0,09	1,60	6,9	0,58	0,09	0,85	12,6
Kratka	0,48	$2 \times 10^{-3}$	2,80	9,5	0,49	$6 \times 10^{-3}$	2,27	6,0
Ana	0,54	0,07	2,80	8,1	0,57	0,08	3,38	12,5
Aibian	0,54	0,07	-2,00	6,5	0,57	0,08	-1,97	12,5
Tom Thumb	0,38	-0,10	2,00	8,5	0,36	-0,12	0,85	10,3
UPI 301	0,49	0,02	5,20	14,9	0,52	0,04	4,23	16,2

LSD<sub>(0,05)</sub>=0,01

LSD<sub>(0,01)</sub>=0,02

LSD<sub>(0,05)</sub>=0,05

LSD<sub>(0,01)</sub>=0,07

Značajna korelacijska povezanost za žetveni indeks je uočena između druge PCA-osi i genotipova Italija i Pobeda, kao i između treće PCA-osi i genotipa Rana niska (Tablica 2.).

Iako su srednje vrijednosti omjera klas/stabljika i žetvenog indeksa na približno istoj razini, udio glavnih komponenti u ukupnoj varijanci pokusa ukazuje na drukčiju strukturu izvora varijacije.

Analiza glavnih komponenti (PCA) za omjer klas/stabljika je objasnila 69% u ukupnoj varijanci pokusa sa prve tri PCA-osi. Pri tome je prva PCA-os (genotip i eko-sredina), kao aditivna komponenta, zastupljena sa 49%. Druga i treća PCA-os, kao neaditivne komponente, koje uključuju interakciju genotip x okolišna su zastupljene sa 20%. Analiza glavnih komponenti za žetveni indeks pokazuje da je prva PCA-os u ukupnoj varijanci pokusa zastupljena sa 41%, dok su druga i treća PCA-os zastupljene sa 26%.

Ispoljena aditivnija priroda omjera klas/stabljika u odnosu na žetveni indeks ukazuje na mogućnost boljeg predviđanja varijacije navedenog parametra, pri čemu se mora imati u vidu da su genski sistemi koji učestvuju u nasljeđivanju svojstava koji grade omjer klas/stabljika poligeni i vrlo kompleksni, a u skladu je sa rezultatima dobivenim u radu Peltonen-Sainio i sur. (2008).

Tablica 2. Udio glavnih komponenti u ukupnoj varijaciji pokusa za omjer klas/stabljika i žetveni indeks ispitanih genotipova pšenice

Genotipovi	Glavne komponente (PCA osi)								
	Omjer klas/stabljika						Žetveni indeks		
	I	II	III	I	II	III			
Bankut 1205	-0,027	0,864 *	0,007	0,303	0,525	0,365			
Compair	0,817 *	0,054	-0,326	0,919 *	-0,290	-0,029			
Atlas 66	0,908 *	0,195	-0,021	0,888 *	0,207	-0,017			
Perdue 3912	0,822 *	0,084	-0,124	0,809 *	0,181	-0,291			
Bersee	0,008	-0,106	-0,789 *	0,049	0,609	0,404			
Stepnjačka 30	-0,877 *	0,212	-0,003	-0,747 *	-0,339	-0,227			
Mironovska 808	-0,894 *	0,121	-0,082	-0,441	0,411	-0,583			
Sremica	-0,626	0,382	0,082	-0,237	0,107	0,533			
Florida	0,055	0,749 *	0,142	0,604	0,145	0,151			
Caldwel	-0,538	-0,289	-0,295	-0,732 *	0,061	0,307			
Italija	0,781 *	0,089	0,201	0,333	-0,755 *	0,208			
Talent	0,024	-0,375	0,593	-0,475	0,345	0,636			
Sava	0,899 *	0,161	-0,026	0,870 *	-0,243	0,148			
Pobeda	-0,113	0,254	0,678	-0,127	0,901 *	0,043			
Concordia	0,923 *	-0,079	0,098	0,887 *	-0,125	0,068			
Mexico 120	-0,802 *	-0,120	-0,050	-0,636	0,266	-0,396			
Rana niska	0,696	0,308	0,123	0,247	0,003	0,798 *			
Kratka	0,835 *	-0,349	0,027	0,561	0,544	0,112			
Ana	0,741 *	-0,050	0,407	0,797 *	-0,228	0,143			
Aibian	-0,664	0,232	-0,037	-0,567	0,318	-0,063			
Tom Thumb	0,739 *	-0,069	0,318	0,544	-0,080	-0,496			
UPI 301	0,870 *	-0,008	-0,262	0,942 *	-0,077	0,057			

\* Značajnost određena prema kritičnoj vrednosti 0,70

## Zaključci

Na osnovi dobivenih rezultata, uočeno je da prosječne vrijednosti ispitivanih genotipova za omjer klas/stabljika i žetveni indeks široko variraju. Sorta Rana niska je ispoljila najstabilniju reakciju za oba analizirana svojstva. Najnestabilniji genotipovi za omjer klas/stabljika su Concordia i UPI 301, a za žetveni indeks Atlas 66 i UPI 301. U objašnjenju varijanci pokusa prva PCA-os ima najvećeg udjela.

Genetska analiza divergentnih genotipova pšenice, podrijetlom iz različitih svjetskih centara oplemenjivanja, uzgajanih u agroekološkim uvjetima Jugoistočne Europe, doprinosi boljem poznavanju genotipova i olakšava odabir roditelja za križanja u budućim programima oplemenjivanja pšenice. Omjer klas/stabljika i žetveni indeks mogli bi se koristiti kao validni parametri u procjeni efikasnosti translociranja hranjivih tvari u generativne dijelove biljke.

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# Varijabilnost uroda germplazme ozime pšenice

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## Sažetak

U dvogodišnjem poljskom pokusu sa 40 genotipova ozime pšenice domaće i strane selekcije priznatih od 1936. godine do danas provedeno je ispitivanje varijabilnosti uroda zrna u agroekološkim uvjetima istočne Slavonije. Između ispitivanih genotipova postojale su statistički visoko opravdane razlike ( $P < 0,01$ ) u prosječnom urodu koji se kretao od  $3,97 \text{ t ha}^{-1}$  u sorte U1 do  $9,22 \text{ t ha}^{-1}$  u sorte Bastide. Postignuti rezultati pokazuju napredak u selekciji tijekom godina te izdvajaju visokorodne domaće i strane genotipove. Ovi bi genotipovi s obzirom na divergentno porijeklo u budućnosti mogli poslužiti kao kvalitetni roditelji za križanja u novim oplemenjivačkim programima za povećanje uroda zrna.

Ključne riječi: ozima pšenica, urod, varijabilnost

## Yield variability in winter wheat germplasm

### Abstract

Field trial experiment was conducted during two vegetation years with 40 genotypes of winter wheat in agroecological conditions of Eastern Slavonia. Genotypes are from Croatian and foreign selection and they were registered from 1936 until today. Tested genotypes showed statistically highly significant ( $P < 0.01$ ) differences in average yield. Average yield varied from  $3.97 \text{ t ha}^{-1}$  in variety U1 to  $9.22 \text{ t ha}^{-1}$  in variety Bastide. Results are showing improvement of selection during examined years and they highlight high yielding domestic and foreign genotypes. These genotypes with divergent pedigrees can serve in the future as a good parents for crossings in new breeding programs for further improvement of winter wheat yield.

Key words: winter wheat, yield, variability

### Uvod

Urod zrna ozime pšenice kompleksno je kvantitativno svojstvo pod velikim utjecajem okolišnih činitelja, ali i svih svojstava biljke (Martinčić i sur., 2003b). Urod je ujedno jedan od glavnih i stalnih ciljeva oplemenjivanja pšenice (Martinčić i sur., 2003a). Veći broj autora bavio se usporedbom uroda starih i novih sorata ozime pšenice (Drezner i sur. 1995; Brancourt-Hulmel i sur., 2003; Mlinar i sur. 2005; Petrović i sur. 2009; Petrović i sur. 2010). U svim navedenim radovima zabilježeno je značajno povećanje uroda zrna modernih sorata pšenice. U provednim ispitivanjima povećanje uroda vezano je za različita svojstva od mogućnosti uzgoja u gušćem sklopu do povećanog žetvenog indeksa. Pri stvaranju sorata ozime pšenice visokog uroda zrna, praćenog odgovarajućom kvalitetom, danas je potrebno posebno obratiti pažnju na održavanje varijabilnosti oplemenjivačke germplazme kako se usljed intenzivne selekcije na povećani urod ne bi smanjila varijabilnost unutar germplazme. Varijabilnost germplazme pšenice esencijalna je za

oplemenjivačke programe jer samo križanja divergentnih roditelja omogućuju segregaciju i rekombinaciju alela u potomstvu te uspješnu selekciju.

### Materijali i metode

Poljski pokus postavljen je tijekom dvije vegetacijske godine 2007./2008. i 2008./2009. po slučajnom bloknom rasporedu u tri ponavljanja na površinama Poljoprivrednog instituta u Osijeku. Veličina osnovne parcele bila je 7,2 m<sup>2</sup>. U pokus je uključeno 40 sorata ozime pšenice (Tablica 1.) iz oplemenjivačkih programa Poljoprivrednog instituta Osijek (PIO), Bc Instituta iz Zagreba, Jošt sjeme-istraživanja iz Križevaca te nove i stare francuske, talijanske, ruske i austrijske sorte. Ispitivane sorte priznate su od 1936. godine do danas, a zauzimale su ili još uvijek zauzimaju značajne površine u proizvodnji u Hrvatskoj ili u drugim europskim zemljama. Tlo na kojem je postavljen pokus je eutrično smeđe tlo na lesu, u prvoj godini predkultura je bila kukuruz, a u drugoj godini soja. U prvoj godini žetva je obavljena 02.07.2008., a u drugoj godini 12.07.2009. Na temelju postignutog uroda po pokusnoj parceli obavljena je procjena uroda u t/ha uz 14% vlage u zrnu. Statistička analiza podataka za urod zrna provedena je pomoću SAS Software 9.1.3. (2002-2003).

### Rezultati i rasprava

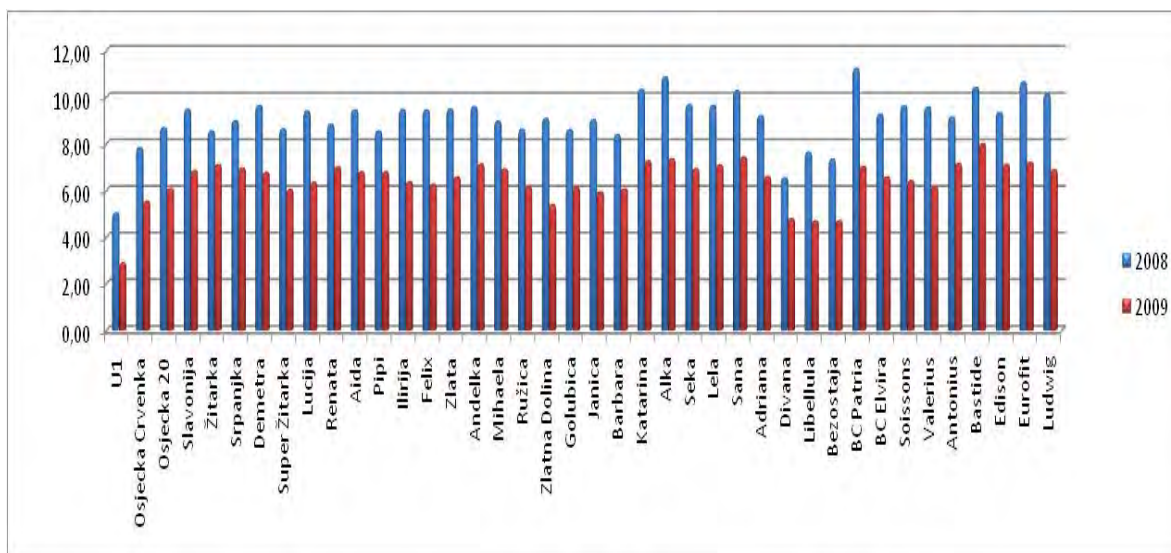
U tablici 1. prikazani su rezultati uroda zrna ispitivanih genotipova ozime pšenice za 2008. i 2009. godinu, prosječni urod te vrijednosti LSD-testa. Genotipovi su poredani prema godini priznanja.

Tablica 1. Urod zrna (t/ha) istraživanih sorti ozime pšenice

Genotip	Porijeklo	Godina priznanja	2008. god.	2009. god.	Prosjek
U1	PIO	1936.	5,04	2,90	3,97
Bezostaja	Rusija	1963.	7,60	4,71	6,15
Libellula	Italija	1965.	7,38	5,06	6,22
Zlatna dolina	Bc Institut	1971.	9,10	5,39	7,24
Osječka crvenka	PIO	1976.	8,30	5,25	6,77
Osječka 20	PIO	1978.	8,69	6,08	7,39
Sana	Bc Institut	1983.	10,28	7,45	8,86
Slavonija	PIO	1984.	9,48	6,48	7,98
Žitarka	PIO	1985.	8,55	7,11	7,83
Soissons	Francuska	1987.	9,97	6,42	8,20
Adriana	Bc Institut	1988.	9,41	6,60	8,01
Srpanjka	PIO	1989.	8,99	6,97	7,98
Demetra	PIO	1991.	9,65	6,40	8,02
BC Patria	Bc Institut	1994.	10,88	7,03	8,96
Divana	Jošt	1995.	6,35	4,73	5,54
Barbara	PIO	1997.	8,63	6,50	7,56
Super žitarka	PIO	1997.	8,31	6,05	7,18
Ludwig	Austrija	1997.	9,80	7,23	8,52
Golubica	PIO	1998.	8,61	6,14	7,38
Edison	Austrija	2001.	9,34	7,12	8,23
Lucija	PIO	2001.	9,41	6,36	7,89
BC Elvira	Bc Institut	2002.	8,75	6,58	7,66
Bastide	Francuska	2002.	10,42	8,01	9,22
Alka	PIO	2003.	10,75	7,36	9,06
Janica	PIO	2003.	9,03	5,94	7,49
Valerius	Austrija	2003.	9,58	6,17	7,88
Antonius	Austrija	2003.	9,14	6,77	7,95
Eurofit	Austrija	2004.	10,42	7,21	8,82
Renata	PIO	2006.	8,84	7,01	7,92
Aida	PIO	2006.	9,18	6,81	7,99
Pipi	PIO	2006.	8,55	6,53	7,54
Katarina	PIO	2006.	10,34	7,27	8,80
Seka	PIO	2006.	9,68	6,94	8,31
Lela	PIO	2006.	9,65	7,10	8,37
Ilirija	PIO	2008.	8,98	6,38	7,68
Felix	PIO	2008.	9,11	6,26	7,69
Zlata	PIO	2008.	9,83	6,58	8,20
Anđelka	PIO	2008.	9,60	7,13	8,36
Mihaela	PIO	2008.	8,85	6,54	7,70
Ružica	PIO	2008.	8,63	6,16	7,40
LSD_0,05			0,725	0,748	0,524
LSD_0,01			0,961	0,992	0,695

Ispitivani genotipovi pokazali su statistički visoko opravdani ( $P < 0,01$ ) utjecaj na urod zrna. Najveći dvogodišnji prosječni urod zrna ostvarila je francuska sorta Bastide  $9,22 \text{ t ha}^{-1}$ , dok je najmanji urod imala sorta U1  $3,97 \text{ t ha}^{-1}$ . Sorta Bastide imala je statistički visoko opravdano ( $P < 0,01$ ) veći urod u odnosu na 34 sorte, a statistički opravdano veći ( $P < 0,05$ ) u odnosu na sortu Katarina. Sorte iz hrvatskih selekcijskih programa Alka ( $9,06 \text{ t ha}^{-1}$ ), Bc Patria ( $8,96 \text{ t ha}^{-1}$ ) i Sana ( $8,86 \text{ t ha}^{-1}$ ), te austrijska sorta Eurofit ( $8,82 \text{ t ha}^{-1}$ ) bile su na istoj razini sa sortom Bastide. Druga po visini uroda bila je sorta Poljoprivrednog instituta Osijek Alka ( $9,06 \text{ t ha}^{-1}$ ), a treća sorta Bc Instituta iz Zagreba Bc Patria ( $8,96 \text{ t ha}^{-1}$ ). Njihov je urod bio statistički opravdano veći ( $P < 0,01$ ) od 34 ispitivane sorte. Najniži urod postigla je najstarija ispitivana sorta u pokusu, sorta U1 ( $3,97 \text{ t ha}^{-1}$ ). Sve sorte imale su u odnosu na U1 statistički visoko opravdano ( $P < 0,01$ ) veći urod. Ovakav se rezultat mogao očekivati s obzirom da je sorta priznata još 1936. godine s visinom stabljike višom od jednog metra. Drugi najniži urod imala je sorta Divana ( $5,54 \text{ t ha}^{-1}$ ). U odnosu na Divanu dvije sorte imaju statistički opravdano veći ( $P < 0,05$ ) urod, a 36 sorata ima statistički visoko opravdano ( $P < 0,01$ ) veći urod. Ovdje je potrebno napomenuti kako je Divana sorta pšenice vrhunske kvalitete (poboljšivač u Komisiji RH), čija je selekcija bila upravo usmjerena na kvalitetu uz postizanje zadovoljavajućeg prinosa (Samobor et al., 2005). Statistički visoko opravdani utjecaj genotipa na urod zrna dobili su i Bede (1998), Martinčić i sur. (2003a), Guberac i sur. (2005) te Drezner i sur. (2010). U istraživanju Dreznera i sur. (2010) sa 18 genotipova pšenice na tri lokacije i dvije godine bila je uključena i sorta Divana, a njeni rezultati sukladni su rezultatima i u ovom istraživanju. Ispitivanjem razlika između sorata pšenice priznatih u rasponu od petnaest godina bavili su se Mlinar i sur. (2005) te su zaključili kako postoje genetske razlike u potencijalu rodosti ispitivanih sorata. Na temelju postignutih rezultata izdvojili su sorte koje objedinjuju visoku produktivnost i stabilnost.

Dobiveni rezultati pokazuju postojanje varijabilnosti između ispitivanih genotipova kao i mogućnost odabira udaljenih genotipova za buduća križanja. Tako je pet sorata s najboljim urodom projeklom iz različitih oplemenjivačkih centara i iz tri različite zemlje. Po jedna francuska i austrijska sorta, jedna sorta Poljoprivrednog instituta Osijek te dvije sorte Bc Instituta Zagreb postigle su odlične rezultate uroda zrna u uvjetima istočne Slavonije i pokazale postojanje široke adaptabilnosti. Pet najboljih sorata imaju različit pedigree, divergentne su po svom podrijetlu i mogle bi u budućim oplemenjivačkim programima poslužiti kao roditeljske komponente za križanja.



Grafikon 1. Urod zrna (t/ha) za 40 sorti ozime pšenice u 2008. i 2009. godini.

U provedenom istraživanju potrebno je naglasiti i velike razlike u urodu zrna između dvije ispitivane godine (grafikon 1.). Znatno veći urod zrna postignut je u 2008. godini. U 2009. godini urod je manji za nekoliko tona po sorti. Najveće smanjenje uroda zabilježeno je u sorte Bc Patria ( $3,85 \text{ t ha}^{-1}$ ). Razlog ovako velikom smanjenju uroda su klimatske prilike tijekom 2008./2009. vegetacijske godine. U ožujku 2009. godine palo je 50% manje oborina u odnosu na višegodišnji prosjek, a u travnju 70% manje oborina. Pšenica se u tom periodu nalazila u fenofazi vlatanja te se zbog povećane transpiracijske površine nalazi u kritičnom razdoblju s obzirom na potrebe za vodom. Smanjena količina potrebne vode dovodi do sterilnosti cvijetova u klasićima i smanjenja uroda zrna. O utjecaju smanjene količine oborina na urod pšenice i variranju uroda ovisno o suši

govore i Petrović i sur. (2010). Mlinar i sur. (2005) navode da je u trogodišnjim poljskim pokusima najmanji urod postignut u ekstremno sušnoj godini.

### Zaključak

U provedenom istraživanju ispitivani genotipovi pokazali su statistički visoko opravdani ( $P < 0,01$ ) utjecaj na urod zrna. Po visini uroda ističe se pet genotipova iz različitih oplemenjivačkih centara i različitih pedigreea (Bastide, Alka, Bc Patria, Sana i Eurofit) koje je u budućim oplemenjivačkim programima moguće upotrijebiti za razvoj nove genetske varijabilnosti.

### Napomena

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# *In vitro* regeneracija pšenice na selektivnom mediju i utvrđivanje varijabilnosti regeneranata

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## Sažetak

Somaklonska varijabilnost biljaka regeneriranih u kulturi biljnog tkiva može biti vrijedan izvor varijabilnosti u oplemenjivanju novih kultivara. Izolirani nezreli embriji pšenice sorte Karla nakon kalusiranja supkultivirani su na MS medij s različitim koncentracijama (tretmanima) polietilen glikola (PEG) u svrhu selekcije stanica kalusa tolerantnih na vodni deficit. Nakon višemjesečne selekcije utvrđena je efikasnost regeneracije biljaka pšenice iz pojedinih tretmana. U zriobi, regenerantima i biljkama polaznog genotipa (kontrola) analizirana su svojstva: (1) broj klasova po biljci, (2) dužina primarnog klasa, (3) broj klasića primarnog klasa, (4) broj zrna primarnog klasa, (5) masa zrna primarnog klasa. Kod regeneranata je utvrđena varijabilnost za sva analizirana svojstva, a visoke maksimalne vrijednosti svojstava nekih regeneranata ukazuju na potencijalno obećavajuće somaklonove.

Ključne riječi: pšenica, *in vitro* selekcija, efikasnost regeneracije, somaklonska varijabilnost

## *In vitro* wheat regeneration on selective medium and assessment of variability of the regenerants

### Abstract

Somaclonal variation of plants regenerated in *in vitro* could be valuable source of variability for breeding of new cultivars. Excised immature embryos of wheat cultivar Karla were after calogenesis subcultivated onto MS medium with different concentrations (treatments) of polyethylene glycol (PEG) in order to select cells tolerant to water deficit. Efficiency of plant regeneration at different treatments was determined after few months of selection. Following traits: (1) number of spikes per plant, (2) primary spike length, (3) no. of spikelets per primary spike, (4) seed number per primary spike, and (5) seed weight per primary spike were evaluated in regenerants and control plants in maturity. Variability for all analysed traits were determined among regenerants and maximal values for traits, higher than in control plants, indicate that among regenerants potentially good somaclones could be selected.

Key words: wheat, *in vitro* selection, efficiency of plant regeneration, somaclonal variation

### Uvod

Biljke regenerirane u kulturi tkiva, osobito ako ona uključuje kalusnu fazu, ponekad se po svojim svojstvima razlikuju od izvornog genotipa i predstavljaju somaklonove koje su prvi opisali Larkin i Scowcroft (1981). Nasljedna somaklonska varijabilnost može biti uzrokovana točkastim mutacijama, kromosomskim aberacijama, promjenom broja kromosoma, promjenom ekspresije gena uslijed metilacije/demetilacije DNA, promijenjenim brojem kopija gena u genomu te aktivacijom transpozona (Veilleux i Johnson, 1998).



Promjene izazvane somaklonskom varijabilnošću često su negativnog smjera, ali mogu biti pozitivne i tada predstavljaju novi izvor varijabilnosti koji se može iskoristiti u oplemenjivanju bilja (Karp, 1995). Kod pšenice somaklonovi su dobiveni za različita svojstva: visinu biljke, debljinu stabljike, veličinu lista, oblik klasa, voštanu prevlaku, sadržaj  $\alpha$ - i  $\beta$ -amilaza, tolerantnost na aluminij, ranozrelost, otpornost na neke bolesti, komponente uroda i veći prinos te sastav proteina zrna (Ahloowalia, 1982; Carver i Johnson, 1989; Arun i sur., 2003; Ahmed i Abdelkareem, 2005; Cooper i sur., 1986). Ukoliko se u hranidbeni medij za inkubaciju kalusa/regeneraciju biljaka doda selektivni agens za *in vitro* selekciju željenog svojstva, moguće je proizvesti somaklonove tolerantne na okolinske stresove kao što su suša, niske temperature, toksičnost aluminijske soli, salinitet. Za proizvodnju somaklonova tolerantnih na sušu kod durum i krušne pšenice kao selektivni agensi korišteni su polietilen glikol (PEG) (Bajji i sur., 2004) i manitol (Abdel-Ghany i sur., 2004).

Cilj ovog istraživanja bio je ispitati efikasnost regeneracije biljaka pšenice sorte Karla u *in vitro* uvjetima tijekom/nakon selekcije kalusa na PEG-u te utvrditi varijabilnost na taj način regeneriranih biljaka za željena svojstva.

### Materijali i metode

U istraživanju je korištena sorta ozime pšenice Karla Zavoda za oplemenjivanje bilja, genetiku, biometriku i eksperimentiranje Agronomskog fakulteta Sveučilišta u Zagrebu. Nezrelo sjeme, četrnaest dana po oprašivanju, ručno je ovršeno i sterilizirano 2 min u 70% etanolu te 20 min u 5.25% natrijevom hipokloritu s dodatkom nekoliko kapi Tween 20 okvašivača, a nakon toga isprano 3X u strilnoj destiliranoj vodi. Nezreli embriji, ukupno njih 800, izolirani su pod stereomikroskopom i položeni na CIM medij za indukciju kalusa (Tablica 1.) u 80 petrijevki. Embriji su na CIM mediju kultivirani 25 dana u mraku pri 26°C. Kalusirani eksplantati su brojani i supkultivirani. Pola od ukupnog broja kalusa supkultivirano je na medij za indukciju kalusa s dodatkom 35% PEG-a (CIM PEG 35%), a pola s dodatkom 40% PEG-a (CIM PEG 40%). Selekcija kalusa na spomenutim medijima odvijala se u mraku pri 26°C 90 dana. Nakon 90 dana selekcije pola kalusa kultiviranih na CIM PEG 35% subkultivirano je na medij za regeneraciju s 35% PEG-a (MSR PEG 35%), a pola na medij za regeneraciju bez PEG-a (MSR). Jednako tako je pola kalusa kultiviranih na CIM PEG 40% subkultivirano na MSR PEG 40%, a pola na MSR. Regeneracija biljaka odvijala se u komori rasta pri 24°C, fotoperiodu 16 sati dan/ 8 sati noć i intenzitetu svjetla od 25  $\mu\text{Em}^2\text{s}^{-1}$ . Regenerirane biljčice su izrezivane s kalusa i premještane u Erlenmayer-ove tikvice na medij za zakorijenjivanje. Nakon zakorijenjivanja po dvije biljke su presađivane u vegetacijske lonce Ø 24 cm s tresetnim supstratom, aklimatizirane, a potom jarovizirane na 4°C 30 dana te -1°C 14 dana, fotoperiodu 12/12 i intenzitetu svjetla od 45  $\mu\text{Em}^2\text{s}^{-1}$ .

Tablica 1. Sastav hranidbenih medija korištenih u istraživanju

CIM (Medij za indukciju kalusa)	*MS + 30 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 2 mg l <sup>-1</sup> 2,4-D + 2,5 g l <sup>-1</sup> Phytigel
CIM PEG 35%	MS + 30 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 2 mg l <sup>-1</sup> 2,4-D + 350 g l <sup>-1</sup> PEG-a 8000
CIM PEG 40%	MS + 30 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 2 mg l <sup>-1</sup> 2,4-D + 400 g l <sup>-1</sup> PEG-a 8000
MSR (Medij za regeneraciju)	MS + 20 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 0,2 mg l <sup>-1</sup> 2,4-D + 2,5 mg l <sup>-1</sup> zeatina
MSR PEG 35%	MS + 20 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 0,2 mg l <sup>-1</sup> 2,4-D + 2,5 mg l <sup>-1</sup> zeatina + 350 g l <sup>-1</sup> PEG-a 8000
MSR PEG 40%	MS + 20 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 0,2 mg l <sup>-1</sup> 2,4-D + 2,5 mg l <sup>-1</sup> zeatina + 400 g l <sup>-1</sup> PEG-a 8000
MSZ (Medij za zakorijenjivanje)	MS + 20 g l <sup>-1</sup> saharoze + 0,1 g l <sup>-1</sup> myo-inozitola + 0,2 mg l <sup>-1</sup> IBA + 3,5 g l <sup>-1</sup> Phytigel

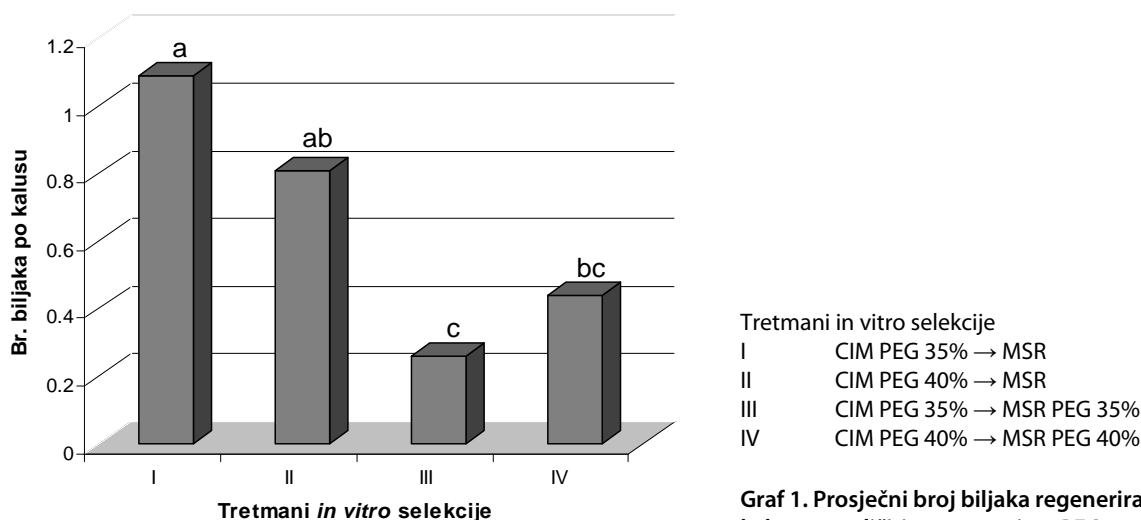
\*MS -Murashige i Skoog osnovni sastav medija (Murashige i Skoog, 1962)

Istim uvjetima jarovizacije podvrgnute su regenerirane biljke ( $R_0$ ) i biljke uzgojene iz sjemena polaznog genotipa. Nakon jarovizacije biljke su premještene u plastenik gdje su uzgajane do zriobe. Na svakoj biljci u zriobi analizirana su slijedeća morfološka svojstva: (1) broj klasova po biljci, (2) dužina primarnog klasa, (3) broj klasića primarnog klasa, (4) broj zrna primarnog klasa, (5) masa zrna primarnog klasa. Za statističku analizu podataka korištena je jednosmjerna analiza varijance, a srednje vrijednosti uspoređivane su Duncanovim testom. Statistička analiza provedena je uz pomoć računalnog programa SAS 9.1.

## Rezultati i rasprava

Prvi znakovi kalusiranja ekasplantata (embrija) bili su vidljivi već 4-5 dana nakon inokulacije. Ukupno je kalusiralo 87% od ukupnog broja postavljenih embrija. Tako visoki postotak kalusiranja potvrđuje rezultata prijašnjih istraživanja (Kereša i sur., 2004). Na osnovi visokog postotka kalusiranja i visokog kapaciteta regeneracije, sorta Karla (linija ZG1) izabrana je za predmetno istraživanje. Nakon prijenosa kalusa na selektivni medij (CIM PEG 35% ili CIM PEG 40%) dijelovi kalusa su nakon nekog vremena nekrotizirali. Regeneracija biljaka, ovisno o mediju (tretmanu) započela je oko 30ak dana nakon supkultivacije na MSR medij (ili MSR s PEG-om), i trajala idućih 45 dana.

Očekivanu značajnu razliku u broju regeneriranih biljaka po kalusu ovisno o mediju (tretmanu) potvrdila je i ANOVA. Najveći broj regeneriranih biljaka po kalusu (1,09) dobiven je u tretmanu CIM PEG 35%→MSR što je bilo i za očekivati jer je to najblaži tretman, a značajno manji broj biljaka (0,44 i 0,26) u tretmanima CIM PEG 40%→MSR PEG 40% i CIM PEG 35%→MSR PEG 35% (graf 1). Nakon zakorijenjivanja i aklimatizacije preživjelo je i uzgojeno 288 regeneranata.



Graf 1. Prosječni broj biljaka regeneriranih po kalusu u različitim tretmanima PEG-a

Iako je svrha selekcije na PEG-u dobivanje somaklonova potencijalno tolerantnih na sušu,  $R_0$  biljke nisu podvrgnute suši, već su kontrolirano samooplođene i uzgajane do zriobe u svrhu proizvodnje dovoljne količine sjemena koje ćemo koristiti za testiranje na sušu u poljskim pokusima uz inducirane uvjete suše. Osim na sušu, regenerirane biljke mogu pokazati somaklonsku varijabilnost za bilo koje svojstvo zbog dugotrajnosti *in vitro* kulture u kalusnoj fazi. U svrhu otkrivanja moguće somaklonske varijabilnosti kod regeneranata je u zriobi analizirano nekoliko svojstava od interesa. Sva analizirana svojstva su kvantitativna svojstva važna za formiranje uroda. Srednje vrijednosti  $R_0$  biljaka regeneriranih iz različitih *in vitro* tretmana bile su na razini, ili niže od srednjih vrijednosti biljaka polaznog genotipa (Tablica 2.). Za sva analizirana svojstva, kod pojedinih  $R_0$  biljaka pronađene su više maksimalne vrijednosti u odnosu na polazni genotip. Među regenerantima iz najblažeg tretmana *in vitro* selekcije (CIM PEG 35%→MSR) zabilježene su maksimalne vrijednosti veće od polaznog genotipa za svako analizirano svojstvo, a razlog tome vjerojatno je veći broj regeneriranih (i analiziranih) biljaka u ovom tretmanu u odnosu na druge. Dužina primarnog klasa je svojstvo za kojeg su maksimalne vrijednosti pronađene među regenerantima iz svih tretmana *in vitro* selekcije u odnosu na polazni genotip. Ivanov i sur. (1998) su za dužinu klasa među linijama pšenice ( $R_3$ ) dobivenima iz kulture tkiva također pronašli vrlo velik broj linija čije su maksimalne vrijednosti bile veće nego kod polaznog genotipa. Treba naglasiti da će realne vrijednosti svih analiziranih svojstava moći biti uspoređene tek u poljskim uvjetima (u ovom pokusu su biljke uzgajane u malim vegetacijskim loncima). Međutim,  $R_0$  biljke s višim maksimalnim vrijednostima svojstava u odnosu na polazni genotip mogle bi biti vrijedni izvor genetskog materijala koji će biti korišten za razvoj novih linija.

Tablica 2. Srednje vrijednosti te minimalne i maksimalne vrijednosti svojstava za pojedine biljke

Svojstvo	Polaz. genotip	Tretman in vitro selekcije			
		I	II	III	IV
Br. kl. po biljci					
SV	3.5a*	3.6a	3.5a	3.2a	3.1a
MNV	2	1	1	1	1
MKV	6	10	9	6	7
Dužina prim. kl. (mm)					
SV	96.9a	85.6c	88.3cb	92.3ab	93.0ab
MNV	90	48	46	73	72
MKV	104	107	110	110	125
Br. klasića prim. kl.					
SV	21.4a	18.3bc	18.4bc	18.0c	19.3b
MNV	19	10	12	16	15
MKV	23	24	22	20	29
Br. zrna prim. kl.					
SV	33.5a	28.1ab	30.2a	22.1b	22.6b
MNV	12	2	1	12	6
MKV	51	54	59	51	52
Masa zrna prim. kl. (g)					
SV	1.23a	0.81b	0.87b	0.83b	0.69b
MNV	0,51	0,02	0,03	0,42	0,15
MKV	1,96	2,01	2,09	1,85	1,66

Oznake za tretmane *in vitro* selekcije iste su kao kod Grafa 1.; \*Vrijednosti označene istim slovom u redu ne razlikuju se značajno prema Duncan-ovom testu; SV-srednja vrijednost; MNV-minimalna vrijednost; MKV-maksimalna vrijednost; Podebljano su označene maksimalne vrijednosti pojedinačnih R<sub>0</sub> biljaka za pojedina svojstva koje su veće od maksimalnih vrijednosti pojedinačnih biljaka polaznog genotipa.

### Zaključak

Nezreli embriji sorte Karla kalusirali su u vrlo visokom postotku na MS mediju s dodatkom auksina 2,4-D. Nakon višemjesečne selekcije na MS mediju s dodatkom PEG-a, efikasnost regeneracije biljaka na kalusima razlikovala se u ovisnosti o koncentraciji PEG-a u mediju. Regeneranti kod kojih su utvrđene maksimalne vrijednosti za pojedina svojstva veće nego kod polaznog genotipa predstavljaju potencijalno vrijedne somaklonove za razvoj novih linija.

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# Small grains varieties developed at the Maize Research Institute, Zemun Polje

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## Abstract

The most important agronomic and technological traits of the following five small grains varieties developed at the Maize Research Institute, Zemun Polje, were presented in this study: Apolon (spring hulless barley), Nektar (winter two-row malting barley), Zlatna (late maturity winter wheat), Zemunska rosa (early maturity winter wheat) and Zenit (winter triticale). These varieties were released by the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia in 2008 and 2009. The two-year average yields of the varieties Apolon, Zemunska rosa and Zenit were the highest, while the yield of Nektar and Zlatna was at the level of the check yield, but they had exceptional technological quality. All varieties showed a good resistance to low temperatures and plant pathogens. The basic property of newly developed varieties is high genetic yielding potential and stable yield, which was successfully combined with high technological quality and/or high tolerance to drought.

Key words: variety, small grains, agronomic and technological traits

## Introduction

The development of new, improved varieties adapted to drought conditions is a fundamental aim of the selection programme on small grains at the Maize Research Institute, Zemun Polje. Beside the spring hulless barley variety Aplon, released by the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia in 2008, the varieties Nektar (winter two-row malting barley), Zlatna (late maturity winter wheat), Zemunska rosa (early maturity winter wheat) and Zenit (winter triticale) were released in 2009. Breeders need varieties that are resistant, or at least tolerant, to locally important diseases, drought, etc., and well adapted to the local climate and ripen at a convenient time (Briggs, 1998). Grain yield is a complex trait in which formation are included yield components that directly or indirectly depend on many agronomic traits: resistance to low temperatures and lodging, intensity and duration of the photosynthetic activity, resistance to diseases, etc. The objective of the present study was to present some of the most important agronomic and technological traits of varieties released in 2008 and 2009 in relation to their checks at the Commission for the Variety Releasing.

## Materials and methods

The study encompasses results on recently developed lines in two-year trials of the Commission for the Variety Releasing of the Republic of Serbia carried out in six locations (Kragujevac, Novi Sad, Pančevo, Sremska Mitrovica, Sombor, Zaječar). Trials were set up according to the randomised complete-block design. The elementary plot size amounted to 5m<sup>2</sup>. Agronomic, physical, chemical and technological traits of varieties were observed. Physical, chemical and technological analyses were performed at the Faculty of Technology in Novi Sad. Tolerance to plant diseases was evaluated in the adult-plant stage under conditions of artificial inoculation and was expressed in% of diseased plants. Resistance to low temperatures was observed in cold storages, and was expressed in% of survived plants. The determination of morphological, physiological, productive and traits of quality was done by widespread methods. Statistical data processing

was performed by the MSTAT-C program.

### Results and discussion

The spring hulless barley variety Apolon was developed by the derivation of a homozygous line from IWHBON'97 (CIMMYT). As presented in Fig. 1, on the average for all years and locations the variety Apolon had a yield of 4587 kg ha<sup>-1</sup>, or higher by 774 kg ha<sup>-1</sup> than the yield of the check variety Golijat, which is a statistically very significant difference ( $P < 0.01$ ). The highest two-year average yield (5594 kg ha<sup>-1</sup>) was recorded in Zaječar.

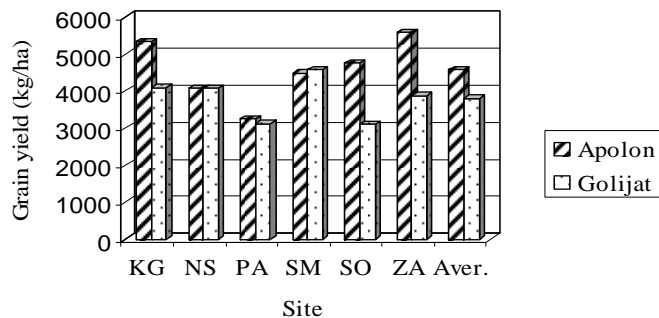


Figure 1. The two-year (2007-2008) grain yield of the variety Apolon obtained in the trials of the Commission for the Variety Releasing

Hulless barley has a special importance in the production of novel and functional food. According to Škrbić et al. (2009),  $\beta$ -glucans are recognised as having important positive health impacts, centred on their benefits in coronary heart disease, cholesterol lowering and reducing a glycaemic response. Inclusion of barley flour in plain wheat bread formulation enhances the  $\beta$ -glucan content of bread, which may have a beneficial effect on human health. In relation to hulled varieties, hulless ones have more proteins, dietary fibres and  $\beta$ -glucans. The  $\beta$ -glucan, i.e. protein content in the variety Apolon amounted to approximately 5.6%, i.e. 17.3%, respectively. Hulless barley varieties should also have good physical traits of kernels (large, well filled with white aleurone) and a high content of dietary fibres. The essential property of hulless barley varieties is very higher% of hulless kernels, which amounted to approximately 95% in the variety Apolon, while% of the first-class kernels (8.3%) was higher than in the check Golijat (7.9%). The most important agronomic traits of the variety Apolon are presented in Tab. 1.

Table 1. Agronomic traits of varieties Apolon, Nektar and checks in two-year trials of the Commission for the Variety Releasing

Trait	Apolon	Golijat	Nektar	NS 525
1000-kernel weight (g/DM)	25.3	25.7	46.2	45.2
Test weight (kg hl <sup>-1</sup> )	76.10	75.05	75.25	73.85
Resistance to low temperatures (%)	-	-	100	40
Resistance to <i>Erysiphe graminis hordei</i> (%)	0	0	10	40
Resistance to <i>Puccinia hordei</i> (%)	0	0	5	5
Heading time	-2.8	-	+4.75	-
Plant height (cm)	83.1	79.9	93.0	90.4
Logging	2.2	2.0	2	1.9

Resistance:% of infection; Heading time: +after and - before the check

The two-row malting barley variety Nektar was developed by crossing NS-183 x (Iris x Alpina) x Novum. The pedigree selection method was applied. As it shown in Fig. 2, the average yield in all locations and years amounted to 8797 kg ha<sup>-1</sup>, which was higher by 80 kg ha<sup>-1</sup> than the average yield of the check variety Novosadski 525. The highest yield of the variety Nektar (9824 kg ha<sup>-1</sup>) was recorded in the location of Pančevo.

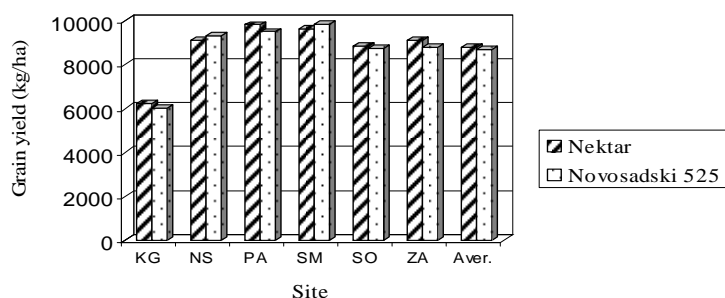


Figure 2. The two-year (2008-2009) grain yield of the variety Nektar obtained in the trials of the Commission for the Variety Releasing

The 1000-kernel weight amounted to 46.2 g/DM in the variety Nektar (vs. 45.2 g/DM detected in the check). Furthermore, the test weight of the natural sample of this variety was greater than the test weight of the check (75.25kg vs. 73.85kg). Grading is an important characteristic from the economical point of view. Grading indicates proportionally this part of the grain yield which remains to the 2.5 and 2.8 mm sieve (Küüts, 1992; Kunze, 1996) and this part is used for malting. The first-class kernels in the variety Nektar amounted to 95.3% of the total grain yield. Other agronomic traits are presented in Tab. 1. Results of trials of the Commission for the Variety Releasing show that the grain protein content amounted to 10.2% (vs. 14.6% in the check) and the content of fine extract amounted to 75.02% (vs. 75.63% in the check).

The wheat variety Zlatna was derived by crossing varieties Jasenica and Rodna. The pedigree selection method was applied. The average yield in all locations and years, is presented in Fig. 3, and amounted to 8967 kg ha<sup>-1</sup>, which was higher by 216 kg ha<sup>-1</sup> than the average yield of the check variety Pobeda. The highest yield (10448 kg ha<sup>-1</sup>) of this variety was detected in the location of Novi Sad.

The variety is late maturity one. The variety Zlatna had a great test weight (84.6 kg hl<sup>-1</sup>), and according to Mladenov et al. (2008), that is an important parameter of technological quality and depends on grain filling, chemical composition, kernel area, nature of admixtures and moisture. Total extraction amounted to 78.9%. Based on the protein content (13.8%) and the sedimentation value (47 ml) it belongs to the first quality class. According to quality parameters the variety Zlatna is an enhancer. The bread volume yield (ml/100g flour) amounted to 582, while loaf quality was 6.3. The most important agronomic traits are presented in Tab. 2.

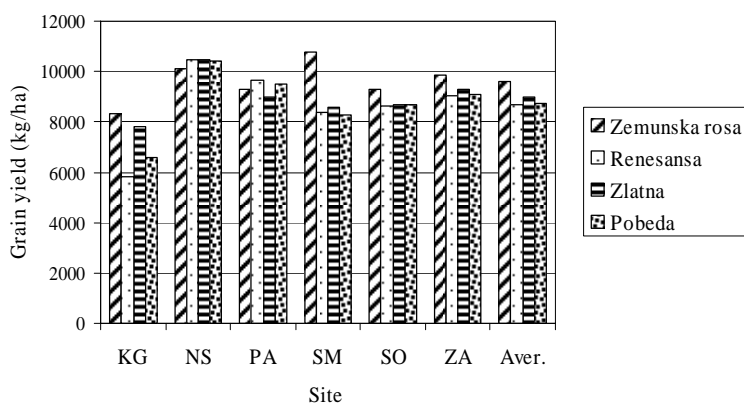


Figure 3. Grain yield of varieties Zemunska rosa, Renesansa, Zlatna and Pobeda in two-year trials (2008-2009) of the Commission for the Variety Releasing.

Table 2. Agronomic traits of varieties Zemunska rosa, Zlatna and checks in two-year trials (2008-2009) of the Commission for the Variety Releasing

Trait	Zlatna	Pobeda	Zemunska rosa	Renesansa
1000-kernel weight (g/DM)	40.1	41.1	44.3	41.3
Test weight (kg hl <sup>-1</sup> )	84.6	83.1	83.7	83.2
Crud protein content (% on DM)	13.8	14.0	11.8	13.5
Resistance to <i>Erysiphe graminis tritici</i> (%)	5	5	10	40
Resistance to <i>Puccinia recondite tritici</i> (%)	10	5	0	0
Heading time	+0.75	-	-0.1	-
Plant height (cm)	91.1	99.2	99.4	98.5
Logging	1.75	1.75	1.6	1.2

Resistance:% of infection; Heading time: +after and - before the check

The winter wheat variety *Zemunska rosa* was developed by crossing varieties *Skopljanka* (Macedonia) and *Proteinka* (Serbia), by the application of the pedigree selection method. As presented in Fig. 3, on the average for all years and locations, the yield of this variety amounted to 9575 kg ha<sup>-1</sup>, which was higher by 918 kg ha<sup>-1</sup> than the yield of the check variety *Renesansa*. This difference was statistically significant. The variety *Zemunska rosa* is tolerant to drought. The average yield recorded in dry 2008 was higher by 9.3% the average yield detected in 2009 that was characterised with the usual amount of precipitation. In 2008, the average yield of the variety *Zemunska rosa* was higher by 5.27% than the yield of the check *Renesansa*. Kernels of the variety *Zemunska rosa* were large and well filled, the 1000-kernel weight amounted to 44.3 g/DM, while the test weight of the clean kernel was 83.7 kg hl<sup>-1</sup>. This is an early maturity variety with good resistance to low temperatures and strong resistance to plant pathogens. According to Shu et al. (2008), disease resistance is one of the most important traits for the development of sustainable agriculture and the use of resistant varieties is the most economical and environmentally safe way of controlling these diseases.

The winter triticale variety *Zenit* was developed by crossing varieties *Knjaz* (Serbia) and *Alzo* (Poland) by the application of the pedigree selection method. On the average for all years and locations, the yield of this variety amounted to 9033 kg ha<sup>-1</sup>, which was significantly higher than the yield of the check *KG20* (7960 kg ha<sup>-1</sup>). As presented in Fig. 4, the highest average yield of this variety (10560 kg ha<sup>-1</sup>) was registered in the location of Novi Sad. This variety was also tolerant to drought and its average yield in dry 2008 was higher by 12% than the average yield in 2009. Moreover, in comparison with the variety *KG20*, the variety *Zenit* had an average yield higher by 13.7% in 2008.

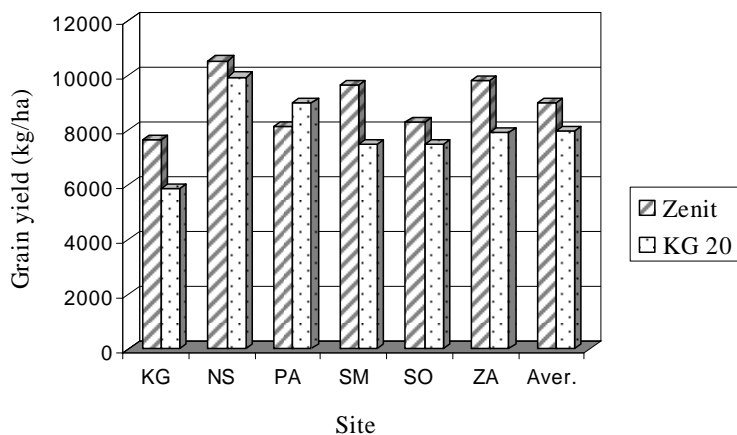


Figure 4. Grain yield of the variety *Zenit* in two-year trials (2008-2009) of the Commission for the Variety Releasing

Besides, the improvement of quality, enhancing resistance to diseases and insects, as well as, to drought and heat stress are also important. The variety *Zenit* had excellent resistance to low temperatures with 80% of survived plants (vs. 20% in the check). It had exceptional resistance to leaf and stem rust (infection of 0% vs. 5% in the check). This variety had a tall stem (122.3 cm), and therefore it could be used for silage. Although the stem was higher by 13.8 cm than the height of the check, the number of lodged plants was 1.6 (vs. 1 in the check). The 1000-kernel weight amounted to 32.6 g/DM. The test weight of clean kernels was 188.8 kg hl<sup>-1</sup>, which was greater than the test weight of the check (182.9 kg hl<sup>-1</sup>).

### Conclusions

The breeding programme of the Maize Research Institute, Zemun Polje, encompasses almost all kinds and types of small grains. High yields of five recently released varieties are successfully combined with high technological quality and/or high tolerance to drought, hence these varieties can be grown under different agroecological regions.



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# Viktor - new triticale variety

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## Abstract

Highly yielding, medium-early variety of facultative triticale named Viktor was created by crossing the genetically divergent parents. This variety created by the Agricultural Institute of Republic of Srpska, had successfully combined the genes responsible for high grain yield potential, good processing quality, excellent resistance to low temperatures, very good resistance to lodging and plant diseases. In three-year trials of the Federal Institute of Agriculture, the variety Viktor achieved significantly higher yields than the standard variety Goran, the difference amounted to 655 kg ha<sup>-1</sup>. The variety Viktor is maturing 6 days earlier compared to the standard. The average raw protein content is 11.7%.

Key words: triticale, variety, yield, processing quality

## Introduction

Triticale (x Triticosecale) is a relatively new, human-made cereal created by crossing two different species from two different genera. It was created more than 100 years ago in order to unify the positive traits of wheat and rye, which is to bring together high level of proteins and energy from wheat with high yield and quality of rye (Radecki and Miller, 1990). The first varieties of triticale were selected and grown in the practical production in the second half of the twentieth century. Modern varieties of triticale have a number of benefits for the successful cultivation: the ability of growing on poor soils, resistance to low temperature and drought, a high potential for grain development and green mass of very good quality.

Due to a number of benefits in production and due to the increased protein content in grain, triticale plays a more prominent role in the production of crops intended for animal feed in the Republic of Srpska and Bosnia and Herzegovina.

Triticale breeding program started at the end of the year 1996 on the territory of Bosnia and Herzegovina, at the Agricultural Institute of Republic of Srpska, and it was focused on the creation of winter and facultative varieties with high and stable yield and good quality, by using an appropriate management system (Mandić et al., 2007). Two varieties were created from this triticale breeding program; the winter variety Oskar registered in 2006 and the facultative variety Viktor registered in 2009.

The aim of this research is to present the comparative advantages of triticale variety Viktor compared to the standard variety Goran.

## Materials and methods

The triticale gene collection at the Agricultural Institute of Republic of Srpska consists of about 200 genotypes and the triticale breeding program is performing about 150 crosses per year. Hybrid material was followed by pedigree method. Phenotypically balanced lines are selected and sown in the preliminary and comparative trials, and after testing applied for recognition to Commission for variety registration afterwards.

Variety Viktor was created by process of simple hybridization in 1996, from genetically divergent parents, varieties Jugo and Bogo, by the pedigree method, and phenotypically uniform variety under the name Viktor, was selected in 2003 from F6 generation. In the following two years, the agronomic and technological traits

were tested in preliminary experiments at the Banja Luka, the trial fields of the Agricultural Institute of Republic of Srpska. Based on the preliminary results the variety Viktor was submitted in 2006 to the Commission for variety registration.

The variety was tested in three-year trials at two localities by comparing with the standard variety Goran. In the trials grain yield, length of vegetation, plant height, lodging resistance, resistance to the causes of plant diseases, and the technological quality were studied. In this research, we have used the results of macro trials conducted by the Agricultural Institute of Republic of Srpska and the Agency for providing professional services in agriculture (Ministry of agriculture, forestry and water management, Republic of Srpska Government, Bosnia and Herzegovina).

## Results and discussion

### Yield

One of the decisive factors in achieving a high yield is the choice of the appropriate variety. According to the results of three-year trials the variety Viktor achieved the highest yield at the location Butmir of 7.120 kg ha<sup>-1</sup> in 2007, which represents a highly significant difference (724 kg ha<sup>-1</sup>) compared to the standard variety Goran (Tab. 1). The highest absolute yield of 7.272 kg ha<sup>-1</sup> the variety released at the second year of study at the location Živinice, which is a significant difference (859 kg ha<sup>-1</sup>) compared to the standard variety Goran.

**Table 1. The grain yield of the triticale variety Viktor (kg ha<sup>-1</sup>) in three-year trials (Federal Institute of Agriculture, Sarajevo)**

Tested variety	Year								
	2007			2008			2009		
	Butmir	Živinice	Avg	Butmir	Živinice	Avg	Butmir	Živinice	Avg
Viktor	7.160 <sup>+</sup>	7.272 <sup>++</sup>	7.216	7.120 <sup>++</sup>	7.020 <sup>++</sup>	7.070	7.080 <sup>++</sup>	6.908 <sup>+</sup>	6.994
Goran	6.320	6.506	6.413	6.400	6.240	6.320	6.468	6.692	6.580
Average	6.740	6.889	6.814	6.760	6.630	6.695	6.744	6.800	6.787
LSD0.05	633.45	617.73		418.81	460.17		354.53	213.46	
LSD0.01	1.048	1.022		692.99	761.43		586.63	353.21	
CV(%)	5.34	5.09		3.52	3.94		2.97	1.78	

In three-year macro trials conducted by the Agricultural Institute of Republic of Srpska, the variety Viktor achieved the yield of 6.430 kg ha<sup>-1</sup>. Uniformly high yields confirm the fact that new triticale variety Viktor achieves high and stable yields in different agroecological conditions, which confirms adaptability of this variety. This suggests that this variety can be grown successfully and provide high yield and at lower level management systems which are very important for growing cereals under conditions of climate changes (Malešević and Panković, 2004). Bearing in mind the potential of this variety and tendency of increasing the area under this plant species in Bosnia and Herzegovina its rapid expansion in production is expected.

### Agronomic traits

Genetic potential is the direct effect of the expression of genes that are determining certain properties or processes (Denčić et al., 1997). In order to have a high genetic potential and stable production potential, a new variety should contain the positive agronomic traits such as: resistance to low temperature, lodging resistance, drought tolerance and resistance to plant diseases, etc. The variety Viktor is maturing 6 days earlier and it is 8.3 cm higher compared to the standard variety Goran (Tab. 2). It has very good resistance to lodging and plant diseases.

**Table 2. Agronomic characteristics of the triticale variety Viktor in three-year trial (Federal Institute of Agriculture, Sarajevo)**

Traits	Viktor	Goran
Length of vegetation to technological maturity	252	258
Plant height (cm)	116	108
Crop lodging (0-9)*	1	1
Resistance to <i>Puccinia recondita</i> (%)**	1	1
Resistance to <i>Puccinia graminis</i> (%)**	1	1
Resistance to <i>Erysiphe graminis</i> (%)**	1	1
Resistance to <i>Fusarium</i> sp. (%)**	2	2

\* 0 = no lodging; 9 = 100% lodging;

\*\*% infection by modified Kobo scale;

### Quality

Hectoliter weight is an important indicator of the quality and depends on grain moisture, fullness, specific weight, chemical composition and the health status of grain. Hectoliter weight is one of the oldest indicators for evaluating the quality of wheat (Mladenov, 1996). The variety Viktor has slightly higher hectoliter weight compared to the standard. The value of 1000-kernel weight indicates that this variety has a medium grain size. Hectoliter weight and 1000-kernel weight are genetically controlled traits that are significantly influenced by environmental factors. Grain protein content of the variety Viktor is 11.77%.

### Conclusion

The new variety Viktor achieved significantly higher yields than the standard variety Goran, the difference amounted to 655 kg ha<sup>-1</sup>. It has a very good resistance to plant diseases and good quality. Variety Viktor is maturing 6 days earlier compared to the standard. The average raw protein content is 11.7%.

With registration of new triticale variety Viktor, assortment of triticale varieties in Bosnia and Herzegovina is richer for one more high-yield, medium-early variety, very good resistance to plant diseases, with wide adaptability, a satisfactory yield stability, and good level of tolerance to drought.

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# Relationships between phenology and yield components in winter barley

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## Abstract

Each yield component of barley is determined by developmental events during specific phenological phases. The number of spikes per unit area is established from planting to jointing. Spikes continue to develop between single ridge and flag leaf elongation and the number of kernels per spike is established from jointing, i.e., it starts from double-ridge of apical meristem development and sets shortly after anthesis. Duration and rate of grain filling determines kernel weight. The objectives of this study were to examine the variation and relationships among phenology and yield components. Twenty-four winter barley cultivars were used in this investigation. The stage of leaf development of the main culm was referenced to the Haun scale. The relationship between kernel weight and growing degree days (GDD) accumulated from anthesis for each plot was determined by fitting the quadratic polynomial. The duration from planting to flag leaf was 1223 GDD across two-rowed varieties and 1304 GDD across six-rowed varieties. The variety NS 519 had the shortest grain fill period (648 GDD), the variety Marinka the longest (940 GDD). GF rate was mainly determined by genotype (44.3% of total variation) and GxY interaction (31.1% of total variation). GF rate across two-rowed varieties was rather higher (7.251 mg 100 GDD<sup>-1</sup>) than across six-rowed varieties (6.395 mg 100 GDD<sup>-1</sup>). Selection for shorter vegetative period and longer grain filling period is recommended in the development of varieties for semiarid conditions of growing.

Key words: winter barley (*Hordeum vulgare* L), phenology, vegetative period, grain filling, yield components

## Introduction

Each yield component of barley is determined by developmental events occurring during specific phenological phases. Number of spikes per unit area is establishing from tillering to jointing. In winter barley, tillering typically starts in the fall and it finishes in the spring. Tillering capacity depends on genetic factors and ecological factors and their interaction (Davidson and Chevalier, 1990). Number of kernels per spike, the second most important yield component, sets in the period from double-ridge stage of apical meristem till shortly after anthesis (Kirby et al., 1981). In this period, rate and duration of spikelet development and floret generation as well as the effectiveness of pollination define the final number of kernels. Generally, spikes develop between single ridge and flag leaf elongation. Kernel weight is the third most important yield component. During first two weeks after anthesis, the number of kernel cells is determined (Brocklehurs, 1977) and, after that, kernel weight is determined by the duration and rate of grain filling (Wiegand and Cuellar, 1981). Plant genotype and environment, first of all temperature and moisture, control the process of kernel filling (Sofield et al., 1977).

To our knowledge, limited data are available about relationships between phenology and yield components of winter barley in semiarid regions of South East Europe. The objectives of this study were to examine (i) the variation of phenology and yield components and (ii) the relationships between growth and yield components.

**Materials and methods**

Twenty-four winter barley cultivars, 12 two-rowed and 12 six-rowed, differing in origin, duration of vegetative and generative phases and other physiological traits were used in this investigation. The trials consisted of two identical blocks. The experimental design of each block was randomized complete block in three replicates. Each plot consisted of six rows 15 cm apart and 5 m long (5 m<sup>2</sup>). Seedling dates were October 4, 1999, October 3, 2000, and October 8, 2001. The sowing rates were 200 seeds m<sup>-2</sup> for the six-rowed and 250 seeds m<sup>-1</sup> for the two-rowed cultivars. Shortly after emergence, five random plants in the second row (first inner row), 30 cm inside the plot, were tagged for observation during the growing season. The stage of leaf development of the main culm was referenced to the Haun scale (Haun, 1973) at intervals of 3-4 days from emergence to heading. All phenological measurements were assessed using growing degree days (GDD) with the base temperature of 0°C.

At anthesis, 60 main spikes from each plot of the first trial that flowered at the same day were tagged. Samples of five tagged spikes/plant were collected from each plot at 3-4 days intervals beginning five days after anthesis till harvest maturity for determination grain filling rate and above ground dry matter accumulation. The relationship between the average weight of one kernel and GDD accumulated from anthesis to physiological maturity was determined for each plot by fitting the quadratic polynomial  $W=a+bt+ct^2$ , where W is kernel dry weight, t is time (GDD) from anthesis and a, b, c are regression coefficients (Pržulj, 2001).

The second trial was used for the determination of yield components in each year and plot, i.e., number of spikes m<sup>-2</sup>, number of kernels spike<sup>-1</sup>, kernel weight spike<sup>-1</sup> and grain yield. Analysis of variance for each trait was conducted by using MSTAT-C program. Simple correlation coefficients were calculated for the relationships between vegetative period and yield components and grain filling period and yield components. Heritability was estimated according to Falconer (1989), by the equation  $h^2=\sigma_g^2/\sigma_f^2$ , where  $\sigma_g^2$  represents genotypic variance and  $\sigma_f^2$  represents phenotypic variance.

**Results and discussion**

Durations of periods from planting to flag leaf and from planting to heading were determined mainly by genotype, although year and GxY interaction also significantly affected these phenological phases (Tab. 1). Genotype controlled the largest part of the variation, as confirmed by high heritability (0.90). The duration from planting to flag leaf stage was 1223 GDD across the two-rowed varieties and 1304 GDD across the six-rowed varieties. The duration from planting to heading ranged from 1337 GDD, in the two-rowed barley variety NS 331, to 1554 GDD, in the six-rowed variety Gerbel. Across years and varieties, the two-rowed type accumulated during this period 87 GDD less than the six-rowed type (data not shown). A general conclusion can be drawn that the two-rowed varieties from Novi Sad had shorter periods from planting to flag leaf and planting to heading than the two-rowed barley varieties from Germany, France, England, and Holland which headed 3 to 10 days later. The six-rowed varieties also exhibited significant differences in the duration of vegetative period but these differences amounted to a few days only and they were not consistent in relation to the geographic origin of the varieties.

**Table 1. ANOVA, percentages of variance components and heritability for the tested traits**

Source of variation	Df	Planting to	Planting to	GF duration	GF rate	Kernels	Kernel wt.		
		flag leaf	heading	(GDD)	(mg 100)		spike <sup>-1</sup>	Grain yield	
		(GDD)		(GDD <sup>-1</sup> )	Spikes m <sup>-2</sup>	spike <sup>-1</sup>	(mg)	(kg ha <sup>-1</sup> )	
Year (Y)	2	**	**	**	**	**	**	**	
Variety (G)	23	**	**	*	**	**	**	*	
GY	46	**	**	**	**	**	**	**	
Percentage of variance components									
Year (Y)	2	13.7	10.4	26.8	18.6	34.1	8.8	4.0	79.0
Variety (G)	23	62.2	59.6	20.5	44.3	32.3	78.9	67.7	6.3
GY	46	14.8	13.8	50.6	31.1	26.5	7.9	15.0	8.4
Error	138	6.3	16.2	2.1	6.0	7.1	4.4	13.3	6.3
$h^2$		0.92	0.90	0.55	0.80	0.77	0.96	0.91	0.64

\*,\*\* - Significant at P=0.05 and 0.01, respectively

The interaction genotype x year determined the main part of variation of grain filling (50.6%). The variety NS 519 had the shortest grain filling period (648 GDD), the variety Marinka the longest (940 GDD) (data not shown). There was no consistency between variety origin and GFD, i.e., among both Serbian and foreign varieties there were genotypes with either short or long GF periods. GF rate was mainly determined by genotype (44.3% of total variation) and by GxY interaction (31.1% of total variation) (Tab. 1). GF rate across the two-rowed varieties was higher (7.251 mg 100 GDD<sup>-1</sup>) than across the six-rowed varieties (6.395 mg 100 GDD<sup>-1</sup>) (data not shown). The negative correlation between the number of kernels per spike and GF rate confirms this finding (Tab. 2). Sonate and NS 27 had the fastest GF rates within the two-rowed and six-rowed varieties, respectively. The slowest GF rates were found in Marinka among the two-rowed varieties and Kearney among the six-rowed varieties. GF duration was under strong ecological influence ( $h^2=0.55$ ) but GF rate was under strong genetic influence ( $h^2=0.80$ ). Van Sanford (1985) and Hunt et al. (1991) found that genetic factors determine to a larger extent the rate of GF while environmental factors, first of all temperature, determine to a large extent the duration of GF. Gebeyehou et al. (1982) and Wong and Baker (1986) reported a positive correlation between an effective filling period and grain yield, but van Sanford (1985) and Darroch and Baker (1986) pointed out that high kernel weight is associated with a high rate of GF. In a previous work Pržulj (2001) found that in semiarid conditions the environment favors a higher rate and shorter duration of GF, i.e., cultivars with faster rate and shorter duration of GF produce higher yields.

Number of spikes m<sup>-2</sup> was influenced by all three factors approximately to the same level, while the other two yield components were mainly determined by the genotype, as confirmed by a high heritability value (Tab. 1). Since contribution of the interaction GxY and error to yield variance was small, the heritability for yield was rather high, although 79% of total variation was due to the year (Tab. 1). The two-rowed varieties had a higher number of spikes m<sup>-2</sup>, a lower number of kernels spike<sup>-1</sup> and a lower kernel weight spike<sup>-1</sup> than the six-rowed varieties. Number of spikes m<sup>-2</sup> was negatively correlated with the periods from planting to flag leaf emergence and from planting to heading. Varieties with a long period from planting to heading develop a large number of kernels per spike in the course of fall and spring. All three yield components, spikes m<sup>-2</sup>, kernels spike<sup>-1</sup>, and kernel weight spike<sup>-1</sup>, were in positive correlation with grain yield (Tab. 2).

Our results showed that the tested varieties differed more in the duration of the pre-heading period than in the duration of the grain filling period. Selection for reduced vegetative period and increased grain filling period is recommended in the development of varieties for semiarid conditions of growing.

**Table 2. Simple correlation coefficients between the means of 24 winter barley varieties in the period 2000-2002 (n=72)**

	Planting to heading	GF duration	GF rate	Spikes m <sup>-2</sup>	Kernels spike <sup>-1</sup>	Kernel wt. spike <sup>-1</sup>	Grain yield
Planting to flag leaf	0.79**	0.15*	-0.39**	-0.51**	0.42**	0.42**	-0.25**
Planting to heading		0.17*	-0.29**	-0.55**	0.45**	0.40**	-0.32**
GF duration			-0.61**	-0.03	0.26**	0.14*	0.39**
GF rate				0.25**	-0.63**	-0.47**	-0.28**
Spikes m <sup>-2</sup>					-0.43**	-0.38**	0.47**
Kernels spike <sup>-1</sup>						0.89**	0.24**
Kernel wt. spike <sup>-1</sup>							0.22**

\*,\*\* Significant at P=0.05 and 0.01, respectively

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# Biochemical and molecular determination of KTI in F2 soybean population

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## Abstract

The aim of this study is comparison of two methods for the determination of the presence of Kunitz trypsin inhibitor in soybean. An F2 population derived from a cross between Kador and Kunitz variety was analyzed by SDS-PAGE and with specific PCR primer to select seeds missing KTI protein. The analysis resulted in 78 genotypes with KTI protein band and 15 with no KTI protein band. From the comparison of gel electrophoresis for Kunitz trypsin inhibitor protein and banding pattern amplified by Satt228 marker, there was a strong agreement between protein band for KTI protein and banding pattern by Satt228 marker. The both methods allow identification of KTI and will be useful in breeding programs.

Key words: Kunitz trypsin inhibitor, molecular markers, SDSPAGE, soybean

## Introduction

Soybean is considered a high quality source of protein for food and feed. However, raw soybean cannot be used for monogastric animal feeding because of the presence of factors that decrease its nutritional value. Among the antinutritional factors present in the soybean seed, the main ones are the protease inhibitors (Pusztai et al., 1997; Armour et al., 1998), which affect the growth and/or basal metabolism of different animal species. The protease inhibitors from soybeans fall biochemically into two main categories: (1) those that have a molecular weight of 20000 to 25000 Da with relatively few disulfide bonds and a specificity directed primarily toward trypsin (Kunitz inhibitor, Kunitz 1945), and (2) those that have a molecular weight of only 6000 to 10000 Da with a high proportion of cystine residues and are capable of inhibiting chymotrypsin as well as trypsin at independent binding sites (Bowman-Birk inhibitor, Birk 1961; Frattali and Steiner 1968). Approximately 80% of the trypsin inhibition is caused by KTI. Soybean kunitz trypsin inhibitor (KTI) is a small, monomeric and non-glycosylated protein containing 181 residues first isolated and crystallized from soybean seeds by Kunitz (1945).

Earlier studies have shown that five electrophoretic forms of KTI existed. The genetic control of four forms, Tia, Tib, Tic, and Tid, has been reported as a codominant multiple allelic series at a single locus (Singh et al. 1969; Hymowitz and Hadley 1972; Orf and Hymowitz 1979). The null phenotype of KTI is inherited as a recessive allele designated *ti* (Orf and Hymowitz 1979). Based on the availability of soybean lacking the KTI protein, it was suggested that KTI protein is not essential for soybean growth or development (Jofuku and Goldberg 1989).

Plant breeders can use molecular markers to select indirectly individuals in segregating populations that carry a gene for a favorable trait if a tight linkage exists between a marker locus and the genetic locus controlling that trait. Kim et al. (2006) were identified DNA marker, Satt228, tightly linked to the Ti locus controlling presence and absence of kunitz trypsin inhibitor protein.

## Materials and methods

An F2 population was derived from a cross between soybean genotype Kador, with kunitz trypsin inhibitor, and a variety Kunitz, lacking KTI. Ninety-three F2 genotypes were analyzed electrophoretically and by

molecular marker to determine the presence or absence of kunitz trypsin inhibitor.

**Protein extraction and electrophoresis** - The protein (KTI) extraction from soybean flour was performed by the procedure of Hymowitz and Hadley (1972). One hundred milligrams of the flour was well mixed with 1.5 ml of extraction buffer (0.092 M TrisHCl pH 8.1, 13.3% sucrose, 0.023 M CaCl<sub>2</sub>, 1 mM PMSF) and kept at room temperature for 30 min with occasional shaking. The mixture was centrifuged in an Eppendorf microcentrifuge for 5 minutes. A 10 µl volume of the supernatant was used for electrophoresis to show the presence of trypsin inhibitor. Protein electrophoresis was performed on a nondenaturing polyacrylamide gel consisting of 10% resolving and 5% stacking section. Separating and stacking gels contained 0.375 M TrisHCl pH 8.8 and 0.250 M TrisHCl buffer, respectively. Both, upper and lower electrophoresis tanks (Mini Protean II, Bio-Rad) were filled with 25 mM Tris, 192 mM glycine running buffer and the electrophoresis performed at (around) 120 V until bromphenol blue marker dye reached the end of the resolving gel.

**DNA extraction and marker analysis** - Five cotyledons of five seeds of each soybean genotype were crushed by liquid nitrogen. The resulting powder was processed as described by Kamiya and Kiguchi (2003). Briefly, seed powder (20-30 mg) was incubated at 55°C for 20 min in 0.2 ml of digestion buffer (10 mM Tris-HCl pH 8.0, 5 mM EDTA, 0.5% SDS, 0.5% Igepal CA-630, 0.5% Tween-20) containing 16 µg proteinase K. After digestion, DNA extraction with one volume of phenol/chlorophorm/isoamyl alcohol (25:24:1) followed by precipitation with one volume of isopropanol was used to purify DNA. The DNA concentration was estimated spectrophotometrically at 260 nm, considering that each absorbance unit corresponds to 50µg ml<sup>-1</sup> of double-stranded DNA (Sambrook et al., 1989).

The sequence of Satt228 marker was 5'-TCATAACGTAAGAGATGGTAAACT-3 (forward) and 5'-CATTATAAGAAAACGTGCTAAAGAG-3'(reverse), (Kim et al. 2006). The DNA was amplified in a reaction mixture of 25 µl containing: 30 ng of genomic DNA, 1.0 unit of *Taq* DNA polymerase, 1X PCR buffer (DreamTaq™ Green Buffer, Fermentas), 2.5 mM MgCl<sub>2</sub>, 0.8 mM dNTPs and 0.5µM of each one of the specific primers pairs for amplification of the alleles *kti*. PCR conditions were as follows: 95°C for 5 min followed by a 15-step touchdown decreasing by 0.5°C each step: 95°C for 30 s, 63.5 to 56°C for 1 min and 72°C for 1 min followed by 25 cycles of 95°C for 30 s, 56°C for 1 min and 72°C for 1 min. The amplification products were separated in 2.5% agarose gel immersed in buffer 1X TBE (Tris-borate 0.09 M, 1mM EDTA). The gel was then stained with ethidium bromide.

## Results and discussion

An F2 population derived from a cross between variety Kador, with KTI, and a variety Kunitz, lacking KTI, was analyzed by SDS electrophoresis and with specific PCR primer to select seeds which lacked these protein.

Parents and 93 F2 genotypes were analyzed through SDS PAGE to determine the presence or absence of kunitz trypsin inhibitor. *TiTi* genotypes had 21.5 kDa band that indicates KTI protein, however *titi* genotypes did not have the band in protein gel electrophoresis from the mature seed (Fig. 1). The observed data for F2 genotypes were 78 seeds with KTI protein band and 15 genotypes with no KTI protein band. These observations fit the expected 3:1 ratio for the presence or absence of the KTI protein band. That was in agreement with results of Kim et al, 2006 who obtained the segregation ratio of 3:1 in the F2 seed and the Chi-square values that strongly suggest that kunitz trypsin inhibitor protein band is controlled by a single recessive gene.

Molecular markers tightly linked to desired genes are a valuable tool to detect genotypes of interest, saving time and resources (Tanksley et al., 1989). With the aid of specific primer Satt228, designed to amplify portions of the recessive alleles *kti*, the seeds of the F2 population from the cross between Kador and Kunitz were analyzed. Satt228 marker very tightly linked to *Ti* locus at distance of 0 cM (Kim et al., 2006). Amplification patterns obtained from Satt228 marker using genomic DNA of parent Kunitz and F2 genotypes with *titi* genotype (Kunitz trypsin inhibitor protein absent) and parent Kador and F2 genotypes with *TiTi* genotype (Kunitz trypsin inhibitor protein present) are shown in Fig. 2. *TiTi* genotypes had allele1, however, *titi* genotypes had allele2.

From the comparison of gel electrophoresis for Kunitz trypsin inhibitor protein and banding pattern amplified by Satt228 marker from the genomic DNA, there was a strong agreement between protein band (21.5 kDa) for Kunitz trypsin inhibitor protein and banding pattern by Satt228 marker. All *TiTi* genotypes which showed 21.5 kDa protein band in protein electrophoresis had the allele 1 amplified by Satt228 marker from the genomic DNA. However, all *titi* genotypes which showed no 21.5 kDa protein band had allele 2

amplified by Satt228 marker. This result indicates that Satt228 marker may be effectively utilized to select the plants with the *titi* genotype.

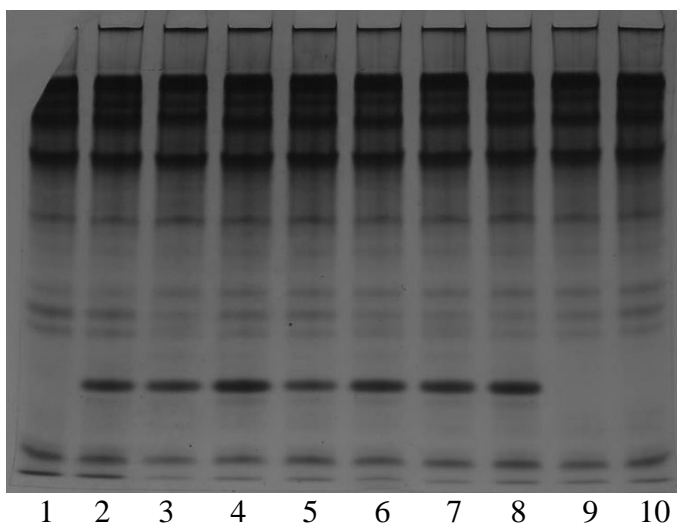
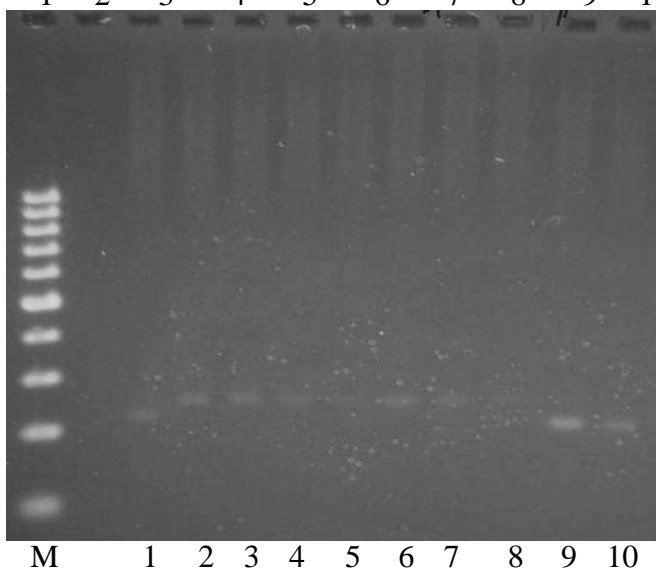


Figure 1. Polyacrylamide gel of protein extracted from parents and F2 seeds. Line 1. Kunitz, 2. Kador, 3.-10. F2 plants, arrow points to the kunitz trypsin inhibitor band (21.5 KDa)



Alel 1  
Alel 2

Figure 2. Sat228 marker analysis of parents and F2 seeds. Line 1. Kunitz, 2. Kador, 3-10 F2 plants

### Conclusion

At present, protein electrophoresis is the most common method used to select lines lacking the Kunitz trypsin inhibitor protein but indirect selection based on DNA marker tightly linked to *Ti* locus is an easier and more efficient method. The availability of soybean lines lacking the kunitz trypsin inhibitor and SSR marker linked tightly to the *Ti* locus may assist in investigations of the function and role of kunitz trypsin inhibitor protein in soybean breeding program.

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# Genetic and phenotypic correlations of yield and its components in soybean

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## Abstract

During two years' experiments, three soybean half-sib populations, each consisted of 10 F<sub>4</sub> lines, were evaluated for phenotypic traits: plant height, number of nodes per plant, pod number per plant, number of seeds per plant, 1000 seed weight and seed yield. In order to examine the association between yield and yield components and determine the components whose selection would lead to improvement of genetic yield potential, genetic and phenotypic correlations were calculated. Based on obtained results, in two populations pod number per plant and seed number per plant were determined as the most reliable and efficient selection criteria in breeding for seed yield. In third population, seed number per plant and 1000 seed mass revealed as the components with the highest influence on seed yield.

Key words: soybean, grain yield, yield components, correlations

## Introduction

The most important goal in soybean breeding programmes is improvement of the seed yield. Soybean yield is a complex trait, determined by a large number of quantitative components whose genetic basis is polygenic (Borojević, 1981). The complexity of the inheritance of this character is enhanced by interactions between numerous genetic and ecological factors. For the improvement in breeding for seed yield it is important to know genetic basis of the inheritance of yield components, as well as interactions among yield components and their correlations with yield. Correlation coefficients are useful in quantifying the size and direction of trait association, and predicting the magnitude and tendency of the changes expected during selection. Although most of the studies reported positive correlation between plant height and seed yield (Prodanović, 1992; Ariyo, 1995; Malik et al., 2007), this trait doesn't affect seed yield directly. Plant height's influence on seed yield is more indirect - through a number of pods and number of seeds per plant (Rajput et al., 1987). According to the research done by Žilić (1996), number of pods is positively correlated with seed yield. On the other hand, Hrutić et al. (1985) had carried out path coefficient analysis and suggested that number of pods affected seed yield primarily indirectly-via number of seeds per plant. Numerous studies observed negative correlation between 1000 seed weight and seed yield (Malik et al., 2007; Žilić, 1996), as long as between 1000 seed weight and number of pods. According to results of Šurlan-Momirović and Nikolić (1990), number of seeds per plant was positively correlated to seed yield, and this character is reported as one with the strongest effect on seed yield (Hrutić et al., 1985). In most of the studies of trait association in soybean, the most important components contributing seed yield are number of pods and number of seeds per plant and 1000 seeds weight (Jocković et al., 1986; Žilić, 1996).

The objective of this study was to examine the association between yield and yield components and determine the components whose selection would lead to improvement of genetic yield potential.

## Materials and method

Three soybean half-sib populations were derived from the following crosses: ZPS 015 x L 91 3103, ZPS 015 x Ravnica and ZPS 015 x ZPS 107. Pedigree method of selection was applied to develop F<sub>4</sub> populations of these

crosses. Each population consisted of 10 F<sub>4</sub> lines selected for good agronomic value. Selected lines and their parents were grown at the experimental field of Maize Research Institute "Zemun Polje" during 2003 and 2004 year. The experiment was designed as a randomized complete block (RCB) with three replications, on basic plot of five square meters. At maturity, 30 plants of each line were randomly selected per replication. Following traits were determined: plant height (cm), number of nodes per plant, pod number per plant, number of seeds per plant, 1000 seed weight (g). After harvesting with small plot combine, grain yield was converted into t ha<sup>-1</sup> and adjusted to standard moisture content (13%). Genetic and phenotypic correlations among six traits were calculated according to variance and covariance analysis (Hallauer and Miranda, 1988).

### Results and discussion

Magnitude of genotypic and phenotypic correlation coefficients was very similar in most of the cases, which indicates minimal influence of environment on these relationships. In ZPS 015 x L 91 3103 population, grain yield had positive correlation with all the characters except 1000 seed weight. Coefficients of genetic correlation showed that the components with the highest influence on seed yield were number of pods per plant ( $r_{gxy}=0.792^*$ ) and number of seeds per plant ( $r_{gxy}=0.643$ ). Hrutić et al., (1985) reported that direct effect of number of pods on seed yield is significantly smaller than indirect influence through the number of seeds per plant. This suggests that selection on the basis of number of pods and number of seeds per plant would be more efficient if directed to increase the number of seeds per pod, instead of number of pods per plant. Number of seeds per plant showed significant positive genotypic correlation with pod number per plant ( $r_{gxy}=0.844^*$ ), which is in accordance to the results of Žilić (1996) and Malik et al., (2007) (Tab. 1).

**Table 1. Genetic ( $r_{gxy}$ , upper diagonal) and phenotypic ( $r_{fxy}$ , lower diagonal) correlation coefficients among six traits in "ZPS 015 x L 91 3103" population**

	Trait					
	Plant height	Num. of nodes plant-1	Pod number plant-1	Seed yield	1000 seed weight	Seeds number plant-1
Plant height		0.797**	0.740*	0.162	-0.939**	0.675
Nodes num. plant-1	0.956**		0.468	0.421	-0.403	0.456
Pod number plant-1	0.740*	0.952**		0.792*	-0.534	0.844*
Seed yield	0.183	0.044	-0.337		-0.373	0.643
1000 seed weight	-0.290	-0.862*	-0.999**	0.144		0.065
Seeds numb. plant-1	0.812*	0.612	0.975**	0.847*	0.123	

\*and\*\* = significant at 0.05 and 0.01 levels

In ZPS 015 x Ravnica population, there was a positive genotypic and phenotypic correlation between seed yield and all examined characters excluding 1000 seed weight. 1000 seeds weight exhibited negative and highly significant correlation with seed yield ( $r_{gxy}=-0.934^{**}$ ), indicating that selection for seed yield would be more effective if conducted in direction of smaller seed. Nevertheless, path-coefficient analysis showed that genetic direct effect of 1000 seeds weight on yield might be suppressed by the high direct effect of pod number and number of seeds per plant (Hrutić et al., 1985). Similarly to previous population, pod number per plant was positively and significantly correlated with number of seeds per plant ( $r_{gxy}=0.834^*$ ). Unlike previous population, in this one coefficients of genetic correlation showed that components with the highest influence on seed yield were number of pods per plant ( $r_{gxy}=0.976^*$ ) and plant height ( $r_{gxy}=0.971^{**}$ ), whereas number of seeds per plant had lower but still strong and significant association with seed yield ( $r_{gxy}=0.856^*$ ). Considering plant height's influence on seed yield as more indirect-via number of pods and number of seeds per plant (Rajput et al., 1987), we observed number of pods per plant followed by number of seeds per plant as components with the most significant effect on seed yield (Tab. 2).

In ZPS 015 x ZPS 107 population (Tab. 3), relationships determined between traits were quite different as compared to findings in ZPS 015 x L 91 3103 and ZPS 015 x Ravnica populations. Weak negative but non significant genotypic correlation was found between grain yield and pod number per plant ( $r_{gxy}=-0.179$ ). For this population, the highest and highly significant genotypic correlation coefficient between seed yield and number of seeds per plant was determined ( $r_{gxy}=0.903^{**}$ ), followed by non significant negative correlation between seed yield and 1000 mass weight. Negative correlation between pod number per plant and seed yield might be due to the fact that genotypes with high number of pods and number of seeds per plant, usually have small 1000 seed weight, suggesting that 1000 seed weight has stronger effect on seed yield than number

of pods. Correlation coefficients, although useful in quantifying the size and direction of trait association, can be misleading if the high correlation between two traits is a consequence of the indirect effects of the traits. For that reason, path analysis is a powerful method which partitions the genotypic correlations into direct and indirect effects of the traits.

**Table 2. Genetic ( $r_{gxy}$ , upper diagonal) and phenotypic ( $r_{fxy}$ , lower diagonal) correlation coefficients among six traits in "ZPS 015 x Ravnica" population**

	Trait					
	Plant height	Num. of nodes plant-1	Pod number plant-1	Seed yield	1000 seed weight	Seeds number plant-1
Plant height		0.475	0.702	0.971**	-0.604	0.548
Nodes num. plant-1	0.482		0.554	0.436	-0.540	0.341
Pod number plant-1	0.980**	0.471		0.976**	-0.812*	0.834*
Seed yield	0.407	0.471	0.553		-0.934**	0.856*
1000 seed weight	-0.612	-0.279	-0.700	-0.448		-0.312
Seeds numb. plant-1	0.654	0.422	0.943**	0.976**	-0.453	

\*and\*\* = significant at 0,05 and 0,01 levels

**Table 3. Genetic ( $r_{gxy}$ , upper diagonal) and phenotypic ( $r_{fxy}$ , lower diagonal) correlation coefficients among six traits in "ZPS 015 x ZPS 107" population**

	Trait					
	Plant height	Num. of nodes plant-1	Pod number plant-1	Seed yield	1000 seed weight	Seeds number plant-1
Plant height		0.566	0.245	0.387	-0.337	0.436
Nodes num. plant-1	0.808*		0.498	-0.112	-0.428	0.316
Pod number plant-1	0.504	0.788*		-0.179	-0.556	0.675
Seed yield	0.087	-0.045	0.218		-0.564	0.903**
1000 seed weight	-0.333	-0.513	-0.714	-0.379		-0.377
Seeds numb. plant-1	0.489	0.378	0.745*	0.967	-0.554	

\*and\*\* = significant at 0,05 and 0,01 levels

## Conclusion

Based on obtained results, in ZPS 015 x L 91 3103 and ZPS 015 x Ravnica populations pod number per plant and seed number per plant were identified as the most important and efficient selection criteria in breeding for seed yield. In ZPS 015 x ZPS 107 population seed number per plant and 1000 seed mass revealed as the components with the highest influence on seed yield. For providing more reliable and precise information of trait association, further studies will be focused on path coefficient analysis.

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# Važniji tehnološki činitelji i ekonomski rezultati pri uzgoju sjemenskog suncokreta na Poljoprivrednom institutu u Osijeku

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## Sažetak

Istraživanja su obavljena tijekom 2005. godine na površinama Poljoprivrednog instituta Osijek, pri uzgoju sjemenskog suncokreta na parceli veličine 10,8 ha. Praćeni su i evidentirani agrotehnički zahvati (konvencionalna agrotehnika za uzgoj sjemenskog suncokreta), a obrađena je organizacija rada i ekonomika. Na temelju izračunatih normi i izrađene tehnološke karte utvrđen je utrošak od 11,38 sati rada strojeva i 65,5 sati rada ljudi. Ukupni troškovi iznosili su 11.343,80 kn ha<sup>-1</sup>, a vrijednost ostvarene proizvodnje iznosila je 21.000,00 kn ha<sup>-1</sup> uz ostvareni državni poticaj. Ostvarena je dobit od 9.657,00 kn ha<sup>-1</sup>. Proizvodnost rada izračunata je na temelju utroška 65,5 sati h<sup>-1</sup> i prinosa od 1,5 t ha<sup>-1</sup>, te iznosi 22,9 kg h<sup>-1</sup>. Na temelju koeficijenta ekonomičnosti od 2,17 i stope rentabilnosti, utvrđeno je da je uzgoj sjemenskog suncokreta ekonomičan (na uloženi 100 kn ostvarena je dobit od 45,90 kn).

Ključne riječi: sjemenski suncokret, tehnologija, tehnika, ekonomski rezultat, dobit;

## Important technological factors and economic results of seminal sunflower production

### Abstract

The research into seminal sunflower production was carried out during 2005 on the arable area of 10.8 ha owned by the Agricultural Institute in Osijek. Agritechnical procedures and work organization were monitored. Based on the calculated norms and technological plans, it was determined that 11.38 hours of machine work and 65.5 hours of human work were needed for production. Total costs amounted to 11343.80 HRK per ha<sup>-1</sup>, and total value of production including state subsidy was 21000.00 HRK per ha<sup>-1</sup>. Gained profit was 9657.00 HRK per ha<sup>-1</sup>. Working productivity was calculated on the basis of 65.5 working hours per h<sup>-1</sup> and yield of 1.5 t per ha<sup>-1</sup>, thus being 22.9 kg per h<sup>-1</sup>. According to coefficient of production efficiency, which was 2.17 and rentability rate, it was determined that production of seminal sunflower was cost effective, as the profit gained on 100.00 HRK invested in the production process amounted to 45.90 HRK.

Key words: seminal sunflower, technology, technique, economic result, profit

## Uvod

Suncokret (*Helianthus annuus* L.) je jedna od četiri najvažnije uljarice u Svijetu (Vratarić i suradnici, 2004). Zbog intenzivnog razvoja hibrida suncokreta s visokim sadržajem ulja, ono postaje sve važnije u prehrambenoj industriji (Seiler et al., 2010). Postoje potrebe za njegovom proizvodnjom na sve većim površinama (Vrandečić i suradnici, 2009). U posljednje vrijeme počelo ga se koristiti i kao pogonsko gorivo za dizel motore (biodiesel).

U razdoblju od 1997. do 2007. godine primjećeno je veliko variranje zasijanih površina i prinosa zrna suncokreta u Republici Hrvatskoj (površine su varirale 20.000 do 50.000 ha, a prinosi od 1,82 do 2,63 t ha<sup>-1</sup>), što rezultira i variranjem cijene suncokreta na tržištu kao i iznosom poticaja (Faostat, 2007). Prema podatcima službene statistike za 2009. godinu svjetska proizvodnja suncokreta odvijala se na 23.841.000 ha s prosječnim prinosom zrna od 1,26 t ha<sup>-1</sup>.

U Republici Hrvatskoj suncokret se uzgaja na 38.361 ha sa postignutim prosječnim prinosom od 2,6 t ha<sup>-1</sup>, te zastupljenošću u ukupnim obradivim površinama od oko 2,5% (Statistički ljetopis, 2009).

## Materijali i metode

Tijekom 2005. godine na Poljoprivrednom institutu Osijek provedena su istraživanja i izračun ekonomskih pokazatelja proizvodnje sjemenskog suncokreta za potrebe ovoga rada. Ispitivanja su obavljena na površini od 10,8 ha na parceli T-31 (Nosal, 2010). Uspjeh u proizvodnji u velikoj mjeri ovisi o kvaliteti sjemena. Od kvalitetnog sjemena zahtijeva se da je visoke klijavosti, visoke tolerantnosti na vanjske stresove, te da nema sjemena drugih kulturnih biljaka i korova. Kod suncokreta, kao stranooplodne biljne vrste, sjemenarstvo se obavlja na sortama i na hibridima (na bazi citoplazmatske muške sterilnosti) koji dominiraju u širokoj proizvodnji u našoj zemlji. Proizvodnja hibridnog sjemena kod dvolinijskih hibrida najjednostavnija je, a bazira se na korištenju citoplazmatske muške sterilnosti te genetske sterilnosti i genetske fertiliteti za restauraciju peluda, koje predstavljaju glavne komponente za sjemensku proizvodnju.

Tablica 1. Tehnološka karta za obavljanje radova pri proizvodnji sjemenskog suncokreta

Redni broj	Popis poslova	Jed. mjera	Agrotehnički zahtjev	Broj ljudi	Učinak norma	Sati po hektaru	
						Strojeva	Ljudi
1.	Prašenje strništa	ha	6-8 cm	1	15,00	0,47	0,47
2.	Uništavanje korova	ha	6-8 cm	1	17,00	0,41	0,41
3.	Utovar mineralnog gnojiva	kg	300 kg ha <sup>-1</sup>	1	45,00	0,16	0,16
4.	Prijevoz mineralnog gnojiva	kg	NPK 7:20:30	1	50,00	0,14	0,14
5.	Rasipanje mineralnog gnojiva	ha	NPK 7:20:30	2	20,00	0,35	0,70
6.	Oranje	ha	30-35 cm	1	5,00	1,40	1,40
7.	Zatvaranje zimske brazde	ha	-	1	11,00	0,64	0,64
8.	Utovar mineralnog gnojiva	kg	200	1	60,00	0,12	0,12
9.	Prijevoz mineralnog gnojiva	kg	NPK 7:20:30	1	75,00	0,09	0,09
10.	Rasipanje mineralnog gnojiva	ha	200	2	30,00	0,23	0,46
11.	Tanjuranje II. prohod	ha	-	1	14,00	0,50	0,50
12.	Priprema za sjetvu	ha	-	1	18,00	0,39	0,39
13.	Dovoz sjemena	t	6-8 kg ha <sup>-1</sup>	1	100,00	0,10	0,10
14.	Sjetva suncokreta	ha	70 x 19-25 cm	2	8,00	0,88	1,76
15.	Doprema vode	l	200 l ha <sup>-1</sup>	1	50,00	0,14	0,14
16.	Zaštita od korova	ha	Racer 25 EC 2 l ha <sup>-1</sup> Dual Gold 1,3 l ha <sup>-1</sup>	2	20,00	0,35	0,70
17.	Utovar mineralnog gnojiva	t	200 kg ha <sup>-1</sup>	2	90,00	0,08	0,16
18.	Prijevoz mineralnog gnojiva	t	KAN 27%	1	150,00	0,05	0,05
19.	Kultivacija prva	ha	3-4 lista	2	7,00	1,00	2,00
	druga	ha	7-8 pari listova	2	8,00	0,88	1,76
20.	Doprema vode	l	200 l ha <sup>-1</sup>	1	50,00	0,14	0,14
21.	Zaštita od bolesti	ha	Konker 1,5 l ha <sup>-1</sup>	2	20,00	0,35	0,70
22.	Okopavanje	ha	-	4	3,50	-	10
23.	Uklanjanje bolesnih biljaka	ha	-	4	5,20	-	20
24.	Uklanjanje atipičnih biljaka	ha	-	5	4,90	-	20
25.	Žetva suncokreta	t	1,5 t ha <sup>-1</sup>	1	4,30	1,63	1,63
26.	Odvoz zrna	t	1,5 t ha <sup>-1</sup>	1	8,00	0,88	0,88
Ukupno sati						11,38	65,5

Za sjemenski suncokret treba biti odabrana površina na kojoj prethodno nije sijan suncokret pet, a soja i ozima uljana repica četiri godine. U tijeku cvatnje sjemenski usjev ne smije dobiti pelud s drugih izvora, poput primjerice komercijalnih usjeva suncokreta.

Kako je suncokret stranooplodna biljka, sjemenski usjev mora biti zasijan na udaljenosti od drugog polja suncokreta 1,5 km (prostorna izolacija).

Pri sjetvi na površini od 10,8 ha ukupno je utrošeno 6,0 kg ha<sup>-1</sup> sjemena. Mineralna gnojidba je obavljena primjenom KAN-a i Uree te kompleksnim gnojivima (NPK formulacije 8:26:26). U osnovnoj gnojidbi primjenilo se 500 kg ha<sup>-1</sup> kompleksnog gnojiva naznačene formulacije, dok se ostali dio gnojiva primjenio predsjetveno i tijekom kultivacije.

Zaštita od korova obavljena je primjenom herbicida Dual 960 Gold u količini 1,5 l ha<sup>-1</sup>, te Racer 25 EC u količini 2,0 l ha<sup>-1</sup>. Za zaštitu od štetnika primjenjen je Dursban-E48, tekući insekticid kontaktnog djelovanja u količini 4,0 l ha<sup>-1</sup>, dok se za zaštitu od bolesti primjenio fungicid Konker u količini 1,5 l ha<sup>-1</sup>.

Sjetva je na Institutu obavljena u redove pneumatskim sijačicama koje imaju odgovarajuće ploče za svaku roditeljsku komponentu. Sklop biljaka za postojeće hibride planiran je između 40.000 do 60.000 biljaka za linije majke i 37.000 do 50.000 biljaka po hektaru za linije oca. Na usjevu sjemenskog suncokreta obavljene se mjere njege usjeva kao i na merkantilnim. Provedena je i obvezatna mjera uklanjanja (prije cvatnje) svih atipičnih biljaka u redovima linije majke, kao i u redovima linije oca (outcross). Atipične biljke su u pravilu robustnije i ranije počinju cvjetati. Nadalje, obavljeno je i uklanjanje fertilnih biljaka u liniji majke od početka do kraja cvatnje.

Nakon završetka cvatnje, linije oca uklonjene su traktorskom kosom, jer usjev koji je prozračan omogućuje bolje uvjete za nalijevanje zrna i zrenje liniji majki. Vlaga u žetvi treba biti ispod 20%, s tim da je najbolje početi žetvu sa 12% vlage, a završiti sa 8%. Na kombajnu je podešen broj okretaja bubnja od 250 do 300 min<sup>-1</sup> da ne bi došlo do oštećenja sjemena koja ne smiju biti veća od 5%.

### Rezultati i rasprava

Na temelju prikupljenih podataka o utrošenom radu i materijalu, te razini ostvarenog prinosa, izračunati su ukupni troškovi, vrijednost proizvodnje i ostvarena dobit pri proizvodnji (Kanisek i sur., 2001).

Ostvaren je prinos od 1.500 kg ha<sup>-1</sup> zrna sjemenskog suncokreta, uz prosječan sadržaj ulja od 49,6%.

Pri proizvodnji sjemenskog suncokreta utrošeno je 11.343,8 kn ha<sup>-1</sup>. Izravni troškovi materijala (troškovi gnojiva i sredstava zaštite) iznosili su 3.247,50 kn ha<sup>-1</sup> i predstavljaju značajan udjel u odnosu na ukupne troškove (28,6%). Troškovi rada strojeva iznose sveukupno 4.790,00 kn ha<sup>-1</sup> i čine udjel od čak 42,2% u odnosu na ukupne troškove.

Uz državni poticaj od 3.000,00 kn ha<sup>-1</sup> ostvarena je ukupna vrijednost proizvodnje od 21.000,00 kn ha<sup>-1</sup>. Nakon podmirenja ukupnih troškova u iznosu od 11.343,80 kn ha<sup>-1</sup> ostvarena je dobit od 9.657,00 kn ha<sup>-1</sup>.

Proizvodnost rada ljudi izračunata je na temelju ostvarenog prinosa izraženog u kg ha<sup>-1</sup> i utroška sati rada ljudi po hektaru kako slijedi:

$$P = \frac{Q(\text{Prinos u kg ha}^{-1})}{T(\text{sati ha}^{-1})} = \frac{1.500,00 \text{ kg ha}^{-1}}{65,50 \text{ sati ha}^{-1}} = 22,9 \text{ kg sat}^{-1}$$

$$P = \frac{T(\text{sati ha}^{-1})}{Q(\text{prinos u t ha}^{-1})} = \frac{65,50 \text{ sati ha}^{-1}}{1,50 \text{ t ha}^{-1}} = 43,7 \text{ sati t}^{-1}$$

Ekonomičnost proizvodnje izračunata je stavljanjem u odnos ostvarene vrijednosti proizvodnje u kn ha<sup>-1</sup> i ukupnih troškova prema obrascu:

$$E = \frac{\text{Vrijednost proizvodnje (kn ha}^{-1})}{\text{Ukupni troškovi (kn ha}^{-1})} = \frac{21.000,00 \text{ kn ha}^{-1}}{9.657,00 \text{ kn ha}^{-1}} = 2,17$$

Rentabilnost proizvodnje izražena je stopom rentabilnosti u postotku. Izračunata je iz odnosa dobiti i ukupnih prihoda. Ona predstavlja razinu ostvarene dobiti na 100 kn uloženi sredstava pri procesu proizvodnje.

$$R = \frac{\text{Dobit (kn ha}^{-1}) \times 100}{\text{Ukupni prihodi (kn ha}^{-1})} = \frac{9.657,00 \text{ kn ha}^{-1}}{21.000,00 \text{ kn ha}^{-1}} \times 100 = 45,90\%$$

Tablica 2. Kalkulacija proizvodnje sjemenskog suncokreta u 2005. godini

Red. broj	Elementi troškova	Jed. mj.	Količina ha <sup>-1</sup>	Cijena po jedinici	Iznos kn ha <sup>-1</sup>
1.	SJEME SUNCOKRETA	kg		0,0	0,0
2.	MINERALNO GNOJIVO - UREA 46% N	kg	200,0	1,4	288,0
	- NPK 8:26:26	kg	500,0	2,4	1220,0
	- KAN 27% N		200,0	1,2	230,0
3.	SREDSTVA ZA ZAŠTITU				
	Dual 960 Gold	lit.	1,5	125,0	187,5
	Konker	lit.	1,5	220,0	330,0
	Dursban	lit.	4,0	85,0	340,0
	Racer	lit.	2,0	317,0	634,0
	Doprema sredstava za zaštitu	lit.+kg	9,0	2,0	18,0
4.	RAD LJUDI				
	Stalno zaposleni	sati	15,5	24,6	381,3
	Povremeno zaposleni	sati	50,0	15,7	785,0
5.	RAD STROJEVA				
	Laki traktor	sati	0,38	352,9	180,0
	Srednji traktor	sati	5,2	264,6	1960,0
	Teški traktor	sati	3,81	358,2,1	1955,0
	Kombajn	sati	1,63	429,4	700,0
6.	OPĆI TROŠKOVI				
	Osiguranje	kn	-	-	450,0
	Zakup	kn	-	-	700,0
	Vodna naknada	kn	-	-	125,0
	Sušenje i dorada	t	1,5	120	180,0
	Amortizacija	kn	-	-	210,0
	Kamate	kn	-	-	250,0
	Troškovi prodaje	kn	-	-	220,0
	UKUPNI TROŠKOVI				11.343,80
PRIHODI					
Red. broj	Vrijednost proizvodnje	jedinica mjere	Količina	Cijena po jedinici	Iznos
1.	Urod	kg	1500,0	12,00	18.000,00
2.	Poticaj	ha	1,0	3.000,00	3.000,00
	VRIJEDNOST PROIZVODNJE UKUPNO	kn			21.000,00
	FINANCIJSKI REZULTAT	kn			9.657,00

### Zaključak

Za proizvodnju sjemenskog suncokreta na Poljoprivrednom institutu u Osijeku 2005. godine utrošeno je 11,38 sati rada strojeva i 65,5 sati rada ljudi.

Ukupni troškovi iznosili su 11.343,80 kn ha<sup>-1</sup>, a vrijednost ostvarene proizvodnje uz ostvareni državni poticaj iznosila je 21.000,00 kn ha<sup>-1</sup>. Proizvodnost rada iznosila je 22,9 kg zrna po satu ljudi, a utrošak sati rada ljudi po toni zrna iznosio je 43,7.

Ostvarena je dobit u iznosu od 9.657,00 kn ha<sup>-1</sup>, uz koeficijent ekonomičnosti proizvodnje od 2,17 i stopu rentabilnosti od 45,9%. Analiza dobivenih rezultata ukazuje na to da je proizvodnja sjemenskog suncokreta ekonomski opravdana i rentabilna uz osigurano tržište.

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# Populacijska varijabilnost cvati crvene djeteline

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## Sažetak

Cilj rada bio je utvrditi varijabilnost i razlike u dužini cvati, promjeru cvati te broju cvjetova po cvati prvog porasta 12 populacija crvene djeteline tijekom dvije uzastopne godine uzgoja sa svrhom procjene (I) vrijednosti testiranih svojstava kao deskriptora istraživanih populacija, te (II) utjecaja godine na testirana svojstva. Ukupni koeficijent fenotipske varijabilnosti dužine cvati bio je 7,55%, promjera cvati 10,90% i broja cvjetova po cvati 16,33%. Efekti populacije i godine na promjer cvati i broj cvjetova po cvati bili su značajni ( $p=0,01$ ). Rezultati ukazuju da svojstva promjera cvati i broja cvjetova po cvati mogu opisati različitosti istraživanih populacija.

Ključne riječi: crvena djetelina, cvat, varijabilnost, populacija

## Population variability of red clover inflorescence

### Abstract

The aim of this study was to estimate the variability and differences in inflorescence length, inflorescence diameter, and number of florets per inflorescence among 12 red clover populations during first growths of two consecutive years in order to evaluate (I) the value of tested traits as a descriptors of differences among investigated populations, and (II) the influence of year on tested traits. Coefficients of total population trait phenotypic variability were 7.55% for inflorescence length, 10.90% for inflorescence diameter and 16.33% for number of florets per inflorescence. Effects of population and year on inflorescence diameter and number of florets per inflorescence were significant ( $p=0.01$ ). Results suggested that inflorescence diameter and number of florets per inflorescence may describe differences among investigated populations.

Key words: red clover, inflorescence, variability, population

### Uvod

Cvat crvene djeteline (*Trifolium pratense* L.) složena je glavica koja značajno utječe na većinu gospodarski važnih svojstava ove kulture, od prinosa sjemena čiste kulture (Forster i sur., 1962.) ili prinosa sijena trajnih livada (Sakanoue, 2004.), do sekrecije nektara (Shuel, 1952.) ili koncentracije izoflavona (Sivesind i Seguin, 2005.). No, slijedom UPOV "Vodiča za provođenje testova na različitost, uniformnost i stabilnost" (TG/5/7, 2001.) i PVPO "Objektivne deskripcije kultivara crvene djeteline" (ST-470-42(04-03), 2000.) u konvencionalnim oplemenjivačkim programima uglavnom se ocjenjuje samo vrijeme i godina cvjetanja, te boja cvati čija je razina ekspresije, uslijed prirodne stranooplodnje i/ili sličnog podrijetla/geografskog lokaliteta, često slična i time nedovoljna za opisivanje razlika u cvati oplemenjivačkih populacija.

Stoga je cilj ovog rada bio utvrđivanje varijabilnosti i razlika u dužini cvati, promjeru cvati te broju cvjetova po cvati populacija crvene djeteline tijekom dvije uzastopne godine uzgoja sa svrhom procjene (I) vrijednosti testiranih svojstava kao deskriptora različitosti istraživanih populacija, te (II) utjecaja godine na testirana

svojstva.

### Materijali i metode

Istraživanje je provedeno na ukupno 12 populacija crvene djeteline različitog podrijetla (11 eksperimentalnih populacija kreiranih na istom lokalitetu u okviru oplemenjivačkog programa na crvenoj djetelini Poljoprivrednog instituta Osijek (TPEXP1 do TPEXP11), te mađarski kultivar Diana).

Populacije su posijane gustoredno (s normom sjetve 20 kg ha<sup>-1</sup>) u osnovne parcele veličine 6 m<sup>2</sup> na selekcijskim površinama Poljoprivrednog instituta Osijek po shemi randomiziranog bloka u četiri ponavljanja početkom ožujka 2009. godine. Analiza cvati provedena je u fazi 10% cvjetanja primarnih vlati prvih kosidbi dvije uzastopne godine istraživanja. Po pet slučajno izabranih glavica svake populacije i ponavljanja uzeto je ručno (8. srpanj 2009. i 25. svibanj 2010. godine), te je određena dužina cvati (cm), promjer cvati (cm) te broj cvjetića po cvati. Analiza podataka provedena je pomoću SAS Software-a 9.1.3 (2002-2003). Duncanov višestruki test ranga (DMRT) korišten je za utvrđivanje značajnosti razlika i rangiranje populacija (na p=0,05).

### Rezultati i rasprava

Raspon vrijednosti dužine cvati kretao se od 2,13 do 2,97 cm u prvoj godini istraživanja i od 2,30 do 3,17 cm u drugoj godini istraživanja. Raspon vrijednosti promjera cvati bio je u prosjeku veći od raspona vrijednosti dužine cvati i kretao se od 1,77 do 3,1 cm u prvoj godini i od 2,1 do 2,97 cm u drugoj godini istraživanja. Broj cvjetića po cvati kretao se od 91,33 do 156,30 u prvoj godini i od 70,33 do 125,70 u drugoj godini istraživanja, što je slično rezultatu Rao i Stephen (2009) koji navode raspon od 72 do 222 (u prosjeku 113,5) cvjetića po cvati. Vrijednosti dužine i promjera cvati bile su u prosjeku za 3,2% i 6,7% više u prvoj godini istraživanja, dok je prosječna vrijednost broja cvjetića po cvati bila viša za 16,32% u drugoj godini istraživanja što je vjerojatno posljedica različitih vremenskih prilika u godinama istraživanja, tj. za oko 2°C nižih temperatura i tri puta većih količina oborina tijekom intenzivnog rasta (travanj i svibanj) prve kosidbe druge godine istraživanja (Tablica 1.). Utjecaj klimatskih čimbenika na svojstva cvijeta roda *Trifolium* navode i Shuel (1952), Van Bogaert (1977), Norris (1985), Pecetti i sur. (2008). Ukupni koeficijent fenotipske varijabilnosti dužine cvati bio je 7,55%, promjera cvati 10,90% i broja cvjetova po cvati 16,33%.

Tablica 1. Srednje mjesečne temperature (°C) i količine oborina (mm) u Osijeku tijekom istraživanja (postaja Osijek-Čepin, DHMZ RH)

Mjesec	Temperatura (°C)		Oborine (mm)	
	2009.	2010.	2009.	2010.
Ožujak	6,7	6,7	26,9	22,0
Travanj	14,6	12,4	18,8	71,0
Svibanj	18,3	16,5	39,2	119,9
Lipanj	19,2	20,4	63,4	234,1

Efekt populacije, godine istraživanja i interakcije populacija x godina istraživanja na dužinu cvati, promjer cvati i broj cvjetića po cvati bio je različit (Tablica 2.).

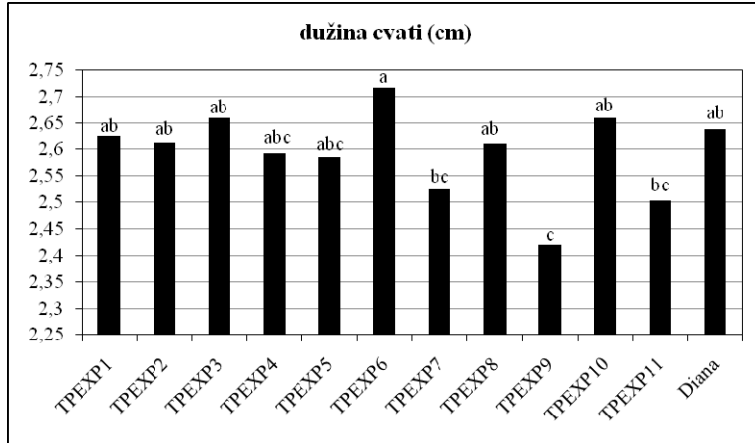
Tablica 2. Sažetak analize varijance (značajnost F-testa) za istraživana svojstva

Izvor varijacije	Stupanj slobode	Dužina cvati	Promjer cvati	Broj cvjetića po cvati
Populacija (P)	11	ns	**	**
Godina (G)	1	ns	**	**
PxG	11	ns	ns	ns

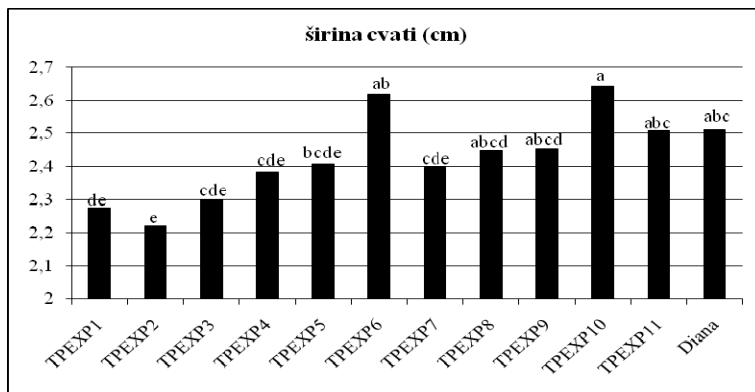
\*\*značajno na p=0,01; ns-nije značajno

Nepostojanje statistički značajnih razlika (na p=0,01) u dužini cvati za sve testirane efekte, kao i neznačajnost efekta interakcije populacija x godina za sva testirana svojstva vjerojatno su posljedica visoke nasljednosti istraživanih svojstava i podrijetla korištenog materijala (11 populacija iz istog izvora). Sličan rezultat navode Hash i sur. (2006.) za *Pennisetum glaucum* L.

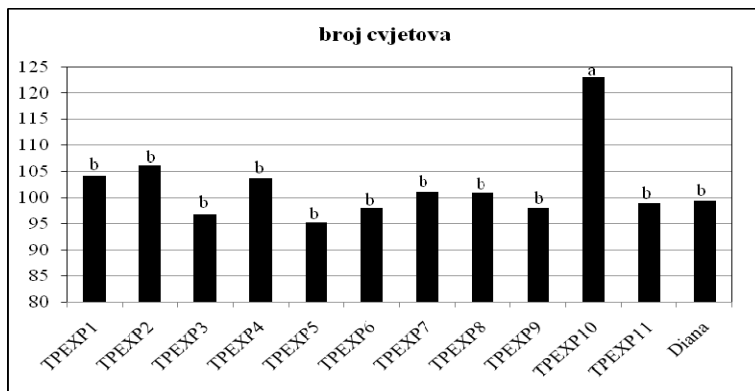
Prosječna vrijednost dužine cvati po populacijama za obje godine istraživanja kretala se od 2,42 (TPEXP9) do 2,71 (TPEXP 6) cm (Graf 1.). Prosječna vrijednost promjera cvati varirala je od 2,22 (TPEXP2) do 2,64 (TPEXP 10) cm (Graf 2.), a prosječan broj cvjetića po cvati od 95,17 (TPEXP5) do 123,08 (TPEXP10) (Graf 3.).



Graf. 1. Prosječna dužina cvati (cm) istraživanih populacija s pripadajućim DMRT rangom na  $p=0,05$



Graf. 2. Prosječan promjer cvati (cm) istraživanih populacija s pripadajućim DMRT rangom na  $p=0,05$



Graf. 3. Prosječan broj cvjetića po cvati istraživanih populacija s pripadajućim DMRT rangom na  $p=0,05$

Najviše vrijednosti promjera cvati i broja cvjetića po cvati TPEXP 10 populacije istraživanja ukazuju na vrijednost populacije kao mogućeg izvora gena za poboljšanje gospodarski važnih svojstava koja su u pozitivnoj korelaciji s cvati crvene djeteline (npr. prinos sjemena).



## Zaključci

Rezultati ovog istraživanja potvrđuju učinkovitost dva od tri testirana deskriptora u određivanju varijabilnosti i različitosti materijala bez obzira na izvor materijala i/ili vanjske čimbenike.

Utvrđena varijabilnost i značajne razlike u promjeru cvati i broju cvjetića po cvati populacija crvene djeteline ukazuju na mogućnost daljnjeg izbora materijala na istraživana svojstva cvati.

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# Značaj prikupljanja lokalnih populacija crvene djeteline (*Trifolium pratense* L.) u Hrvatskoj

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## Sažetak

Lokalne populacije crvene djeteline predstavljaju vrijedan genetski izvor u kreiranju kultivara prilagođenih domaćim agro-ekološkim uvjetima uzgoja. Cilj istraživanja bio je prikupiti sjeme te prikupiti podatke o florističkom sastavu nalazišta lokalnih populacija crvene djeteline. Od 2007. do 2010. godine prikupljeno je sjeme lokalnih populacija (33 populacije) na području sjeverne, središnje i gorske Hrvatske. Na proučavanim nalazištima zabilježeno je 212 biljnih svojiti iz 45 porodica. Na nalazištima je utvrđena prisutnost velikog broja vrsta što je indikator prirodne sukcesije koja prijeti opstanku lokalnih populacija crvene djeteline.

Ključne riječi: crvena djetelina, lokalna populacija, sukcesija, genetska erozija

## The importance of collecting local population of red clover (*Trifolium pratense* L.) in Croatia

### Abstract

Local populations of red clover are a valuable genetic resource for creation varieties adapted to local agro-ecological farming conditions. The aim of this research was to collect seeds of red clover from the local populations and data on floristic composition of their habitats. Seeds from 33 local populations were collected in North, Central and Highlands Croatia, during 2007 and 2010. As much as 212 species from 45 families were recorded in the area covered with the research. The presence of large number of species indicates the development of natural succession, which threatens the survival of local red clover populations.

Key words: red clover, local population, succession, genetic erosion

### Uvod

Crvena djetelina (*Trifolium pratense* L.) je važna krmna leguminoza. Popravlja strukturu i plodnost tla, te štiti tlo od erozije. Zbog povoljnog odnosa omjera ugljika i dušika omogućuje brže razlaganje organske tvari u tlu (Mišković, 1986).

Većina istraživanja na crvenoj djetelini provedena su na komercijalnim kultivarima (Leto, 1997; Frame i sur., 1998; Grljušić, 2003; Ulloa i sur., 2003; Popović i sur., 2007; Primorac i sur., 2007; Muntean, 2008), a malo na lokalnim populacijama (Kölliker i sur., 2003; Herrmann, 2006). Šoštarić-Pisačić (1967) i Čížek (1970) navode da su najbolje djeteline lokalnog porijekla, a Gikić (1967) nadopunjuje da su lokalne populacije tokom godina najbolje adaptirane na ekološke uvjete i daju veće prirode sijena te su otpornije na sušu i smrzavanje. Šoštarić-Pisačić (1967), Čížek (1970) i Kölliker i sur. (2003) navode da lokalno adaptirane populacije djetelina imaju veću oplemenjivačku vrijednost u odnosu na populacije iz drugih geografskih područja.

Zahvaljujući različitim klimatskim uvjetima koji prevladavaju na području R. Hrvatske i njenom

zemljopisnom položaju, hrvatska flora je bogata biljnim vrstama. Travnjaci su u potpunosti antropogene tvorevine nastale potiskivanjem šumske vegetacije, a održavaju se košnjom, ispašom ili paljenjem. Sve te antropogene aktivnosti u posljednje vrijeme su smanjenog intenziteta ili su potpuno nestale zbog napuštanja tradicionalne poljoprivredne proizvodnje. Te promjene posljedično su uzrokovale i promjene travnjačke vegetacije, odnosno njenu sukcesiju prema klimazonalnoj vegetaciji, koja je gotovo redovito šumska vegetacija. Javlja se obrnuti proces zarastanja travnjaka šikarom i šumom koji se naziva sukcesija. Snaga borbe biljnih vrsta za njihovo održavanje u određenim uvjetima sredine je vrlo različita (Knežević, 1977), a ovisi od svojstava rasta (životni oblik, način razmnožavanja, trajanje života) i ekoloških zahtjeva (pedološka i klimatološka obilježja staništa) (Ellenberg, 1952).

U Hrvatskoj je do nedavno prevladavao tradicionalni način gospodarenja površinama na kojima se nalazi crvena djetelina. Međutim zbog napuštanja tradicionalne poljoprivredne proizvodnje dolazi do prirodne sukcesije koja prijeti opstanku biljnih vrsta, a među njima i lokalnih populacija crvene djeteline.

Naše lokalne populacije crvene djeteline predstavljaju izuzetno vrijedan genetski izvor važan u kreiranju kultivara prilagođenih domaćim agro-ekološkim uvjetima. Ovakva istraživanja je neophodno potencirati naročito kada postoji opasnost od genetske erozije.

Cilj istraživanja bio je pronaći nalazišta lokalnih populacija crvene i prikupiti njihovo sjeme te prikupiti podatke o florističkom sastavu nalazišta u svrhu procjene izraženosti sukcesije i genetske erozije lokalnih populacija crvene djeteline.

### Materijali i metode

Preliminarnim istraživanjem tijekom 2007. godine na području Hrvatskog Zagorja, Žumberka i Samoborskog gorja pronađeno je 29 lokacija (nalazišta) na kojima su bile prisutne lokalne populacije crvene djeteline. Zbog kontinuiranog napuštanja tradicionalnog načina održavanja površina i zaraštavanja istih u 2008. godini za daljnja istraživanja preostalo je svega 18 lokacija na kojima su još bile prisutne lokalne populacije crvene djeteline. Tijekom 2008., 2009. i 2010. godine nastavljen je rad na pronalaženju nalazišta i prikupljanje sjemena lokalnih populacija crvene djeteline na području sjeverne i središnje Hrvatske (grad Zagreb, Zagrebačka županija, Međimurska županija, Varaždinska županija, Krapinsko-zagorska županija, Karlovačka županija) te gorske Hrvatske (Ličko-senjska županija i Primorsko-goranska županija) (Tablica 1.).

Na istraživanim lokacijama bilježen je i floristički sastav. Za determinaciju biljnih vrsta korišteni su uobičajeni ključevi i ikonografije (Hegi, 1906-1931; Javorka and Csapody, 1934; Bonnier, 1962; Tutin et al., 1964-1980, 1993; Domac, 1994; Knežević, 2006). U tablici 1. navode se podaci o broju vrsta zabilježenih na istraživanom staništu, nadmorskoj visini, ekspoziciji, te inklinaciji.

### Rezultati i rasprava

U okviru prikupljačkih ekspedicija u razdoblju od 2007.-2010. godine prikupljeno je sjeme 33 lokalnih populacija crvene djeteline. Na području Grada Zagreba i Zagrebačke županije prikupljeno je 17 populacija, na području Međimurske županije jedna populacija, Varaždinske županije dvije populacije, Krapinsko-zagorske županije 14 populacija, Karlovačke županije tri populacije, Ličko-senjske županije četiri populacije i Primorsko-goranske županija sedam populacija crvene djeteline (Tablica 1.).

Analizom florističkog sastava istraživanih lokacija (48 lokacija) zabilježeno je 212 biljnih vrsta unutar 45 porodica. Uočljiv je trend napuštanja i zapuštanja livada, te posljedično odvijanja procesa sekundarne sukcesije. Veliki broj vrsta koji je zabilježen na livadama istraživanih područja pokazuje da se tim staništima ne ukazuje potrebna pažnja u smislu gospodarenja (košnja, gnojidba i dr.) što je učestala pojava na području sjeverozapadne Hrvatske (Dujmović Purgar i Hulina, 2006). Najveći broj vrsta je zabilježen na lokacijama koje naočigled zaraštavaju iz godine u godinu, a sukcesija je pojačana s obzirom na veliku blizinu šume i najčešće okruženost cijele površine šumskim raslinjem (Drašći Vrh - 53 vrste, Zagorska Sela - 40 vrsta, Zlatar Bistrica - 39 vrsta, Čveki, Bedekovčina, Donja Pušća - 37 vrsta). Randić (2007) i Krstonošić (2009) u svojim radovima potvrđuju utjecaj okolne vegetacije na usmjeravanje sekundarne sukcesije. Nakon napuštanja gospodarenja livadama nastaju izraziti procesi sukcesije koji dovode do promjene florističkog sastava (Randić, 2007). Randić (2007) na području Primorsko-goranske županije ističe da je na 75% livada, od ukupno proučavanih, prisutni izraziti znakovi zaraštavanja drvenastom vegetacijom. Daljnjim razvojem

sukcesije smanjuje se broj vrsta što potvrđuje i Randić (2007). Naime, proces sukcesije livada popraćen je smanjenjem biološke i krajobrazne raznolikosti (Randić, 2007). Vremenski tijek sukcesije varira od slučaja do slučaja i teško je predvidljiv (Randić, 2007; Alegro i sur., 2010) što se može potvrditi i našim istraživanjem.

**Tablica 1. Opis nalazišta crvene djeteline na području R. Hrvatske**

Županija	Nalazište	Broj vrsta	Nadmorska visina (m)	Ekspozicija	Inklinacija (%)
Grad Zagreb	Uz nasip rijeke Save, kod "Kockice"	31	107	S	0
	Medvednica	24	561	S	8
Zagrebačka	Dugo Selo	16	106	SW	1
	Kupljenovo	34	131	E	5
	Donja Pušća	37	147	W	5
	Planina Donja	19	295	S	10
	Kašina	24	215	E	0
	Hutin	27	185	E	10
	Sopotski Slap	27	549	SE	5
	Drašći Vrh	53	451	NE	5
	Sošice	29	560	SE	5
	Drmići	33	538	W	40
	Stojdraga	26	490	W	10
	Gornje Selo	19	562	S	0
	Reštovo	29	515	W	5
	Blata	28	688	W	0
Blaževo brdo	22	897	W	0	
Međimurska	Celje (kod Preloga)	27	160	SW	0
Varaždinska	Gornje Jesenje	19	352	NW	5
	Trakošćan	34	260	W	10
Krapinsko-zagorska	Presečno	31	184	W	10
	Kumrovec	32	234	S-SE	5
	Bedekovčina	33	219	E	10
Krapinsko-zagorska	Krapinske toplice	17	194	W	50
	Čveki	37	162	W	5
	Bedekovčina 2	37	172	N	5
	Lug Zabočki	25	151	SE	5
	Klanječko jezero	26	146	NE	5
	Zagorska Sela	40	214	NW	8
	Desinić	16	226	NE	45
	Zlatar Bistrica	39	185	W	5
	Lobor	20	276	SW	30
	Tugonica	31	169	NW	5
	Zlatar	23	167	S	0
Karlovačka	Svetice	33	281	N	0
	Svetice 2	33	318	SW	5
	Jaškovo	22	165	N	0
Ličko-senjska	Vodoteč	29	575	NW	5
	Križpolje	24	559	N	0
	Prokike	30	515	S	10
	Sertić Poljana	26	700	SE	10
Primorsko-goranska	Gerovski kraj	29	652	NE	0
	Mali lug	20	551	E	0
	Mandli	21	338	SW	0
	Čabar	20	566	NE	25
	Laz Svinjska kuća	37	918	SW	0
	Laz Lividraga	25	943	S	5
	Laz Šegina	14	976	NW	5

## Zaključci

U razdoblju od 2007. do 2010. godine na 48 lokacija prikupljene su 33 lokalne populacije crvene djeteline. Na livadama istraživanog područja zabilježeno je ukupno 212 biljnih svojti iz 45 porodica. Utvrđena je prisutnost velikog broja biljnih vrsta što je indikator prirodne sukcesije koja prijeti opstanku vrsta među kojima su i lokalne populacije crvene djeteline.

## Zahvala

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# Seed yield and yield components of red clover (*Trifolium pratense* L.) genotypes

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## Abstract

The objective of this study was to evaluate seed yield and yield components (stem number per plant, inflorescence number per stem, inflorescence number per plant, flower number per inflorescence, seed number per inflorescence and seed fertility) in individual plants of ten genotypes of red clover grown at low plant density (70 x 40 cm) in order to single out genotypes that have a higher seed yield potential. Significant differences among genotypes were determined for flower number per inflorescence, seed number per inflorescence, flower fertility and seed yield. The results obtained suggest that certain genotypes may be used for further selection work.

Key words: red clover, genotypes, seed yield, seed yield components

## Introduction

Seed yield of red clover (*Trifolium pratense* L.) is mostly dependent upon the genetic background of cultivar, environmental conditions, first cut date, presence of insect pollinators, and genotype/environment interaction (Steiner et al., 1995). The high variability and genetic plasticity of the species are the result of the extremely xenogamous character of fertilisation and entomophilous pollination (Taylor and Smith, 1979). The high variability and adaptability to diverse environmental conditions have contributed to the development, through natural selection, of a large number of local ecotypes that show superiority under particular growing conditions (Helgadottir, 1996).

Given the high genetic potential for biomass yield in the species herewith studied, selection work should involve monitoring of major traits of seed yield and yield components. Improvement of the seed yield production potential is rarely seen as an important criterion during the early stages of red clover selection. Breeding for increased seed yield potential has also been further hampered by the absence of clearly defined interrelation between seed yield and yield components. However, the significant genotype-specific correlation between harvest index and seed yield suggests the possibility of an increase in seed yield without any adverse effects on forage yield (Elgersma and Van Wijk, 1997).

The objective of this study was to analyse seed yield and yield components in red clover genotypes in order to select genotypes that have higher seed yield potential. The genotypes would serve as a good basis for further hybridisation and development of cultivars that would exhibit higher seed yield, apart from higher forage yield potential.

## Materials and methods

This experiment was set up on 4 June 2009 as an on-field trial at the Veterinary Extension Service in Čačak (43°54'39.06" N, 20°19'10.21" E, 246 m a.s.l.) on alluvial soil acid in reaction ( $\text{pH}_{\text{H}_2\text{O}}$  4.8), poor in nutrients and low in organic matter. Primary tillage was coupled with incorporation of 300 kg ha<sup>-1</sup> N<sub>15</sub>P<sub>15</sub>K<sub>15</sub> into the soil. The factorial trial was established as a completely randomised block design in five replications with 20 plants per 4x1.4 m plot. Plants were grown under low density at a spacing of 70x40 cm. A total of ten red clover genotypes, including nine diploid genotypes (G1, G2, G4, G8, G9 and G10 selected from cvs. Viola, Una, Kolubara, Avala, K-17 and K-39, respectively, and G3, G6 and G7 selected from local populations found

in the vicinity of Čačak) and the tetraploid genotype G5 selected from cv. K-27 Tetra, were used in the study. The second cut of the second year of cultivation was analysed for seed yield and yield components. Mechanical weed control was employed on a number of occasions. No irrigation was employed.

Mean air temperatures during the 2009 growing season (April through September) were 1.33°C above the ten-year average, whereas total rainfall was 351 m<sup>-2</sup> below average.

The seed yield components undergoing an on-field analysis included the following: stem number per plant, inflorescence number per stem, and inflorescence number per plant. The components were counted on five plants randomly selected from the plot. Laboratory analyses involved determination of flower number per inflorescence and seed number per inflorescence (on a sample of ten inflorescences randomly selected from individual plants), fertility (number of fertile flowers during seed maturation stage based on the relationship between seed number and flower number per inflorescence) and thousand seed weight (using 5x100 seed weight). The actual seed yield was determined from yield components (inflorescence number per plant, seed number per inflorescence, thousand seed weight) and calculated for seed yield given as g/plant.

The results on seed yield and yield components were subjected to a single-factor analysis of variance (SPSS, 1995). The significance of differences between mean values was tested by the LSD test. The correlation between seed yield and yield components was evaluated by calculating the simple correlation coefficient based on ten measurements of flower number per inflorescence, seed number per inflorescence, and fertility i.e. five measurements of stem number per plant, inflorescence number per both stem and plant, and seed yield per plant.

## Results and discussion

No significant differences in stem number per plant and inflorescence number per stem were observed in the genotypes tested (Tab. 1). The average stem number per plant was 23, ranging from 19 (G1) to 29.2 (G2). The average number of inflorescences per stem was 3.95, being within a range of 2.9 (G3) to 4.7 (G2). As reported by Vasiljević et al. (2010), the average number of inflorescences per stem in cv. Una was 6.7 under row spacing of 40 cm and seed rate of 2.1 kg ha<sup>-1</sup>. The lower inflorescence number per stem in the present study was most likely associated with low soil pH i.e. lower nutrient availability.

The average number of inflorescences per plant was 85.8. A significantly higher number was found in G2 than in G3, G4, G9, G10. Montardo et al. (2003) suggests that inflorescence number per plant is among major yield components that should be given due attention in red clover selection for higher seed yields.

Flower number per inflorescence was substantially higher in G3 (100.0) than in other genotypes excepting G1(91.3) and G10 (88.0). Oliva et al. (1994) report an average flower number per inflorescence in cv. Kenland to range from 101 to 142. Julen (1956) and Miladinović (1978) found large differences in flower number per inflorescence among red clover genotypes.

Genotypes G1 and G10 gave a significantly higher seed number per inflorescence (57.8 and 56.7) as compared to the other genotypes, excepting G3 (52.5). Seed number per inflorescence was substantially lower in G5, which was an expected result, given its being a tetraploid. Đukić et al. (2010) produced an average of 105.9 seeds per inflorescence in cv. Una at a row spacing of 60 cm. Wilczek and Ćwintal (2008) report the range of 61 to 74 for seed number per inflorescence in cv. Parada. Additionally, the same authors underline that seed number per inflorescence and flower fertility are the most important seed yield components of red clover. Jevtić et al. (2007) and Wilczek and Ćwintal (2008) also suggest the strong effect of insect pollinators on seed number per inflorescence. The lower seed number per inflorescence and decreased fertility in the present study were most likely due to the high rainfall amounts during the pollination season.

The average flower fertility for the genotypes was 50.8%. Fertility was significantly higher in G8 (68.8%), G10 (64.4%), G1 (63.3%) and G2 (63.4%) as compared to G4, G6 and G5 (Tab. 1). Oliva et al. (1994) report flower fertility in red clover cultivars to range from 76 to 99%. Wilczek and Ćwintal (2008) observed fertility variations of 51.2-69.8% across years, suggesting that high rainfall amounts during flowering may substantially reduce fertility and harvest index as compared to the potential seed yield.

The average seed yield per plant was 5.1 g. Seed yield was substantially higher in G10 (8.0 g), G2 (7.9 g) and G1 (7.3 g) than in G4 and G5 (Tab. 1). The lowest seed yield was obtained with G5, being in agreement with the results of Vojin (2007) who suggested significantly higher seed yield in diploid genotypes than in



tetraploid cultivars. Herrmann et al. (2006) report that the average seed yield per plant in two red clover genotypes was 5.72 g, with the range being 0.71-11.31 g.

**Table 1. Mean seed yield and yield components of red clover genotypes: stem number per plant-SNP, inflorescence number per stem-INS, inflorescence number per plant-INP, flower number per inflorescence-FPI, seed number per inflorescence-SNI, flower fertility-F (%), and seed yield-SY (g per plant).**

Genotype	SNP	INS	INP	FPI	SNI	F	SY
G <sub>1</sub>	19.0	4.2	82.4ab	91.3ab	57.8a	63.3ab	7.3a
G <sub>2</sub>	29.2	4.7	130.2a	67.0d	42.5bcd	63.4ab	7.9a
G <sub>3</sub>	27.8	2.9	76.8b	100.0a	52.5ab	52.5bc	6.9ab
G <sub>4</sub>	24.7	4.0	80.2b	72.9bcd	33.5de	45.9c	2.9bc
G <sub>5</sub>	22.6	4.5	97.6ab	60.6d	2.1f	3.5d	0.4c
G <sub>6</sub>	23.6	3.6	86.2 ab	68.6cd	30.8e	44.9c	4.0abc
G <sub>7</sub>	21.0	4.1	83.8 ab	69.4cd	35.7cde	51.4bc	4.0abc
G <sub>8</sub>	21.2	4.2	85.0 ab	65.4d	45.0bc	68.8a	5.6ab
G <sub>9</sub>	19.6	3.4	61.4b	76.7bcd	39.1cde	50.1bc	4.5ab
G <sub>10</sub>	21.2	3.9	74.2b	88.0abc	56.7a	64.4ab	8.0a
$\bar{x}$	23.0	3.9	85.8	76.0	39.6	50.8	5.1
ANOVA	ns	ns	ns	**	**	**	**

The values denoted with different small letters within columns are significantly different at ( $P < 0.05$ ) in accordance with the LSD test; \*\*-F test significant at  $p < 0.01$ ; ns-F test non-significant.

**Table 2. Coefficients of correlation among stem number per plant (SNP), inflorescence number per stem (INS), inflorescence number per plant (INP) and seed yield per plant (PS).**

	INS	INP	PS
SNP	-0.27	0.32*	0.23
INS	-	0.46*	0.16
INP	-	-	0.57*

\* Significant at  $p < 0.05$

**Table 3. Coefficients of correlation between seed number per inflorescence (SNI), flower number per inflorescence (FPI) and flower fertility (F) (%).**

	SNI	F
FPI	0.82*	-0.30*
SNI	-	0.22*

\* Significant at  $p < 0.05$

Inflorescence number per plant was positively correlated with stem number per plant and inflorescence number per stem (Tab. 2). Additionally, a significant positive correlation was observed between inflorescence number per plant and seed yield per plant. The results obtained are in agreement with those reported by Montardo et al. (2003) and Herrmann et al. (2006). Moreover, Herrmann et al. (2006) emphasise that inflorescence number per plant is a primary component determining seed yield.

Flower number per inflorescence was positively correlated with seed number per inflorescence and negatively correlated with flower fertility (Tab. 3). A positive correlation was also observed between seed number per inflorescence and flower fertility. Herrmann et al. (2006) reported a positive correlation between seed yield per plant and seed number per plant, seed yield per plant and flower fertility, and seed number per inflorescence and flower fertility.

Vasiljević et al. (2000) observed that coefficients of genetic correlation showed that seed yield per plant was mostly dependent upon seed yield per inflorescence, flower number per inflorescence and number of productive stems per plant. The authors also suggest significant positive genetic correlations between inflorescence number and internode number per stem i.e. green material yield, as confirmed by Steiner and Alderman (2003). Identical findings were reported by Ianucci and Martinello (1998) in their study on three Mediterranean clover populations. The obtained results suggest justifiability of selection for both forage and seed yield.

## Conclusion

The test genotypes showed substantial differences in inflorescence number per plant, flower number per inflorescence, seed number per plant, seed fertility and seed yield per plant.

G<sub>1</sub>, G<sub>2</sub> and G<sub>10</sub> stood out in terms of seed yield and yield components.

The calculated values of correlation coefficients suggest that the highest effect on yield per plant was produced by number of inflorescences per plant and, indirectly, by flower number per inflorescence. Further selection should be focused on increasing values of the said traits.

Irrespective of stem number per plant, inflorescence number per stem, inflorescence number per plant and flower number per inflorescence, the tetraploid genotype G5 had very low flower fertility, being reflected in seed number per inflorescence and total seed yield per plant.

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# Procjena heterozisa za prinos zelene mase lucerne

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## Sažetak

Cilj ovog istraživanja bio je procijeniti heterozis za prinos zelene mase lucerne u  $F_1$  populacijama. U 2007. godini provedena su dialelna križanja između sorti/populacija u svim kombinacijama. Tijekom dvogodišnjeg razdoblja devet roditelja i njihovih 36  $F_1$  križanaca ispitivano je kroz osam otkosa. Kombinacije križanja u kojima su kao roditelji korištene hrvatska i argentinska populacija te američka i australijska sorta imale su najveći prinos zelene mase te značajne pozitivne vrijednosti heterozisa. Navedene roditeljske germplazme predstavljaju potencijalne heterotične grupe te bi njihovo korištenje tijekom selekcijskog procesa u okviru našeg oplemenjivačkog programa moglo voditi do daljnjeg povećanja prinosa lucerne.

Ključne riječi: lucerna, heterozis, prinos, dialelna križanja, oplemenjivanje

## Estimation of heterosis for forage yield in alfalfa

### Abstract

The objective of this research was to estimate forage yield heterosis in  $F_1$  populations. In 2007 all cultivars/populations were intercrossed in a diallel mating design. During two consecutive years the nine parents and their 36  $F_1$  progenies were investigated across eight cuts. Crossing combinations where Croatian and Argentinean population as well as American and Australian cultivar were used as parents, had the highest forage yield and significant positive heterosis. This parental germplasm represent potential heterotic groups which utilization during selection process in our breeding program could lead to further increasing of alfalfa forage yield.

Key words: alfalfa, heterosis, yield, diallel crosses, breeding

### Uvod

Genetski napredak u povećanju prinosa lucerne znatno je sporiji u odnosu na druge poljoprivredne kulture. Procjenjuje se da je prinos lucerne od sredine prošlog stoljeća rastao samo 0,15-0,30% po godini, dok se prinos kukuruza u istom razdoblju povećao prosječno za 2% po godini (Skinner i sur., 2000; Sakiroglu i Brummer, 2007). Jedan od najznačajnijih razloga povećanja prinosa je korištenje efekta heterozisa tj. pojave kada je potomstvo superiornije u pojedinom svojstvu/svojstvima u odnosu na roditelje. Ograničavajući čimbenici proizvodnje komercijalnih hibrida lucerne i njihove šire uporabe su brojne specifičnosti vrste kao što su izražena inbreeding depresija, poliploidnost, alogamnost i složena građa cvijeta (Scotti i Brummer, 2010). Jedna od mogućnosti efikasnijeg korištenja heterozisa u oplemenjivanju lucerne je razvoj poluhibrida

koji nastaju križanjem genetski divergentnih populacija (heterotičnih skupina) nakon nekoliko ciklusa fenotipske rekurentne selekcije, a potomstva formirana na ovaj način rezultat su interpopulacijskih (50%) i intrapopulacijskih (50%) križanja (Brummer, 1999). Genetska divergentnost između roditeljskih populacija osnovni je preduvjet za ekspresiju heterozisa, međutim populacije moraju biti i dobri kombinatori kako bi se postigao visoki hibridni vigor. Temeljna saznanja koja oplemenjivačima bilja omogućuju uspješno korištenje heterozisa su poznavanje odnosa između elitnih oplemenjivačkih populacija i identifikacija heterotičnih grupa (Segovia-Lerma i sur., 2004).

Cilj ovog istraživanja bio je (i) procijeniti heterozis za prinos zelene mase lucerne u  $F_1$  populacijama nastalih križanjem genetski divergentne roditeljske germplazme, (ii) usporediti vrijednosti prinosa novo nastalih populacija sa roditeljima, (iii) procijeniti vrijednost korištenih sorti/populacija kao potencijalnih heterotičnih grupa za povećanje prinosa lucerne u okviru našeg oplemenjivačkog programa.

### Materijali i metode

U provedenom istraživanju kao roditelji korištene su sorte/populacije (9) lucerne različitog geografskog porijekla: sorta OS-66 (OS) i dvije oplemenjivače populacije (PCP i RS-1) kreirane u Hrvatskoj na Poljoprivrednom institutu Osijek u okviru oplemenjivačkog programa lucerne na Odjelu za oplemenjivanje i genetiku krmnog bilja, australijska sorta Aurora (AUR), argentinska populacija oznake AGP, američka sorta Magnum V (ASM), poljska sorta Radius (POR), srpska sorta NS Mediana ZMS (SSM) i francuska populacija oznake FRP.

Izbor roditeljske germplazme u većini slučajeva obavljen je na osnovi ostvarenih visokih vrijednosti značajnih agronomskih svojstava tijekom trogodišnjeg ispitivanja (2004.-2006.) u rasadniku lucerne (72 sorte/populacije, tri ponavljanja/108 biljaka) zasnovanom na pokusnom polju Poljoprivrednog instituta Osijek. U 2007. godini provedena su dialelna križanja između izabranih roditeljskih germplazmi u svim kombinacijama (36 kombinacija križanja). Slučajno izabranih osam biljaka svake od devet sorti/populacija ručno je križano (oko 80 cvjetova/biljka=oko 600 cvjetova/kombinacija) kako bi se proizvelo sjeme  $F_1$  generacije.

Sjetva roditeljske germplazme i  $F_1$  populacija (45 sorti/populacija) obavljena je 17. ožujka 2008. godine na pokusnom polju Poljoprivrednog instituta Osijek po metodi slučajnog blokno rasporeda u tri ponavljanja. Sjeme svih roditelja i  $F_1$  populacija posijano je ručno u dva reda s razmakom biljaka unutar reda od 0,50 m te između redova od 0,40 m. Svaki materijal bio je zastupljen s 24 biljke/ponavljanje. Tijekom 2008. i 2009. godine provedeno je osam košnji (tri u godini sjetve i pet u drugoj vegetacijskoj godini). Prinos zelene mase utvrđivan je u svakom otkosu obje godine istraživanja na svim individualnim biljkama svakog pokusnog materijala. Košnja biljaka obavljena je ručno srpom na visinu od 5-7 cm iznad razine tla, a pokošena masa izvagana je odmah u polju na elektronskoj vagi (Ohaus Scout II). Zbrajanjem prinosa zelene mase svih košnji utvrđen je ukupni prinos zelene mase biljke (g), a prikazan je kao prosječni godišnji prinos dvogodišnjeg istraživanja (g).

Dobiveni podaci obrađeni su analizom varijance (ANOVA) uz LSD-test pomoću SAS STAT 9.1 računalnog programa koristeći GLM proceduru (SAS Institute Inc, 2002-2003). U dobivenim kombinacijama križanja za prinos zelene mase lucerne procijenjen je MP (*midparent*) i HP (*high-parent*) heterozis (H). MPH je opisan kao vrijednost svojstva  $F_1$  populacije ( $F_1$ ) u odnosu na prosječnu vrijednost svojstva oba roditelja ( $P_1$  i  $P_2$ ), a izračunat je prema izrazu:  $MPH=100 \times [F_1 - \{(P_1+P_2)/2\} / \{(P_1+P_2)/2\}]$ . HPH je opisan kao vrijednost svojstva  $F_1$  populacije ( $F_1$ ) u odnosu na vrijednost svojstva boljeg roditelja u križanju (HP), a izračunat je prema izrazu:  $HPH=100 \times (F_1 - HP) / HP$ . Značajnost heterozis učinka procijenjena je primjenom Studentovog t-testa (Al Lawati i sur., 2010).

### Rezultati i rasprava

Analizom varijance utvrđene su statistički opravdane razlike između sorti/populacija (uključeni roditelji i  $F_1$  populacije) za prinos zelene mase. Prosječne vrijednosti prinosa proučavanih materijala prikazane su u tablici 1. Roditeljskom sortom OS-66 postignut je najveći prinos (OS, 1455 g biljka<sup>-1</sup>), što nije bilo opravdano veće od prinosa koji je dobiven sortom Magnum V (ASM, 1451 g biljka<sup>-1</sup>). U odnosu na prosjek roditeljske germplazme (1236 g biljka<sup>-1</sup>) navedene sorte imale su za 17,71%, odnosno, 17,39% veći prinos zelene mase po biljci. Roditeljska populacija FRP imala je značajno najmanji prinos (927 g biljka<sup>-1</sup>). Kod  $F_1$  populacija najveći

### Procjena heterozisa za prinos zelene mase lucerne

prinos zelene mase po biljci utvrđen je u kombinacijama križanja PCP x AGP (1694 g biljka<sup>-1</sup>), AUR x ASM (1595 g biljka<sup>-1</sup>), OS x ASM (1527 g biljka<sup>-1</sup>), PCP x AUR (1466 g biljka<sup>-1</sup>), OS x AUR (1440 g biljka<sup>-1</sup>) i AGP x ASM (1415 g biljka<sup>-1</sup>). Ovih šest križanaca, od ukupno promatranih 36 F<sub>1</sub> populacija, ostvarilo je značajno veći prinos od roditeljskog prosjeka a povećanje prinosa se kretalo od 14,48% do 37,05%. Američka sorta Magnum V (ASM) i australijska sorta Aurora (AUR) pojavljuju se u najvećem broju kombinacija križanja (ASM u tri kombinacije očinski roditelj, AUR u tri kombinacije očinski i majčinski roditelj) što ukazuje da su navedene germplazme poželjan donor gena za povećanje prinosa zelene mase lucerne. Kombinacije križanja u kojima su kao roditelji korišteni visoko prinostni materijali istog geografskog porijekla (hrvatska sorta OS-66 i oplemenjivačka populacija PCP) imale su niže prinose u odnosu na prinose F<sub>1</sub> populacija nastalih križanjem ovih roditelja s visoko prinostnim divergentnim materijalima. Korištenje genetski divergentne germplazme u križanjima osnovni je preduvjet za mogućnost povećanja prinosa lucerne i identifikaciju potencijalnih heterotičnih grupa, što su pokazala i ova istraživanja a dobiveni rezultati sukladni su navodima brojnih autora (Segovia-Lerma i sur., 2004; Maureira-Butler i sur., 2007, Madril i sur., 2008; Irwin i sur., 2010).

**Tablica 1. Prosječni prinos zelene mase (g biljka<sup>-1</sup>) roditelja (podvučene vrijednosti) i njihovih F<sub>1</sub> populacija (vrijednosti iznad dijagonale) tijekom dvogodišnjeg ispitivanja (2008., 2009.)**

	OS	PCP	RS-1	AUR	AGP	ASM	POR	SSM	FRP
OS	<u>1455*</u>	1147	1206	1440*	1313	1527**	1046	1232	1055
PCP		<u>1273</u>	1211	1466**	1694**	1335	1174	1235	1064
RS-1			<u>1144</u>	1262	1374	1002	1004	1190	1059
AUR				<u>1348</u>	1379	1595**	1168	1306	1215
AGP					<u>1240</u>	1415*	1255	1071	1207
ASM						<u>1451*</u>	1285	1292	1223
POR							<u>1008</u>	1183	958
SSM								<u>1284</u>	1180
FRP									<u>927</u>
Prosjek roditelja									1236
LSD 0.05									169
LSD 0.01									224

\*, \*\* Prinosi značajno veći od prosjeka roditelja za  $\alpha=0,05$  i  $0,01$

**Tablica 2. Procjena MP heterozisa (vrijednosti iznad dijagonale,%) i HP heterozisa (vrijednosti ispod dijagonale,%) za prinos zelene mase kod 36 F<sub>1</sub> populacija**

	OS	PCP	RS-1	AUR	AGP	ASM	POR	SSM	FRP
OS		-15,8**	-7,2	2,7	-2,5	5,1	-15,0*	-10,0	-11,4
PCP	-21,1**		0,2	11,8*	34,8**	-1,9	2,9	-3,4	-3,3
RS-1	-17,1*	-4,8		1,3	15,3**	-22,7**	-6,7	-1,9	2,3
AUR	-1,0	8,7*	-6,4		6,6	14,0*	-0,8	-0,8	6,8
AGP	5,9	33,0**	10,8*	2,3		5,2	11,6*	-15,1*	11,3
ASM	4,9	-7,9	-30,9**	9,9*	-2,4		4,5	-5,5	2,8
POR	-28,1**	-7,7	-12,2	-13,3	1,2	-11,5		3,2	-0,9
SSM	-15,3*	-3,7	-7,2	-3,1	-16,5*	-10,9	-7,8		6,8
FRP	-27,5**	-16,4*	-7,4	-9,8	-2,7	-15,7*	-4,9	-8,0	

\*, \*\* Heterozis značajno različit od nule za  $\alpha=0,05$  i  $0,01$

Dobivene procjene MPH i HPH za prinos zelene mase lucerne u ispitivanim kombinacijama križanja prikazane su u tablici 2. MPH se kretao od -22,7% (kombinacija križanja RS-1 x ASM) do 34,8% (kombinacija križanja PCP x AGP), a HPH od -30,9% (RS-1 x ASM) do 33,0% (PCP x AGP). Značajne pozitivne vrijednosti MPH i HPH za prinos zelene mase utvrđene su kod četiri kombinacije križanja (PCP x AGP, PCP x AUR, RS-1 x AGP i AUR x ASM) tj. prinosi ovih kombinacija bili su superiorniji u odnosu na prinos boljeg roditelja u križanju, što ukazuje na dominantno i superdominantno djelovanje gena. Jedna kombinacija križanja (AGP x POR) bila je značajno bolja od roditeljskog prosjeka. Negativni značajni MPH i HPH utvrđeni su kod osam kombinacija križanja OS x PCP, RS-1 x ASM, OS x POR, AGP x SSM, OS x SSM, OS x FRP, PCP x FRP i ASM x FRP. Negativni heterozis dobiven u ovim kombinacijama vjerojatno je posljedica izrazite nekomplementarnosti između roditeljskih germplazmi i/ili jačeg učinka negativnih gena prisutnih kod obje roditeljske komponente. Dobivene vrijednosti MPH i HPH u ovom radu u skladu su rezultatima koje su dobili Segovia-Lerma i sur. (2004) provodeći slično istraživanje (HPH od -33% do 23%,

MPH od -21% do 55%), te Bhandari i sur. (2007) proučavajući kombinacijsku sposobnost i heterozis između visoko prinosa primki lucerne (HPH od -17,9% do 16,3%, MPH od -17% do 16,7%). Niže procjene MPH i HPH od vrijednosti dobivenih u provedenom istraživanju navode Milić i sur. (2010) i Madril i sur. (2008), što je vjerojatno uzrokovano različitim genetskim potencijalom za prinos između proučavanih germplazmi lucerne.

### Zaključci

Na osnovi provedenoga istraživanja i dobivenih rezultata možemo zaključiti da su kombinacije križanja u kojima su kao roditelji korištene hrvatska i argentinska populacija (PCP i AGP) te američka i australijska sorta (Magnum V i Aurora) imale najveći prinos zelene mase te značajne pozitivne vrijednosti heterozisa. Navedene roditeljske komponente/germplazme predstavljaju potencijalne heterotične grupe te bi njihovo korištenje tijekom selekcijskog procesa u okviru našeg oplemenjivačkog programa moglo voditi do daljnjeg povećanja prinosa lucerne.

### Zahvala

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# Correlation between the yield and the yield components of *Lotus corniculatus* L. genotypes

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## Abstract

In our environmental conditions, there are a large number of *Lotus corniculatus* L. populations and they differed in productivity and morphological characteristics. The objective of this study was to determine correlative relations among certain quantitative traits. It was investigated 20 genotypes of local originated *Lotus corniculatus* L.. They were obtained in the previous cycle of selection from natural populations and different locations throughout Bosnia and Herzegovina. The results showed a high correlation between the yield of green mass per plant with plant height and number of stems per plant, while the seed yield was very significantly high correlated with the number of pods per plant.

Key words: *Lotus corniculatus* L., genotype, yield, correlation.

## Introduction

*Lotus corniculatus* L. (Birdsfoot Trefoil) is an important perennial legume for the production of forage. From agricultural point, *Lotus corniculatus* L. is the most important species in the genus *Lotus* and well adaptable with different plant communities. It provides high nutritive value, so it is used as a component mixed with other plants namely for pasture, hay, silage, haylage and like a green feed.

Local populations that adapt well to local environmental conditions, represented a large number of agronomically important characteristics. This plant species is a tetraploid ( $2n=24$ ) and allotetraploid in which occurs mostly bivalent pairing and tetrasomic inheritance (Miller et al., 1975).

In our climate and soil conditions, there are a large number of populations of *Lotus corniculatus* L. which have high genetic variability. Variability in agronomically important traits is very important in order to find the most productive local populations and further process of breeding.

The objectives of our study were to determine correlative relations between some quantitative traits and to select genotypes with the most dominant features for the breeding according to value-based correlations.

## Materials and methods

The experiment was set up during two growing seasons (2006-2007), at the site Bumbara (Manjaca N44°44'59" E17°02'52", 431 m above sea level). It was investigated 20 genotypes of local originated *Lotus corniculatus* L. And they were obtained in the previous cycle of selection from natural populations and different locations throughout Bosnia and Herzegovina.

The sowing of seeds was conducted on March 17, 2006 in Jiffy containers. The seeds were planted in substrate, and the containers were transferred into the greenhouse after sowing.

10 plants of each genotype were transplanted by on the area of 5m x 16m (10 columns, 50 cm wide and 20 rows, 80 cm wide). It was no isolation between plants and the reproduction between plants was free. Morphometric analysis of the plants was made during 2006-2007 on five randomly selected individuals.

100 plants (five plants of each genotype) in one growing season were measured parameters as following: yield of green mass (GMY), plant height (PH), number of stems per plant (NSP), number of pods (NPP), stem

thickness (SW), yield of air-dried hay (DMY), seed yield per plant (SYP), weight of 1000 seeds (TSW) and number of seeds per pod (NSPo).

Analysis was performed on the first and second mowing. GMY, SW, PH, NSP and DMY were measured in the first mowing, while NPP, SYP, NSPo and TSW were measured in the second mowing. The first mowing was done when the flowers blossomed 50% (for forage), and the second mowing was done when 65% pods received golden brown colour in August (for seed production).

The GMY was measured on an electronic balance (Kern) after the first mowing in the experimental plot. Samples that were dried in paper bags at greenhouse were weighted for the DMY by the electronic balance (Kern). The PH was measured before mowing, by selecting the five stems of each plant and expressed as average plant height (cm). The SW was measured immediately after mowing by using a Caliper (between first and second node above cutting point) taking five stems and reported as average value (mm). The NSP was analyzed by counting on each plant after the first mowing. The NPP was analyzed by counting on each plant after the second mowing. Seeds from pods of each plant were separated manually and weighted (Kern) and reported as SYP (g). The TSW was observed in the laboratory of Faculty of Agriculture. The NSPo was calculated as the average of counting from ten pods from each plant.

The results were analyzed using SAS 9.1. program using the CORR (SAS, 2003) procedure. Correlations between the studied traits were calculated as Pearson correlation coefficients and the significance of certain relationships was determined.

## Results and discussion

Correlative analysis determined the degree of agreement between the characteristics, regardless of what is the dependent and independent variable (Hallauer and Miranda, 1988). Selection for one characteristics, compensatory changes in other characteristics will appear, and because of that it is necessary to know the correlations between the most important characteristics of the selection material. Phenotypic selection of individuals for one characteristics often change other characteristics that were related.

In this research, positive correlations of characteristics per year and the average values were found. The average correlation coefficients values were similar on both years (Figure 1 and 2). The correlation coefficients of GMY were highly significant with DMY (0.96\*\*), PH (0.69\*\*), SW (0.57\*\*), NSP (0.73\*\*), NPP (0.76\*\*) and SYP (0.69\*\*), while no significant differences for TSW were observed. For the NSPo (-0.37) were negatively correlated, but not statistically significant (Tab. 1). The results indicated that there were very high correlation between GMY and DMY and high correlation between the NSP and the PH.

Table 1. Simple correlation coefficients between examined characteristics in 20 genotypes

	GMY	DMY	PH	SW	NSP	NPP	SYP	TSW	NSPo
GMY	-	0.96**	0.69**	0.57**	0.73**	0.76**	0.69**	0.03	-0.37
DMY	0.001	-	0.74**	0.54*	0.68**	0.84**	0.82**	-0.02	-0.36
PH	0.001	0.001	-	0.79**	0.54*	0.72**	0.67*	0.26	-0.09
SW	0.008	0.013	0.001	-	0.29	0.48*	0.29	0.45*	-0.11
NSP	0.001	0.001	0.013	0.218	-	0.73**	0.55*	0.01	-0.38
NPP	0.001	0.001	0.001	0.033	0.001	-	0.88**	0.01	-0.44*
SYP	0.001	0.001	0.001	0.210	0.012	0.001	-	0.12	-0.02
TSW	0.896	0.925	0.275	0.046	0.955	0.956	0.651	-	0.56**
NSPo	0.113	0.116	0.702	0.639	0.094	0.054	0.415	0.011	-

\*, \*\* Significant at  $p < 0.05$ ,  $p < 0.01$

Pearson Correlation Coefficients,  $N = 0$  Prob  $> |r|$  under  $H_0: \rho = 0$

The SAS System, The CORR Procedure.

Abbreviations: GMY-green mass yield (g), DMY-air-dry hay yield (g), PH-plant height (cm), SW-stem thickness (mm), NSP-number of stems per plant, NPP-number of pods / plant, SYP-seed yield per plant (g), TSW-mass of 1000 seeds (g), NSPo-the number of seeds per pod.

The greatest significance of PH was observed in NPP and SYP parameters and this result showed that better insolation of plants provides higher production of generative organs especially for all plants in the family *Fabaceae*. Tall plants with fewer stems, and low plants with many stems do not provide abundant production of vegetative mass (Radić, 2010). During breeding activities, due to the correlation relationships and other



parameters, plants which have good predisposition in high production of forage and seed should be selected for future works.

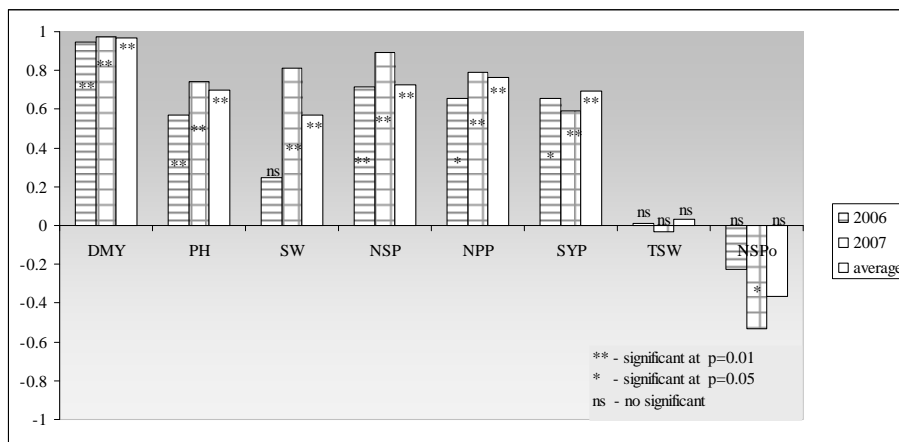


Figure 1. The correlation coefficients of yield of green mass.

The correlation coefficients of the SW were highly significant with the GMY (0.57\*\*), DMY (0.54\*\*) and PH (0.78\*) and for the value of NPP (0.48\*) and TSW (0.45\*) were statistically significant. The obtained values showed that the SW was correlated with parameters that directly affect the biomass production, and no significant difference on the generative parameters. The SW was extensively correlated with PH, because the thicker stem plants give mostly higher growth rate and greater mass. However, most of thicker stem plants provide less nutritional value, while thinner stem plants are susceptible to kneel. Because of these properties, the selection with plants that grants intermediate characteristics are more suitable, while those plants with extreme values are not desirable.

The correlation coefficients for the NPP were negative significantly correlated for the NSPo (-0.44\*). The results showed that increasing in the NPP cause decreasing in the NSPo.

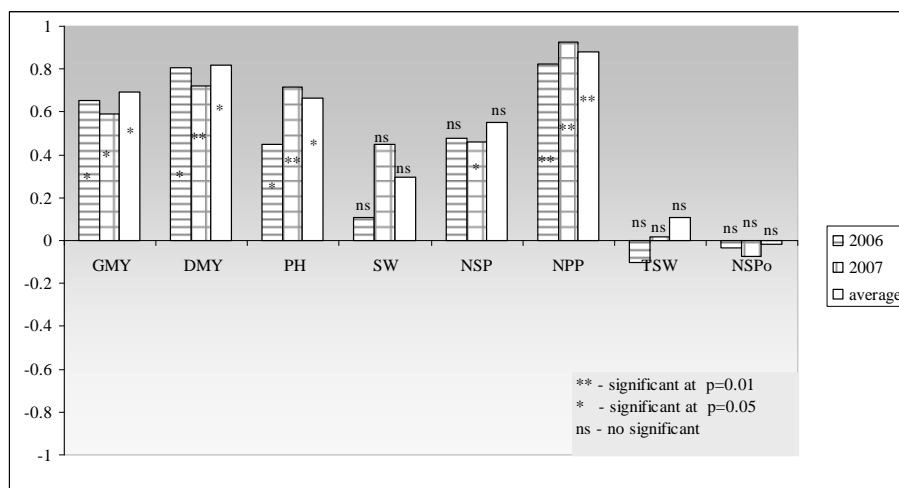


Figure 2. The correlation coefficients for seed yield.

The correlations coefficients for the SYP were highly significant with the GMY (0.69\*\*), the DMY (0.82\*\*) and the NPP (0.88\*\*), and for the values of the PH (0.67\*) and the NSP (0.55\*) were statistically significant, while for the SW (0.29), the TSW (0.12) and the NSPo (-0.02) were not statistically significant (Tab. 1). The highest positive correlation was detected with the NPP, so the selection of genotypes for seed production should be done with those with a large NPP (Figure 2).

The low seed yield is one of the limited factors in the spread of this plant species (Vuckovic, 2005). With the bursting pods at maturity when it comes to unravelling and loss of seed, there are also other factors that influence the production of seeds such as a long flowering period, large numbers of unfertilized flowers, lack of pollinators, genotype and others (Sindhu, 2004).

For a successful selection, it is important to know the genetic variability and inheritable properties. Correlative relationships showed the connection among properties. Most agronomically important properties (GMY, DMY, PH, etc.) have additional effects, thus total gene effects affecting expression of the properties and therefore the selection for these properties is complex and time-consuming. Obtained data can be a useful for being criteria selection for increasing the yield of *Lotus corniculatus* L..

### Conclusions

According to the research of different genotypes of *Lotus corniculatus* L., the following conclusions about the correlated relationship between yield and yield components can be drawn:

Positive correlations between forage yield and yield components of seeds were found.

The correlation coefficients of green mass yield were very highly significant with a yield of hay, a highly significant with the number of stems, pods and seed yield.

It was found a very high significance of seed yield with the number of pods per plant.

Significant positive correlations of seed yield per plant with a yield of green mass, yield of air-dried hay and number of pods per plant were found, indicated the possibility of improving the yield of seed and utility of each component for a selection criteria in breeding.

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# Ocjena kvalitete sjemenskog krumpira

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## Sažetak

Cilj istraživanja bio je izvršiti ocjenu kvalitete sjemenskog krumpira u prometu u razdoblju od 2000. do 2005. godine. Ocjenom kvalitete dvadeset i tri sorte utvrđeno je da je prosječna zastupljenost gomolja većih od gornje granice (55 mm) i gomolja sa težim mehaničkim oštećenjima dubljim od 5 mm u sadnom materijalu sjemenskog krumpira u kategoriji elita (E) bila manja u odnosu na kategoriju original (A). Zastupljenost gomolja drugih sorata i gomolja manjih od donje granice (35 mm) nije zabilježena ni u jednom uzorku. Sadni materijal sjemenskog krumpira svih ispitivanih sorata je dobrog kvaliteta i ispravnog zdravstvenog stanja, što zadovoljava zakonom propisane vrijednosti.

Ključne riječi: kvaliteta, gomolj, krumpir, sorta, kategorija

## Assessing the quality of seed potatoes

### Abstract

The aim of this study was to be evaluated the quality of seed potatoes in market from 2000 to 2005 year. Assessing the quality of twenty-three cultivars showed that the average involvement of tubers larger than the upper limit (55mm) of tubers and tubers with severe mechanical damage deeper than 5mm in of seed potatoes in category elite (E) was lower compared to the original category (A). Seed tubers of other cultivars and smaller than the lower limit (35mm) is not found in any sample. Planting material of seed potatoes of all examined cultivars is of good quality and proper health condition, which meets the statutory value.

Key words: quality, tuber, potato, cultivars, category.

### Uvod

Dobar kvalitet sjemena za sadnju krumpira uvjet je za dobivanje zdravih, jakih biljaka koje će dati visok prinos dobre kvalitete (Struik i Wiersema, 1999). Kvaliteta sadnog materijala krumpira određen je svojstvima sjemenskih gomolja: fiziološkom starošću, krupnoćom (veličinom, masom) gomolje i zdravstvenim stanjem (Milošević, 2000; Poštić i sur., 2009). Fiziološka starost definira se kao "stupanj razvoja sjemenskih gomolja krumpira" (Struik, 2009). Još su davne 1959. Reestman i de Wit konstatirali, a Morris (1966) potvrdio da je stupanj razvoja klica na krupnijim gomoljima veći u odnosu na sitnije gomolje i da je broj glavnih stabljika razvijenih na gomolju u korelaciji sa veličinom gomolja. Krupnoća gomolja utječe na životnu sposobnost i određuje veličinu i krajnji prinos biljke (Rykbost i Locke, 1999). Krupnoća sjemenskog gomolja je važno svojstvo i merljiva komponenta kvalitete sjemena. Značaj krupnoće gomolja ogleda se preko broja klica i vigora, međutim, ograničena je i povezana sa fiziološkom starošću gomolja (Beukema i van der Zaag, 1990; Poštić, 2006; Poštić i sur., 2009). Sadni materijal sjemenskih gomolja krumpira mora biti potpuno zdrav,

odnosno bez prisutnosti patogena uzročnika i štetočina krumpira (Milošević, 1998; Poštić i sur., 2010). Samo uz uporabu sjemena dobrog kvaliteta i ostale jednake uvjete (agrotehnika, gnojidba, navodnjavanje i zaštita) moguća je ekonomična i rentabilna proizvodnja krumpira (Poštić i sur., 2010). Cilj istraživanja bio je izvršiti ocjenu kvalitete sjemenskog krumpira u prometu u razdoblju od 2000. do 2005. godine.

### Materijali i metode

Kao materijal u istraživanjima poslužili su uzorci sjemenskog krumpira dvadeset tri sorte (Desiree, Kondor, Jaerla, Cleopatra, Liseta, Kennebec, Carera, Rodeo, Fabula, Inovator, Bartina, latona, Frisia, Red Scarlet, Courage, Concurent, Marabel, Amorosa, Morene, Laura, Asterix, Van Gogh i Jupiter) prikupljeni u razdoblju od 2000. do 2005. godine. Ocjena je obuhvatila 340 uzoraka sadnog materijala sjemenskog krumpira koji je pripadao kategorijama elita (E) i original (A). Uzorci veličine 200 gomolja u frakciji promjera (35-55 mm) poslužili su za ocjenu kvalitete sjemenskog krumpira koja je izvedena u laboratoriju za ispitivanje kvaliteta sjemena i sadnog materijala poljoprivrednog bilja Instituta za zaštitu bilja i životnu sredinu u Beogradu. Kalibriranje sadnog materijala uzoraka krumpira izvedeno je ručno, dok je ocjena zdravstvenog stanja utvrđena primjenom vizuelne metode i enzimskom imunoadsorpcijskom metodom Elisa-testa koju su definirali Clark i Adams (1977). Prema Pravilniku o kakvoći sjemena poljoprivrednog bilja (Sl. list SFRJ br. 47/87) definirane su vrijednosti i ocjenjivana je zastupljenost sljedećih pokazatelja kvaliteta sjemenskog krumpira: gomolja drugih sorti može biti do 0,05%, gomolja većih od gornje granice 55 mm (do 4%), gomolja manjih od donje granice 35 mm (do 6%), gomolja sa teškim mehaničkim oštećenjima dubljim od 5 mm (do 1,5%) i stranih primjesa i zemlje (do 1%). Zdravstveno stanje ispitivano je prema Pravilniku o zdravstvenom pregledu usjeva i objekata za proizvodnju sjemena, rasada i sadnog materijala i zdravstvenom pregledu semena, rasada i sadnog materijala (Sl. glasnik RS br.119/2007) i obuhvaćeno je (Tablica 1.):

Tablica 1. Dozvoljeni (%) zastupljenosti štetnih organizama u sjemenskom krumpiru

Štetni organizmi	Dozvoljeni (%) u sadnom materijalu u prometu	
	Original (A)	Elita (E)
<i>Synchytrium endobioticum</i>	0	0
<i>Phytophthora infestans</i>	1	1
<i>Spongospora subteranea</i>	4	4
<i>Fusarium spp.</i>	2	2
<i>Rhizoctonia solani</i>	25	10
<i>Streptomyces scabies</i>	5 (kraste zahvataju manje od 1/3 površine)	
<i>Erwinia carotovora</i>	0	0
Leafrol virus, PVY, PVA i PVX	6	1
<i>Globodera rostochiensis</i> i <i>G. pallida</i>	0	0

Dobiveni rezultati su obrađeni statistički, korištenjem osnovnih pokazatelja deskriptivne statistike (SD i CV) kojima je utvrđeno apsolutno i relativno odstupanje ispitivanih obilježja od sredine.

### Rezultati i rasprava

Prosječna zastupljenost gomolja većih od gornje granice (55 mm) u sadnom materijalu sjemenskog krumpira u kategoriji original (A) je bila 1,50%, dok u kategoriji elite (E) 0,71% (Tablica 2.). Sorte Rodeo, Fabula, Frisia, Courage, Concurent i Van Gog bile su bez učešća gomolja većih od gornje granice u obje kategorije. Najveći postotak zastupljenosti gomolja većih od gornje granice u kategoriji (A) imala je sorta Morene i Jupiter 4,00%, dok je u kategoriji (E) imala također sorta Jupiter 2,50% (Tablica 2.). Velike razlike u masi gomolja jedne partije sjemena negativno se može odraziti na prinos i kvalitetu gomolja kao i neujednačeno nicanje (Rykbost and Locke, 1999; Poštić, 2006).

Zastupljenost gomolja sa težim mehaničkim oštećenjima dubljim od 5 mm u prosjeku u kategoriji (A) bilo je 0,35%, dok je u kategoriji (E) 0,24% (Tablica 2.). Najviše zastupljenih gomolja sa teškim mehaničkim oštećenjima imala je sorta Morene u kategoriji (A) 0,50%, odnosno u kategoriji (E) 0,40% (Tablica 2.). Najmanju vrijednost oštećenih gomolja u kategoriji (A) postigla je sorta Amorosa (0,25%), dok je u kategoriji (E) sorta Van Gog 0,10% (Tablica 2.). Postotak oštećenih gomolja treba svesti na najmanju moguću mjeru jer

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takve partije sjemena se teško čuvaju u skladištu zbog povećane respiracije, gubitaka vode, izloženost bolestima (Jakovljević, 1995; Milošević, 1998) i skraćenja perioda dormancije (Burton, 1990).

Tablica 2. Prosječni kvaliteta sorata krumpira u razdoblju od 2000.-2005. godine.

Sorta	Gomolja drugih sorata (%)		Gomolja većih od gornje granice (%)		Gomolja manjih od donje granice (%)		Gomolja sa teškim mehaničkim oštećenjima (dubljim od 5 mm) (%)		Stranih primjesa i zemlje (%)	
	A	E	A	E	A	E	A	E	A	E
Kategorija										
Desiree	-	-	2,43	0,64	-	-	0,34	0,22	0,33	0,27
Kondor	-	-	3,30	1,10	-	-	0,43	0,23	0,33	0,22
Jaerla	-	-	2,00	1,31	-	-	0,45	0,24	0,25	0,23
Cleopatra	-	-	0,40	0,30	-	-	0,28	0,20	0,28	0,21
Liseta	-	-	2,00	0,80	-	-	0,31	0,30	0,40	0,30
Kennebec	-	-	1,50	1,00	-	-	0,40	0,32	0,35	0,26
Carera	-	-	1,30	0,50	-	-	0,35	0,20	0,30	0,20
Rodeo	-	-	0	0	-	-	0,33	0,20	0,40	0,30
Fabula	-	-	0	0	-	-	0,33	0,27	0,35	0,30
Inovator	-	-	3,00	2,00	-	-	0,40	0,30	0,36	0,33
Bartina	-	-	1,00	0,50	-	-	0,35	0,20	0,40	0,30
Latona	-	-	1,50	0,50	-	-	0,40	0,30	0,30	0,25
Frisia	-	-	0	0	-	-	0,30	0,20	0,28	0,25
Red Scarlet	-	-	2,50	1,0	-	-	0,40	0,30	0,40	0,30
Courage	-	-	0	0	-	-	0,35	0,25	0,30	0,20
Concurent	-	-	0	0	-	-	0,30	0,21	0,25	0,20
Marabel	-	-	1,00	0,50	-	-	0,50	0,40	0,30	0,20
Amorosa	-	-	0	0	-	-	0,25	0,20	0,30	0,20
Morene	-	-	4,00	2,00	-	-	0,30	0,20	0,30	0,20
Laura	-	-	2,50	0,70	-	-	0,40	0,31	0,30	0,24
Asterix	-	-	2,00	1,00	-	-	0,30	0,22	0,30	0,25
Van Gog	-	-	0	0	-	-	0,30	0,10	0,40	0,20
Jupiter	-	-	4,00	2,50	-	-	0,30	0,20	0,30	0,20
Prosjek	-	-	1,50	0,71	-	-	0,35	0,24	0,32	0,24
SD	-	-	1,33	0,71	-	-	0,06	0,06	0,05	0,04
CV	-	-	89,06	100,29	-	-	17,59	25,88	14,89	17,82

Kategorija (A) imala je veću prosječnu zastupljenost stranih primjesa i zemlje 0,32%, u odnosu na kategoriju (E) 0,24% (Tablica 2.). Sorte Jaerla i Concurent imale su najmanje stranih primjesa i zemlje 0,25%, dok su najveću vrijednost 0,40% (Tablica 2.) imale sorte Liseta, Rodeo, Bartina, Red Scarlet i Van Gog. U kategoriji (A) najmanje stranih primjesa 0,20% imale su sorte Carera, Courage, Concurent, Marabel, Amorosa, Morene, Van Gog i Jupiter, dok je najviše 0,33% (Tablica 2.) kod sorte Inovator. Povećana prisutnost stranih primjesa (djelova biljaka krumpira, korova i raznog sjemena) i zemlje može biti izvor zaraze i otežati čuvanje sjemenskog krumpira u skladištu. Sjemenskih gomolja drugih sorata i gomolja manjih od donje granice (35 mm) nije zabilježeno ni u jednom sjemenskom uzorku. Sitnije sjeme može biti slijepo ili posjedovati samo jednu klicu (Nielson et al., 1989), odnosno mala veličina djelova sjemena dovodi do usporenog klijanja i opadanja broja stabljika zavisno od sorte (Rykbost i Locke, 1999). Utvrđeno prisustvo karantenskih i ekonomski štetnih biljnih bolesti, štetočina i virusa bilo je unutar dozvoljenih granica za kategorije (A) i (E) koje su propisane Pravilnikom o zdravstvenom pregledu usjeva i objekata za proizvodnju sjemena, rasada i sadnog materijala i zdravstvenom pregledu sjemena, rasada i sadnog materijala (Sl. glasnik RS br.119/2007). Sjemenski sadni materija treba da bude bez prisustva bolesti i štetočina koji zadržavaju u zemljištu dugi niz godina to je vrlo teško (i skupo) za kontrolu (npr. Synchronium, Globodera) (Beukema and van der Zaag, 1990).

### Zaključak

Zastupljenost gomolja većih od gornje granice (55 mm) u uzorcima kod svih sorata kretala se u okviru zakonskih normi do 4%. Vrijednost ovog pokazatelja kvalitete su veće u kategoriji (A) nego u kategoriji (E).

Najveću zastupljenost gomolja iznad gornje granice od svih sorata imala je sorta Jupiter sa 4% u kategoriji (A) i 2,50% u kategoriji (E). Prosječna zastupljenost gomolja sa teškim mehaničkim oštećenjima dubljim od 5 mm u uzorcima svih sorata u kategoriji (A) je 0,35%, dok je u kategoriji (E) 0,24%. Sorta Marabel imala je najveće vrijednosti ovog pokazatelja 0,50% u kategoriji (A), odnosno 0,40% u kategoriji (E). Sorte u kategoriji (E) imale su prosječno manju zastupljenost stranih primjesa i zemlje 0,24%, dok su u kategoriji (A) imale 0,32%. Razlike ovog pokazatelja između pojedinih sorata u kategoriji (A) su male (0,01-0,15%), dok su u kategoriji (E) još manje (0,01-0,13%). Sortna čistoća ispitivanog sadnog materijala sjemenskog krumpira je visoka jer nije utvrđena niti jedan gomolj drugih sorata u uzorcima. Veličina gomolja je bila u okviru date kalibraže (35-55 mm) i nije utvrđena zastupljenosti gomolja manjih od donje granice (35 mm) ni u jednom uzorku sjemenskog krumpira. Zdravstveno stanje svih ispitivanih sorata sjemenskog krumpira kategorija (A) i (E) bilo je u okviru zakonom propisanih normi i ispunjavali su uvjete stavljanja sadnog materijala krumpira u promet. Sadni materijal sjemenskog krumpira obje kategorije je dobre kvalitete što je dobra osnova da uz ostale uvjete proizvodnje (agrotehnika, gnojidba, navodnjavanje i zaštita) mogu se ostvariti visoki prinosi dobre kvalitete.

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# Identification and discrimination of *Ocimum basilicum* L. morphotypes

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## Abstract

In order to assess morphological variability and to classify basil accessions into morphotypes, a total of 97 basil (*Ocimum basilicum* L.) accessions was characterized using 27 morphological traits. Cluster analysis based on phenotypic dissimilarity matrix yielded six clearly defined clusters representing distinct morphotypes: Lettuce-leaf, Small-leaf, True basil, Purple basil (A), Purple basil (B), and Purple basil (C). A Neighbour-net diagram based on the same dissimilarity matrix allowed the visualization of apparently conflicting data, such as caused by hybridization between phenotypically very different ancestors.

Key words: basil, accession, morphological traits, morphotypes, Neighbour-net

## Introduction

Classification of basil (*Ocimum basilicum* L.) into morphotypes is hampered by high levels of intravarietal morphological variability reflecting a long history of cultivation and breeding (Simon et al., 1990; Carović-Stanko et al., 2010a). A standardized descriptor list for basil developed by the International Union for the Protection of New Varieties of Plants (UPOV, 2003) aspire to set out the principles which are used in the examination of distinctness, uniformity and stability ('DUS testing') identifying appropriate characteristics for variety description. The aim of this study was to analyse the usefulness of the descriptor list in order to classify the accessions held at the Collection of Medicinal and Aromatic plants of the Department of Seed Science and Technology, Faculty of Agriculture, University of Zagreb.

## Materials and methods

A total of 97 basil accessions, fully documented at the Croatian Plant Genetic Resources Database available at [cpgrd.zsr.hr](http://cpgrd.zsr.hr), was included in the field trial, each represented by 12 plants. 'Basil (*Ocimum basilicum* L.): Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability' (UPOV, 2003) were used in order to score 27 morphological traits.

Phenotypic dissimilarity between pairs of accessions was calculated using the proportion-of-shared-alleles distance (Bowcock et al., 1994) as implemented in MICROSAT (Minch, 1997). In our case, the proportion-of-shared-alleles was treated simply as the proportion of traits for which two accessions share a same trait state (i.e. category). Cluster analysis based on dissimilarity matrix was performed using the unweighted pair-group method (UPGMA) as implemented in NEIGHBOR programme of the PHYLIP ver. 3.6b software package (Felsenstein, 2004). A neighbour-net diagram (Bryant and Moulton, 2004) was constructed from the same distance matrix using SplitsTree 4 (Huson and Bryant, 2006).

## Results and discussion

Out of 27 morphological traits 24 were polymorphic in the set of 97 basil accessions. Six clearly defined clusters have been detected representing distinct morphotypes (Fig. 1). Cluster I representing Lettuce-leaf basil morphotype was composed of accessions which were discriminated by the shape, width and blistering of the leaf blade. Accessions belonging to cluster II represented Small-leaf basil morphotype and were discriminated by rounded plant habit and short plant height. The typical green basil accessions including cultivars 'Genovese' and 'Sweet basil' were grouped together in Cluster III representing True basil morphotype. Purple basil forms formed additional three clusters. Cluster IV referred as Purple basil (A) morphotype grouped accessions displaying anthocyanin coloration on stems but having green leaves while Cluster V, Purple basil (B) morphotype included purple-leaf accessions being 'Dark Opal' the most typical cultivar. Cultivar 'Purple Ruffles' was not included in any of five clusters representing a different morphotype, Purple basil (C). The classification of basil into six morphotypes as reported previously by Carović-Stanko et al. (2010b) was confirmed in a larger set of accessions.

A Neighbour-net diagram revealed the complexity of the pattern of shared states among the accessions (Fig. 2). While overall classification into six morphotypes was supported, a great morphological variability within nearly all morphotypes was observed. In contrast to commonly used clustering methods, a network method allows the visualization of apparently conflicting signals, such as, in our case, caused by hybridization between phenotypically very different ancestors. The positioning of a number of accessions in intersections reconnecting the branches that were separating parental accessions indicated the complex history of breeding mainly for decorative purposes by crossing different morphotypes. Such crosses resulted in a huge number of basil cultivars with variations in leaf colour, size and shape, flower colour, growth characteristics and aroma.

Four groups of representative accessions as indicated in Figs 1 and 2 included from five to 20 accessions sharing all the analysed trait states. In case of True basil morphotype, two groups were detected, one being 'Genovese' (20 accessions) and the other 'Sweet basil' (7 accessions). Similarly, in case of Purple basil (A) morphotype eight accessions were found to be morphologically identical, while five accessions of the cultivar 'Dark Opal' from different origins formed a group of indistinguishable representative accessions of the morphotype Purple basil (B). The accessions belonging to these groups will be treated as representative of the corresponding morphotype/cultivar and after its molecular genotyping and biochemical analyses this information could be used for unambiguous identification of true-to-type plants.

## Conclusions

The classification of basil into six morphotypes could be of practical importance in the management of germplasm collection, basil production and breeding. A considerable level of phenotypic variability exists also within morphotypes suggesting that the genetic diversity of the species could be readily exploited for the development of new cultivars. Documentation of passport data and morphological characterization of the basil accessions held at the Collection of Medicinal and Aromatic plants is the first step towards a comprehensive assessment of variability that will include the analyses on both biochemical (essential oil content and composition) and genetic level (molecular markers).

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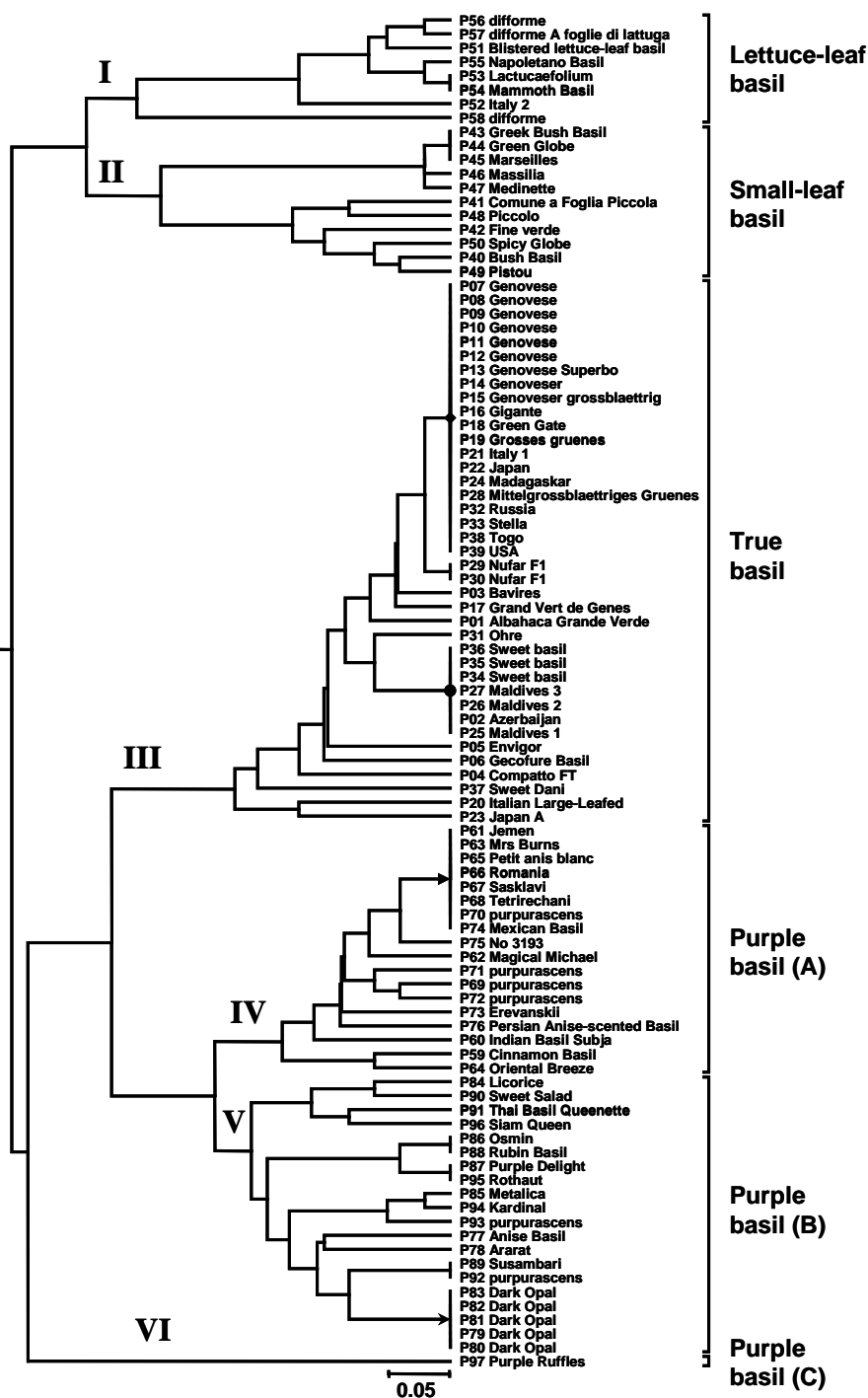


Figure 1. UPGMA dendrogram based on 24 morphological traits in 97 basil accessions. Morphotypes are indicated on the right. Groups of representative accessions are indicated as explained in Fig. 2.

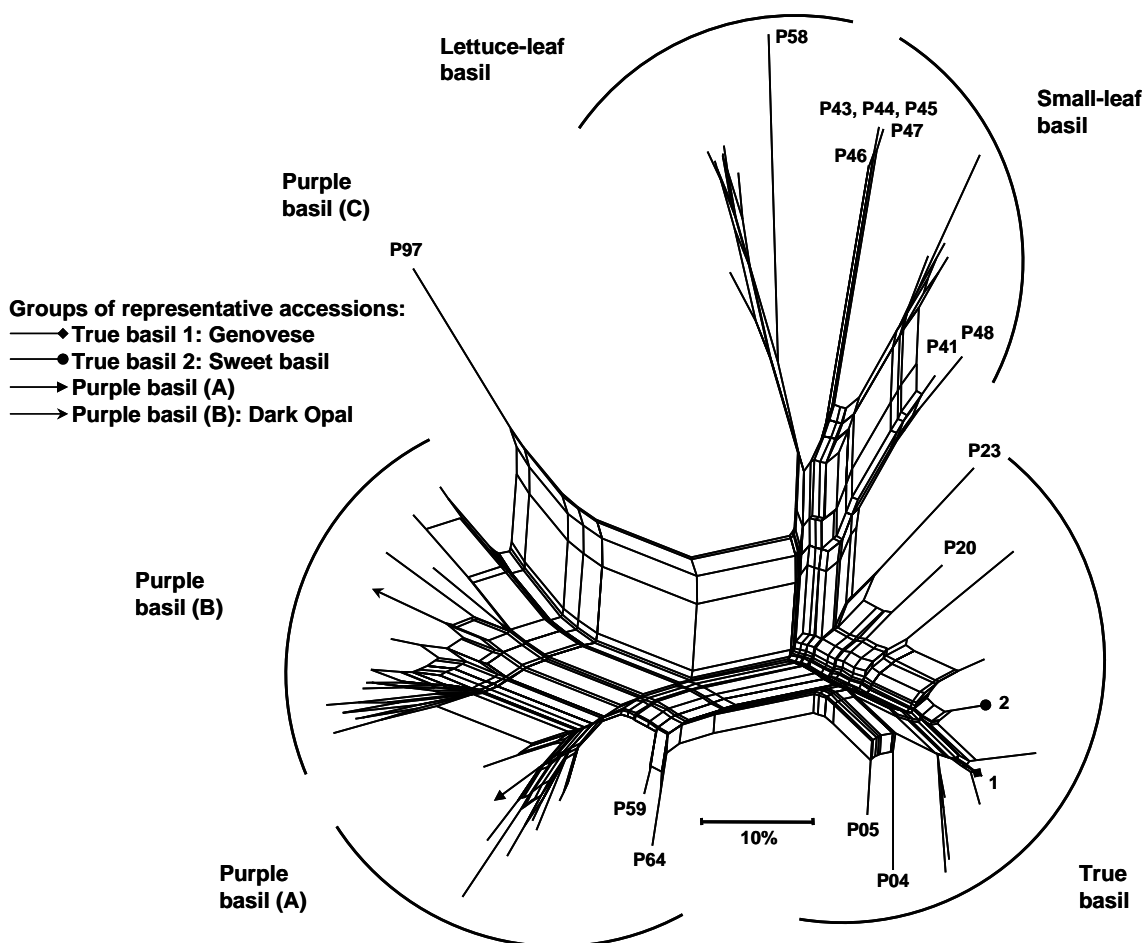


Figure 2. Neighbor-net diagram representing the morphological relationships among 97 basil accessions classified into six morphotypes. Groups of representative accessions within True basil (1 and 2) as well as within Purple basil (A) and (B) morphotypes are indicated.

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# Utjecaj temperature, svjetlosti i dužine čuvanja na kvalitetu i brzinu klijavosti sjemena bosanske zvončike (*Symphyandra hofmanni* Pantocs.)

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## Sažetak

*Symphyandra hofmanni* Pantocs. (Campanulaceae) je endemična vrsta srednje Bosne koju je 1847. godine otkrio Otto Sendtner na stijenama oko Srebrenika kod Tuzle, ali tek je 1881. godine kao novu vrstu opisuje mađarski botaničar J. Pantocsek. Endemične biljne vrste su interesantne za znanstvena istraživanja, prvenstveno zbog pokušaja njihovog očuvanja, kako na lokalitetima gdje se u prirodi nalaze, tako i kroz uvođenje u uzgoj, kao mjera ex-situ zaštite.

Cilj ovog rada je da se istraži utjecaj temperature, svjetlosti i starosti sjemena na klijavost sjemena *Symphyandra hofmanni* Pantocs., kao prilog upoznavanju uzgojnih mogućnosti ove endemične biljne vrste.

Ključne riječi: *Symphyandra hofmanni* Pantocs., temperatura, svjetlost, dužina čuvanja sjemena, kvaliteta sjemena

## The effect of temperature, light and storage time to the seed quality and germination time of bosnian ring bellflower (*Symphyandra hofmanni* Pantocs.)

### Abstract

Species *Symphyandra hofmanni* Pantocs. belongs to family Campanulaceae. It is the endemic plant species in the central Bosnia, discovered in year 1847. by Otto Sendtner on the rocks around Srebrenik near Tuzla and it was described as a new species in 1881 by the Hungarian botanist J. Pantocsek. The endemic plants are very interesting object for scientific studying for the efforts of their conservation, in their natural habitats, as well as cultivation, as the measure of ex-situ protection.

The aim of this paper is to examine the effect of the temperature, light and storage time to the germinability of the *Symphyandra hofmanni* Pantocs. seed, in order to contribute to the cultivation possibilities of this endemic plant species.

Key words: *Symphyandra hofmanni* Pantocs., temperature, light, storage time, seed quality

## Uvod

*Symphyandra hofmanni* ili bosanska zvončika iz porodice Campanulaceae je endemična vrsta srednje Bosne (Šilić, 1984) koju je na vapnenastim stijenama kod Srebrenika, sjeverozapadno od Tuzle otkrio dr. Otto Sendtner u proljeće 1847., ali je zbog odsustva cvjetova pogrešno pretpostavio da se radi o *Campanula wanneri* Rochel (syn. *Symphyandra wanneri* Heuffel). Tek je 1881. godine mađarski botaničar Pantocsek utvrdio da se radi o novoj vrsti i dao njen potpuni opis.

Prema radovima koje je objavio Karlo Malý, *Symphyandra hofmannii* je endem centralne Bosne, sa arealom u slivu rijeka Bosne i Vrbasa. Rasprostranjena je u brdskom području (140-900 m n.v.), na različitim kamenitim podlogama: vapnencima, serpentinima, silikatnim stijenama škriljevca i gabru. Gotovo uvijek se nalazi u blizini vodotoka, ali je zabilježena i u rijetkim termofilnim šumama i na brdskim livadama.

Fukarek (1956) navodi da, ako se uspoređi karta rasprostranjenosti populacija bosanske zvončike sa kartom na kojoj su označene srednjovjekovne utvrde i gradovi (u blizini Banja Luke, oko Jajca i Travnika, u blizini starih gradova Vranduka, Maglaja, Doboja, Srebrenika kod Tuzle) može se primijetiti podudarnost areala biljke i područja u kojem je u srednjem vijeku bilo mnogo feudalnih dvoraca i utvrda. On navodi i pretpostavku da se bosanska zvončika razvila od biljke koja je uzgajana u feudalnim vrtovima. Zbog izraženih dekorativno-estetskih svojstava, bosanska zvončika bi se mogla veoma uspješno koristiti u dekorativne svrhe (Šilić i Abadžić, 1991).

Cilj ovoga rada je bio da se u oglednom razdoblju 2008. do 2010. godine, ispita kvaliteta sjemena *Symphyandra hofmannii* Pantocs., djelovanje temperature, svjetlosti i starosti sjemena na klijanje, kako bi se dao prilog poznavanju ove vrste i da bi se ispitala mogućnost njenog uvođenja u hortikulturnu praksu u cilju očuvanja u ex-situ uslovima.

## Materijal i metode

*Symphyandra hofmanni* Pantocs. je dvogodišnja biljka sa repasto zadebljalim glavnim korijenom. Prve godine biljka stvara lisnu rozetu sastavljenu od sitnih listova obraslih kratkim dlakama koji se naredne godine suše, a iznad njih se razvija stabljika koja je uspravna, razgranata i visoka oko 16 do 40 cm. Listovi su naizmjenični, izduženi, tupi ili zašiljeni, nepravilno grubo dvostruko nazubljeni i više ili manje urezani. Cvat je metličasta, široka ili usko piramidalna. Cvjetovi su viseći, bijeli, kada precvjetaju žućkasti, 2,5 do 3,2 cm dugi i do 2,5 cm široki, cjevasto-zvončasti, sa 5 kratkih šiljatih ili tupih vrhova, obraslih trepljama (Malý K. 1948; Beck-Mannageta *et al*, 1983).

Biljka cvjeta od lipnja do kraja ljeta. Razmnožava se sjemenom, koje je ovalno, plostano, smeđe boje, dugo 1,2 mm a široko 0,6 mm. Od velikog broja čimbenika koji uvjetuju i omogućavaju klijanje sjemena, temperatura i svjetlost su među najvažnijima (Mayer i Poljakoff-Mayber, 1963). Veoma važan čimbenik koji utječe na klijavost sjemena je i dužina čuvanja sjemena (Damnjanović *et al*, 2009).

Sjeme *Symphyandra hofmannii* koje je korišteno u ovom radu je sakupljeno u Botaničkom vrtu Zemaljskog muzeja u Sarajevu u jesen 2008. godine. Eksperiment je proveden u laboratoriji Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu. Jedna polovina sjemena je iskorištena u proljeće 2009., a druga u proljeće 2010. godine. Sjeme je naklijavano u Petrijevim posudama na filter papiru koji je umjereno vlažen destiliranom vodom, u termostatu pri temperaturi od 17, 22, i 25 °C. Navedene vrijednosti su odabrane jer se radi o termofilnoj vrsti (Malý, 1948). Za svaku vrijednost temperature postavljeno je po 800 sjemenki, od kojih je jedna polovina naklijavana u tami (što se postiglo umotavanjem Petrijevih posuda u aluminijsku foliju), a druga na svjetlosti. Nakon 30 dana utvrđen je broj proklijalih sjemenki temeljem kojeg je određena klijavost sjemena. Praćena je i brzina klijanja sjemenki.

## Rezultati i rasprava

### Utjecaj temperature na klijavost sjemena *Symphyandra hofmanni*

Da bi se izbjeglo pogrešno tumačenje rezultata zbog utjecaja svjetlosti, utjecaj temperature na klijavost sjemena *Symphyandra hofmanni* je praćen na sjemenkama koje su naklijavane u Petrijevim posudama umotanim u aluminijsku foliju.

Tablica 1. Utjecaj temperature na klijavost sjemena (%) *Symphyandra hofmanni*

Godina	17 °C	22 °C	27 °C
2009.	2,25 ± 1,5	39,25 ± 2,5	14,75 ± 3,8
2010.	1 ± 0,8	22,25 ± 3,3	2,75 ± 1,3
Prosjek	1,62 ± 1,3	30,75 ± 9,5	8,75 ± 6,9

Na osnovu podataka iz tablice 1. se može ustanoviti da su sjemenke naklijavane pri temperaturi od 22 °C imale najveću klijavost (30,75% sjemenke skladištene jednu i 22,25% sjemenke skladištene dvije godine). Najmanja klijavost (2,25% u prvoj i 1% u drugoj godini) zabilježena je kod sjemenki koje su kližale pri temperaturi od 17 °C. Preporuka je da se sjetva sjemena bosanske zvončike u svrhu korištenja biljaka u hortikulturi provodi u zaštićenom prostoru, ili na otvorenom u kasno proljeće ili u ranu jesen, jer je primjetno da temperatura iznad 27 °C negativno utječe na klijavost sjemena ove biljne vrste.

Gligorijević-Danon (1970) navodi da su najbolji rezultati naklijavanja sjemena bosanske zvončike ostvareni pri temperaturi od 25 °C, ali u tom radu nije istraživano klijanje pri temperaturi od 22 °C.

Vrijednosti klijavosti sjemena bosanske zvončike testirane su t-testom kako bi se utvrdilo da li temperatura opravdano utječe na klijavost ili su razlike slučajne. Ustanovljene su značajne razlike u klijavosti između svih istraživanih temperatura, odnosno, da temperatura značajno utječe na klijavost sjemena ove biljne vrste.

#### Utjecaj svjetlosti na klijavost sjemena *Symphyandra hofmanni*

Utjecaj svjetlosti na klijavost sjemena bosanske zvončike istraživao je usporedbom broja proklijalih sjemenki u Petrijevim posudama zaštićenim i izloženim djelovanju svjetlosti, pri istim uvjetima temperature i vlažnosti.

Tablica 3. Utjecaj svjetlosti na klijavost sjemena (%) *Symphyandra hofmanni*

Temperatura (°C)	Tama		Svjetlo	
	2009.	2010.	2009.	2010.
17	2,25 ± 1,5	1 ± 0,8	15,5 ± 3,7	1,75 ± 1,0
22	39,25 ± 2,5	22,25 ± 3,3	80,5 ± 4,2	36,5 ± 5,6
27	14,75 ± 3,8	1,5 ± 1,0	34,25 ± 5,1	2,75 ± 1,5
Prosjek	18,75	8,25	43,42	13,67
	13,5		28,54	

Podaci u tablici 3. ukazuju da je, bez obzira na godinu istraživanja, klijavost sjemenki naklijavanih u Petrijevim posudama izloženim svjetlu (28,54%) bila mnogo veća u odnosu na klijavost sjemenki naklijavanih bez prisustva svjetlosti (13,5%). Na osnovu navedenog, može se zaključiti da je *Symphyandra hofmanni* svjetloključajuća biljka i da se sjeme poslije sjetve treba pokriti vrlo tankim slojem supstrata ili uopće ne pokrivati.

#### Utjecaj dužine čuvanja na klijavost sjemena *Symphyandra hofmanni*

U istraživanju je korišteno sjeme sakupljeno u jesen 2008. godine. Polovica sakupljenog sjemena korištena je u proljeće 2009, a polovica u proljeće 2010. Rezultati istraživanja utjecaja starosti sjemena na klijavost prikazani su u tablici 4.

Tablica 4. Utjecaj dužine čuvanja na klijavost sjemena (%) *Symphyandra hofmanni*

Uvjeti klijanja	Klijavost sjemena starosti 1 godine		Klijavost sjemena starosti 2 godine	
Tama	17°C	2,25 ± 1,5	1 ± 0,8	
	22°C	39,25 ± 2,5	22,25 ± 3,3	
	27°C	14,75 ± 3,8	1,5 ± 1,0	
Svjetlost	17°C	15,5 ± 3,7	1,75 ± 1,0	
	22°C	80,5 ± 4,2	36,5 ± 5,6	
	27°C	34,25 ± 5,1	2,75 ± 1,5	
Prosjek		31,08	10,96	

Rezultati iz tablice 4. ukazuju da se povećanjem starosti sjemena bosanske zvončike smanjuje klijavost sjemena. Bez obzira na uvjete klijanja, jednogodišnje sjeme imalo je prosječnu klijavost 31,08%, a dvogodišnje svega 10,96%.

#### Brzina klijanja sjemena *Symphyandra hofmanni* u zavisnosti od temperature, svjetlosti i dužine skladištenja

U obje godine istraživanja naklijavanje sjemenki trajalo je 30 dana. Naklijavanje sjemenki provedeno je od 18.04. do 18.5.2009. i od 04.04. do 4.5.2010. Početak klijanja, odnosno, pojava prvih proklijalih sjemenki, bio je različit obzirom na uvjete svjetlosti, temperature i starosti sjemena. Brzina klijanja sjemena prikazana je u tablici 5.

Tablica 5. Utjecaj temperature, svjetlosti i starosti sjemena na brzinu klijanja *Symphyandra hofmanni*

		17°C		22°C		27°C	
		Tama	Svjetlo	Tama	Svjetlo	Tama	Svjetlo
Broj dana do	2009	20	17	10	8	10	9
početka klijanja	2010	24	21	13	10	14	12

Na osnovu analize podataka iz tabele 5. može se utvrditi da sjeme bosanske zvončike, bez obzira na svjetlost i starost sjemena, najbrže klije pri temperaturi 22 °C, a najsporije pri 17 °C. Bez obzira na temperaturu i starost sjemena, klijanje je brže na svjetlosti. Također u svim uvjetima sjeme staro jednu godinu klije brže nego sjeme staro dvije godine. Najbrže klijanje (8 i 9 dana) ostvarilo je jednogodišnje sjeme izloženo svjetlosti pri temperaturi 22 i 27 °C.

#### Zaključci

Na osnovu istraživanja kvalitete i brzine klijavosti sjemena *Symphyandra hofmanni* pri različitoj temperaturi, uvjetima svjetlosti i dužine čuvanja, a u svrhu njenog korištenja u hortikulturi, mogu se izvesti sljedeći zaključci:

- Najveća klijavost sjemenki ostvarena je pri temperaturi 22 °C, kod sjemenki starih jednu godinu 30,75% i kod sjemenki starih dvije godine 22,25%,
- Najmanja klijavost zabilježena je pri temperaturi 17°C, kod sjemenki starih jednu godinu 2,25% i kod sjemenki starih dvije godine 1%,
- Klijavost sjemenki pri svjetlosti (28,54%) bila je veća u odnosu klijavost sjemenki bez prisustva svjetlosti (13,5%),
- Klijavost sjemenki smanjuje se starenjem, odnosno, jednogodišnje sjeme ima veću klijavost (31,08%) u odnosu na dvogodišnje (10,96%),
- Klijanje je najbrže pri temperaturi 22°C,
- Svjetlost ubrzava klijavost,

Starenjem sjemena brzina klijanja se smanjuje, pa je sjeme potrebno sijati što je prije moguće.

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**Utjecaj temperature, svjetlosti i dužine čuvanja na kvalitetu i brzinu klijavosti sjemena bosanske zvončike (Symphyandra hofmanni Pantocs.)**

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# The rootstock effect in the Hungarian watermelon production

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## Abstract

Due to the importance of the subject, the aim of the experiment was to study the quantitative and qualitative changes in response to watermelon grafting. Combinations of watermelon variety 'Bonta' with interspecific hybrid and *Lagenaria* rootstocks were studied in the experiment. The grafted and non-grafted plants were planted at different row and plant spacing. Fruit number and weight, also yield, have been established. A qualitative analysis followed the harvests. Refractometric value was measured at the beginning of sampling process, using a digital hand refract meter. Total and reducing sugar contents were determined using the Luff-Schorl method.

Key words: *Citrullus lanatus* var. *vulgaris*, grafting, yield, refractometric value, sugar content

## Introduction

Watermelon production has a great tradition in Hungary. Descriptions of watermelon cultivation appeared as early as the 18<sup>th</sup> century, which show that at that time it was one of the most important articles of provision. By the present days, the grafting of watermelon has gained in importance. Due to the extreme weather characteristics of the country, a further considerable increase in the area of grafted plants is expected.

In order to select the suitable combination of rootstock and scion variety it is necessary to know the characteristics of the rootstock: the type of root system, resistance, effect on growth vigour, effect on fruit ripening, etc. As many as 6 to 7 varieties can be considered for watermelon rootstock. In Asia, grafted vegetables had already been brought into cultivation several centuries ago (Lee and Oda, 2003). In Korea and Japan grafted watermelon transplants were produced on a large scale already in 1920 (Lee, 1994), but in the Western world their use in production started only from 2005 onwards (Ristaino and Thomas, 1997). The reason of using grafted transplants consisted in the protection against soil borne pests and diseases, as chemical and genetic methods had failed to reach the desired effect (Oda, 2002). Grafted transplants show a better reaction to novel diseases besides offering a cheaper and more flexible solution compared to the development of a resistant variety by breeding. Simultaneously, it can assist in the improvement of quality and yields (Lee and Oda, 2003; Nisini et al., 2002; Oda, 2002; Rivero et al., 2003; Romero et al., 1997; Shimada and Moritani, 1977; Yetisir and Sari, 2003; Traka-Marovna et al., 2000).

Nowadays, for the use of grafting many other reasons exist, e.g. resistance of grafted plants to low and high temperatures, increased salt tolerance, increased absorption and more efficient use of water (Cohen and Noar, 2002).

Due to the importance of the subject, the aim of the experiment was to study the quantitative and qualitative changes in response to watermelon grafting by the different type of rootstocks, interspecific hybrid and *Lagenaria* genus.

### Material and methods

Combinations of watermelon variety 'Bonta' and two rootstock types were studied in the experiment. The interspecific hybrid rootstock was represented by 'RS 841' and the *Lagenaria* genus by the variety 'FR Strong'. It was considered important to study both types of rootstock, due to different characteristics. The experiment was set up in the greatest watermelon growing region of Hungary.

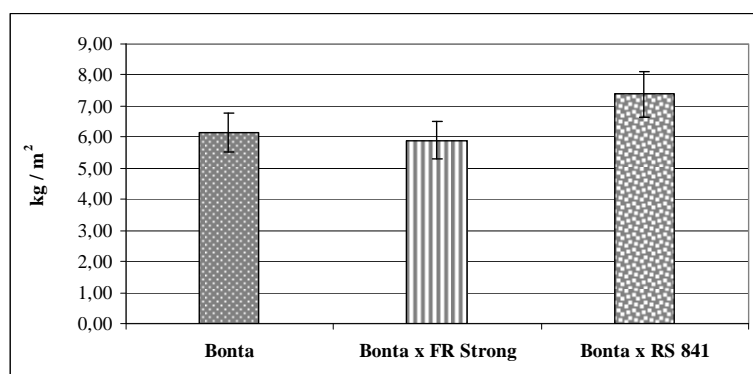
Seeds of the scion variety were sown in polystyrene trays with 96 cells, on 3<sup>rd</sup> of March 2009. The rootstocks and the own-root plants used for control were sown in soil blocks on 11<sup>th</sup> of March 2009. The grafting by the simple 'Japanese' one cotyledon grafting method was done on 19<sup>th</sup> of March 2009. The method essentially consists in leaving one cotyledon of the rootstock and removing the other cotyledon together with the shoot tip, by an oblique (approximately 45°) cut. Also an oblique cut was made on the scion variety hypocotyls and than the two plant parts were carefully fitted together and fixed with special clips. The grafted plants were placed in the grafting chamber where suitable conditions are provided for graft union formation.

The experiment was conducted in the 3 replication on the soil type chernozem belonging to the category I. The grafted and non grafted plants were planted at different row and plant spacing, 3.2 x 1 m (0.31 plant·m<sup>-2</sup>) and 3.2 x 2 m (0.16 plant·m<sup>-2</sup>), respectively. Plants received four pesticide treatments over the growing season. No difference was made in the fertirrigation.

Fruit number and weight, also yield, have been established. For the purpose of laboratory analysis 1 fruit per replication was picked in approximately the same state of development. Samples were homogenized in a mixer and the refractometric value was determined by the manual digital refract meter (PAL-1, ATAGO) at the beginning of sample processing, in the optimum time for picking or, at the latest, one day later. The settled refractometric values corresponded to the amount of soluble dry matter (sugar, in this particular case) of the analysed material. Total and reducing sugar contents were determined using the Luff-Schorl method.

### Results and discussion

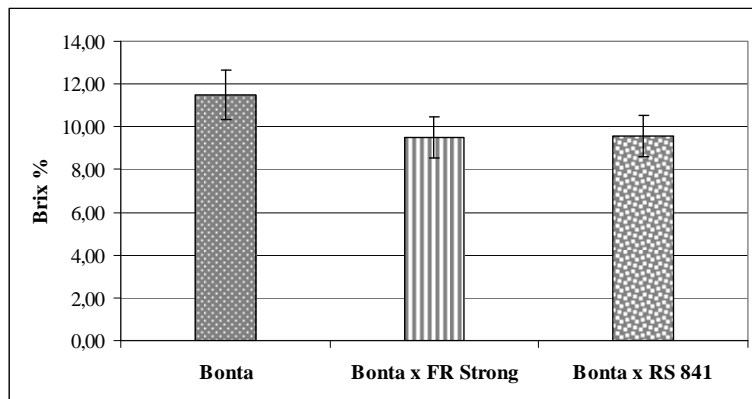
Fruit harvest, consisting of 3 pickings, began on the 6th of July 2009 and terminated with the removal of the plants on the 15th of July 2009. No difference was observed between the time of ripening of the non-grafted and the grafted plants.



Graph 1 Yield of the variety 'Bonta' and grafted variants, 2009

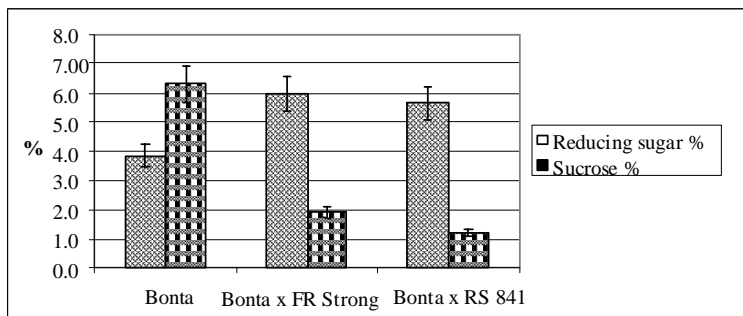
Yield increase in response to grafting is described in the literature and also the yield reducing effect of certain rootstock types. In the experiment, neither rootstock types resulted with significant yield increase. The lowest result was achieved by the 'Bonta' grafted on the rootstock *Lagenaria*, but no significant decrease in yields was observed compared to the non grafted treatment. The highest yield was obtained by the 'Bonta' grafted on the interspecific rootstock 'RS 841' (graph 1).

The highest refractometric values of homogenized watermelon fruits samples, which positively manifested in flavour, showed non grafted plants (graph 2). Grafting with both rootstock types resulted in the decrease of refractometric values. No significant difference was observed between the refractometric values affected by the rootstock types.



Graph 2 Refractometric values of the variety 'Bonta' and grafted variants, 2009

Analysing the sugar content, the percentage of reducing sugars was determined. Glucose and fructose which are reducing sugars, showed an inverse proportion between the grafted and the non grafted variants (graph 3). The sucrose portion and the refractometric values achieved in the graft treatments had the same relationship to data noted in non grafted treatment. The highest refractometric values was obtained on the non grafted 'Bonta' and also the highest sucrose content was registered on this variety, though the highest standard deviation was observed here. The reducing sugar contents of the fruits of 'Bonta' grafted on different rootstocks showed almost the same values.



Graph 3 Sugar contents of the variety 'Bonta' and grafted variants, 2009

## Conclusions

In the year of the experiment the variety 'Bonta' grafted on both rootstock types (interspecific hybrid and *Lagenaria*,) proved to be more resistant to adverse weather conditions, which is attributed to the more intense activity of roots. Intensive field vegetable production, including watermelon production, involves great investment and high risks. Grafting, as a kind of vegetative propagation, can reduce the growing risks together with greater yield stability.

The majority of growers and experts generally calculate with higher yield in the case of grafted watermelon, independent of the type of rootstock, compared to non grafted plants. According to this field experiment it can be concluded that grafting did not produce increased watermelon yields in each case. 'Bonta' grafted on the rootstock in *Lagenaria* type, 'FR Strong', produced around 4% lower yields than the non grafted plant. On the other hand, the interspecific hybrid rootstock 'RS 841' showed about 20% higher yield than the non grafted variant. In the course of the field tests no sign of postponement of ripening was seen, mentioned by many authors. Based on the respective tests, the rootstock 'RS 841' proved to be superior to rootstock 'FR Strong'.

In the measurement of the refraction in the laboratory tests it was concluded that grafting resulted a decrease of the values registered. None of the plants grafted on either of the rootstock had fruits showing the same or a higher Brix% compared to the fruits of the non grafted plants.

In the determination of sugar content inverse proportionality was found between the reducing and the non reducing sugars. The fruits of the non grafted plants had higher sucrose content than the fruits from the grafted plants. The proportion of the reducing sugars (glucose and fructose) showed an opposite pattern. In

the fruits of the grafted plants higher values of these fractions were measured. Based on these results it can be concluded that the refractometric values and sucrose responsible for the sweet taste are in a close correlation as a high Brix% is coupled with a high sucrose value.

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# Utjecaj sorte, izravnog prekrivanja i roka berbe na rast i prinos mladog krumpira

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## Sažetak

Cilj istraživanja je bio utvrditi utjecaj sorte, prekrivanja usjeva i roka berbe na rast i prinos mladog krumpira. Najbrže su nikle sorte Adora i Jaerla, a Berber je imao najviše izdanka po matičnom gomolju. Prekrivanje je ubrzalo nicanje, rast i cvatnju. Sorte nisu utjecale na tržišni prinos, ali je zato Jaerla imala najveći prinos netržišnih gomolja >80 mm, a Berber <30 mm. Prekrivanjem se povećao tržišni prinos, prinos gomolja >80 mm i ukupan prinos, a smanjio prinos gomolja <30 mm, osobito u 1. roku berbe. Rok berbe nije utjecao na tržišni prinos, ali je prinos bolesnih i oštećenih gomolja bio veći u 2. roku. U proizvodnji mladog krumpira preporučuje se prekrivanje agrotekstilom i berba u ranijem roku.

Ključne riječi: *Solanum tuberosum* L., agrotekstil, ranozrelost, rani krumpir, tržišni prinos

## Effect of variety, direct covering and date of harvest on the early potato growth and yield

### Abstract

The effect of cultivar, direct covering, and date of harvest on growth and yield of early potato were studied. The fastest germination was found in Adora and Jaerla, while the highest number of sprouts was found in Berber. Germination, growth and flowering were enhanced by covering. Marketable yield was not affected by cultivar, but non-marketable one was the highest for Jaerla (>80 mm) and Berber (<30 mm). Yield of tubers >80 mm, marketable and total yield were higher for covered plants. The yield of tubers <30 mm was lower in covered plants in first harvest. The marketable yield was not effected by the date of harvest, but yield of diseased and damaged tubers increased in the second harvest. Use of direct covering and early harvest could be recommended for early potato production.

Key words: early potato, early yield, marketable yield, nonwoven polypropylene cover, *Solanum tuberosum* L.

### Uvod

Prema definiciji svjetski priznatih UNECE standarda iz 2006. godine, pod pojmom rani krumpir podrazumijevaju se "...gomolji krumpira dobiveni od ranih sorti i/ili pobrani na početku sezone u zemlji uzgoja, pobrani prije potpune zrelosti, stavljeni na tržište odmah nakon berbe i čija se kožica lako skida bez guljenja".

Proizvodnja mladog, odnosno, ranog krumpira u Hrvatskoj ima dugogodišnju tradiciju u obalnom području Dalmacije i Istre (Lešić i sur., 2002). Upravo klimatski uvjeti tih područja omogućavaju najraniju komercijalnu berbu mladog krumpira, na otvorenom, koja u prosjeku započinje nakon 1. svibnja u Dalmaciji i 20-ak dana kasnije u Istri. Međutim, tržište zahtjeva još raniju proizvodnju što je sa standardnom tehnologijom u postojećim klimatskim uvjetima nemoguće postići.

Glavni limitirajući faktori u ranoj proizvodnji mladog krumpira su temperature tla i zraka u prvoj polovici vegetacijskog razdoblja (Sale, 1979; Nishibe i sur., 1989). Zbog toga je nužan ispravan izbor sorti i tehnologije koja će i pri nižim okolinskim temperaturama ubrzati razvoj gomolja do veličine pogodne za berbu.

Na sortnoj listi RH iz 2010. godine nalazi se čak 136 različitih sorti krumpira (Zavod za sjemenarstvo i rasadničarstvo, 2010). U proizvodnji je prošireno svega desetak sorti od kojih je samo nekoliko pogodno za ranu proizvodnju mladog krumpira. Sorte pogodne za ranu proizvodnju mladog krumpira moraju imati sposobnost brzog formiranja i rasta gomolja, one već za 60 do 70 dana od sadnje daju ekonomski prihvatljive gomolje određene tehnološke krupnoće (Lešić i sur., 2002).

Jedan od načina osiguranja veće temperature tla i zraka oko biljke je izravno prekrivanje usjeva agrotekstilom (netkana polimerna vlakna). Prekrivanje usjeva krumpira agrotekstilom značajnije utječe na povećanje prinosa ranog mladog krumpira u odnosu na nepokriveni usjev u najranijim rokovima berbe (Hamouz i sur., 2005; Jablońska-Ceglarek i Wadas, 2005).

Zbog toga je cilj ovog istraživanja bio utvrditi utjecaj sorte, izravnog prekrivanja i roka berbe na nicanje, rast i prinos ranog mladog krumpira u Istri na crvenici.

### Materijal i metode

Trofaktorijalni poljski pokus postavljen je tijekom 2008. godine na obiteljskom gospodarstvu u okolici Pule (Pomer). Pokus je postavljen po split-split-plot shemi u tri ponavljanja.

Glavni faktor (sorta) uključivao je četiri sorte koje se najčešće koriste za proizvodnju mladog krumpira u Istri: Adora, Jaerla i Berber (bijele) te Red Scarlet (crvene boje kože). Pod-faktor (prekrivanje) obuhvaćao je uzgoj bez prekrivanja usjeva i s prekrivanjem agrotekstilom, te pod-pod-faktor (rok berbe) imao je dvije stepenice, iskapanje krumpira 62 i 70 dana nakon nicanja ispod agrotekstila, odnosno, 2. i 10. lipnja.

Osnovna parcela sastojala se od 4 reda krumpira ukupne širine 3,5 m i dužine 10,5 m (36,75 m<sup>2</sup>). Obračunsku parcelu činila su dva srednja reda.

Nakon berbe pretkulture, tlo je u kasnu jesen orano na 30 cm dubine, gnojeno kompleksnim mineralnim gnojem NPK 7-14-21 (753 kg/ha) i frezано. Nekoliko dana prije sadnje gomolji krumpira su tretirani insekticidno-fungicidnim preparatom Prestige (1 dcl na 100 kg gomolja). Cijeli gomolji kalibraže 28 do 35 mm posađeni su 13. veljače na razmak 0,70 m x 0,35 m, što daje sklop 4,08 biljaka na m<sup>2</sup>. Nakon sadnje apliciran je herbicid Sencor u količini 1 kg/ha, nakon čega je postavljen agrotekstil trgovačkog imena Lutrasil, težine 17 g/m<sup>2</sup>. Parcele prekrivene agrotekstilom otkrivene su 50 dana nakon nicanja (20. svibnja). Tijekom vegetacije provedene su osnovne mjere njege. Zaštita usjeva od štetočinja provedena je dva puta preparatom Ridomil MZ u koncentraciji od 0,3%. Kultivacija je provedena u fazi kada su biljke bile visoke oko 15 cm, a nagrtanje je provedeno plugom nagrtačem, također, jednom pred zatvaranje redova. Navodnjavanje rasprskivačima je provedeno jednom tijekom cvatnje krumpira.

Nicanje 100% biljaka prekrivenog usjeva bilo je 30. do 31. ožujka, a neprekrivenog 5. do 6. travnja. Mjerenje parametara rasta obavljeno je 3 tjedna nakon nicanja krumpira ispod agrotekstila (21. travnja) na 20 biljaka po tretmanu za sortu, odnosno, 10 biljaka po tretmanu za prekrivanje. Za mjerenje su uzete srednje biljke iz dva srednja reda po parceli. Od parametara rasta određena je visina najvišeg izdanka, broj izdanaka po matičnom gomolju i broj listova najdužeg izdanka (list duži od 2 cm).

Berba krumpira obavljena je prema planu u dva roka berbe i to prva 62, a druga 70 dana nakon nicanja ispod agrotekstila (2. i 10. lipnja). U prvom roku berbe iskapanje gomolja je obavljeno ručno vilama, a u drugom roku berbe plugom razgrtačem. Gomolji su sortirani na tržne (promjer 30 do 80 mm) i netržne (promjer > 80 mm i < 30 mm te bolesni i oštećeni) te su izbrojani i izvagani po kategorijama. Na osnovu toga određen je prinos po kategorijama i ukupan prinos.

Dobiveni podaci su statistički obrađeni analizom varijance, a srednje vrijednosti su uspoređene LSD-testom na razini signifikantnosti  $P \leq 0,05$  (SAS, 1999).

## Rezultati i rasprava

Sorta i prekrivanje agrotekstilom utjecali su na nicanje biljaka, dok je agrotekstil više utjecao na mjerene parametre rasta i cvatnju od sorte (tablica 1). Broj dana od sjetve do nicanja kao i broj izdanaka po matičnom gomolju ovisio je o sorti. Sorte Adora i Jaerla niknule su jedan dan prije u odnosu na ostale dvije sorte, dok je Berber imao veći broj izdanaka po posađenom matičnom gomolju u odnosu na preostale sorte. Da je broj izdanaka po matičnom gomolju sortna karakteristika potvrđuje, također, Lešić i sur. (2002). Prekrivanje Lutrasilom ubrzalo je nicanje za čak 6 dana u odnosu na neprekriven usjev. Biljke krumpira koje su bile prekrivene agrotekstilom imale su veći broj izdanaka po posađenom matičnom gomolju i veći broj listova po izdanku od neprekrivenih biljaka. Brže nicanje i bolji vegetativni rast mladog krumpira prekrivenog agrotekstilom, u svom istraživanju ostvarili su Hamouz i sur. (2005). Neprekrivene biljke nisu cvale za razliku od prekrivenih koje su imale u prosjeku 22% biljaka u cvatu. Brže nicanje, jači vegetativni rast te cvatnja vjerojatno je uvjetovano višom temperaturom i boljim uvjetima koji su vladali ispod agrotekstila u odnosu na neprekriven usjev. Ove činjenice slažu se s istraživanjima Hamouza i sur. (2005) koji ističu da je povoljniji utjecaj agrotekstila na rast i razvoj krumpira zabilježen u godinama s nepovoljnijim klimatskim prilikama u početnom razvoju usjeva. Naime, oni ističu da je temperatura tla i minimalna dnevna temperatura viša u usjevu pokrivenom agrotekstilom u odnosu na neprekriveni, što je vrlo bitno na početku vegetacije kada na otvorenom još ne vladaju optimalni uvjeti za rast i razvoj krumpira.

**Tablica 1. Utjecaj sorte i izravnog prekrivanja na nicanje i rast mladog krumpira (tri tjedna nakon nicanja ispod Lutrasila) u Puli (Pomer), 21.4.2008.**

Tretmani	Broj dana od sjetve do nicanja	Postotak niknulih biljaka (%)	Visina najvišeg izdanka (cm)	Broj izdanaka po matičnom gomolju	Broj listova najdužeg izdanka	Broj procvalih biljaka
Sorta(S)						
Adora	49 b <sup>1</sup>	100 a	20,1 a	2,4 b	8,1 a	1,2 a
Berber	50 a	97 a	22,8 a	3,9 a	8,5 a	0,8 a
Jaerla	49 b	97 a	19,2 a	2,3 b	8,1 a	1,0 a
Red Scarlet	50 a	97 a	20,8 a	2,5 b	8,0 a	1,3 a
Prekrivanje agrotekstilom (P)						
Lutrasil	47 a	100 a	29,8 a	3,0 a	10,3 a	2,2 a
Bez	53 b	97 a	11,6 b	2,6 b	6,1 b	0,0 b
Lutrasila						
Interakcija						
S x P	ns <sup>2</sup>	ns	ns	ns	ns	ns

<sup>1</sup>Različita slova u stupcima pokazuju značajne razlike temeljem LSD-testa na razini signifikantnosti  $P \leq 0,05$  za istraživane faktore

<sup>2</sup>ANOVA, ns - nije signifikantan ( $P > 0,05$ )

Najveći utjecaj na prinos mladog krumpira između istraživanih faktora ima prekrivanje usjeva agrotekstilom (tablica 2). Sorta nije značajnije utjecala na prinos tržnih, bolesnih i oštećenih gomolja kao ni na ukupni prinos. Međutim, najveći prinos gomolja promjera  $> 80$  mm imala je sorta Jaerla, dok sorta Berber uopće nije imala takvih gomolja, ali je zato imala najveći prinos gomolja manjih od 30 mm. Razlika u veličini gomolja povezana je s genetskom konstitucijom sorte. Naime sorta Berber formira u prosjeku gomolje manje prosječne mase i ubraja se u nešto kasnije sorte po dozrijevanju u odnosu na ostale istraživane sorte.

Prekrivanje usjeva Lutrasilom povećalo je prinos tržnih gomolja za 10,6% u odnosu na neprekriveni usjev. Prinos gomolja  $> 80$  mm i ukupan prinos, također, je povećan kod usjeva krumpira koji je prekriven agrotekstilom, ali je zato smanjen prinos gomolja  $< 30$  mm što se može tumačiti bržim razvojem i rastom gomolja uslijed povoljnije mikroklike ispod agrotekstila. U istraživanjima Hamouz i sur. (2005) te Hamouz i Dvořák (2004) prekrivanje usjeva agrotekstilom povećalo je prinos gomolja mladog krumpira od 14,9% do 507,8%, ovisno o uvjetima u sezoni proizvodnje. U ovom istraživanju pojava bolesnih i oštećenih gomolja nije ovisila o prekrivanju usjeva agrotekstilom.

Rok berbe značajnije je utjecao samo na pojavu bolesnih i oštećenih gomolja, a time i na ukupan prinos gomolja. Naime, u prvom roku berbe nije bilo bolesnih i oštećenih gomolja mladog krumpira za razliku od drugog roka. Ovaj je rezultat i logičan obzirom da sa starenjem usjeva učestalije dolazi do pojave bolesti i štetnika na biljci pa tako i na gomoljima.



## Utjecaj sorte, izravnog prekrivanja i roka berbe na rast i prinos mladog krumpira

Značajan utjecaj interakcija utvrđen je između sorte i prekrivanja na prinos gomolja < 30 mm, zatim interakcija sorte i roka berbe na prinos bolesnih i oštećenih gomolja te interakcija između prekrivanja i roka berbe na prinos tržnih gomolja i ukupnog prinosa (tablica 2). Interakcijom sorte i prekrivanja utvrđeno je da uzgoj bez prekrivanja agrotekstilom kod Berbera i Jaerla utječe na povećanje prinosa gomolja < 30 mm za razliku od Adore i Red Scarleta gdje je prinos malih gomolja podjednak kod prekrivenog i neprekrivenog usjeva (podaci nisu prikazani). Kod sorte Berber, rok berbe nije utjecao na razvoj bolesnih i oštećenih gomolja kao što je to bio slučaj s ostalim sortama (podaci nisu prikazani). Naime, kod tri ostale sorte u drugom roku berbe utvrđen je prinos gomolja koji su bili bolesni i oštećeni. To se može tumačiti time što je sorta Berber nešto kasnija sorta pa se pojava bolesti i štetnika na gomolju pojavljuje kasnije sa sazrijevanjem gomolja. Interakcijom prekrivanja i roka berbe utvrđeno je da je najmanji prinos tržnih gomolja i ukupan prinos ostvaren u prvom roku berbe bez prekrivanja (podaci nisu prikazani). To nam govori da prekrivanje nije značajno utjecalo na tržni prinos u kasnijim rokovima berbe jer se ne ostvaruju značajno veći prinosi u odnosu na neprekriveni usjev, ali se zato povećavaju troškovi nabavke i postavljanja agrotekstila, što se mora uzeti u obzir prilikom preporuka tehnologije uzgoja mladog krumpira. Ove rezultate potvrđuju istraživanja Hamouza i sur. (2005) koji su utvrdili značajno veće prinose mladog krumpira uzgajanog ispod agrotekstila u prvim rokovima berbe dok se u kasnijim rokovima berbe, krajem lipnja, prinos nije razlikovao od neprekrivenog usjeva.

Tablica 2. Utjecaj sorte, izravnog prekrivanja i roka berbe na prinos mladog krumpira u Puli (Pomer), 2008.

Tretmani	Tržni gomolji, t/ha (Ø 30-80 mm)	Netržni gomolji, t/ha			Ukupno gomolja, t/ha
		(Ø >80 mm)	(Ø <30 mm)	Bolesni i oštećeni	
Sorta (S)					
Adora	30,4 a	0,2 b	1,2 b	0,1 a	31,9 a
Berber	35,9 a	0,0 b	3,4 a	0,0 a	39,3 a
Jaerla	30,3 a	1,6 a	1,9 b	0,4 a	34,2 a
Red Scarlet	35,8 a	0,4 b	1,3 b	0,0 a	37,5 a
Prekrivanje agrotekstilom (P)					
Lutrasil	34,9 a	0,9 a	1,7 b	0,2 a	37,7 a
Bez Lutrasila	31,2 b	0,2 b	2,2 a	0,1 a	33,7 b
Rok berbe (R)					
Berba, 2.6.	32,4 a	0,4 a	1,8 a	0,0 b	34,6 b
Berba, 10.6.	33,7 a	0,7 a	2,1 a	0,3 a	36,8 a
Interakcija					
S x P	ns	ns	**	ns	ns
S x R	ns	ns	ns	*	ns
P x R	*	ns	ns	ns	*
S x P x R	ns	ns	ns	ns	ns

<sup>1</sup>Različita slova u stupcima pokazuju značajne razlike temeljem LSD-testa na razini signifikantnosti  $P \leq 0,05$  za istraživane faktore

<sup>2</sup>ANOVA, ns - utjecaj nije signifikantan ( $P > 0,05$ ) ili je signifikantan pri  $P < 0,05^*$ ,  $P < 0,01^{**}$

### Zaključak

U ovom istraživanju, sorta nije značajnije utjecala na tržni prinos mladog krumpira. Prekrivanje agrotekstilom značajno je povećalo prinos tržnih gomolja, gomolja većih od 80 mm i ukupan prinos, ali je zato smanjilo prinos gomolja manjih od 30 mm, što je naročito izraženo u prvom roku berbe. Rok berbe nije značajnije utjecao na tržni prinos, ali u drugom roku berbe možemo očekivati veći prinos bolesnih i oštećenih gomolja. Stoga se, u proizvodnji ranog mladog krumpira preporučuje prekrivanje usjeva agrotekstilom i berba u ranijim rokovima.

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# Aspekt obnove i zaštite Botaničkog vrta Zemaljskog muzeja BiH u svrhu očuvanja ambijentalnih vrijednosti

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## Sažetak

Najstarija kulturna i znanstvena ustanova u Bosni i Hercegovini Zemaljski muzej, smješten u građevine u stilu talijanske renesanse u centru Sarajeva na površini od 24.070 m<sup>2</sup> u svom sklopu sadrži i Botanički vrt. Botanički vrt je objekt specijalne namjene i vrijedan je spomenik kulturno-historijskog naslijeđa. Zauzimajući površinu od 14.270 m<sup>2</sup>, a imajući u vidu urbanističku karakteristiku Zemaljskog muzeja BiH za Sarajevo, po svojoj lokaciji, stilu, tradiciji i publicitetu zahtijeva pravilan pristup pri obnovi i zaštiti ne mijenjajući pri tome specijalnu namjenu istog, odnosno utemeljene ekološke i biološke principe. Prikupljanjem dostupnog dokumentacijskog i literaturnog materijala o Botaničkom vrtu Zemaljskog muzeja iz institucija BiH: Arhiv, Nacionalna biblioteka, Biblioteka Zemaljskog muzeja i provedenim procesom identifikacije i inventarizacije biljnog fundusa u Botaničkom vrtu, kao i izvršenim mjerenjima i procjenom pojedinačnog i ukupnog stanja, dati su prijedlozi mjera zaštite kao i prijedlozi budućeg izgleda, kako bi se vrtna površina Zemaljskog muzeja BiH valorizirala kao vrijedan dokument vremena u kojem je nastao.

Cilj rada je da se provedenim procesom identifikacije i inventarizacije biljnog fundusa kao i izvršenom analizom cjelokupne vrtno površine Zemaljskog muzeja BiH ukaže na značaj mogućnosti realizacije nekih segmenata prvobitnih, nerealiziranih zamisli Botaničkog vrta prilikom obnove, radi stvaranja harmonične sredine bioloških i arhitektonskih elemenata.

Ključne riječi: Zemaljski muzej BiH, zbirke hortikulturno vrijednih biljaka, zaštita, obnova

## The aspect of reconstruction and protection of the Botanical Garden of the National Museum of Bosnia and Herzegovina for the purpose of preservation of ambiental values

### Abstract

The National Museum is the oldest cultural and scientific institution in Bosnia and Herzegovina, and it is placed in italian renaissance-style building in the centre of Sarajevo, on the surface of 24.070 m<sup>2</sup>, which comprises a Botanical Garden. The Botanical Garden is the object with special purpose, and the valuable monument of cultural and historical inheritance. It takes the area of 14.270 m<sup>2</sup>, and considering the urbanistic characteristics of the National Museum of Bosnia and Herzegovina by its location, style, tradition and publicity it requires a correct approach in reconstruction and protection, by not changing its special purpose, meaning, its basic ecological and biological principles. By collecting available documentation and literature sources about the Botanical Garden of Bosnia and Herzegovina from The

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Proceedings. 46<sup>th</sup> Croatian and 6<sup>th</sup> International Symposium on Agriculture. Opatija, Croatia (501-505)

Archive, The National Library, The Library of The National Museum of Bosnia and Herzegovina and by conducting process of identification and inventarisation of plant fundus in the Botanical Garden, and the conducted measurements and assessments of the individual and overall condition, the proposals for the protection measurements and the proposals for the future appearance, in order to valorise the Botanical Garden's surface as the valuable document of the time that it was created in.

The aim of this paper is to show the importance of the possibilities of realisation of some segments of the first, unrealized ideas about the Botanical Garden upon the reconstruction, for the creation of harmonical unity of the biological and architectural elements, by the conducted process of identification and inventarisation of plant fundus, and the analysis of the entire garden surface of the National Museum of Bosnia and Herzegovina.

Key words: National Museum of Bosnia and Herzegovina, collections of horticulturally valuable plants, protection, reconstruction

## Uvod

Pojava gradskih zelenih površina u Sarajevu javlja se u austrougarskom periodu. Do tada nije ni bilo potrebe za njima, jer je svaka obitelj imala vlastitu kuću u ansamblu, s baštom i avlijom (Kurto, 1998.). Zajedno s arhitekturom i urbanizmom, uloga vrtova i parkova u Sarajevu se mijenja i biva u funkciji vladajuće klase (Avdić & Ljujić-Mijatović, 2003.). Urbanizacijom u XX. stoljeću, naročito nakon 1945. godine, izgradnja se manje-više odvijala nekontrolirano, što je imalo za posljedicu da stilske vrijednosti kao dio kulturne baštine i tradicije u različitim epohama budu znatno narušene (Ljujić-Mijatović & Švrakić, 2006.). Imajući u vidu urbanističku karakteristiku Zemaljskog muzeja za Sarajevo po svojoj lokaciji, stilu, tradiciji i publicitetu, prilikom obnove Botaničkog vrta potrebno je zaštititi stilski i povijesni kontekst istog (Kurto, 1998.). U svrhu očuvanja ambijentalnih vrijednosti razmatrane su metode obnove kao što su restauracija, rekonstrukcija, rekonpozicija, replika, konzervacija i revitalizacija kako bi se pravilno pristupilo obnovi vrtne površine Zemaljskog muzeja s aspekta očuvanja botaničko-hortikulturnog spomenika u skladu s monumentalnim građevnim zdanjima kao jedinstvenog kulturno-historijskog i prirodoslovnog objekta od prvorazrednog značaja za našu kulturnu i prirodnu baštinu nastalu u austrougarskom periodu.

## Materijal i metode

Botanički vrt Zemaljskog muzeja osnovan 1913./1914. godine jeste prva namjenski građena institucija te vrste u Bosni i Hercegovini. Brojnim namjenskim sadržajima ucrtanim u konačnu verziju plana date su smjernice za uspostavu ove površine koja će se urbanistički, prema Luncov-oj klasifikaciji zelenih površina, ubrojiti u kategoriju nasada specijalne namjene (Ljujić-Mijatović & Mrdović, 1998.). Nasadi, konceptijski tada već određeni, a kasnije sadržajno prošireni i upotpunjeni, uzdići će vrtu površinu Zemaljskog muzeja na zavidan nivo. Iako na znatno manjoj površini u usporedbi s europskim botaničkim vrtovima, sadržajno biljni fundus postepeno se povećavao do broja od 3000 biljnih vrsta (Šilić, 1988.). Na taj način je vrtna površina Zemaljskog muzeja u potpunosti ispunjavala svoju osnovnu, namjensku zadaću u kojoj je spomenuti broj biljnih vrsta, podvrsta i varijeteta sađen u svrhu znanstveno-istraživačkog rada po određenom planu i programu (Kreševljaković, 1969.; Krzović, 1987.; Kundela *et al.*, 2007.).

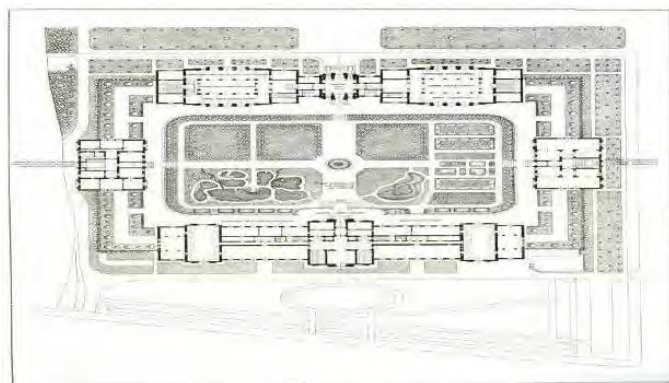
Međutim, tragom arhivskih dokumenata prikupljenih iz institucija Bosne i Hercegovine: Arhiv, Nacionalna biblioteka i Biblioteka Zemaljskog muzeja doznaje se više o prvobitnoj namjeni zelene površine Zemaljskog muzeja, kojoj se davao mnogo veći značaj kao gradskoj zelenoj površini austrougarskog perioda.

Originalnim planom predviđena i dokumentirana namjena zelene površine Zemaljskog muzeja razmatrana je radi izbora metoda obnove i zaštite, kojima bi se nekim dijelovima Botaničkog vrta vratila predviđena funkcija radi očuvanja stilskog i povijesnog karaktera cjelokupne zelene površine. Identifikacija biljnog fundusa vršena je radi ocjene pojedinačnog i cjelokupnog stanja iskorištenosti vrtne površine, a usporedba s prvobitnom, idejno-projektnom dokumentacijom (skice, tlocrti i planovi), u svrhu vraćanja predviđene funkcije neiskorištenim dijelovima Botaničkog vrta, da bi se zaštitio karakter zelene površine uz objekt kulturno-historijskog naslijeđa iz austrougarskog perioda.

U svrhu očuvanja ambijentalnih vrijednosti u konačnici je dat prijedlog rješenja korištenja vrlo značajne, neiskorištene vrtne površine u neposrednoj blizini monumentalne građevine.

### Rezultati i rasprava

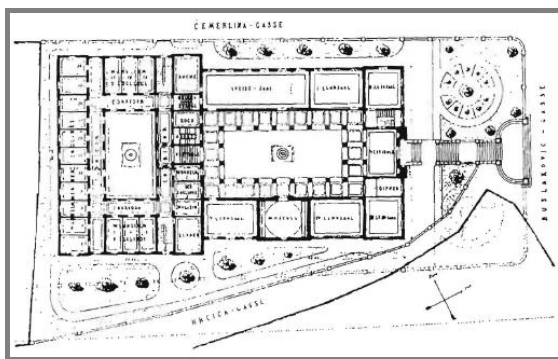
Prikupljanjem arhivske građe o Botaničkom vrtu, odnosno uvidom u prvobitnu zamisao uređenja zelene površine Zemaljskog muzeja, može se pratiti kako je dolazilo do izmjena u osmišljavanju uređenja ove zelene površine tijekom jednog desetljeća, sve do konačne uspostave plana Botaničkog vrta. Skice, tlocrti, i planovi iz 1906., 1907., 1912. i 1913./1914. godine to potvrđuju.



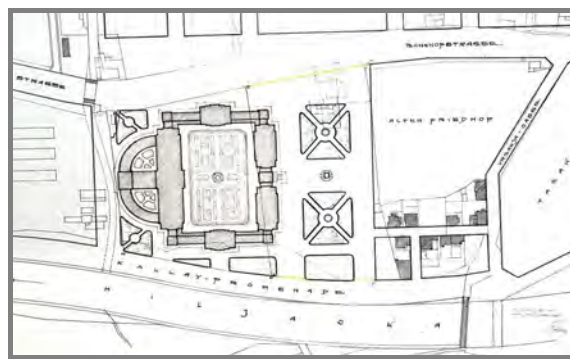
Slika 1. Tlocrt cjelokupnog građevinskog rasporeda novog Zemaljskog muzeja u prizemlju

(Glasnik Zemaljskog muzeja u BiH, XXVI. 1914., tabla V.)

Period nastanka Botaničkog vrta vezuje se za početni period uređenja gradskih zelenih površina u Sarajevu pod upravom Austrougarske monarhije. Specifičnosti vrtne baštine, iako nedovoljno istražene, na neki način se mogu upoznati preko projekata arhitektonskih zdanja tog perioda. Impozantna građevna zdanja arhitekta Karla Paržika iz tog perioda u prvobitnim planovima imaju vrtne rješenja, stilski usmjerena k renesansnim vrtovima koje karakterizira monumentalnost, potpuna simetrija, terase s vrtim parterima i vodoscoci. Ne ulazeći dublje u problematiku parkovne baštine austrougarskog perioda dat je prikaz tlocrta (sl. 2., sl. 3.) u kontekstu sličnosti prvobitnog stilskog rješenja zelene površine Šerijatske sudačke škole i plana uređenja okolice Zemaljskog muzeja.



Slika 2. Plan Šerijatske sudačke škole, 1887. godina



Slika 3. Plan Botaničkog vrta, 1907. godina

Biblioteka Zemaljskog muzeja BiH

Prema originalnom planu (sl. 3.), zelena površina Zemaljskog muzeja imala je funkciju gradske zelene površine, riješene parterom, a sama građevina, podignuta na tadašnjoj periferiji grada predstavljala je početak planiranog širenja Sarajeva ka ravnici Sarajevskog polja, čime je ujedno i svjedok urbanog razvoja grada. Zbog navedenih činjenica pristup obnovi Botaničkog vrta treba u potpunosti biti zaštitnog karaktera valorizirajući površinu kao jedinstveni kulturno-historijski spomenik od prvorazrednog značaja naše kulturne i prirodne baštine nastale u austrougarskom periodu. Naime, parkovno uređen prostor oko paviljona i niži Botanički vrt, kojeg opasuje terasa koja ga vezuje s paviljonima i paviljone međusobno, visoke

su urbane kvalitete primjerene namjeni. Tako, muzejski kompleks, iako velik, zbog vanredno oblikovane paviljonske koncepcije ne djeluje ni najmanje glomazno ni strano ambijentu grada (Božić, 1989.). Iz raspoloživog dokumentacionog materijala u prvobitnom planu uređenja zelene površine u oblikovnom i strukturalnom smislu uočljiva je stilska karakteristika renesansnih vrtova. Iako konceptijski znatno izmijenjen u odnosu na skice, tlocрте i planove iz 1906., 1907., 1912. i 1913./1914. godine, može se uočiti da centralni dio Botaničkog vrta Zemaljskog muzeja zadržava karakteristične, osnovne elemente renesansnih vrtova. Dakle, površina je i dalje planski organizirana kao jedinstvena cjelina, dispozicija je i dalje geometrijska, iako izmijenjena biološkim sastavom. Pravilne geometrijske zelene plohe dijele unakrsne staze koje vode do stepeništa sa uzdignutom terasom istovremeno ih povezujući sa samom građevinom. Iz dokumentacionog materijala prvobitne zamisli ove vrtne površine (sl. 3.) geometrijske zelene plohe izdijeljene na manje četverokutne zelene površine u konačnoj verziji plana (sl. 1.) čine jedinstvenu cjelinu koja povezuje centralnu os sa središnjom fontanom. Terasa sa silaznim stepeništima, simetrični raspored vrtnih elemenata i dekorativni element vodoskoka ukazuju da su zadržane osnovne odlike renesansne vrtne umjetnosti (Milić, 1995.). Identifikacijom i analizom prisutnosti bioloških elemenata površinu Botaničkog vrta možemo okarakterizirati kao pejzažnu. Naime, prisutnost elemenata klasičnog stila zadržano je samo fragmentno i odnosi se na parkovno uređen prostor ispred glavnog ulaza u muzej okrenut ka glavnoj saobraćajnici. Da bi se spomenuti vrtni stil naglasio i istakao u oblikovnom i strukturalnom smislu, potrebno je unošenje onih bioloških elemenata koji su zastupljeni u renesansnim vrtovima.

Kako se elementi kompozicije u renesansnim vrtovima uglavnom ponavljaju noseći u sebi težnju za što većom izražajnošću, nameće se činjenica da parkovno uređen prostor ispred muzeja s geometrijski oblikovanom živicom i izložbenim arheološkim eksponatima u svrhu očuvanja cjeline i stilske karakteristike zelene površine Zemaljskog muzeja treba ponoviti. Za ovakvo rješenje razmatran je dio vrtne površine uz građevni objekt okrenut ka rijeci Miljacki, odnosno mirnijem dijelu grada. U vrijednosti ambijenta, arhitekture i vizure kao povezane cjeline razmatran je način primjene biljaka visoke hortikulturene vrijednosti putem podizanja ružičnjaka u klasičnom stilu. Ruže su predviđene za sadnju u lijehe geometrijskih oblika obrubljene nisko orezanom živicom (*Buxus sempervirens* L.) kako bi se istakla sva njihovu raskoš i suptilnost pojedinačnih skupina ruža.

Ružičnjak zasnovan na linijama geometrijske jednostavnosti, odnosno simetrije, većim dijelom obrubljen balustradama terase, omogućio bi povezanost s građevinom i osigurao harmoniju bioloških i arhitektonskih elemenata. Usklađivanje ruža u ružičnjaku, također, treba biti na način da se u skupinama ne manjim od pet jedinki usklade i različite veličine, što podrazumijeva sadnju niskih skupina naprijed, visokih u sredini a penjačica uz betonske staze. Površinu izdijeljenu betonskim stazama povezale bi ruže penjačice na pergolama, koje bi ujedno istakle i značajne ulaze u arheološke depoe. Time bi se omogućilo i izlaganje skulptura - arheoloških eksponata iz antike i srednjeg vijeka, čime bi se naglasio povijesni i stilski kontekst vrtne površine Zemaljskog muzeja s drugim europskim povijesnim renesansnim vrtovima. Geometrijski oblikovanom živicom ovaj bi prostor implicirao parkovno uređen prostor ispred muzeja gledajući na širi prostor u smislu očuvanja vrijednosti ambijenta, arhitekture i vizure kao povezane cjeline.

### Zaključci

- Raspoloživa arhivska građa o Botaničkom vrtu dokumentira izmjene nastale u osmišljavanju uređenja zelene površine Zemaljskog muzeja BiH tijekom jednog desetljeća do konačne uspostave plana.
- Planirana površina imala je više funkciju gradske zelene površine, riješene parterom, koja s građevinom predstavlja početak planiranog urbanog razvoja grada u austrougarskom periodu.
- Identifikacijom i analizom prisutnosti bioloških elemenata površina Botaničkog vrta okarakterizirana je kao pejzažna.
- Elementi klasičnog stila zadržani su samo fragmentno i odnose se na parkovno uređen prostor ispred glavnog ulaza u muzej, okrenut ka glavnoj prometnici.
- U Botaničkom vrtu su zadržane osnovne odlike renesansne vrtne umjetnosti: simetrični raspored vrtnih elemenata, terasa sa silaznim stepeništima i dekorativni element vodoskoka.
- Da bi se postigla izražajnost stilske kompozicije renesansnih vrtova, s elementima koji se ponavljaju, predlaže se podizanje ružičnjaka u klasičnom stilu na dijelu vrtne površine uz građevni objekt okrenut ka rijeci Miljacki.

- Geometrijski oblikovanom živicom ovaj bi prostor implicirao parkovno uređen prostor ispred muzeja gledajući na širi prostor u smislu očuvanja vrijednosti ambijenta, arhitekture i vizure kao povezane cjeline.

Pristup obnovi Botaničkog vrta treba u potpunosti biti zaštitnog karaktera, valorizirajući površinu kao jedinstveni kulturno-historijski spomenik kulturne i prirodne baštine nastale u austrougarskom periodu.

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# Prinos i kvaliteta "cherry" rajčice u hidroponskom uzgoju

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## Sažetak

Cilj ovog istraživanja bio je utvrditi komponente prinosa i kvalitativna svojstva dvije hibridne sorte "cherry" rajčice u hidroponskom uzgoju na kamenoj vuni, pri standardnoj i 50% povećanoj koncentraciji amonijevog nitrata u hranivoj otopini. Ovisno o primijenjenoj otopini, po biljci 'Sakura' je ubrano 76 do 80, dok je po biljci 'Sweet Million' ubrano od 62 do 75 tržnih plodova, mase 34, odnosno, 24 do 25 g. Veći broj krupnijih plodova rezultirao je znatno većim prinom sorte Sakura (8,15 do 8,88 kg/m<sup>2</sup>) u odnosu na sortu Sweet Million (5,05 do 5,92 kg/m<sup>2</sup>). U plodovima je utvrđen udio suhe tvari u rasponu od 7,96 do 9,16%. Udio topive suhe tvari je iznosio od 7,40 do 7,90 °Brix.

Ključne riječi: *Lycopersicon esculentum* Mill., amonijev nitrat, agronomska svojstva, suha tvar, topiva suha tvar

## Yield and quality of soilless grown cherry tomato

### Abstract

The aim of this study was to determine the yield components and quality characteristics of two cherry tomato cultivars grown on rockwool and fertigated with standard and 50% increased ammonium nitrate concentration in the nutrient solution. Depending on the applied solution, between 76 and 80, and between 62 and 75 marketable fruits per plant, weighted 34, ie, 24 to 25 g was harvested from cultivars Sakura and Sweet Million, respectively. Increasing number of larger fruits resulted in significantly higher yield of cultivar Sakura (8.15 to 8.88 kg/m<sup>2</sup>) compared to the cultivar Sweet Million (5.05 to 5.92 kg/m<sup>2</sup>). Dry matter content ranged from 7.96 to 9.16%, while the total soluble solids content was from 7.40 to 7.90 °Brix.

Key words: *Lycopersicon esculentum* Mill., ammonium nitrate, agronomic traits, dry matter, total soluble solids

### Uvod

Tržište svježih rajčica sve više traži plodove "cherry" i "coctail" rajčice zbog njihovih kvalitativnih i dekorativnih svojstava. Plodovi "cherry" rajčice mogu biti crvene, crveno-narančaste i žute boje. Sitni plodovi "cherry" kultivara imaju masu oko 15 do 20 g, dok nešto krupniji "coctail" plodovi teže oko 30 do 50 g. Broj plodova u grozdu varira ovisno o kultivaru. Budući da sve više proizvođača hidroponske rajčice zbog zahtjeva tržišta u svoj sortiment uvodi sorte "cherry" rajčice, provedeno je istraživanje s ciljem utvrđivanja kvantitativnih i kvalitativnih svojstava "cherry" rajčice u hidroponskom uzgoju na kamenoj vuni, pri standardnoj i povećanoj koncentraciji amonijevog nitrata u hranivoj otopini.



## Materijal i metode

Istraživanje je provedeno tijekom 2008. godine u negrijanom zaštićenom prostoru Zavoda za povrćarstvo, na pokušalištu Maksimir. U istraživanje su bila uključene dvije hibridne sorte "cherry" rajčice, 'Sakura' i 'Sweet Million'. Sjetva sjemena u čepove kamene vune je obavljena 13. ožujka, pikiranje biljčica u kocke 27. ožujka, a sadnja na ploče kamene vune 5. svibnja. Redovi su bili razmaknuti 100 cm, a biljke unutar reda 33 cm, tako da je ostvaren sklop 3,3 biljke/m<sup>2</sup>. Osnovnu parcelu su činile dvije ploče kamene vune sa 6 biljaka. Pokus je postavljen po metodi slučajnog blokno rasporeda u šest ponavljanja.

Nakon sadnje sve biljke su prihranjivane standardnom hranivom otopinom, sastava planiranog prema Sonneveldu (1991, prema Adams 2002). U spremnicima je pripravljena gotova hraniva otopina koja je sustavom navodnjavanja kapanjem distribuirana do svake biljke. Broj obroka je varirao od 12 nakon sadnje do 24 u punoj vegetaciji. Volumen hranive otopine po biljci iznosio je do 4,2 L dnevno. Variranje koncentracije amonijevog nitrata u hranivoj otopini započelo je mjesec dana nakon sadnje. Osim standardne otopine, primijenjena je otopina s 50% povećanom koncentracijom.

Tijekom vegetacije, biljke su redovito omatane oko veziva i pinicirani su zaperci. Cvjetne grane su prikraćivane na 10 do 11 cvjetova. Svakodnevno su mjerene minimalna i maksimalna temperatura i vlaga zraka u zaštićenom prostoru. pH- i EC-vrijednosti hranive otopine te koncentracija iona makroelemenata utvrđene su periodički u laboratoriju. Berba je započela 26. lipnja i trajala do 20. kolovoza. Obavljeno je četrnaest berbi tijekom kojih su ubrani pojedinačni plodovi s osam grozdova. Prilikom berbe utvrđeni su broj tržnih i netržnih plodova po biljci te masa i prinos tržnih plodova za svaki grozd i ukupno. U dva navrata, sakupljeni su uzorci plodova u kojima je utvrđen je udio suhe i topive suhe tvari.

Statistička obrada rezultata je obavljena analizom varijance (ANOVA), a prosječne vrijednosti su testirane LSD testom na razini signifikantnosti  $p \leq 0,01$  i  $p \leq 0,05$ .

## Rezultati i rasprava

Uz primjenu standardne otopine, po biljci sorte Sakura ubrano je 75,8 tržnih i 2,4 netržna ploda u odnosu na sortu Sweet Million gdje je po biljci ubrano 61,5 tržnih i 8,4 netržnih plodova. Pri povećanoj koncentraciji amonijevog nitrata kod sorte Sakura je ubrano 80,2 tržnih i 3,4 netržna ploda po biljci, dok je kod sorte Sweet Million ubrano 75,4 tržnih i 9,2 netržnih plodova po biljci (tablica 1). Primjenom obje koncentracije hranive otopine broj ubranih tržnih plodova bio je veći kod sorte Sakura, a broj netržnih kod sorte Sweet Million. Istovremeno, broj tržnih plodova sorte Sweet Million je značajnije varirao, što pokazuju veće vrijednosti standardne devijacije u odnosu na sortu Sakura.

Tablica 1. Broj ubranih plodova po biljci s odstupanjima od srednjih vrijednosti

Interakcija	Plodova po biljci	
	Tržni	Netržni
SAN1	75,8 ± 2,43	2,4 ± 2,22
SAN2	80,2 ± 3,43	3,4 ± 0,98
SMN1	61,5 ± 6,30	8,4 ± 1,14
SMN2	75,4 ± 9,63	9,2 ± 3,46

SA = Sakura; SM = Sweet Million; N1 = standardna otopina; N2 = +50% NH<sub>4</sub>NO<sub>3</sub>

Iz ostvarenih rezultata vidljiv je pozitivan utjecaj povećane koncentracije amonijevog nitrata na broj tržnih plodova po biljci. Conversa et al. (2001) nisu proveli prikraćivanje cvjetnih grana tako da je broj ubranih plodova bio znatno veći nego u našem istraživanju. Po biljci 'Sakura' su ubrali 182 ploda, a po biljci 'Sweet Million' 275 plodova. Prosječan broj plodova po grozdu iznosio je 17,2 kod 'Sakura' i 30,6 kod 'Sweet Million'.

Sorta Sakura je na svim grozdovima razvila krupnije plodove (28 do 40 g) u odnosu na sortu Sweet Million (23 do 26 g). Kod obje sorte najkrupniji plodovi su ubrani sa šestog grozda. Sastav hranive otopine nije značajno utjecao na masu plodova ubranih s pojedinog grozda, osim na sedmom grozdu kad su znatno krupniji plodovi ubrani s biljaka prihranjivanih standardnom otopinom (tablica 2). Sorta Sakura je u interakciji s obje primijenjene hranive otopine razvila znatno krupnije plodove (28 do 40 g) u odnosu na sortu Sweet Million (22 do 27 g).

Testirane hibridne sorte međusobno su se značajno razlikovale po masi tržnih plodova za period berbe (tablica 2), dok koncentracija amonijevog nitrata u hranivoj otopini nije imala signifikantan utjecaj. Plodove mase 34 g tijekom perioda berbe razvile su biljke 'Sakura' prihranjivane standardnom i otopinom s povećanom koncentracijom amonijevog nitrata. Ti su plodovi statistički bili znatno krupniji od plodova 'Sweet Million' bez obzira na sastav hranive otopine (25 i 24 g). Povećanje koncentracije amonijevog nitrata u hranivoj otopini nije utjecalo na masu ploda sorte Sakura, odnosno, dovelo je do smanjenja mase ploda sorte Sweet Million. Smanjenje mase ploda nije bilo značajno.

Tablica 2. Masa tržnih plodova (g) ubranih s pojedinog grozda i za period berbe

Faktor	Grozđ								Ukupno
	I	II	III	IV	V	VI	VII	VIII	
Sorta									
SA	28 A*	33 A	29 A	31 A	36 A	40 A	38 A	35 A	34 A
SM	25 B	24 B	23 B	24 B	25 B	26 B	25 B	24 B	25 B
Dušik									
N1	27	29	26	28	30	34	33 a	29	30
N2	26	28	26	28	31	32	30 b	30	29
S x D									
SAN1	28 a	33 a	30 a	31 a	35 a	40 a	39 a	34 a	34 a
SAN2	28 a	33 a	29 a	31 a	37 a	40 a	37 a	35 a	34 a
SMN1	25 b	25 b	22 b	24 b	25 b	27 b	27 b	24 b	25 b
SMN2	24 b	23 b	23 b	24 b	26 b	24 b	22 c	24 b	24 b
LSD	2,30	3,14	3,19	2,86	2,55	4,36	2,77	4,90	1,65

SA = Sakura; SM = Sweet Million; N1 = standardna otopina; N2 = +50% NH<sub>4</sub>NO<sub>3</sub>

\*Različita slova predstavljaju značajno različite prosječne vrijednosti prema LSD testu, (a) p≤0,05 i (A) p≤0,01.

Ostvarena masa plodova tijekom berbe znatno je veća od ostvarene u istraživanjima Conversa et al. (2001). U njihovom pokusu masa ploda 'Sakura' iznosila je 16,3 g, a 'Sweet Million' 9,7 g. Masa plodova ostalih "cherry" sorata u pokusu je bila u rasponu od 8,3 do 23,7 g. Leonard i et al. (2000) su u svom istraživanju ostvarili masu ploda od 13,2 do 15,9 g. Gautier et al. (2005) su pri prikraćivanju cvjetnih grana na 7 cvjetova ostvarili prosječnu masu ploda od 5,91 do 6,16 g, a pri prikraćivanju na 14 cvjetova od 5,45 do 6,30 g. Znatno krupniji plodovi u našem istraživanju rezultat su manjeg broja plodova u grozdu, što je ostvareno prikraćivanjem cvjetnih grana.

Najveći prinos tržnih plodova ostvaren je kod sorte Sakura na šestom grozdu (1,26 kg/m<sup>2</sup>), dok je najmanji prinos ostvaren kod sorte Sweet Million na sedmom grozdu (0,45 kg/m<sup>2</sup>). Tijekom razdoblja plodonošenja prinosi sa različitih grozdova su se značajno razlikovali kod obje sorte (tablica 3). Ovisno o koncentraciji amonijevog nitrata u hranivoj otopini uočavaju se znatne razlike u prinosu tržnih plodova sa pojedinih grozdova. Najveći prinos tržnih plodova ostvaren je na trećem grozdu pri povećanju koncentracije NH<sub>4</sub>NO<sub>3</sub> te je iznosio 1,17 kg/m<sup>2</sup>. Najmanji prinos je ostvaren na petom grozdu pri standardnoj koncentraciji i iznosio je 0,64 kg/m<sup>2</sup>. Najveći prinos tržnih plodova po grozdu među interakcijama sorta x koncentracija amonijevog nitrata je ostvaren na šestom grozdu sorte Sakura pri 50% povećanoj koncentraciji i iznosio je 1,62 kg/m<sup>2</sup>. Najmanji prinos (0,34 kg/m<sup>2</sup>) ostvaren je na petom grozdu kod sorte Sweet Million pri standardnoj koncentraciji.

Sorta Sakura je u razdoblju plodonošenja ostvarila signifikantno veći prinos (8,52 kg/m<sup>2</sup>) od sorte Sweet Million (5,48 kg/m<sup>2</sup>) (tablica 3). Primjenom otopine s povećanom koncentracijom amonijevog nitrata postignut je 12,2% viši prinos nego primjenom standardne hranive otopine (6,6 kg/m<sup>2</sup>). U interakciji s hranivim otopinama obje sorte su postigle veće prinose uz primjenu hranive otopine s povećanom koncentracijom amonijevog nitrata, s tim da su prinosi sorte Sakura (8,15 i 8,88 kg/m<sup>2</sup>) bili signifikantno veći od prinosa sorte Sweet Million (5,05 i 5,92 kg/m<sup>2</sup>).

Conversa et al. (2001) su ostvarili ukupni prinos 3,0, odnosno 2,6 kg/biljci kod sorata Sakura i Sweet Million. Tržni prinos je iznosio 2,1 odnosno 2,2 kg/biljci. Signore et al. (2008) su u uvjetima povećanog saliniteta ostvarili ukupni prinos od 2448 do 2655 g po biljci. Od toga je 83, odnosno, 175 g/biljci bilo netržno.

Tablica 3. Prinos tržnih plodova ubranih s pojedinog grozda i za period berbe, kg/m<sup>2</sup>

Faktor Sorta	Grozđ								Ukupno
	I	II	III	IV	V	VI	VII	VIII	
SA	0,94 a	1,16	1,18 a	0,90 a	0,92 a	1,26 A	1,14 a	1,02 a	8,52 A
SM	0,71 b	1,08	0,93 b	0,72 b	0,51 b	0,49 B	0,45 b	0,61 b	5,48 B
Dušik									
N1	0,82	1,15	0,94 b	0,73 b	0,64	0,67 b	0,89	0,76	6,60
N2	0,83	1,09	1,17 a	0,89 a	0,78	1,07 a	0,70	0,86	7,41
S x D									
SAN1	1,01 a	1,18	1,07 ab	0,75 b	0,94 a	0,89 b	1,31 a	0,99	8,15 a
SAN2	0,87 a	1,13	1,29 a	1,06 a	0,89 a	1,62 a	0,97 b	1,05	8,88 a
SMN1	0,62 b	1,12	0,81 b	0,71 b	0,34 b	0,45 b	0,47 c	0,53	5,05 b
SMN2	0,80 ab	1,05	1,05 ab	0,73 b	0,67 ab	0,52 b	0,43 c	0,68	5,92 b
LSD	0,25	0,35	0,35	0,22	0,34	0,46	0,18	0,58	1,57

SA = Sakura; SM = Sweet Million; N1 = standardna otopina; N2 = +50% NH<sub>4</sub>NO<sub>3</sub>

\*Različita slova predstavljaju značajno različite prosječne vrijednosti prema LSD testu, (a) p≤0,05 i (A) p≤0,01.

Udio suhe tvari je u plodovima ubranima u srpnju varirao od 7,96 do 8,79%, dok je u kolovozu bio viši i iznosio od 8,86 do 9,16%. Porast udjela suhe tvari u kolovozu u odnosu na srpanj zabilježen je kod svih interakcija. U srpnju su također utvrđena i veća odstupanja od srednje vrijednosti tako da su standardne devijacije iznosile od 0,17 do 0,36, dok su u kolovozu bile između 0,05 i 0,20 (tablica 4).

Udio topive suhe tvari je bio ujednačeniji u oba roka uzorkovanja i s manjim odstupanjima. U srpnju je iznosio od 7,40 do 7,57 °Brix, a u kolovozu od 7,77, do 7,90 °Brix (tablica 4). Iako je u plodovima sorte Sweet Million uzgajanim pri većoj koncentraciji amonijevog nitrata utvrđen veći udio suhe tvari u srpnju (8,60%) u odnosu na sortu Sakura (7,96 i 8,13%), u istim je plodovima utvrđeno manje topive suhe tvari (7,40 °Brix) nego kod sorte Sakura (7,50 i 7,53 °Brix).

Tablica 4. Udio suhe i topive suhe tvari u plodu s odstupanjima od srednjih vrijednosti

Interakcija	Suha tvar,%		Topiva suha tvar, °Brix	
	Srpanj	Kolovoz	Srpanj	Kolovoz
SAN1	7,96±0,17	8,86±0,18	7,50±0,10	7,77±0,06
SAN2	8,13±0,36	9,14±0,09	7,53±0,12	7,87±0,06
SMN1	8,79±0,34	9,16±0,20	7,57±0,12	7,90±0,10
SMN2	8,60±0,29	8,97±0,05	7,40±0,20	7,83±0,06

SA = Sakura; SM = Sweet Million; N1 = standardna otopina; N2 = +50% NH<sub>4</sub>NO<sub>3</sub>

Conversa et al. (2001) su prilikom berbe u listopadu utvrdili 7,1 i 7,7% suhe tvari kod sorata Sakura i Sweet Million, odnosno, 6,5 i 7,2 °Brix topive suhe tvari. U berbi u studenom udio suhe tvari je iznosio 7,3 i 5,7%, a topive suhe tvari 6,9 i 5,6 °Brix. Raffo et al. (2002) su utvrdili porast udjela suhe i topive suhe tvari tijekom perioda dozrijevanja. Plodovi "cherry" kultivara 'Naomi', brani u tehnološkoj zrelosti sadržavali su 7,38% suhe tvari i 6,07 °Brix topive suhe tvari. U istraživanjima Leonardi et al. (2000) ista je sorta sadržavala između 7,45 i 9,49% suhe tvari, te između 6,05 i 7,87 °Brix topive suhe tvari. Gautier et al. (2005) su pri manjem opterećenju (7 plodova u grozdu) utvrdili 12,9% suhe tvari u plodu, a pri opterećenju sa 14 plodova u grozdu od 11,8 do 12,7%, ovisno o položaju ploda u grozdu.

### Zaključci

Udio tržnih plodova u ukupnom broju plodova je varirao od 88 do 96,9%.

Sorta Sakura je na svim grozdovima razvila značajno krupnije plodove od sorte Sweet Million, što je rezultiralo visoko signifikantnom razlikom u masi ploda za period berbe između testiranih sorata. Koncentracija amonijevog nitrata nije imala značajan utjecaj na masu ploda.

Značajne razlike u masi ploda rezultirale su 55,5% većim ukupnim tržnim prinosom sorte Sakura u odnosu na sortu Sweet Million (5,48 kg/m<sup>2</sup>). Pri povećanoj koncentraciji amonijevog nitrata ostvaren je 12,3% veći prinos nego pri primjeni standardne otopine. Sorta Sakura je u interakciji s obje otopine ostvarila znatno veći prinos od sorte Sweet Million.

Ovisno o interakciji sorte i koncentracije amonijevog nitrata u hranivoj otopini, udio suhe tvari u plodu je bio u rasponu od 7,96% do 9,16%, a topive suhe tvari od 7,40 do 7,90 °Brix.

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# Utjecaj metode pripreme hranive otopine na prinos rajčice

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## Sažetak

Cilj je istraživanja bio usporediti komponente prinosa dva krupnoplodna hibridna kultivara rajčice (Belle, Buran) u uzgoju na kamenoj vuni, s pripremljenom hranivom otopinom od pojedinačnih soli i od vodotopljivih kompleksnih NPK-gnojiva. Veći prinos i veći broj tržnih plodova po biljci postignut je primjenom hranive otopine pripremljene iz vodotopljivih kompleksnih NPK-gnojiva.

Ključne riječi: *Lycopersicon esculentum*, hranive soli, NPK-gnojiva, komponente prinosa

## Tomato yield as affected by nutrient solution preparation method

### Abstract

The aim of research was to compare the yield components of two beefsteak tomato cultivars (Belle, Buran) grown on rockwool, and fertigated with nutrient solutions prepared from nutrient salts and water soluble NPK fertilizers. Higher number of marketable fruits per plant, and higher yield of marketable fruits were achieved by the application of nutrient solutions prepared from water soluble NPK fertilizers.

Key words: *Lycopersicon esculentum*, nutrient salts, NPK fertilizers, yield components

### Uvod

U hidroponskom se uzgoju pripremom hranive otopine biljkama osigurava potrebna količina hraniva u određenom omjeru. Koncentrirane otopine se pripremaju otapanjem pojedinačnih hranivih soli ili kompleksnih gnojiva uz dodatak kalcijeva nitrata ili neke druge soli po potrebi. Prednost pripreme hranive otopine iz pojedinačnih soli je u lakšem korigiranju sastava u slučaju nedostatka ili viška određenog hranivog elementa u zoni korijena.

Cilj istraživanja je bio usporediti komponente prinosa krupnoplodnih kultivara rajčice u uzgoju na kamenoj vuni, s pripremljenom hranivom otopinom od pojedinačnih soli i od kompleksnih vodotopljivih NPK-gnojiva.

### Materijal i metode

U istraživanju su bila dva hibridna kultivara rajčice, Belle i Buran. Istraživanje je provedeno tijekom 2009. godine. Testirana su agronomska svojstva rajčice.

Presadnice su sađene 8. svibnja na ploče kamene vune, u fazi 7 do 8 razvijenih listova, na razmak 100 cm ×

33 cm (sklop 3,03 biljke na m<sup>2</sup>). Dvofaktorijalan pokus je postavljen u negrijanom plateniku po metodi slučajnog bloknog rasporeda u 4 ponavljanja. Osnovnu parcelu su činile 2 ploče kamene vune sa 6 biljaka.

Nakon sadnje sve biljke su prihranjivane standardnom hranivom otopinom (tablica 1), sastava prema Sonneveldu (1991, prema Adams, 2002). U spremnicima je pripravljena gotova hraniva otopina koja je sustavom navodnjavanja kapanjem distribuirana do svake biljke. Broj dnevnih obroka je varirao od 6 nakon sadnje do 24 u punoj vegetaciji. Volumen hranive otopine po biljci iznosio je do 3,82 L dnevno. Mjesec dana nakon sadnje započela je fertirigacija 50% biljaka otopinom pripremljenom od dva kompleksna gnojiva, Universol Orange 16-5-25+3MgO i Peters Excel CalMag Finisher 13-5-20+7CaO+3MgO, prvo u količini 0,7 kg, drugo 1,05 kg za pripremu 1000 L gotove otopine, uz dodatak HNO<sub>3</sub>. Od kompleksnih gnojiva dobivena je hraniva otopina sastava prikazanog u tablici 1.

Cvatovi su skraćeni na 5 cvjetova. U laboratoriju su periodički, u šest navrata, utvrđene pH- i EC-vrijednosti hranive otopine te koncentracija iona makroelemenata. Berba je započela 2. srpnja i trajala do 17. rujna. Bilo je 15 berbi. Brani su plodovi s osam grozdova. Tijekom berbe su utvrđeni broj i masa tržišnih i netržnih plodova za svaki grozd i ukupno po biljci. Statistička obrada rezultata je obavljena analizom varijance (ANOVA), a prosječne vrijednosti su testirane LSD-testom na razini signifikantnosti p≤0,01 i p≤0,05. Korišten je program MSTAT-C (Nissen, 1983).

**Tablica 1. Preporučeni sastav standardne hranive otopine (spremnik i zona korijena) prema Sonneveldu i sastav hranive otopine iz spremnika s kompleksnim gnojivima**

Hranivo	Spremnik		Zona korijena		Spremnik s otopinom iz kompleksnih gnojiva (mg/L)
	mmol/L	mg/L	mmol/L	mg/L	
NO <sub>3</sub>	13,75	193	17,0	228	236
NH <sub>4</sub>	1,25	17,5	<0,5	7	37
Urea-N	-	-	-	-	23
H <sub>2</sub> PO <sub>4</sub>	1,25	39	0,7	22	120
SO <sub>4</sub>	3,75	120	5,0	160	126
K	8,75	342	7,0	274	324
Ca	4,25	170	7,0	280	159
Mg	2,0	48	3,5	85	50
	μmol/L	mg/L	μmol/L	mg/L	
B	30,0	0,33	50,0	0,55	-
Cu	0,75	0,05	0,7	0,04	-
Fe	15,0	0,80	15,0	0,80	-
Mn	10,0	0,55	7,0	0,38	-
Mo	0,5	0,05	-	-	-
Zn	5,0	0,33	7,0	0,50	-
EC, dS/m	2,3		3,0		2,8

## Rezultati i rasprava

### pH- i EC-vrijednosti hranive otopine

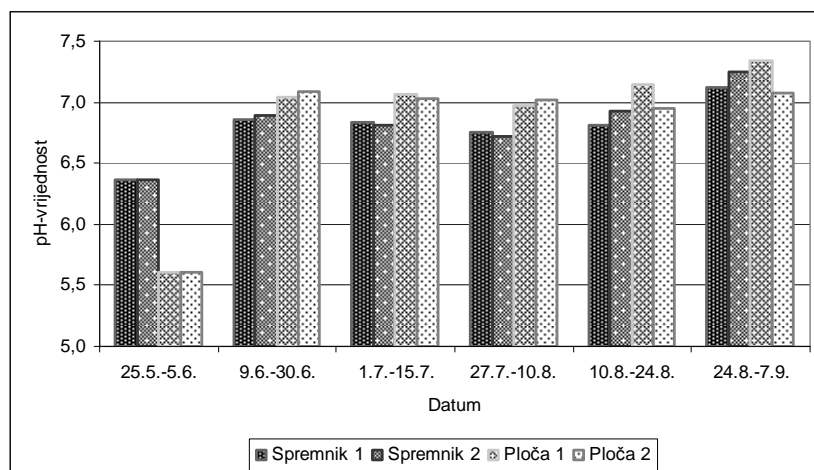
pH-vrijednosti hranive otopine u spremnicima su održavane od 6,36 do 7,25, s prosječnom vrijednošću oko 6,8. Zbog toga, osim na početku, od lipnja do kraja vegetacije pH-vrijednosti u zoni korijena obih otopina bile su oko 7,0 (grafikon 1), što je više od optimalnih za rajčicu.

Resh (2001) preporuča da se ploče kamene vune prije sadnje, zbog svoje alkalne reakcije (pH 7,0 do 8,5) natope vodom s dodatkom kiseline (pH 5,0 do 5,2), a nakon stabiliziranja pH-vrijednosti u ploči da se koristi hraniva otopina pH-vrijednosti 5,5 do 6,0.

Standardna hraniva otopina u spremniku imala je EC-vrijednosti tijekom vegetacije između 3,0 i 3,7 dS/m, prosječno oko 3,2 dS/m. EC-vrijednosti u spremniku NPK-otopine bile su u rasponu od 1,9 do 3,3 dS/m, prosječno oko 2,4 dS/m. Prosječna EC-vrijednost standardne otopine u zoni korijena biljaka bila je oko 5,6 dS/m. To je posljedica njezina porasta u mjesecu kolovozu na 5,9 dS/m, a zatim, čak na 9,5 dS/m (grafikon 2), odnosno, nakupljanja hranivih soli u zoni korijena. Biljke uzgajane uz NPK-otopinu imale su u zoni korijena manju EC-vrijednost, između 2,3 i 4,0 dS/m, prosječno oko 3,0 dS/m, što je optimalno za rajčicu.

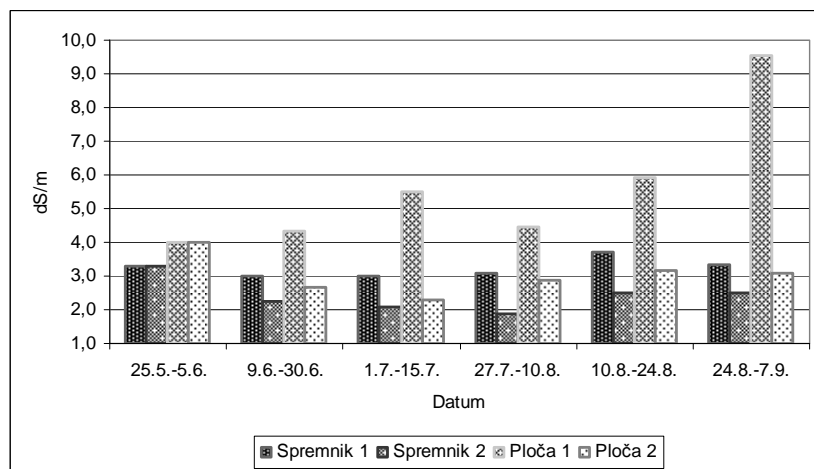
## Utjecaj metode pripreme hranive otopine na prinos rajčice

Papadopolus (1991) navodi različite EC-vrijednosti hranjive otopine ovisno o fazi razvoja: 2,5 dS/m prilikom sadnje; postupno povećanje do 3,5 dS/m kroz 4 do 6 tjedana nakon sadnje; od 1,8 do 2,3 dS/m za normalnu ishranu i od 1,8 do 2,5 dS/m za rast plodova. Sarkar i sur. (2008) navode da je primjena dviju otopina planirane EC-vrijednosti 4,0 dS/m rezultirala porastom EC-vrijednosti u zoni korijena na 16,1 dS/m pri fertirigaciji kapanjem, odnosno, na 29,6 dS/m pri subirigaciji. Oztekin i sur. (2007) navode negativan utjecaj povećanog saliniteta na prinos i masu ploda. Claussen i sur. (2006) su utvrdili da povećana koncentracija hraniva ne rezultira uvijek poboljšanjem kvalitete plodova, što potvrđuju Fandi i sur. (2010), koji su pri povećanim koncentracijama N, P i K ostvarili viši prinos u odnosu na kontrolnu otopinu, a pri smanjenoj koncentraciji P viši udio topljive suhe tvari i veću ukupnu kiselost.



Grafikon 1. pH-vrijednost hranjive otopine u spremnicima i u zoni korijena rajčice

1 = standardna hraniva otopina; 2 = NPK-otopina



Grafikon 2. EC-vrijednosti hranjive otopine (dS/m) u spremnicima i u zoni korijena rajčice

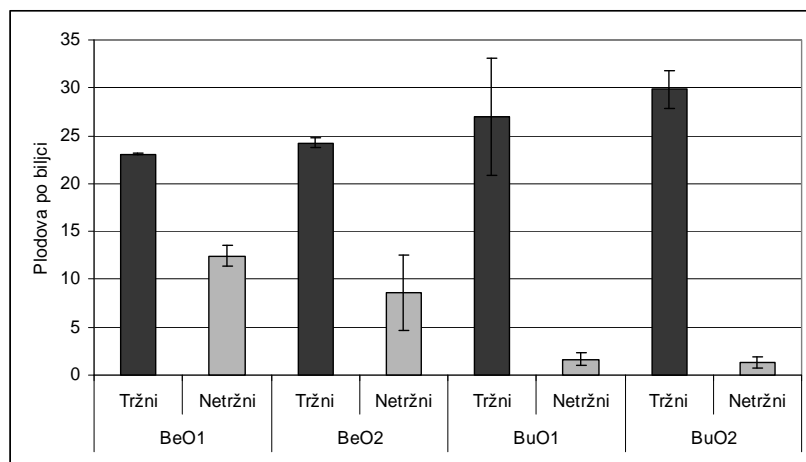
1 = standardna hraniva otopina; 2 = NPK-otopina

### Broj tržnih i netržnih plodova po biljci

Po biljci se planiralo ubrati 40 plodova. Taj broj je bio znatno manji, od 30 do 35 (grafikon 3). Iznosio je od 23 (kultivar Belle, standardna otopina) do 30 (kultivar Buran, NPK-otopina). Obratno, iste su kombinacije imale najveći (12), odnosno, najmanji (2) broj netržnih plodova po biljci. Razlike u broju tržnih i netržnih plodova po biljci uvjetovale su i veliku varijabilnost udjela netržnih u ukupnom broju plodova, od 6,3 do 34,3%.

Benko (2009) navodi da je po biljci s 8 grozdova ubrano od 28 do 33 tržna ploda, a Benko i sur. (2010) da je s osam grozdova istih kultivara ubrano od 30 do 34 tržna i 2 do 3 netržna ploda po biljci. Udio netržnih plodova je iznosio od 5,4 do 8,4%. Fandi i sur. (2010) navode kako je povećanje koncentracije glavnih hraniva (N, P i K) rezultiralo znatno većim brojem tržnih plodova u odnosu na standardnu otopinu. Oztekin i sur. (2007) su utvrdili negativan utjecaj porasta saliniteta na ukupan broj plodova u proljetnom periodu, dok

ga u jesenskom nije bilo. U istraživanju Sarkara i sur. (2008) tip otopine nije utjecao na broj plodova, ali je utvrđen signifikantan utjecaj metode primjene otopine, kapanjem ili subirigacijom.



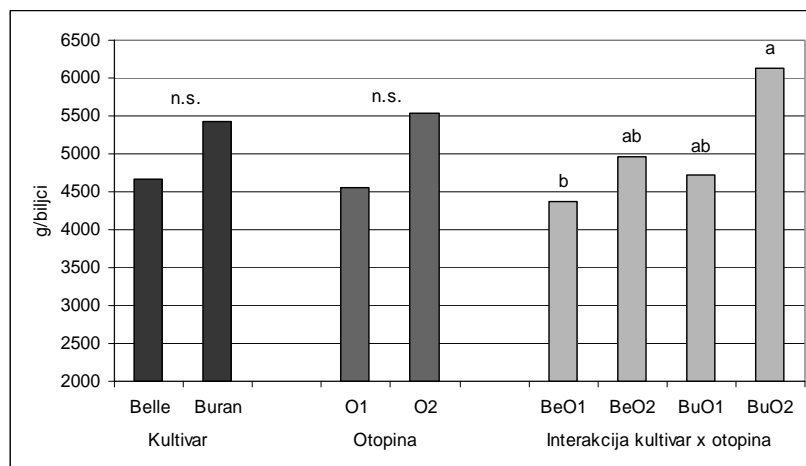
Grafikon 3. Prosječan broj tržnih i netržnih plodova po biljci

Be = kultivar Belle; Bu = kultivar Buran; O1 = standardna hraniva otopina; O2 = NPK-otopina

#### Ukupan prinos

Kultivar Buran je ostvario trži prinos 5429 g, a kultivar Belle 4671 g po biljci. Primjenom NPK-otopine dobiven je trži prinos 5546 g, a uz primjenu standardne otopine 4553 g po biljci. Razlike u prinosima između kultivara, kao i između primijenjenih otopina, nisu bile značajne. Signifikantne su razlike utvrđene između kombinacija (grafikon 4). Najviši je prinos ostvario (6129 g po biljci) kultivar Buran, uzgajan uz primjenu NPK-otopine. Taj je prinos bio signifikantno veći od prinosa kultivara Belle uz primjenu standardne otopine (4379 g po biljci), ali ne i od prinosa ostalih dviju kombinacija, kultivara Belle uz primjenu NPK-otopine (5000 g/biljci) i kultivara Buran uz standardnu otopinu (4700 g po biljci).

Radošević (2010) je ostvarila više prinose kultivara Belle i Buran. Uz primjenu standardne otopine kultivar Buran je ostvario prinos od 7440, a kultivar Belle 6866 g po biljci. Benko (2009) navodi da je pri interakciji kultivara i koncentracije kalcijeva nitrata u hranivoj otopini ostvaren prinos od 13,78 do 25,25 kg/m<sup>2</sup>. Pad prinosa pri porastu saliniteta navode Oztekin i sur. (2007) te Sarkar i sur. (2008) pri subirigaciji u odnosu na metodu kapanjem.



Grafikon 4. Prinos trži plodova, g po biljci

Be = kultivar Belle; Bu = kultivar Buran; O1 = standardna hraniva otopina; O2 = NPK-otopina



## Zaključci

Zbog održavanja visoke pH-vrijednosti (6,5 do 7,0) pripremljenih hranivih otopina, u zoni korijena pH-vrijednosti su bile previsoke (oko 7,0 i više). U pripremljene otopine trebalo je dodati više dušične kiseline. EC-vrijednosti pripremljene standardne otopine (3,2 dS/m) bile su nešto veće od preporučenih za rajčicu. Zbog toga, u zoni korijena uz standardnu otopinu došlo je do nakupljanja hraniva iznad optimalnih koncentracija. EC-vrijednost je porasla do 9,5 dS/m krajem ljeta. Povećanjem fertirigacije, pojačao bi se istek otopine. Oba su kultivara uz primjenu NPK-otopine imali veći broj tržnih plodova (Belle, 27; Buran, 30), nego uz primjenu standardne otopine. Znatno je veći udio netržnih plodova imao kultivar Belle, od 27,3 do 34,3%, ovisno o primijenjenoj otopini, od kultivara Buran, od 6,3 do 10% netržnih plodova. Nije bilo značajnih razlika u ukupnom prinosu između sorata, kao ni između primijenjenih hranivih otopina. Najveći je prinos dobiven uzgojem kultivara Buran uz NPK-otopinu (6129 g po biljci), jer je imao i najveći broj tržnih plodova po biljci. Bolje upravljanje fertirigacijom i primjena automatike za pripremu otopine dala bi drukčije rezultate.

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# Effect of pre-sowing fertilization to the level of pea lodging

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## Abstract

The aim of the research was to establish the effect of complex NPK fertilizer rate to the level of lodging of pea for human consumption. The two-year average level of pea lodging was 45.1%. In both studied years statistically the lowest lodging level was observed at the earliest cultivar 'Tamiš' (30.2 and 28.2% in 2007 and 2008, respectively), except in comparison with the cultivar 'Fruškogorac' in 2008 (38.0%). Regularity in lodging was not expressed from the aspects of treatment with different pre-sowing NPK fertilizer rates. Increased yield per plant caused a higher degree of pea plants lodging.

Key words: vegetable, *Pisum sativum* L., cultivars, fertilization, lodging

## Introduction

In plant production there are trends to produce larger quantities of food with maximum rationalization of the mineral fertilizers application. Growth of garden pea (*Pisum sativum* L.) has long lasting tradition in Serbia. Short vegetation period and high nutritive value of grain stimulate pea production and consumption (Gvozdenović et al., 2002; Jovičević et al., 2002). Accessible nutrients, especially nitrogen, are usually the limiting factor in obtaining a high yield of agricultural plant dry matter. Grain legumes contain large amounts of protein and for their and yield creation, greater quantities of nitrogen are necessary. However, one significant part of the required nitrogen they insure through biological fixation from the atmosphere. Phosphorus is of great importance in plant production, since its deficiency in soil often limits plant growth and development, while potassium has very important role in plant water regime (Kastori, 1998). Potassium is also important for generative development of plants, flowering, fertilization and grain filling. As summer pea cultivars have a short vegetation period and shortened period of adoption of plant assimilates for additional plant nutrition, only mineral NPK fertilizers are used (Glamočlija, 1997; Gvozdenović et al., 2007). Besides this, seed bacterisation is also recommended in growing peas, because it achieved higher number of pods and seeds per plant, 1000 grain weight and grain weight per plant (Uher, 2006).

Slight lodging occurs immediately after the formation of pods and grains, due to they grow and gain weight during their development. If in that period and/or later appeared abundant precipitation, followed by stormy wind, lodging of crops occur. If plant density is small and plants are not well linked to each other by tendrils, lodging is more pronounced. Mineral nutrition has great impact on the lodging of plants, especially if too much nitrogen fertilizers are added. Influence of variety also has an impact to the lodging of crop. High and middle varieties are more prone to lodging than low. Lodging leads to a yield reduction of peas combining for industrial processing, due to technical inability of combine head to raise and detach beans from the soil. Such peas are losing in their quality, because lying on the soil causes rotting of pods, and consequently grains, by pathogenic and saprophytic fungi. The aim of this study was to determine the degree of pea cultivars lodging affected by different pre-sowing doses of NPK fertilizer.

## Material and methods

In order to solve the given task in experimental economics of Secondary Agricultural School in Bačka Topola, during 2007-2008 trials were derived on carbonate chernozem soil type. The basic cultivation was performed in the fall at the depth of 30 cm, and by the end of the winter pre-sowing cultivations were finished. Pre-crop in 2007 was onion, and 2008 pepper. In research five cultivars of different maturity groups were observed. Three cultivars ('Tamiš', 'Dunav' and 'Fruškogorac') were developed in Institute of Field and Vegetable Corps in Novi Sad while two are of Dutch origin ('Orcado' and 'Joff'). 'Tamiš' is very early cultivar, 'Danube' early, 'Fruškogorac' middle early, 'Orcado' middle late and 'Joff' late cultivar. The two factor experiment was designed as split-plot method, according to the plan of divided plots in replications. The basic plots were cultivars, and within them sub-plots were three treatments of pre-sowing complex NPK fertilizer 15-15-15 rate (300, 500 and 0 kg ha<sup>-1</sup> as control variant). The area of basic plot was 5 m<sup>2</sup>. In harvest maturity, for the purpose of analysis, 10 plants were taken from central rows. Height of plants (cm) and stem length (cm) were measured in the field. Degree of pea plants lodging (%) was determined upon mathematical calculations. Data were processed by analysis of variance. LSD test was applied to establish significant difference among treatments (Hadživuković, 1991). Data on temperatures and precipitation were obtained from referent meteorological station in Bačka Topola.

## Results and discussion

Pea is species that grows in moderately moist and chilly climate (Gvozdenović et. al., 2007). Both years of study were marked by very high temperatures and notable precipitation with very unfavourable schedule.

**Table 1 Mean monthly, decade and long-term air temperature during pea vegetation period, Bačka Topola.**

Month	Mean air temperature (°C)								
	Decade						Monthly		Long-term (1975-2006)
	I		II		III		2007	2008	
2007	2008	2007	2008	2007	2008	2007	2008		
March	9.0	7.3	11.0	7.5	8.3	7.4	9.4	7.4	6.5
April	12.2	10.9	15.0	13.8	16.3	14.4	13.7	13.1	11.5
May	16.6	14.9	19.2	19.2	20.8	21.7	18.9	18.7	17.3
June	22.1	22.0	24.8	20.4	24.4	25.6	23.8	22.7	20.6

Mean monthly temperatures in 2007 were not in compliance with the long-term monthly average for pea vegetation period (Table 1). During the pea vegetation period in 2007 precipitation sum was higher for 30.6% in comparison with long-term average. Precipitation had very unfavourable schedule, because in April fell only 1.2 l·m<sup>-1</sup> rain, due to the initial growth of peas was slowed. In May fell even 171.3 l·m<sup>-1</sup> (Table 2). In 2008 temperatures of all vegetation months were also above the long-term average. As well, during the pea vegetation period of 2008, 26% more precipitation was measured in relation to long-term average, although in April was twice less precipitation. However, very important factor in the technology of production, especially in conditions without irrigation, is the schedule of precipitation that significantly affect the dynamics of growth and development of plants and the formation of a stable yield (Dozet, 2009).

**Table 2 The decade, monthly and long-term precipitations sum during pea vegetation period, Bačka Topola**

Month	Precipitation sum (mm)								
	Decade						Monthly		Long-term average (1975-2006)
	I		II		III		2007	2008	
2007	2008	2007	2008	2007	2008	2007	2008		
March	36.1	26.8	0.3	24.5	21.4	20.6	57.8	71.9	34.7
April	0	4.2	1.2	17.5	0	1.3	1.2	23.0	46.1
May	87.2	14.6	14.6	5.1	69.5	21.9	171.3	41.6	53.9
June	16.6	30.2	5.0	85.8	17.7	7.6	39.3	123.6	71.8

The average level of pea lodging for both years of the study was 45.1%, while in 2007 it was 47.3% and in 2008 year 42.8% (Table 3). In both studied years the smallest degree of lodging had the earliest cultivar 'Tamiš' (20.2 cm, i.e. 28.2%), which is statistically significantly lower lodging in comparison to all other tested cultivars, except 'Fruškogorac' in 2008.

**Table 3 Effect of cultivar and pre-sowing fertilizer rate on level of pea lodging in the field (%)**

Fertilizer rate (kg·ha <sup>-1</sup> )	Cultivar					$\bar{X}$
	Tamiš	Dunav	Fruškogorac	Orcado	Joff	
2007						
0	26.8	44.4	44.3	57.5	54.5	45.5
300	36.9	44.5	40.7	48.4	59.9	46.1
500	26.8	57.5	46.7	57.6	63.2	50.4
$\bar{X}$	30.2	48.8	43.9	54.5	59.2	47.3
Treatment	LSD 5%		LSD 1%			
Cultivar	6.1		8.5			
Fertilizer rate	5.0		6.7			
Cultivar×Fertilizer rate	11.2		14.9			
2008						
0	24.9	42.3	50.0	57.5	53.3	45.6
300	32.4	47.0	29.1	52.9	52.4	42.8
500	27.2	45.6	35.0	56.2	36.3	40.1
$\bar{X}$	28.2	45.0	38.0	55.5	47.3	42.8
Treatment	LSD 5%		LSD 1%			
Cultivar	11.7		16.2			
Fertilizer rate	4.9		6.6			
Cultivar×Fertilizer rate	11.0		14.7			
Average 2007 - 2008						45.1

During both years of the research there was no regularity in terms of treatment with different pre-sowing levels of fertilization. In 2007 doses of fertilizer did not significantly affect the level of pea lodging, while in 2008 control treatment had significantly higher percentage of lodged plants compared to treatment with 500 kg·ha<sup>-1</sup> of NPK. Observation of the interaction (cultivar × fertilizer) in 2007 showed that all cultivars tested, except 'Tamiš', had the highest degree of lodging at the largest applied fertilizer rate. However, only by the cultivar 'Danube', the difference was significantly higher than the control.

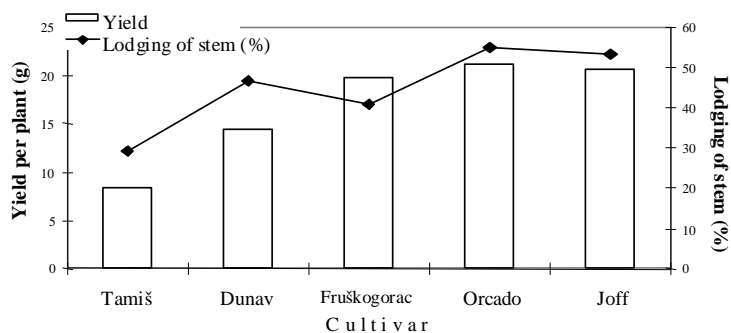
In 2008, the largest, statistically equal pea lodging was reported in following combinations of cultivars and fertilizer rates: 'Orcado' × 0, 300 and 500 kg·ha<sup>-1</sup>, 'Joff' × 0 and 300 kg·ha<sup>-1</sup>, 'Fruškogorac' × 0 kg·ha<sup>-1</sup> and 'Dunav' × 300 kg·ha<sup>-1</sup> (57.5, 52.9, 56.2, 53.3, 52.4, 50.0 and 47.0%, respectively). The smallest pea lodging, without statistical differences had combinations of cultivar 'Tamiš' with all studied fertilizer rates and cultivar 'Fruškogorac' with 300 kg·ha<sup>-1</sup> (24.9, 32.4, 27.2 and 29.1%, respectively).

In 2008 the dose of fertilizer did not significantly affect the lodging level of cultivars 'Tamiš', 'Danube' and 'Orcado', since the proportion of lodged plants was in the range 24.9 to 32.4% at 'Tamiš', 42.3 to 47.0% at 'Dunav' and 52.9 to 57.5% at 'Orcado'.

Combination of cultivar 'Fruškogorac' and control variant had greater lodging (50.0%) compared with the variations of fertilization by 300 kg ha<sup>-1</sup> (29.1%) and 500 kg ha<sup>-1</sup> of NPK (35.0%). The combination of 'Fruškogorac' × 300 kg·ha<sup>-1</sup> NPK recorded the lodging of 29.1% which was significantly lower than at the combination of the same fertilizer range and cultivars 'Orcado' (52.9%), 'Joff' (52.4%) and 'Dunav' (47.0%). The combination of fertilization by 500 kg ha<sup>-1</sup> of NPK and cultivar 'Tamiš' recorded statistically significantly lower degree of lodging (27.2%) compared with the variety 'Dunav' (45.6%) and 'Orcado' (56.2%). At the control fertilization, 'Tamiš' had highly statistically significantly lower percentage of lodging in relation to the combination of this level of fertilizer with all studied cultivars.

Increased yield per plant caused a higher degree of pea plants lodging. Varieties of shorter vegetation lodged less, and also yielded less per plant (Graph 1).

## Effect of pre-sowing fertilization to the level of pea lodging



Graph 1 Yield per plant affecting pea lodging

### Conclusion

Based on results, conclusions are the following:

The average level of pea lodging for both studied years was 45.1%. The lowest level of lodging was for the earliest cultivar 'Tamiš' and it was statistically very significant decrease compared to all other tested varieties, except in comparison with the variety 'Fruškogorac' in 2008. Regularity in lodging was not established from the aspects of treatment with different pre-sowing levels of NPK fertilizer. Increased yield per plant caused a higher degree of pea plants lodging. Cultivars of a shorter vegetation lodged less, and also yielded less per plant.

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# Utjecaj drenažne hranive otopine na parametre fotosinteze i prinos krastavca

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## Sažetak

Cilj istraživanja bio je utvrditi utjecaj drenažne hranive otopine na parametre fotosinteze i komponente prinosa u hidroponskom uzgoju krastavca na anorganskom supstratu. Pokus s dva kultivara krastavca (Adrian i Caman) prihranjivana novom i drenažnom hranivom otopinom postavljen je u stakleniku Instituta. Primijenjena tretiranja nisu imala utjecaja na parametre fotosinteze izuzev na provodljivost puči kod biljaka prihranjivanih drenažnom otopinom. Komponente ranog i ukupnog prinosa nisu bile pod utjecajem primijenjene hranive otopine. Premda nisu zabilježene razlike između testiranih kultivara, cv. Adrian ostvario je 30% veći rani i 20% veći ukupni prinos nego Caman.

Ključne riječi: *Cucumis sativus* L., hidroponski uzgoj, kamena vuna, provodljivost puči

## Influence of nutrient solution recirculation on cucumber leaf gas exchange and yield

### Abstract

The aim of this study was to determine the influence of nutrient solution recirculation on leaf gas exchange and yield of cucumbers in hydroponics on anorganic substrate. Experiment with two cucumber cultivars (Adrian and Caman) was established in Institute greenhouse using new and recirculated nutrient solution. Applied treatments did not have impact on photosynthetic parameters apart stomatal conductance in plants treated with recirculated solution. Early and total yield were not influenced by used nutrient solutions. Although cultivar differences were not recorded, early and total yield of cv. Adrian were 30% and 20% higher compared to Caman, respectively.

Key words: *Cucumis sativus* L., hydroponics, rockwool, stomatal conductance

### Uvod

Od 2003. godine zabilježen je značajan porast uzgoja povrća u zaštićenim prostorima u Hrvatskoj (Benko i sur. 2008). Veliki doprinos tome je uvođenje hidroponskih tehnika i tehnologija u uzgoju povrća na inertnim supstratima. Takav uzgoj omogućuje cjelogodišnju proizvodnju jedne kulture, odnosno visoku specijaliziranost proizvođača. U tim sustavima uzgoja povrća može se maksimalno iskoristiti kapacitet rodosti pojedinog kultivara (Lešić i sur., 2004), a gnojidba se, u znatno većoj mjeri nego kod konvencionalne proizvodnje, temelji na potrebama biljke. Međutim, najmanje 20 do 30% od ukupno primijenjene količine hranive otopine se procjeđuje (Papadopoulos, 1994) i najčešće ispušta u okoliš. Samo mali broj proizvođača ima zatvoreni (recirkulirajući) sustav uzgoja kojim se procijeđena hraniiva otopina vraća u fertirigacijski sustav, odnosno, ponovo koristi. U zatvorenim sustavima hidroponskog uzgoja smanjuju se troškovi proizvodnje i onečišćenje okoliša, no zbog ponovnog vraćanja hranive otopine u sustav dolazi do nakupljanja

netopivih soli (Borošić i sur. 2007). Podizanjem koncentracije soli (veće od preporučene za uzgoj) kod zatvorenih hidroponskih sustava, rezultat je razlike u usvajanja između iona otopine i vode, a što dovodi do reduciranja rasta biljke i prinosa (Sonneveld, 2000; Benko i sur., 2006). Krastavac je osjetljiva kultura na povećanu koncentraciju soli u zoni korijena, te se efekt zaslanjivanja ranije uočava nego kod tolerantnih kultura (Sonneveld i Kreij, 1999). Visoki EC hranive otopine u rizosferi reducira prinos, masu i broj plodova krastavca (Trajkova i sur., 2006.). Cilj istraživanja bio je utvrditi utjecaj drenažne hranive otopine na parametre fotosinteze i komponente prinosa u hidroponskom uzgoju krastavca na anorganskom supstratu.

### Materijal i metode

U stakleniku Instituta za jadranske kulture, postavljen je pokus s dva kultivara krastavca. Kultivari su uzgajani u hidroponu na kamenoj vuni (KRAN-IZOL s.r.o., Češka) i prihranjivani svježom ili ponovno upotrijebljenom (drenažnom) hranivom otopinom. Sjeme krastavca cv. Adrian i Caman (Rijk Zwaan, Nizozemska) posijano je u čepove kamene vune (20 x 25 mm) 6. kolovoza 2009. godine te zaliveno vodovodnom vodom. Biljke su pikirane 11. kolovoza, u fazi razvijenih kotiledona, visine 4 cm, u kocke kamene vune (65 x 75 x 75 mm). Kocke su prethodno natopljene hranivom otopinom EC-vrijednosti 2 dS m<sup>-1</sup> i pH-vrijednosti 3,5 kako bi se neutralizirala alkalna reakcija supstrata. Fertirigacija je obavljena hranivom otopinom za krastavac pH-vrijednosti 5,5 i kemijskog sastava (mg L<sup>-1</sup>): N 235; P 40; K 295; Mg 35; Ca 165; Fe 1; Mn 0,85; Zn 0,72; Mo 0,12; Cu 0,09 i B 1,55 (Sonneveld i Kreij, 1999). Električni konduktivitet podizan je za 1 dS m<sup>-1</sup> dnevno, kako bi se presadnice prilagodile povećanju koncentracije hranive otopine nakon sadnje u kocke kamene vune do EC 4 dS m<sup>-1</sup> s kojim su navodnjavane do sadnje. Presadnice s razvijenih pet listova posađene su u ploče kamene vune (75 x 200 x 1000 mm) 26. kolovoza, u dvoredne trake na razmak 120 x 40 x 50 cm (2,5 biljaka po m<sup>2</sup>), a primijenjen je uzgojni oblik "jednostrani kišobran" (Papadopoulos, 1994). Pokus je postavljen po principu slučajnog bloknog rasporeda u tri ponavljanja. Fertirigacija je obavljena svakodnevno hranivom otopinom za krastavac (Sonneveld i Kreij, 1999), pH 5,5-6,5 i EC 2,2 dS m<sup>-1</sup>, sustavom navodnjavanja kapanjem, kapaljkama (Toro Company, El Cajon, Calif.) kapaciteta 3 litre na sat, povezanim mikrokapilarnom cjevčicom do kocke kod svake biljke. Količina i broj navodnjavanja određeni su prema minimalnoj količini dnevno procijeđene hranive otopine (drenažne) od ukupno dodane hranive otopine (minimalno 25%). Tijekom prvih sedam dana nakon sadnje sve biljke su navodnjavane novom hranivom otopinom, a drenaža je prikupljena. Sedmi dana nakon sadnje na polovini biljaka počela se primjenjivati drenažna hraniva otopina, dok su kontrolne biljke cijelo vrijeme navodnjavane s novom hranivom otopinom. Na prikupljenoj drenažnoj otopini, s oba tretirana, obavljena je korekcija EC- i pH-vrijednosti dodatkom vodovodne vode i 0.1M sulfatnom kiselinom (H<sub>2</sub>SO<sub>4</sub>). Svaki deset dana u drenažnu hranivu otopinu dodana je 1/3 nove hranive otopine. Tijekom pokusa, praćeni su parametri fotosinteze (LI-6400, USA) i utvrđen je rani i ukupni prinos. Berba je počela 21. rujna i trajala do 31. listopada (40 dana), a obavljeno je 16 berbi. Statistička analiza podataka obavljena je računalnim programom STATVIEW (SAS programski paket, Version 5.0) i SAS (SAS Institute, 1999).

### Rezultati i rasprava

Provodljivost puči tijekom 21 dan od početka tretiranja varirala je od 0,57 do 1,1 mol m<sup>-2</sup> s<sup>-1</sup> (tablica 1). Provodljivosti puči značajno se razlikovala između biljaka uzgajanih primjenom nove i drenažne hranive otopine prvi dan od početka tretiranja (tablica 1).

Za pretpostaviti je da je do razlika došlo uslijed stresa uzrokovanog razlikama u ionskom sastavu otopine na što su se biljke brzo prilagodile te već četvrti dan od početka tretiranja nisu zabilježene značajne razlike (tablica 1). Prema vlastitim istraživanjima (Dumičić, 2009.), presadnice su uzgojene s EC 4 dS m<sup>-1</sup>, jer kod takvog uzgoja biljke se brzo adaptiraju na nove uvjete nakon sadnje. Kod testiranih kultivara nisu zabilježene razlike u provodljivosti puči tijekom početne primjene drenažne hranive otopine (tablica 1). Dobiveni rezultati sukladni su rezultatima Ehret i sur. (2005) koji su kod uzgoja ruže utvrdili da nema razlika između otvorenog i recirkulirajućeg sistema uzgoja tijekom prvih osam tjedana od početka tretiranja. Isti autor su utvrdili značajne razlike daljnjim uzgojem u zatvorenom sustavu. Kod ostalih parametara fotosinteze (intenzitet fotosinteze i transpiracija) tijekom 21 dana od početka tretiranja nisu zabilježene značajne razlike između tretiranja (podaci nisu prikazani).

Za rani prinos uzete su vrijednosti prve tri berbe dok je ukupni prinos ostvaren tijekom 40 dana berbe. Broj plodova u ranom prinosu iznosio je od 3 do 3,9 po biljci i nije bio pod utjecajem hranive otopine i kultivara

(tablica 2). Biljke tretirane s novom hranivom otopinom ostvarile su 11% više plodova po biljci i 7% veći rani prinos od biljaka tretiranih s drenažnom hranivom otopinom. Masa ploda varirala je od 244,9 do 269,7 g, a rani prinos od 0,74 do 1,07 kg i nisu bili pod utjecajem tretiranja (tablica 2). Kod cv. Adrian zabilježen je 30% veći rani prinos u usporedbi s cv. Caman. Također je na cv. Adrian ubrano 23% više plodova koji su bili 10% teži od plodova cv. Caman.

**Tablica 1. Utjecaj primijenjene hranive otopine na provodljivost puči ( $\text{mol m}^{-2} \text{s}^{-1}$ ) krastavca cv. Adrian i Caman uzgajanih na kamenjnoj vuni tijekom 21 dan od početka tretiranja**

Tretiranje	Dana od početka tretiranja				
	1	4	11	14	21
Hraniva otopina (HO)					
Nova	0,81 b1	1,06	0,74	0,74	1,01
Drenažna	0,91 a	1,00	0,66	0,59	1,01
Kultivar (Cv.)					
Adrian	0,88	1,10	0,71	0,77	0,99
Caman	0,83	0,96	0,70	0,57	1,02
Signifikantnost					
HO	*	ns	ns	ns	ns
Cv.	ns	ns	ns	ns	ns
HO x Cv.	ns	ns	ns	ns	ns

1 \* P < 0,05; \*\* P < 0,01; \*\*\* P < 0,001 i ns - nije signifikantno

**Tablica 2. Utjecaj primijenjene hranive otopine na broj plodova (kom/biljci), masu ploda (g) te rani (prve tri berbe) i ukupni prinos (kg/biljci) dva kultivara krastavca (Adrian i Caman) uzgajanih na kamenjnoj vuni tijekom 40 dana berbe**

Tretiranje	Komponente prinosa					
	Rani prinos			Ukupni prinos		
	Broj plodova	Masa ploda	Prinos	Broj plodova	Masa ploda	Prinos
Hraniva otopina (HO)						
Nova	3,6	259,1	0,96	12,4	290,2	3,59
Drenažna	3,2	257,9	0,89	10,6	283,6	3,00
Kultivar (Cv.)						
Adrian	3,9	269,7	1,07	12,5	291,9	3,66
Caman	3,0	244,9	0,74	10,4	282,0	2,93
Signifikantnost						
HO	ns <sup>1</sup>	ns	ns	ns	ns	ns
Cv.	ns	ns	ns	ns	ns	ns
HO x Cv.	ns	ns	ns	ns	ns	ns

1 \* P < 0,05; \*\* P < 0,01; \*\*\* P < 0,001 i ns - nije signifikantno

Tijekom 40 dana berbe ostvaren je ukupni prinos od 2,93 do 3,66 kg po biljci i nisu zabilježene značajne razlike između tretiranja (tablica 2). Biljke prihranjivane novom hranivom otopinom ostvarile su 17% veći ukupni prinos, dok je kod cv. Adrian zabilježen 20% veći ukupni prinos u usporedbi s cv. Caman. Do većih i značajnih razlika vjerojatno nije došlo i zbog toga što su biljke uzgajane tijekom perioda kraćeg dana i nižih temperatura. Pored toga, prije ponovne primjene hranive otopine korigirale su se EC- i pH-vrijednosti te je svakih deset dana dodana u tank 1/3 nove hranive otopine, što je vjerojatno usporilo efekt netopivih soli. Jači negativan utjecaj netopivih soli, što navode Borošić i sur. (2007), vjerojatno nije došao do izražaja zbog relativno kratkog perioda uzgoja (osam tjedana), a što se slaže s podacima Ehret i sur. (2005) kod uzgoja ruža.

## Zaključci

Primijenjena drenažna hraniva otopina u hidroponskom uzgoju krastavca na kamenjnoj vuni, tijekom rujna i listopada nije značajno utjecala na smanjenje prinosa. Iako bez statističke opravdanosti, kultivar Adrian ostvario je veći rani i ukupni prinos (30 i 20%).



## Zahvala

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# Utjecaj sorte i roka uzgoja na prinos i sadržaj makroelemenata u cvatu brokule

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## Sažetak

Budući da je na tržištu prisutan raznolik sortiment brokule, cilj istraživanja bio je izdvojiti perspektivne sorte s obzirom na prinos i sadržaj pojedinih makroelemenata (dušik, fosfor, kalij i kalcij) u vršnom cvatu. Tijekom jednogodišnjeg istraživanja u 2008. godini u uvjetima sjeverozapadne Hrvatske ostvarene su veće vrijednosti mase i prinosa vršnog cvata, te dušika, fosfora i kalija tijekom ljetno-jesenskog roka uzgoja, dok je u proljetno-ljetnom roku ostvarena veća količina kalcija. Niti jedna od testiranih sorti ne ističe se istovremeno visokim prinosom i količinom minerala.

Ključne riječi: *Brassica oleracea* var. *italica*, fosfor, kalcij, kalij, vršni cvat

## Broccoli yield and macronutrient content affected by cultivar and growing period

### Abstract

As numerous broccoli cultivars are available in Croatia, the aim of the research was to select promising hybrid broccoli cultivars with appropriate yield and content of some macroelements (nitrogen, phosphorus, potassium and calcium) in top inflorescence. During the one-year research in northwestern Croatia tested broccoli cultivars achieved higher values of mass, yield, nitrogen, phosphorus and potassium in top inflorescence during summer-autumn growing period, while the calcium content was higher in spring-summer growing period. Neither cultivar can be pointed out with the high values of yield and minerals in both growing periods.

Key words: *Brassica oleracea* var. *italica*, phosphorus, calcium, potassium, top inflorescence

### Uvod

Brokula (*Brassica oleracea* var. *italica*) se, u usporedbi s najčešće konzumiranim kupusnjačama, ističe svojom hranidbenom vrijednosti na što utječe i udio pojedinih minerala. Mineralni sastav cvata brokule ovisi o količini biogenih elemenata u tlu, ali i složenom utjecaju genotipa, abiotskih te agrotehničkih čimbenika tijekom vegetacije. Količina kalcija, magnezija i sumpora ovisi o genotipu što opravdava odabir određenih sorata s ciljem postizanja bolje nutritivne kvalitete (Rosa i sur., 2002).

U agroekološkim uvjetima kontinentalne Hrvatske uzgoj brokule moguć je u proljetnom i jesenskom roku budući da su optimalne temperature za njezin rast i razvoj od 15 do 18 °C (Toth i sur., 2007). Temperature više od 25 °C produžuju razdoblje do formiranja cvata, ali i uzrokuju pojavu sitnijih te rahlijih cvatova ili čak izostanak cvata, što rezultira nižim prinosom (Fabek, 2010). Rosa i sur. (2002) proučavaju utjecaj roka uzgoja na sadržaj nekih minerala (fosfora, kalcija i magnezija). Slične rezultate pokazuje istraživanje Žutić (2002) u

kojem rok uzgoja utječe na količinu minerala u rozeti kineske raštike.

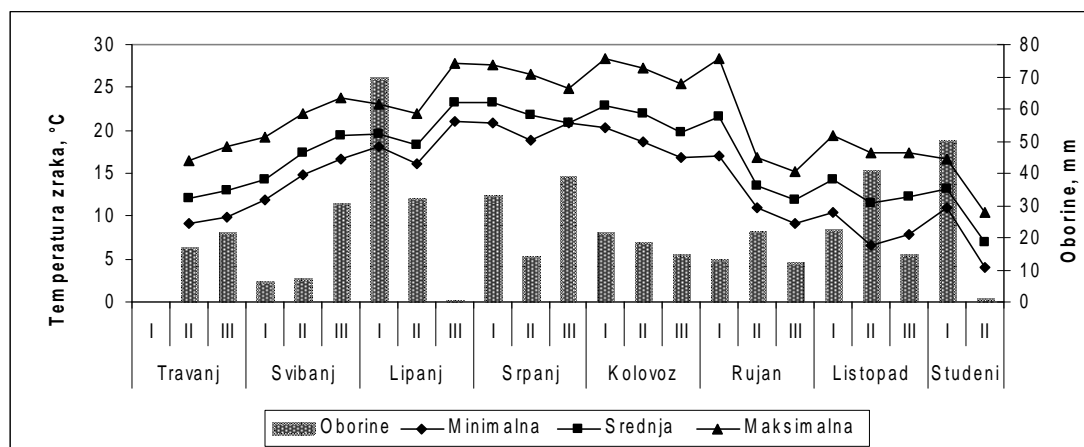
Brokula za svoj rast i razvoj zahtijeva velike količine dušika (Vågen, 2003), no prema Sorensen (1998) povećana gnojidba dušikom smanjuje količinu suhe tvari, kalija, vitamina C i vlakana, a povećava prinos, koncentraciju nitrata, dušika i karotena u cvatu brokule. Veću količinu kalija, kalcija, magnezija, željeza i cinka u cvatu brokule pri povećanju aplicirane doze dušika utvrdili su Yoldas i sur. (2008). Budući da je na tržištu prisutan raznolik sortiment, cilj istraživanja bio je izdvojiti perspektivne sorte brokule s obzirom na prinos i sadržaj pojedinih makroelemenata (dušik, fosfor, kalij i kalcij) u vršnom cvatu, tijekom različitih uzgojnih rokova.

### Materijal i metode

Istraživanje je provedeno u dva roka uzgoja (proljetno-ljetni i ljetno-jesenski) tijekom 2008. godine, na obiteljskom poljoprivrednom gospodarstvu u Zagrebu. U oba roka uzgoja, poljski pokusi su postavljeni po metodi slučajnog blokno rasporeda u četiri ponavljanja. U proljetno-ljetnom roku testirano je 13, a u ljetno-jesenskom roku 12 hibridnih sorata brokule. Presadnice s grudom supstrata sadene su 11. travnja i 17. srpnja u proljetno-ljetnom, odnosno ljetno-jesenskom roku uzgoja. Sklop od 3,3 biljke m<sup>-2</sup> ostvaren je razmakom sadnje 0,6 m x 0,5 m. Kemijskom analizom tla, na obje pokusne površine, utvrđena je dobra opskrbljenost humusom i osnovnim hranivima te je provedena gnojidba sa 200 kg N, 80 kg P<sub>2</sub>O<sub>5</sub> i 215 kg K<sub>2</sub>O ha<sup>-1</sup>. Tijekom vegetacije primijenjene su agrotehničke mjere prihrane, zaštite, međuredne kultivacije i navodnjavanja kišenjem prema potrebi. Ovisno o roku uzgoja, berba je započela 11. lipnja i 12. rujna, odnosno 62 i 58 dana nakon sadnje. Tijekom višekratnih berbi mjerena je masa vršnog cvata temeljem koje je određivan prinos, a pripremani su i reprezentativni uzorci vršnog cvata brokule za laboratorijske analize mineralnog sastava. Standardnim analitičkim metodama za biljni materijal (AOAC, 1995) određivani su kalij, kalcij, fosfor i dušik. Utjecaj sorte na količinu pojedinih minerala i prinos brokule utvrđen je metodom analize varijance, a prosječne su vrijednosti testirane LSD testom na razini signifikantnosti p≤0,05 i p≤0,01.

### Rezultati i rasprava

U grafikonu 1 prikazane su prosječne vrijednosti temperature zraka te ukupnih oborina tijekom proljetno-ljetnog i ljetno-jesenskog roka uzgoja u 2008. godini (meteorološka postaja Maksimir). Nakon sadnje u proljetno-ljetnom roku uzgoja, odnosno tijekom druge i treće dekade travnja, srednje dekadne temperature zraka bile su nepovoljne za rast brokule (12 i 12,9 °C). Prema Lešić i sur. (2004) u razdoblju nakon sadnje presadnica brokule optimalne su temperature od 20 do 24 °C. McKeown i sur. (2004) kao optimalne za generativni rast biljaka iz skupine kupusnjača navode temperature od 15,6 i 18,3 °C, s prosječnim maksimalnim temperaturama od 23,9 °C. Tijekom intenzivne berbe vršnog cvata testiranih sorata, u trećoj dekadi lipnja, vrijednosti maksimalnih dnevnih temperatura zraka bile su u rasponu od 25,5 do 32,4 °C (podaci nisu prikazani) što je rezultiralo većim udjelom netržnih (rastresitih) cvatova. McKeown i sur. (2004) ističu nepovoljan utjecaj visokih temperatura na prinos i tržišnu vrijednost te nutritivnu kvalitetu brokule, cvjetače i krumpira.



Grafikon 1. Meteorološki uvjeti tijekom uzgoja brokule u 2008. godini (Zagreb-Maksimir)

Iako je količina oborina tijekom proljetno-ljetnog roka uzgoja bila nedovoljna (232,7 mm) budući da Lešić i sur. (2004) kao optimalnu količinu oborina navode 400 mm, tijekom prve dekade lipnja, odnosno formiranja cvata ranijih sorata brokule zabilježeno je 69,7 mm oborina što je pozitivno utjecalo na tržnu vrijednost i prinos sorata Captain, Chevalier i Green Magic. Prema Gutezeit (2004) tijekom formiranja cvata biljkama treba osigurati dovoljnu količinu vode (25 mm) što će omogućiti bolje usvajanje mineralnih hraniva, a time i kvalitetniji razvoj cvata te optimalni prinos.

Tijekom ljetno-jesenskog roka uzgoja količina oborina bila je ravnomjernije raspoređena i veća (279,6 mm) nego u proljetno-ljetnom uzgojnom roku. Nakon sadnje, u trećoj dekadi srpnja zabilježeno je 39 mm oborina, što je uz optimalne vrijednosti srednje i maksimalne temperature (20,9 i 24,9 °C) rezultiralo dobrim primitkom i razvojem presadnica brokule. Tijekom kolovoza srednje dekadne temperature zraka bile su u rasponu od 19,7 do 22,9 °C, odnosno više od optimalnih za rast brokule, a značajniji pad temperature zabilježen je tijekom druge dekade rujna (13,5 °C). Povoljni meteorološki uvjeti tijekom listopada i studenoga (podaci nisu prikazani) rezultirali su manjim brojem netržnih cvatova.

Između testiranih sorata brokule utvrđene su statistički značajne razlike u masi i prinosu vršnog cvata (tablica 1). Tijekom ljetno-jesenskog roka uzgoja ostvarene su veće vrijednosti mase i prinosa vršnog cvata (353 g i 11,7 t ha<sup>-1</sup>) što je rezultat povoljnijih agroekoloških uvjeta tijekom vegetacije. U proljetno-ljetnom roku uzgoja ostvaren je manji prosječni prinos vršnog cvata (10,8 t ha<sup>-1</sup>) što je sukladno rezultatima Sorensen (1998) ostvarenih pri gnojidbi sa 210 kg dušika ha<sup>-1</sup>.

Tijekom proljetno-ljetnog roka uzgoja sorta Marathon ostvarila je najveću masu vršnog cvata (376 g), statistički jednaku sorti Captain (364 g). Masa cvata ostalih sorata bila je u rasponu od 293 (sorta Belstar) do 355 g (sorta Chevalier), dok je prinos vršnog cvata varirao od 9,8 t ha<sup>-1</sup> (sorte Lucky i General) do 12,4 t ha<sup>-1</sup> (sorta Marathon). Razlike u komponentama prinosa između sorata bile su izraženije u ljetno-jesenskom roku uzgoja, a najveću masu i prinos tržnog vršnog cvata ostvarila je sorta Parthenon (448 g i 14,8 t ha<sup>-1</sup>), statistički jednaku sorti Chevalier (411 g i 13,6 t ha<sup>-1</sup>). Osim sorte Green Magic, sve su sorte ostvarile masu cvata veću od 300 g, odnosno prinos iznad 10 t ha<sup>-1</sup>. Visoke temperature tijekom formiranja cvata ranih sorata brokule (General i Green Magic), u prvoj dekadi rujna, utjecale su na njihov niži prinos.

Tablica 1. Masa i prinos tržnog vršnog cvata brokule

Sorta	Proljetno-ljetni rok		Ljetno-jesenski rok	
	Masa (g)	Prinos (t/ha)	Masa (g)	Prinos (t/ha)
Agassi	312 abc*	10,3 abc	344 CDE	11,3 CDE
Belstar	293 c	10,2 abc	366 BC	12,1 BC
Captain	364 ab	12,0 ab	-	-
Chevalier	355 abc	11,7 abc	411 AB	13,6 AB
Fiesta	336 abc	11,1 abc	335 CDEF	11,1 CDEF
General	296 bc	9,8 c	305 EF	10,1 EF
Green Magic	347 abc	11,5 abc	287 F	9,5 F
Heraklion	308 abc	10,2 abc	316 DEF	10,4 DEF
Ironman	316 abc	10,4 abc	351 CDE	11,6 CDE
Lucky	297 bc	9,8 bc	356 CD	11,7 CD
Marathon	376 a	12,4 a	372 BC	12,3 BC
Montop	311 abc	10,3 abc	351 CDE	11,6 CDE
Parthenon	346 abc	11,4 abc	448 A	14,8 A

\*Različita slova predstavljaju značajno različite prosječne vrijednosti prema LSD testu, (a) p≤0,05 i (A) p≤0,01.

U istraživanju Toth i sur. (2007) prosječan prinos vršnog cvata tijekom ljetno-jesenskog roka uzgoja bio je 9,1 t ha<sup>-1</sup>, odnosno 30% veći od prinosa ostvarenog u proljetno-ljetnom roku. Prema Mihov i Antonova (2009) tijekom ljetno-jesenskog roka uzgoja, pri razmaku sadnje 0,8 m x 0,4 m (3,1 biljka m<sup>-2</sup>) ostvarena masa cvata bila je u rasponu od 410 do 500 g, dok je prinos varirao od 12 do 14,9 t/ha.

U vršnom cvatu testiranih sorata brokule utvrđene su statistički značajne razlike u količini nekih makroelemenata (tablica 2). Tijekom proljetno-ljetnog roka uzgoja količina dušika u vršnom cvatu brokule varirala je od 351 do 690 mg N 100 g<sup>-1</sup> svježe tvari, dok je tijekom ljetno-jesenskog roka bila u rasponu od 446 do 650 mg N 100 g<sup>-1</sup> svježe tvari. Sorte Lucky i General u oba se roka uzgoja ističu visokom količinom dušika u vršnom cvatu (598 i 596 mg N 100 g<sup>-1</sup> svježe tvari u proljetno-ljetnom roku, odnosno 650 i 620 mg N 100 g<sup>-1</sup> svježe tvari u ljetno-jesenskom roku). U istraživanju Gutezeit (2004) u proljetnom i jesenskom roku uzgoja utvrđena je manja količina dušika u cvatu brokule (395 do 456 i 431 do 470 mg N 100 g<sup>-1</sup> svježe tvari).

## Utjecaj sorte i roka uzgoja na prinos i sadržaj makroelemenata u cvatu brokule

Prosječna količina fosfora u cvatu brokule tijekom oba roka uzgoja bila je podjednaka (190 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> svježe tvari), značajno veća od vrijednosti Lešić i sur. (2004) prema kojima količina fosfora u cvatu brokule varira od 68 do 87 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> svježe tvari. U oba roka uzgoja sorta Chevalier ostvarila je najveću količinu fosfora u vršnom cvatu (218 i 240 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> svježe tvari u proljetno-ljetnom, odnosno ljetno-jesenskom roku).

Tijekom proljetno-ljetnog roka uzgoja količina kalija u vršnom cvatu bila je u rasponu od 186 (sorta Green Magic) do 386 mg K<sub>2</sub>O 100 g<sup>-1</sup> svježe tvari (sorta Montop). U ljetno-jesenskom roku uzgoja sve su sorte, osim sorte Montop, akumulirale veću količinu kalija u cvatu brokule, pri čemu je prosječna vrijednost bila 334 mg K<sub>2</sub>O 100 g<sup>-1</sup> svježe tvari.

Sve testirane sorte, osim Green Magic, Montop i Lucky, u proljetno-ljetnom roku uzgoja ostvarile su značajno veću količinu kalcija u vršnom cvatu, u rasponu od 36 do 70 mg Ca 100 g<sup>-1</sup> svježe tvari, pri čemu je prosječna količina kalcija bila 25% veća nego u ljetno-jesenskom roku uzgoja. Budući da je tijekom proljetno-ljetnog roka uzgoja intenzitet transpiracije veći uslijed visokih temperatura, premještanje kalcija u nadzemne dijelove biljke je intenzivnije. Ostvarene vrijednosti su značajno veće od rezultata Jahangir i sur. (2004) prema kojima brokula sadrži od 25,2 do 29,2 mg Ca 100 g<sup>-1</sup> svježe tvari.

Tablica 2. Količina nekih makroelemenata u vršnom cvatu brokule

Sorta	Proljetno-ljetni rok				Ljetno-jesenski rok			
	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca
	mg/100 g svježe tvari				mg/100 g svježe tvari			
Agassi	392 H*	208 BC	383 A	43 BC	620 B	207 B	363 B	35 C
Belstar	414 G	193 E	346 B	70 A	597 C	206 B	371 B	20 DE
Captain	690 A	211 AB	281 F	40 CD	-	-	-	-
Chevalier	379 I	218 A	328 D	49 B	574 E	240 A	393 A	25 D
Fiesta	351 J	173 FG	294 E	43 BC	446 H	183 D	333 D	15 E
General	586 D	176 FG	219 H	64 A	620 B	173 E	298 G	60 A
Green Magic	615 B	177 FG	186 I	37 CD	593 CD	166 EF	311 EF	45 B
Heraklion	399 H	168 G	261 G	43 BC	587 D	183 D	297 G	40 BC
Ironman	451 F	199 CDE	321 D	43 BC	649 A	207 B	337 CD	22 DE
Lucky	598 C	195 DE	262 G	43 BC	650 A	172 E	318 E	46 B
Marathon	391 H	179 F	297 E	36 D	554 F	194 C	341 CD	26 D
Montop	480 E	156 H	386 A	38 CD	500 G	162 F	307 F	41 BC
Parthenon	374 I	203 BCD	336 C	41 CD	560 F	196 C	344 C	27 D

\* Različita slova predstavljaju značajno različite prosječne vrijednosti prema LSD testu, p≤0,05.

## Zaključci

Rezultati jednogodišnjeg istraživanja tijekom 2008. godine u uvjetima sjeverozapadne Hrvatske ukazuju na značajne razlike testiranih sorti u prinosu te količini pojedinih makroelemenata vršnog cvata brokule. Veće vrijednosti mase i prinosa vršnog cvata, te dušika, fosfora i kalija utvrđene su u ljetno-jesenskom roku uzgoja, dok je u proljetno-ljetnom roku ostvarena veća količina kalcija.

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# The effect of color shade nets on the greenhouse climate and pepper yield

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## Abstract

The goal of the three-year trial was to evaluate the influence of different colored shade nets (photoselective) on the plant development, yield and quality of bell pepper (*Capsicum annuum* L.). Pepper was grown under four different colored shade-nets (pearl, red, blue and black) with different relative shading (40% and 50%). Exposure to full sunlight was used as a control. Used color-shade nets improved productivity by moderating climatic extremes. Depending on the year, the total fruit yields (t/ha) under the colored shade nets were higher by 113 to 131%, relative to the open field. In this investigation the potential use of pearl and red colored shade nets (40% by FAR) was demonstrated.

Key words: photoselective net, solar radiation, *Capsicum annuum* L., yield

## Introduction

During the last decades, due to increased air temperature and intensity of solar radiation caused by climate changes, an increasing area of crops is being grown under shading materials of various types. ColorNets represent a new agro-technological concept, which aims at combining the physical protection, together with differential filtration of the solar radiation. They are based on the incorporation of various chromatic additives, light dispersive and reflective elements into the netting materials during manufacturing. It is either applied by itself over net-house constructions, or combined with greenhouse technologies. The ColorNet approach was evaluated in numerous ornamentals (Nissim-Levi et al., 2008), vegetables (Fallik et al., 2009, 2010), fruit trees (Shahak et al., 2004a) and vineyards. Netting is frequently used to protect agricultural crops from excessive solar radiation (shade-nets), improving the thermal climate (Kittas et al., 2009), sheltering from wind and hail and exclusion of bird and insect-transmitted virus diseases (Teitel et al., 2008). The shading of crops results in number of changes on both local microclimate and crop activity. These changes on local microclimate modify CO<sub>2</sub> assimilation and consequently crop growth and development (Kittas et al., 2009). Smith et al. (1984) observed that under shading nets the air temperature was lower than that of the ambient air, depending on the shading intensity. Shade netting not only decreases light quantity but also alters light quality to a varying extent and might also change other environmental conditions. The target responses are those determining the commercial value of each crop, including yield, product quality, and rate of maturation (Shahak et al., 2004b). The total area of protected vegetable cultivation in different types of greenhouse in Serbia reached 2-3.000 ha and the main vegetables are, peppers, tomatoes, cucumbers... The use of shading nets has become very popular in Serbia due to the very high temperatures in the summer season (35~42 °C). Pepper grown in an arid region under red and yellow shade nets, had a significant higher yield compared with black nets of the same shading factors, without reducing fruit size. In addition, the export-quality fruit yield was also significantly increased under the red and yellow shade nets (Fallik et al., 2009).

The goal of the present three-year trial was to evaluate, the influence of different colored shade nets on the plant development, yield and quality of fresh harvested pepper.

## Material and methods

The experiments were performed in an experimental garden located at village Moravac near Aleksinac, (Longitude: 21° 42' E, Latitude: 43° 30' N, altitude 159 m) on the central area of South Serbia, during spring and summer of 2008 to 2010. Trials were set up to the randomized complete block design with three replications. The shading nets were mounted on a structure about 2.0 m height over the plants same as a screen house or combined with greenhouse technologies.

### Net characteristics

In order to test the effect of shading nets (colour and shading intensity), four different shading nets were used: the photosensitive nets include “colored-ColorNets” (red, blue and black) as well as “neutral-ColorNets” (pearl) with shading intensity of 40% and 50% relative shading (photosynthesis active radiation-PAR) and were compared with the open field microclimate and production. Color shade nets were obtained from Polysack Plastics Industries (Nir-Yitzhak, Israel) under the trade mark ChromatiNet.

### Plant material

The pepper (*Capsicum annum* L.) ‘Cameleon’ was planted with an intra-row distance of 0.30 m and an inter-row distance of 0.60 m, and the final plant density was 5,6 plants per m<sup>2</sup>. The plants were grown following the technique that is usually implemented by the local producers. Seedlings (60day-old plants) were transplanted on May 5, while the shading nets were installed above the crop on June 10 (35 days after transplanting). The measurements were carried out until September 5.

### Light interception by nets

A Sun Scan light interception measurement system was used for solar radiation properties measurements. The effect of nets on the interception of light was measured daily as a percentage of total above canopy photosynthetically active radiation (PAR), using a Sun Scan SS1-UM-1.05 (Delta-T Devices Ltd Cambridge, UK) with a 64 sensor photodiode linearly sorted in a 100 cm length sword. Readings were in units of PAR quantum flux ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ ). Solarimeter - SL 100 is easy to use portable autonomous solarimeter that measures solar irradiation range from 1 to 1300 W·m<sup>2</sup>. All spectral data were expressed as radiation intensity flux distribution in W m<sup>-2</sup> nm<sup>-1</sup>.

## Results and discussion

The word Colorshade Net is termed for a net which prevents excess sunlight and retain soil moisture levels for proper plants growth. This leads to an increase in productivity (yield) of the plants. The response of pepper plants to shading will probably vary in different geographical areas, seasons and cultivars, and from different agricultural practices such as planting density, irrigation, fertilization, and other factors. The microclimates were similar under nets, with slightly lower values of temperature and air humidity than in the open air.

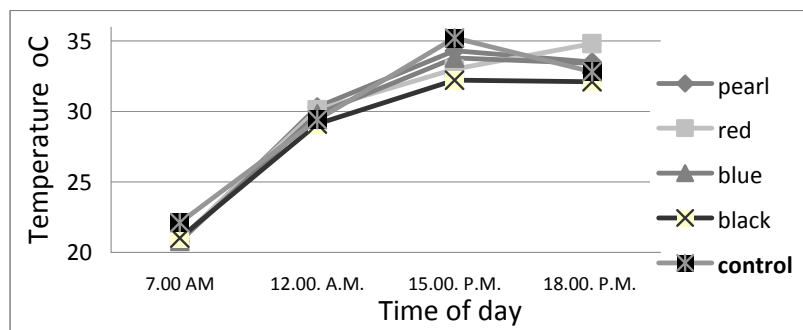


Figure 1. The influence of color nets on average temperature during July

The average air temperature (at July 15) below different color-shade nets was between 0.9 °C (pearl) and 3.0 °C (black) lower in comparison with air temperature at open field (control) (figure 1). Advantages of color-shade net are reflected in temperature control: improves productivity by moderating extremes of

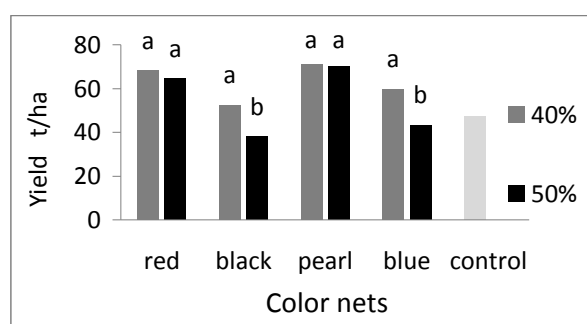


temperatures. Air movement is restricted, thus reducing wind damage to the crop and evaporation of soil moisture. Air beneath the shade cloth stays humid which is of further benefit to the plant. Wind speed inside the screenhouse was reduced by more than 50% (data not show).

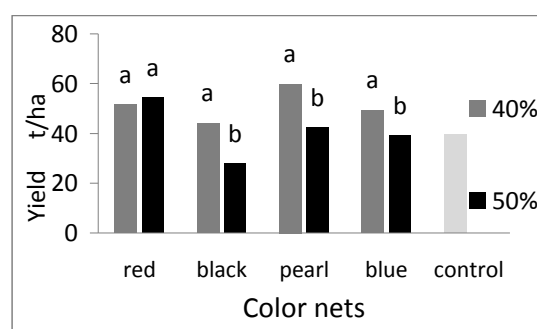
**Table 1. Solar radiation and Photosynthetically Active Radiation of sunny day at noon - July**

Color Nets	Solar radiation (W·m <sup>-2</sup> )				Photosynthetically Active Radiation (PAR) $\mu\text{mol m}^{-2}\text{s}^{-1}$			
	Plastichouse + color nets		Only color nets		Plastichouse + color nets		Only color nets	
	Relative shading		Relative shading		Relative shading		Relative shading	
	40%	50%	40%	50%	40%	50%	40%	50%
Red	595	586	623	600	666,4	584,6	958,9	708,6
Black	412	414	469	417	779,2	649,5	841,5	693,5
White	555	492	569	515	675,1	572,0	858,4	768,7
Blue	498	447	521	474	561,5	456,5	696,7	644,4
Control	Plastichouse 857		Open field 942		Plastichouse 1111,4		Open field 1593,7	

Results (table 1) show that net radiation depending of color nets and intensity of shadow. Solar radiation was lower in the plastic house (857 W·m<sup>-2</sup>) in relation to radiation in the open field (942 W·m<sup>-2</sup>). Compared with the control, solar radiation was significantly reduced by the 50% shadow intensity in relation to that of 40%. The greatest decrease in radiation intensity was recorded below black net with 50% shade (515 W·m<sup>-2</sup>). It seems that while the solar radiation in the greenhouse without shading reached very high level during the midday, solar radiation in shaded greenhouse (with 50% shading) did not exceed 650 W·m<sup>-2</sup>. From table 1 we can see that incoming solar radiation between the control greenhouse and the greenhouse with the highest shading intensity (50%) was 410 W·m<sup>-2</sup> and 270 W·m<sup>-2</sup> for black and red color-nets, respectively. Our data shows that during a sunny day in July (with solar radiation at 950 W·m<sup>-2</sup>) the reduction did not exceed 1 °C in greenhouse with moderate shade so, air temperature increased for 1 °C with every solar radiation increasing by 100 W·m<sup>-2</sup>. The net radiation is strongly correlated to the incoming solar radiation, in analogy to what is known to occur over open ground. Under high solar radiation conditions (in South Serbia at July and August) value of photosynthetic photon flux density (PPFD) is about 1600  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ , so unshaded plants were exposed to high heat stress throughout the growing season. Value for PPFD varied between 1593  $\mu\text{mol m}^{-2}\cdot\text{s}^{-1}$  on sunny days and 700 to 920  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  when it was cloudy. Shade was not uniform in that there were patches of light which changes during the course of the day and fell on different part of the plants. It was possible to find horizontal differences in PPFD greater than 500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  at a given time (table 1). The solar radiation registered on sunny days resulted in high PAR values (maximum 1600 to 2000  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ), which are common in southern Europe arid conditions. On cloudy days (complete clouds cover), the maximum values ranged from 800 to 900  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ . In both cases, the registered values were twice as great as those for northern Europe (Belgium, Germany, etc.) and for this reason radiation disability is not a limitation even when black net is used (maximum PAR values around 1200  $\mu\text{mol m}^{-2}\text{s}^{-1}$ ), Iglesias and Alegre (2006).



**Figure 2. Influence of color shade nets integrated with greenhouse on pepper yield**



**Figure 3. Influence of color shade nets on pepper yield (t/ha)**

Plants grown under black color-nets with 40% shadow had higher yield for 10.5% than control plants grown without nets. It was founded that red and pearl shade nets significantly increased the total yield (43.5% and 49.5%) which was associated with both higher productivity (number of fruits produced per plant) and larger fruits (data not show). Pepper under 50% shadow achieved similar fruit yield in comparison with yield

obtained from 40% color shade nets, except under black shade net where achieved yield was lower than control. The relative difference between the colored and the black shade nets with regards to export-quality fruit yield was even more prominent. Rylski and Spigelman (1986) showed that under field conditions during the summer, a reduction in radiation of approximately 26% had a significant impact and increased production in *C. annuum* compared with exposure to full sunlight. With roughly 50% shade, commercial production was greater than in full sunlight, although less than with 26%. Under greenhouse conditions in Israel, increased shading rate between 40 and 90% resulted with a higher flower abscission rate and reduced assimilation rates which differed among the cultivars (Aloni et al., 1996). Depending on the year, the total fruit yields (t/ha) under the colored shade nets were higher by 113 to 131%, relative to the equivalent black shade net. The higher fruit yield resulted mostly from enhanced fruit production rates, namely the number of fruits produced per plant, while average fruit size was not significantly affected in most cases. Research results showed that shading of bell pepper plants affected both fruit yield and quality. Total and marketable yield increased with 40% shading level and then decreased with increased shading level (50%). Reduced total and marketable yield of un-shaded plants was probably caused with high heat stress. Moderate shading (about 40%) of bell pepper may be an option to reduce heat stress conditions and extend the spring-summer season toward September.

### Conclusion

The photosensitive, light-dispersive shade nets provide a new, multi-benefit tool for crop protection. Changing the light intensity and radiation spectrum has a large impact on the total production system: microclimate and energy consumption are influenced, costs and benefits are affected. Research on light in horticultural systems is necessary for a sustainable and market-oriented greenhouse production in the future.

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# Effect of different doses of slow-disintegrating fertilizer on the fresh seasoning herb quality

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## Abstract

The use of fresh spices has considerably expanded lately. There are various plant species used as fresh spices. Sweet basil and garden balm production for fresh spices is commercially very important due to the possibility of the whole-year production, with implementation of various growing technologies. This paper deals with the influence of various doses (0 to 4g/l) of the slow-disintegrating fertilizer *Scotts (Osmocote Exact, 15:9:9:MgO + microelements)* implemented into the growing substratum before seeding, on the quality of fresh spices (sweet basil and garden balm). Considering of nitrate levels in the plants, results indicate that the slow-disintegrating fertilizer doses should not exceed 2 g/l in the sweet basil production or 1 g/l in garden balm production.

Key words: fresh herb, garden balm, nitrates, quality, sweet basil

## Introduction

There is a worldwide tendency to use fresh spices within the food industry. This is due to the fact that fresh spices more strongly influence taste and smell than dry ones, that they improve food digestion and are excellent preserving agents, too (Štrbac and Beatović, 2007). Since the interest in fresh spices has increased, the technology of seasoning herbs production is to be improved. Seasoning herbs are used in cookery and therefore they have to be produced in accordance with European regulations which include strict control of hygiene, fertilizers and protective substances applied during the production (Jelačić et al., 2006).

When producing food, one should bear in mind that, apart from other food contaminants, high nitrate content in victuals can cause harmful effects on the human organism. In order to decrease high risks within human nutrition, the World Health Organization prescribes maximum amounts of daily nitrate intake through food (63.7 mg), which mainly comes from vegetables. This is to impose controlled production of spices of high biological quality and minimum nitrate content. According to the above-mentioned, we should always search for new technological solutions of production and improve old ones, from the selection of new-generation cultivars and hybrids with higher nitrate tolerance accumulation to the mineral nutrition regulation etc (Kastori and Petrović, 2003).

Sweet basil (*Ocimum basilicum* L.) and garden balm (*Melissa officinalis* L.) are seasoning herbs, especially important in the Mediterranean region (Putievsky et al., 2001). Production of basil and garden balm as fresh spices is of great commercial relevance due to the possibility of the whole-year production, with implementation of various growing technologies. Sweet basil has been used as a fresh spice in cookery and industrial production of the famous sauce "*Peste alla Genovese*" in Mediterranean countries, especially Italy, since a good while ago (Tesi et al., 1995).

Various manners of production of sweet basil, garden balm and other seasoning herbs have been used lately in order to produce raw material of the best possible quality. Different fertilizers are applied within intensive production systems. Application of slow-disintegrating fertilizers is quite new in Serbia.

Fertilizers which discharge or release biogenic elements in a controlled manner belong to the group of slow-disintegrating fertilizers. The fact that a one-time application of such fertilizers fully satisfies the plant's needs for mineral nutrients represents their advantage. These fertilizers release biogenic elements in a controlled manner and at the precise time intervals. Their complete activation at the moment of application,

that is at the moment of planting, is thus prevented, which usually happens when implementing ordinary mineral fertilizers. Therefore, creation of high salt concentration in the substrate, which mainly causes plant decay when grown in containers and pots, is prevented (Hanić, 2000).

Slow-disintegrating fertilizers have mainly been used in production of decorative plants and flowers. Over the past few years, their influence on the quality of flower nursery plants, medicinal, aromatic and seasoning herbs has also been examined (Vujošević et al., 2007; Jelačić et al., 2007, 2008).

Aware of the influence of increasing fertilizer doses, we have begun to examine implementation of various doses of slow-disintegrating fertilizers, all in order to observe their influence on the quality of fresh spices: sweet basil and garden balm.

### Materials and methods

Researches with the above-named goal were implemented during the year 2010 in the greenhouse of the Faculty of Agriculture of Belgrade - Zemun. Using the *speedling system*, basil and garden balm were grown in polystyrene multi-cell trays (Beatović et al., 2006).

Table 1. Technical properties of multi-cell trays

Cell volume (cm <sup>3</sup> )	Cell number	Cell shape	Container size (cm)	Number of plants per m <sup>2</sup>	Volume of substrate per container (cm <sup>3</sup> )
76	40 (5x8)	Inverted cone	53 × 31 × 5,5	243	3040

Commercial substrate was used in basil and garden balm production. Standard methods were applied so that agrochemical characteristics might be determined, and the procedure was carried out in the Laboratory of Agrochemistry of the Faculty of Agriculture of Belgrade - Zemun (Džamić et al., 2000).

Table 2. Agrochemical properties of substrate

pH		% Humus	% N	C/N	mg/100 g		ppm	
H <sub>2</sub> O	KCl		Total		P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	NH <sub>4</sub> <sup>+</sup>	NO <sub>3</sub> <sup>-</sup>
5,88	5,66	68,37	1,034	38,3:1	94	64	60,2	97,3

Various doses of the slow-disintegrating fertilizer were used as treatments: 0 g/l of substrate (control - no fertilizer applied), 1 g/l of substrate, 2 g/l of substrate, 3 g/l of substrate and 4 g/l of substrate. The slow-disintegrating fertilizer *Scotts (Osmocote Exact)*, with the 15:9:9:9MgO + microelements, was applied to the seeding substrate (g/l) prior to the seeding.

The large-leaved sweet basil cultivar 'Genovese' and the garden balm cultivar 'Citron' were also included within the experiment. A few sweet basil and garden balm seeds were manually seeded in each container cell, on March 12 and February 23 respectively. After germination, there was one plant left in each pot. The standard nurturing measures were applied during the period of production: watering, shading and airing. Sweet basil production lasted up to 75 days while garden balm production lasted up to 80 days. The random sample method was applied, and 31 plants were chosen from each treatment. The following parameters of the sweet basil and garden balm quality were analyzed: plant height (cm), number of leaves, number of lateral branches, fresh plant weight (g) and nitrate content within the plant material (mg/kg) by method of Jelenić and Džamić, (1989). Results of the research were presented through the basic descriptive and analytical statistics indicators. The central tendency indicators were used to calculate arithmetic mean ( $\bar{X}$ ). ANOVA was used for data processing, while examination of the statistical relevance of differences among average values between treatments was carried out by means of the t-test.

### Results and discussion

Implementation of increasing doses of the slow-disintegrating fertilizer for sweet basil production in containers considerably influenced all analyzed parameters (Table 3).

The biggest fertilizer dose (4 g/l) was applied in order to get the highest sweet basil plant, but there were no considerable differences in the plant height when fertilizer doses of 3 and 4 g/l were applied (25,95 and 26.06

cm, respectively). Increasing doses of the fertilizer also influenced the number of leaves per plant. The highest number of leaves (9,41) was produced when the dose of 4 g/l was applied. However, there were no statistically relevant differences when doses of 2, 3 and 4 g/l were applied, which indicated that increase in the fertilizer dose did not considerably influence the number of leaves per plant.

**Table 3. Influence of the slow-disintegrating fertilizer on the quality of fresh sweet basil used as a spice**

Doses of slow-disintegrating fertilizer	Plant height (cm)	Number of leaves per plant	Fresh plant weight (g)	Content of nitrate (mg/kg)
0 (test)	17,44	8,00	3,25	107
1 g/l	20,21	8,51	4,95	207
2 g/l	22,38	9,22	5,64	275
3 g/l	25,95	9,35	7,01	448
4 g/l	26,06	9,41	7,20	662
LSD	0,05	1,30	0,42	65
	0,01	1,75	0,63	97

Increased quantities of the fertilizer also influenced the sweet basil plant weight. Application of the 3 and 4 g/l doses produced the highest average fresh weight (7.01 and 7.20 g, respectively). However, these two values showed no statistically relevant differences in the plant mass. Table 3 indicates that the nitrate content within the plant material fluctuated from 107 mg/kg in the control treatment to 662 mg/kg in the treatment with the highest dose of slow-disintegrating fertilizer. Accordingly, there were statistically considerable differences among average values of the nitrate content in sweet basil. The results comply with researches of Tessy et al. (1995). Within researches in production of flower nursery plants, medicinal, aromatic and seasoning herbs (Jelačić et al., 2007 and 2008; Beatović et al., 2008) the effect of implementation of the slow-disintegrating fertilizer and the positive influence of various doses were noticed.

Various doses of the slow-disintegrating fertilizer considerably influenced the height of garden balm (Table 4). The highest value of plant height (22,32 cm) was achieved in the production with the highest fertilizer dose. This value was twice as high as in treatment with no fertilizer implemented. The analyzed parameter showed high statistically relevant differences among all treatments of the experiment. The increasing fertilizer doses also positively influenced the number of lateral garden balm branches, but considerably less than the plant height.

**Table 4. Influence of various doses of slow-disintegrating fertilizer on the quality of garden balm used as fresh spice**

Doses of slow-disintegrating fertilizer	Plant height (cm)	Number of lateral branches	Plant weight (g)	Content of nitrate (mg/kg)
0 (test)	11.13	3.11	2.15	214
1 g/l	15.44	3.23	3.55	334
2 g/l	19.65	3.89	3.87	588
3 g/l	20.77	4.34	4.45	958
4 g/l	22.32	4.36	4.98	1431
LSD	0,05	0,43	0,35	70,24
	0,01	1,77	0,47	134,11

The biggest plant weight (4,98 g) was produced with implementation of the highest fertilizer dose (Table 4). Between the highest and the lowest weight, there was a high average difference by more than 100%. There were high statistically relevant differences in the nitrate content, as well. Nitrate content in garden balm fluctuated from 214 mg/kg in the treatment with no fertilizer implemented to 1431 g/l in the treatment with the highest fertilizer dose. The nitrate content values were considerably higher than the values achieved in the sweet basil experiment, indicating that garden balm is a highly nitrate accumulating plant species.

## Conclusion

According to the results of the experiment, it can be concluded that implementation of increasing doses of slow-disintegrating fertilizer considerably influences the quality of sweet basil and garden balm nursery

plants. Dose of 3 g/l strongly influenced the sweet basil morphological characteristics and the fresh herb yield, as well. Fertilizer doses of 2 and 3 g/l are acceptable since they do not cause too high nitrate accumulation. The highest fertilizer dose implemented in garden balm production (4 g/l) has had the most considerable influence on the plant height, number of lateral branches and plant weight. As for the nitrate content, the fertilizer dose of 1 g/l is recommended.

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# The yield of tomato cultivars grown in organic and conventional system

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## Abstract

Three tomato varieties were grown in the greenhouse during 2008-2010, using two growing systems: organic and conventional. Production substrate consisted of 30% soil, 50% manure and 20% peat and a small part of the marble. Planting (2.64 plants/m<sup>2</sup>) was done on April 18 and harvest lasted from June to beginning of September. Organic system obtained optimal production level but with higher costs of cultivation compared with the conventional one. At the same time, organic tomatoes achieved a better price, guaranteed placement, so that the entire production is placed at 1.8 € per kg. The best results were obtained by variety Elpida F<sub>1</sub> in organic production with an average yield of 89.87 t/ha.

Key words: *Lycopersicon esculentum* Mill., variety, production system, yield

## Introduction

Organic agriculture is developing rapidly, and statistical informations are now available from 154 countries of the world. According to the Research Institute of Organic Agriculture (FiBL), and the International Federation of Organic Agriculture Movements (IFOAM), 35 million hectares of agricultural land was under organic management (both certified and in conversion) in 2008. In Switzerland for instance, organic vegetables account for 10% of all vegetables sold. In U.S., organic fruit and vegetables account for 37% of all organic food sales (retail value). The largest producer is Italy (121.000 hectares). Key challenges for organic horticultural crops, especially for fresh consumption, tend to be insect pest and disease management, weed control in vegetables, and resource efficiency (Wiler, 2010).

Organic agriculture in Greece has its roots in the ecological movement at the beginning of the 1980s. The first organic farmers were mostly amateurs who experimented with different organic cultivation methods. Commercial organic agriculture started in 1982 with the demand for organic currants (sultanas) from a Dutch firm. Individual farmers converted their farms in the following years, supervised by foreign certification and inspection bodies. In 1999, both the share of organically utilised area as well as the number of organic farmers reached 0.6% of the overall country. EU-Regulation 2092/91 brought a major change. Many farmers officially converted their farms to organic agriculture. A second expansion took place after the introduction of hectare subsidies in 1996 with the adoption of the EU-Regulation 2078/92. In Greece, there is now 3.8% of total arable land under organic production or 317.824 ha with about 24.057 registered manufacturers.

According to the FAO, tomato is the second most widely cultivated vegetable in the world after potato, with worldwide annual production of nearly  $1.25 \times 10^8$  tons of fresh tomato from  $4.6 \times 10^6$  ha. China, the USA and Turkey are the leading producers (FAO, 2006). This study is focused on tomatoes because the fresh tomato consumption per capita (8.1 kg in 2000) and tomato products consumption per capita (31.1 kg in 2000) in the United States is very high, second only to the potato (Lucier et al., 2000). Tomatoes are important not only because of the large amount consumed, but also because of their high health and nutritional contributions to humans. A survey conducted by the University of California at Davis ranked tomatoes as the single most important fruit or vegetable of western diets in terms of overall source of vitamins and

minerals. Most important, tomato consumption has been shown to reduce the risks of cardiovascular disease and certain types of cancer, such as cancers of prostate, lung, and stomach (Canene-Adams et al., 2005). The benefits of tomatoes and tomato products have been attributed mostly to the significant amount of lycopene contained, which constitutes 80 to 90% of the total carotenoid content present in tomatoes and tomato products. Tomatoes provide an important and significant source of vitamin C (19 mg/100 g of fresh weight), lycopene (3.0 mg/100 g of fresh weight), and flavonoids (USDA, 2006.). Greece is at the 15<sup>th</sup> place in the world and at the 3<sup>rd</sup> place in Europe with a total annual tomato production of 1,338,600 MT. Tomato is very important crop in the total Greek export and it is located on the fourth place, just behind the olive, cotton and grapes (FAOSTAT, estimated, 2008). Organic tomatoes production in its simplest form means going back to the production methods that farmers used before the advent of synthetic chemicals. This production method avoids or largely reduces the use of synthetic chemical inputs, such as fertilizers and pesticides, and aims to minimize negative effects on the environment and maintains the biological diversity of the soil (Mäder et al., 2002).

In this study, the effect of conventional and organic production systems on yield, physicochemical properties of three greenhouse tomato cultivars was determined. The tomatoes were cultivated in certified organic fields and in a conventional field in Sapes (Rodopi region, North-East Greece).

### Material and methods

Three tomato varieties (Robin-F<sub>1</sub>, Amati-F<sub>1</sub> and Elpida-F<sub>1</sub>) were grown in the greenhouse (plastic tunnel 3.5 m high, covered by termolux 180 µm) during 2008-2010 located in the Sapes, North-Eastern Greece, using organic and conventional growing system. Substrate for the production consisted of 30% soil, 50% manure and 20% peat and a small part of the marble.

Tomato seeds were sown on first decade of February in seed trays containing a peat and perlite mixture. At the third true leaf stage, the seedlings were transplanted to the soil with plant density 2.64plant/m<sup>2</sup>. Soil solarization against the nematodes was applied before transplanting. It was an early-medium production. Planting was done on April 18 and harvest period lasted from mid-June to late August. Production systems were differ about the fertilizer used (organic: goat manure; conventional: mineral fertilizer NPK 12-12-17, Nitrophos blue special+2MgO+8S+Trace elements - amount of 400 kg/ha), the number of phytosanitary treatments (larger in organic system), and the pesticide types applied (preventive in the organic system and preventive or healing with variable period of effectiveness in the conventional one). All plants were irrigated using drip irrigation. As the plants grew, all lateral shoots were manually removed and poles were used to support single stem plants. Plants were topped after sixth truss. Bumblebees were used for pollination during the organic tomato production in the greenhouse.

### Yield

Yield was evaluated through the fruits harvesting from eight central rows in the plots, with 10 pits harvested per variety. Fruits were classified as unmarketable or marketable, whether the fruits defects were presented or not.

### Statistical analyses

All statistical analyses were performed using SAS procedure (SAS Institute, Cary, NC) for analyses of variance. Means were compared by Tukey's multiple range test.

### Results and discussion

Effective greenhouse production means dealing with environmental conditions. Location properties relate to components such as: climate (irradiation, temperature, the length of the day, water balance, etc.), edaphic (structure, chemical and biological soil properties, water and air content at different water tensions), and management (cultivation measures) factors.

Greenhouse vegetable production offers advantages compared to production at the open field with regard to quality assurance principally, because the plants are not exposed directly to the rapid changes of climate conditions. An important role for this purpose is also the cultivar selection by using tomato hybrid varieties



## The yield of tomato cultivars grown in organic and conventional system

with a high yield potential and a good fruit quality. Combinations of manure, peat and small part of the marble were used for fertilization in organic production, and mineral fertilization was included in conventional production as the control. Organic fertilization results in improved yield and fruit quality compared to conventional fertilization. In addition, organic fertilization should be supported in order to facilitate reuse and disposal of organic wastes and to maintain and/or increase soil fertility.

There was significant difference in the fruits number per plant between cultivars in production system tested. The number of fruits per plant (from 13.9 to 20.7) in organic system was significantly higher than in conventional (between 10.3 and 14.9).

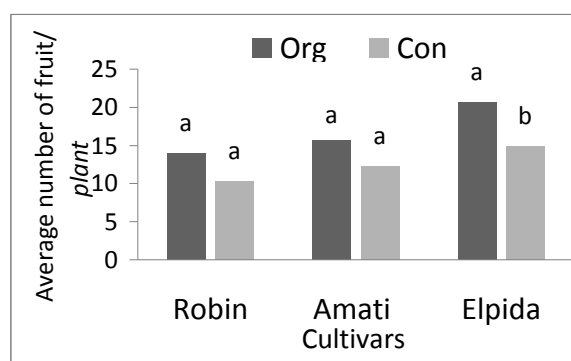


Figure 1 Average fruit number per plant in different tomato cultivation systems

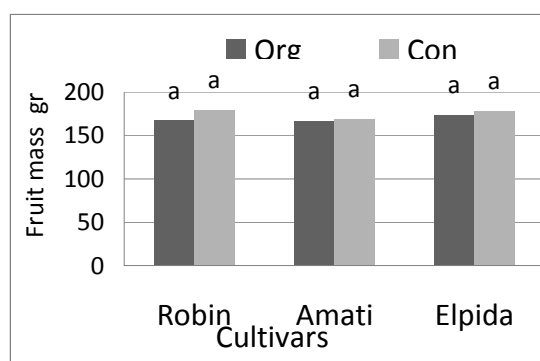


Figure 2 Average fruit mass (g) in different different tomato cultivation systems

There were no significant differences between production systems in varieties 'Robin' and 'Amati' (figure 1) while 'Elpida' produced significantly more fruits per plant as compared to the other cultivars in conventional system. 'Elpida' is a prolific cultivar as a whole, and produced significantly more per plant under organic conditions too. However, this comparison is between production systems.

Average fruit mass depends of cultivars and production system. Overall, fruit mass was higher in all cultivars in conventional production. The fruit weight ranged from 166.9 to 179.3g (Robin F<sub>1</sub> in convencional production). There were no significant differences in the fruit weight between individual cultivars and production systems (figure 2). Thicker pericarp tissue and high skin wax in 'Elpida' fruit could serve as a good water reservoir and would most probably contribute to fruit firmness (data not shown).

There are many aspects to be considered when analyzing differences in production between the organic and conventional production system. The overall purpose of comparing organic and conventional production system was to determine whether yield or fruit quality would be compromised by converting from a conventional to an organic production system. Significant plant diseases or pest was not determined during the entire course of organic-biological tomato production. Duration of organic-biological production from planting till harvest was shorter than in the conventional production.

Table 1 Yield of three tomato cultivars in organic and conventional production system

Cultivar	Robin F <sub>1</sub>		Amati F <sub>1</sub>		Elpida F <sub>1</sub>	
	Organic	Convent.	Organic	Convent.	Organic	Convent.
2008	70.61	51.35	79.96	62.77	92.87	77.42
2009	75.82	55.0	64.56	59.4	100.45	74.68
2010	31.21	31.12	51.18	34.4	76.28	48.36
Average	59.21	45.82	65.23	52.19	89.87	66.82
LSD 1%	28.68		17.01		16.56	
LSD 5%	66.15		39.24		38.20	

Average commercial production of the three cultivar tested in organic system (71.4 t/ha) was significantly higher than average of the three cultivars in conventional system (54.95 t/ha). The best result was achieved by variety Elpida F<sub>1</sub> in organic production with an average yield of 89.87 t/ha (table 1). Differences in the yield between production years were evidence. In the third year of the study total yield was the lowest. We surmise that these differences resulted from climatic conditions because the temperature in early summer

was approximately 2 °C lower compared to the first and second year. It is generally supposed that lower temperature may result in lower intake of organic fertilizers. Organic fertilization resulted in improved yield and fruit quality compared to conventional fertilization (Polat et al. 2010). Martinia et al. (2004) reported that there was no difference in tomato (*Lycopersicon esculentum* Mill.) growth or yield between an established organic system and the comparable conventional system. When production system data were combined, marketable yield was not affected by cultivar. When averaged across cultivars, organic yield was only about 63% of the conventional one. Stoleru et al. (2007) showed that fertilizing with mature manure resulted with increased tomato yield from 59.1 t/ha (when 'Arletta' was fertilized with 30 t/ha) to 65.4 t/ha (when 'Belle' was fertilized with 40 t/ha). The differences between regions were associated with soil type and climate and, demonstrated the need for more studies to be carried out under different conditions (Polat et al. 2010).

### Conclusions

High tunnels are a valuable tool for organic farmers, improving crop yields and quality while reducing many disease and pest problems relative to the open field. Further studies will help to determine cultivation system and selection of varieties in tomato production in high tunnels.

Organic system let to obtained optimal production level but with higher costs of cultivation (certification procedures, manual weeding, higher cost per unit of fertilizer, phytosanitary treatments applied etc.) compared with conventional farming. At the same time, organic tomatoes achieved a better price and guaranteed placement, so that the entire production is placed at 1.8 euro per kg. The agricultural production system and cultivation practices are critical factors in determining yield and food nutritional quality.

Three tomato hybrid varieties were cultivated in conventional and organic production in the greenhouse to evaluate the yield and fruit quality. Maximum yields were obtained 'Elpida' cultivar in organic production.

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# Tomato quality parameters from organic greenhouse production

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## Abstract

The aim of this study was to compare fruit quality parameters of tomato cultivars grown in organic and conventional growing system. Higher levels of TSS, sugars and vitamin C were determined in conventional tomatoes. Tomatoes grown organically contained substantial amounts of lycopene and carotenoids. Results have shown differences between cultivars and growing seasons. Cultivar Elpida achieved the highest TSS content (5.08 °Brix), sugar (4.10 mg·100<sup>-1</sup> g f.w.) and lycopene (3.75 mg·100<sup>-1</sup> g f.w.) among tested cultivars. Total sugar and acid ratio of organic tomato fruits ranged from 0.41 to 0.47% citric acid, which resulted with favorable fruits flavor in comparison to conventional tomato.

Key words: *Lycopersicon esculentum* Mill., growing system, total soluble solids, lycopene, vitamin C

## Introduction

Tomato (*Solanum lycopersicum*, syn. *Lycopersicon esculentum* Mill.) is an annual horticultural fruit with a worldwide distribution and high economic value. Its consumption benefits human health because of its high antioxidant compounds content. Increased interest in organic tomato production imposed the need to evaluate the quality and nutritional value of organic tomato. Research has shown that organic agricultural plants contain more total and reducing sugars and flavonoids (Rembiałkowska et al., 2003). French Agency for Food Safety (AFSSA) and Lairon (2010) in published studies of the nutritional and sanitary quality of organic food conclude that organic plant products contains more dry matter and minerals (Fe, Mg); contains more antioxidant compounds such as phenols and salicylic acid; 94-100% of organic food does not contain any pesticide residues and organic vegetables contains about 50% less nitrates. Other scientists have argued that a valid comparison of nutritional quality would require the same cultivars growing at the same location, in the same soil and with the same amounts of nutrients, conditions which all normally differ between the two systems (Magkos et al., 2003). Research results of organic and conventional production effects on quality sometimes were contradictory. In terms of quality, some studies reported better taste, higher vitamin C contents and higher levels of other quality related compounds for organically grown products. Several other studies have found the opposite or no differences in taste or other measured quality characteristics between organically and conventionally grown fruits and vegetables (Caris-Veyrat et al., 2004). The aim of this study was to compare fruit quality parameters of tomato cultivars grown in organic and conventional growing system.

## Material and methods

Three tomato varieties (Robin-F<sub>1</sub>, Amati-F<sub>1</sub> and Elpida-F<sub>1</sub>) were grown in the greenhouse (plastic tunnel 3.5 m high, covered by termolux 180 µm) during 2008-2010 located in the Sapes, North-Eastern Greece, using organic and conventional growing system. Conventional greenhouse technology and horticultural practices were slightly different from organic greenhouse production. The main variations are concerned with pest control and fertility. In conventional cultivation mineral fertilizers and chemical plant protection were

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applied.

Ripe tomato fruit samples were chemically analyzed twice: at the beginning of fructification period and at the end of cultivation. At pink stage of ripening by visual inspection, samples were collected for quality analyses (color, firmness, total soluble solids, total sugar, total acidity vitamin C content, carotenoids and lycopene content). For sensory evaluation fruits were evaluated by trained descriptive panelists on the harvest day. All analyzes were carried out in Technological Faculty of Novi Sad and Analytical Laboratory of Biolab Epirus (Tzimas s. Bioepirus Ltd), Ioannina - Greece. Total soluble solids (TSS) were determined by refractometer and results were reported as °Brix at 20 °C. Titrable acidity (TA) was measured with aliquots (5ml) of juice that were titrated to pH 8,1 with 0,1N NaOH (required to neutralize the acids of tomatoes in phenolphthalein presence) and the results were expressed as citric acid percentages. Total and reducing sugars content was determined by the Luff-Shoorl's method, vitamin C content by Tillman's method, carotenoids (lycopene) by the liquid column chromatography method.

The qualitative fruits characteristics results were statistically calculated using the Statgraphics 4.1 program, specifically Tukey's test at  $\alpha = 0.05$ .

### Results and discussion

The results of the chemical analysis are presented in figures 1 to 4. Organically grown tomato fruits contained 4.73 °Brix of TSS while the fruits from conventional growing system contained 4.79 °Brix of TSS. Obtained results showed that the accumulation of TSS at organic and conventional cultivation system did not show any statistically significant difference (figure 1). Irrespective of the cultivation method used and tested tomato cultivars, 'Elpida' fruits contained the highest level of TSS (5.08 °Brix). Tomato fruits from conventional system contained more total sugars (3.80 mg·100<sup>-1</sup>g f.w.) in comparison with organic fruits (3.75 mg·100<sup>-1</sup>g f.w.) but difference is not statistically significant. Conventional tomato fruits 'Amati' and 'Robin' contained more total sugars (3.85mg 100<sup>-1</sup>gf.w.) in both periods of analysis in comparison with 'Elpida' (3.71 mg·100<sup>-1</sup>g f.w.) but 'Elpida' fruits from organic cultivation, contained more total sugars (4.1 mg·100<sup>-1</sup>g f.w.) in comparison to other tested cultivars (figure 2).

The concentration of sugars varies greatly as a function of the cultivar and cultivation conditions. According to Dorais et al. (2001), the concentration of sugars may vary from 1.66 to 3.99% and 3.05 to 4.65% of the fresh matter, as a function of the cultivar and cultivation conditions, respectively.

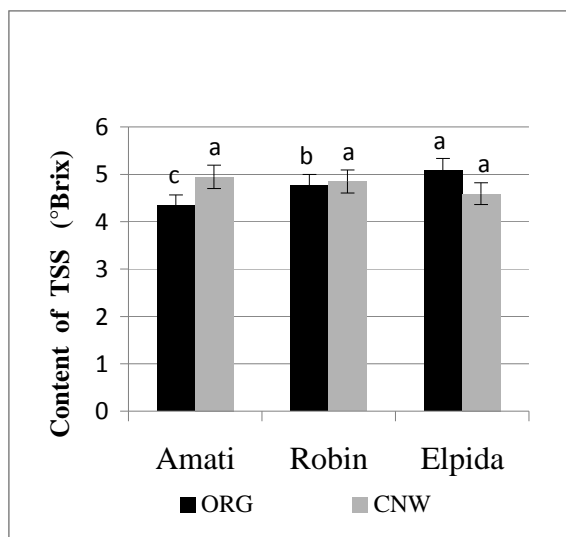


Figure 1 TSS content in organic and conventional tomato production

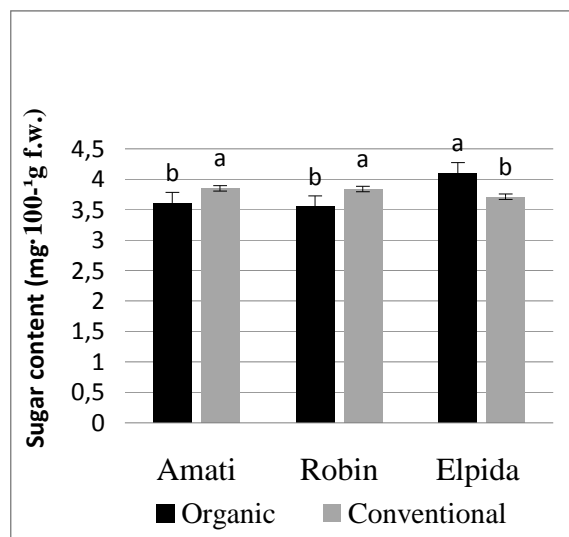


Figure 2 Sugar content in organic and conventional tomato production

The organic acid in a tomato fruit consist of mainly citric and malic acid with a range of 0.3-0.6% (Helyes, 1999). The results obtained showed that conventional tomatoes contained more organic acids (0.48%) in comparison to those cultivated by organic methods (0.45%), in all periods of analysis. At the same time, it should be noted that 'Elpida' was richer in organic acids in comparison to other examined cultivars,

independently from the used cultivation system (table 1). As with the sugars, the organic acids are crucial to the flavour of the fruits.

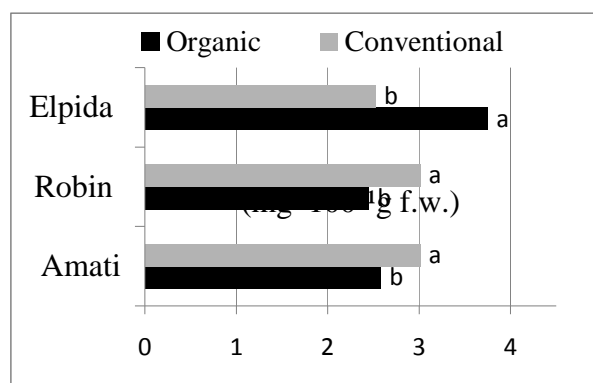
There is a continuous variation in the fruit acidity during its development and maturation, increasing with the fruit growth until reaching its maximum with the development of coloration and diminishing with the advance of maturation. Conventional tomatoes contained statistically higher level of vitamin C (11.9 mg·100<sup>-1</sup>g f.w) in comparison with organic ones (11.4 mg·100<sup>-1</sup>g f.w.). It was also founded that 'Elpida' contained more vitamin C in comparison to other two tomato cultivars. Vitamin C content in 'Elpida' fruits was 12.1 mg·100<sup>-1</sup>g f.w. in organic tomatoes and significantly higher (12.5 mg·100<sup>-1</sup>g f.w.) in conventional ones (table 1).

**Table 1 Total acidity and vitamin C content in fruits of three tomato cultivars at the organic and conventional production system**

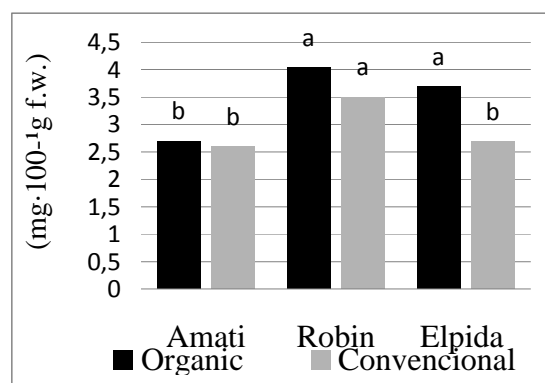
Production system	Organic production		Conventional production	
Quality trait	Total acidity	Vitamin C	Total acidity	Vitamin C
Cultivar		mg·100 <sup>-1</sup> g f.w.		mg·100 <sup>-1</sup> g f.w.
Amati	0.41 b	11.1	0.48	11.5
Robin	0.47 a	11.0	0.47	11.6
Elpida	0.47 a	12.1	0.49	12.5
Significancy	*	n.s.	n.s.	n.s.

\* P < 0,05

The results obtained have shown that conventional tomatoes contained more total sugars and more organic acids. Carbohydrates, acids and their interactions are important components of sweetness, sourness, and flavor intensity in tomatoes. Carbohydrates and organic acids are major determinants of tomato quality (Helyes et al., 2006).



**Fig.3 Lycopene content in organic and conventional tomato fruit**



**Fig.4 Carotenoides content in organic and conventional tomato fruit**

The results showed that the lycopene content in organic tomatoes was higher, in comparison to conventional ones. The average content of this pigment at the organic fruit was 2.92 mg·100<sup>-1</sup>g f.w., while for conventional tomatoes was 2.84 mg·100<sup>-1</sup>g f.w (figure 3). Different tomato cultivars obtained different lycopene levels. At the same time, it should be noted that at the 'Elpida' in organic production contained more lycopene in fruits (3.75 mg·100<sup>-1</sup>g f.w.) than the other cultivars. Red color is initiated by lycopene, which is the most abundant carotenoid in ripe tomatoes, that comprise up to 90% of the total carotenoids present. The most important isomers of lycopene are cis- and trans-lycopene (Clinton, 1998). The trans- configuration represents 95.4% of the lycopene in fresh tomatoes. Lycopene is the pigment principally responsible for the characteristic deep-red color of ripe tomato fruits and tomato products. According to Brandt et al. (2003) significantly higher lycopene content was observed in glasshouse-grown tomato (83.0 mg kg<sup>-1</sup> f.w.) compared to field-grown (59.2 mg kg<sup>-1</sup> f.w.), at different harvesting times. According to Farkas (1994) lycopene production is inhibited when environmental temperature is above 32 °C. Lycopene content changed significantly during maturation and accumulated mainly in the deep red stage (Helyes, 2006).

Tomatoes from organic cultivation contained more carotenoides compared to conventional cultivation (figure 4.). Cultivar Amati contained significantly lower carotenoides level in both cultivation systems.

Organic 'Robin' tomatoes contained the highest carotenoid level in fruits (4.03 mg·100<sup>-1</sup>g f.w) than the other cultivars (figure 4.). So far, very few studies have been conducted about tomato fruit quality from organic cultivation. In Sweden, the impact of cultivation methods on tomato quality has been investigated for three years and organically produced tomatoes showed a higher vitamin C, lycopene and chlorine content (Lundegårdh, 2000). In our study, significantly higher content of carotenoids in organically grown tomato was found only in cultivar Elpida. These results can be only compared to similar results obtained earlier (Rembialska et al., 2003).

### Conclusions

In general, significant differences between tomatoes grown under conventional or organic farming systems could not be identified.

Organically produced tomato contained more carotenoids and lycopene while the conventionally produced one contained more TSS, sugars, vitamin C and had higher titratable acidity.

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# Utjecaj koncentracije IBA i tipa supstrata na razvoj korijenja u proizvodnji presadnica pelargonija (*Pelargonium zonale* L.)

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## Sažetak

Uspješnost proizvodnje presadnica pelargonija (*Pelargonium zonale* L.) ovisi o razvoju adventivnog korijenja. Cilj istraživanja bio je utvrditi najpogodniji supstrat i koncentraciju hormona indol maslačne kiseline (IBA) za razvoj adventivnog korijena i ukorjenjivanje reznica pelargonija. Pokus je postavljen po split-plot shemi sa supstratom kao glavnim faktorom (Substrat 2, Valentin za sjetvu i pikiranje i Steckmedium), a tretmanima IBA (0%, 1% i 2%) kao podfaktorom. Određivanje postotka ukorjenjivanja, te morfoloških karakteristika korijena vršena su 14, 21 i 28 dana nakon sadnje reznica (DNS). Najveći korijenov sustav 28 DNS razvile su reznice uzgajane u Substratu 2, 291,3 cm duljine, 39,6 cm<sup>2</sup> površine i 0,70 cm<sup>3</sup> volumena, te reznice tretirane s 2%, 327,7 cm duljine, 37,8 cm<sup>2</sup> površine i 0,64 cm<sup>3</sup> volumena. Najveći postotak ukorjenjivanja postignut je u supstratu Valentin, 100% te kod tretmana 1% IBA, 91,7%.

Ključne riječi: adventivno korijenje, pelargonije, presadnice, IBA, supstrati.

## Influence of IBA concentrations and type of substrates on the root development in geranium (*Pelargonium zonale* L.) seedling production

### Abstract

Successful geranium (*Pelargonium zonale* L.) seedling production is associated with adventitious root formation. The aim of these research was to investigate the most suitable substrat and concentration of indol butyric acid (IBA) for adventitious root formation and rooting of geranium cuttings. The experiment was set up by split-plot design, with substrat as main factor (Substrat 2, Valentin for sowing and pricking out and Steckmedium) and IBA treatments (0, 1% and 2%) as subfactor. Percentage of rooting and root morphological characteristics was determined at 14, 21 and 28 day after planting (DAP). The biggest root system, compared to other treatments on 28 DAP was observed on cuttings planted in Substrat 2 (291,3 cm total root length, 39,6 cm<sup>2</sup> total root area and 0,70 cm<sup>3</sup> total root volumen) and on cuttings treated with 2% IBA (327,7 cm total root length, 37,8 cm<sup>2</sup> total root area and 0,64 cm<sup>3</sup> total root volumen). Overall highest percent of rooting was detected on treatments with substrate Valentin (100%) and treatments with 1% IBA (91,7%).

Key words: geranium, seedling production, IBA, substrates, adventitious root.

## Uvod

Rod *Pelargonium* obuhvaća oko 250 vrsta, a najpoznatija je *Pelargonium zonale* (Vermeulen, 2001). Pelargonije se mogu razmnožavati vegetativno i generativno (Lindgren i Tod, 2002). Visoko oplemenjeni kultivari pelargonija razmnožavaju se reznicama. Reznice posađene u supstrat nakon dva tjedna započinju razvoj adventivnog korijena, a nakon trideset dana ukorijenjene reznice se mogu presađivati (Lindgren i Tod, 2002). U konvencionalnoj proizvodnji pelargonija od regulatora rasta koriste se retardanti koji skraćuju dužinu internodija (Lindgren i Tod, 2002). Razvoj adventivnog korijenja preduvjet je uspješnog vegetativnog razmnožavanja (Geiss i sur., 2009). Razvoj adventivnog korijenja prirodno se javlja kod brojnih biljnih vrsta, no može se i umjetno potaknuti ozljeđivanjem biljke ili tretiranjem fitohormonima (Geiss i sur., 2009). Kevers i sur. (1997) definiraju tri stadija razvoja adventivnog korijenja: indukcija (period prije histoloških promjena), inicijacija (dioba stanica koja dovodi do formiranja internog korijenovog meristema) i ekspresija (interni rast korijenovog primordija i izbijanje korijena). Svaki stadij u razvoju adventivnog korijenja zahtjeva specifične uvjete (Kevers i sur., 1997). Razvoj adventivnog korijenja kompleksan je proces pod utjecajem većeg broja čimbenika kao što su fitohormoni, svjetlost, status hranjiva, stresni uvjeti poput ozljeđivanja te genetske karakteristike, a problemi vezani uz razvoj adventivnog korijenja rezultiraju značajnim ekonomskim gubicima (Geiss i sur., 2009). Cilj ovog istraživanja bio je utvrditi najpogodniji supstrat i koncentraciju hormona IBA za razvoj adventivnog korijena i ukorjenjivanje reznica pelargonija.

## Materijal i metode

Pokus je proveden u klima komori Agronomskog fakulteta u Zagrebu po split-plot shemi, u tri repeticije, gdje je glavni faktor predstavljao tretman različitim supstratima za ukorjenjivanje, Substrat 2 (Klasmann - Deilmann GmbH 49744 Geeste Germany), Valentin za sjetvu i pikiranje (Terrasan GmbH & Co. KG, Rosenweg 2-4 Germany) i Steckmedium (Klasmann - Deilmann GmbH 49744 Geeste Germany), a podfaktor tretman različitim koncentracijama IBA 0, 1 i 2% (Rhizopon BV, 2394 CE Hazerswoude-Rijndijk, Holland). Za proizvodnju presadnica pelargonija korištene su reznice stabljike. Reznice su uzimane s ujednačeno razvijenih biljaka. Svaki tretman bio je zastupljen s dvanaest reznica. Prije sadnje u supstrate baza reznice je umakana u praškasti hormon IBA koncentracije 1% i 2% te kontrolu, bez hormona. Ukorjenjivanje se odvijalo u komorama rasta pri 16/8 i 23/20°C odnosa dan/noć i 75% relativne vlage zraka, uz redovito zalijevanje. Reznice su ukorjenjivane tijekom 4 tjedna. Morfološke karakteristike adventivnog korijenovog sustava (ukupna duljina, ukupna površina i ukupni volumen) te postotak ukorijenjenih reznica određivan je 14, 21 i 28 dana nakon sadnje (DNS). Uzorkovane biljke vađene su iz lončića, korijenje je temeljito isprano od supstrata te je skenirano i analizirano pomoću WinRizho scanera i softwera (Regent Instruments, Canada Quebec). Podaci su statistički obrađeni analizom varijance, a srednje vrijednosti uspoređene su Duncan's multiple range testom kad je f test bio signifikantan na razini  $P \leq 0,05$ , pomoću SAS 9.1 paketa (SAS Institute Inc. Cary, NC, USA, 2002.-2003.).

## Rezultati i rasprava

Statističkom analizom podataka nije utvrđen interakcijski učinak različitih tipova supstrata i tretmana različitim koncentracijama IBAe na morfološke karakteristike korijena te na postotak ukorjenjivanja. Utjecaj različitih tipova supstrata i tretmana različitim koncentracijama IBA na morfološke karakteristike korijena pelargonija prikazan je tablicom 1., a grafikonima 1., 2. i 3. prikazan je utjecaj različitih tipova supstrata na morfološke karakteristike korijena pelargonija. Grafikonima 4., 5. i 6. prikazan je utjecaj tretmana različitim koncentracijama IBAe na morfološke karakteristike korijena pelargonija.

Tablica 1. Prosječni postotni udio ukorijenjenih reznica pelargonija po tretmanima supstratima i IBAom.

Tretmani IBA	% ukorijenjenih reznica	Tretmani supstratima	% ukorijenjenih reznica
0%	83,3	Substrat 2	58,3
1%	91,7	Valentin	100,0
2%	50,0	Steckmedium	66,3

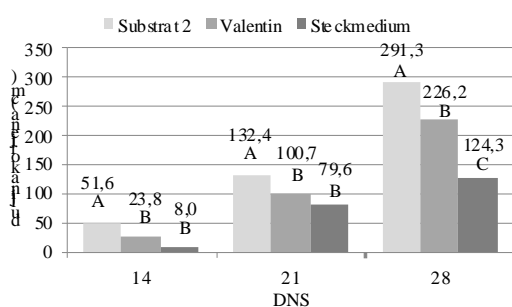
Statistički značajne razlike u duljini, poršini i volumenu korijena 14, 21 i 28 DNS utvrđene su kod reznica pelargonija ukorjenjivanih u supstratima Substrat 2 i Steckmedium. Statistički značajne razlike u



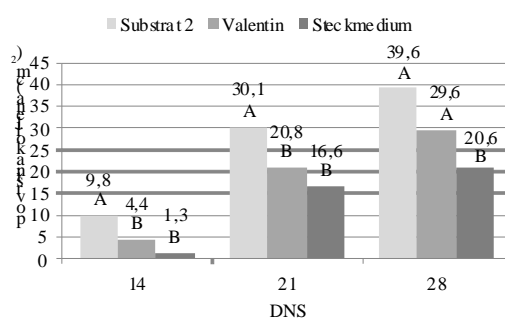
**Utjecaj koncentracije IBA i tipa supstrata na razvoj korijenja u proizvodnji presadnica pelargonija (Pelargonium zonale L.)**

morfološkim karakteristikama korijena pelargonija ukorjenjivanih u supstratima Substrat 2 i Valentin utvrđene su u sva tri mjerenja, osim za površinu korijena 28 DNS te za volumen korijena 21 i 28 DNS. Nisu utvrđene statistički značajne razlike u morfološkim karakteristikama korijena pelargonija ukorjenjivanih u supstratima Valentin i Steckmedium, osim za duljinu i površinu korijena 28 DNS. Statistički najdulji korijen 28 DNS razvile su pelargonije uzgajane u supstratu Substrat 2 (291,3 cm), a najkraći u supstratu Steckmedium (124,3 cm), no istovremeno u Substratu 2 ostvaren je najmanji postotak ukorjenjivanja reznica 58,3%.

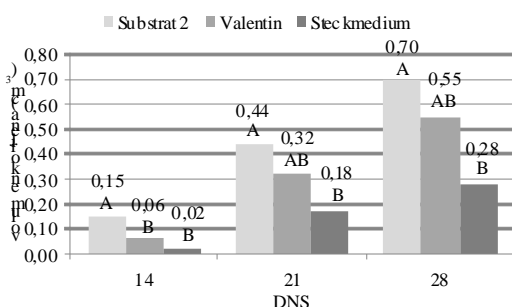
Druege i sur. (2004) navode da je razvoj adventivnog korijena kod pelargonija osjetljiv na nedostatak dušika. Isti autori navode da se kod slabe opskrbe dušikom reducira broj adventivnog korijenja kod reznica pelargonija. Razlike u mineralnom sastavu supstrata mogu biti razlog razlikama u duljini, površini i volumenu adventivnog korijenja, naime sadržaj dušika u Steckmediumu je iznosio 67,0 mg L<sup>-1</sup>, dok je kod Substrata 2, 180 mg L<sup>-1</sup>. Geiss i sur. (2009) navode da je utjecaj mineralnih tvari na razvoj i rast adventivnog korijenja vrlo složen i pun interakcija, te navode da kalcij, dušik i cink značajno utječu na broj, a fosfor, željezo, dušik i mangan na duljinu adventivnog korijenja



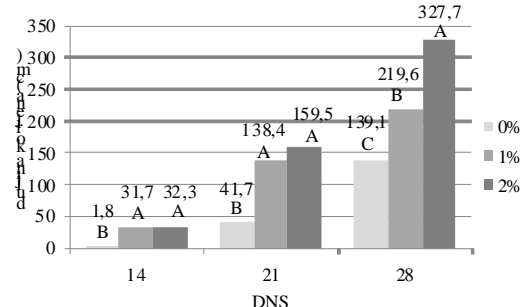
**Graf. 1. Utjecaj tipa supstrata na duljinu korijena pelargonija 14, 21 i 28 DNS.**



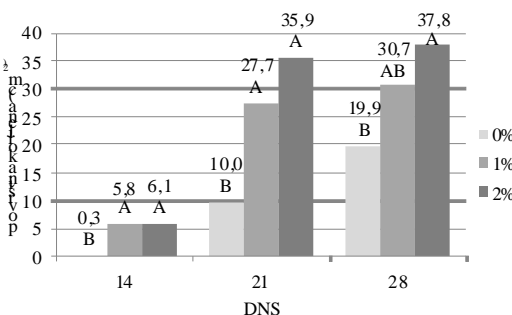
**Graf. 2. Utjecaj tipa supstrata na površinu korijena pelargonija 14, 21 i 28 DNS.**



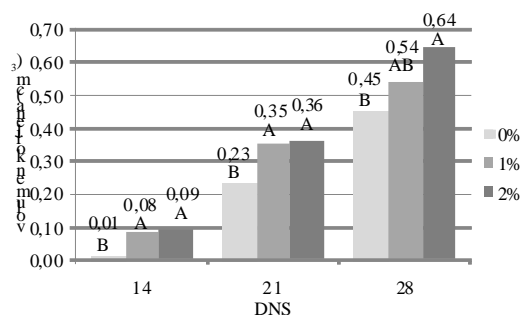
**Graf. 3. Utjecaj tipa supstrata na volumen korijena pelargonija 14, 21 i 28 DNS.**



**Graf. 4. Utjecaj koncentracije IBA na duljinu korijena pelargonija 14, 21 i 28 DNS.**



**Graf. 5. Utjecaj koncentracije IBA na površinu korijena pelargonija 14, 21 i 28 DNS.**



**Graf. 6. Utjecaj koncentracije IBA na volumen korijena pelargonija 14, 21 i 28.**

Različita slova označavaju statistički značajne razlike ( $P \leq 0,05$ ;  $n=12$ ) DNS - dana nakon sadnje.

Najveći prosječni postotak ukorjenjivanja postignut je kod reznica ukorjenjivanih u supstratu Valentin (100%), a najmanji u supstratu Substrat 2 (58,3%). Razlog slabijeg ukorjenjavanja reznica u Substratu 2 vjerojatno leži u visokom sadržaju soli  $1,92 \text{ g L}^{-1}$ , dok Steckmedium sadrži  $0,56 \text{ g L}^{-1}$ , a Valentin  $0,87 \text{ g L}^{-1}$ . Negativni utjecaj soli na rast korijena vezan je uz osmotsku aktivnost otopine što inhibira primanje vode i mineralnih tvari i/ili toksičnog učinka pojedinih iona soli (Bernstein i Hayward, 1958). Ioni  $\text{Na}^+$  zamjenjuju ione  $\text{Ca}^{2+}$  na staničnoj stijenci i membrani te time utječu na permeabilnost membrane (Le Heye i Epstein 1970), a u stanici smanjuju količinu  $\text{K}^+$  iona te remete osmotski potencijal stanice (Serrano i Rodriguez-Navaro, 2001). Kalij i kalcij imaju nezamjenjivu ulogu u rastu stanice, kalijevi ioni kao regulatori osmotskog potencijala, a  $\text{Ca}^{2+}$  kao sekundarni glasnici i važni građevni elementi stanične stijenke.

Statistički značajne razlike u duljini, površini i volumenu korijena 14, 21 i 28 DNS utvrđene su kod reznica pelargonija tretiranih s 2% IBA i kontrole. Također su utvrđene statistički značajne razlike morfoloških karakteristika adventivnog korijenja pelargonija tretiranih s 1% IBA i kontrole kod svih mjerenja osim za površinu i volumen 28 DNS. Nisu utvrđene statistički značajne razlike u morfološkim karakteristikama korijena pelargonija tretiranih s 1% i 2% IBA, osim za duljinu korijena 28 DNS. Auksini imaju središnju ulogu u razvoju adventivnog korijenja (Kawase, 1971) i redovito se koriste za poticanje razvoja adventivnog korijenja kod različitih kultura (Geiss i sur., 2009). Najdulji ( $327,7 \text{ cm}$ ), površinom ( $37,8 \text{ cm}^2$ ) i volumenom ( $0,64 \text{ cm}^3$ ) najveći korijen 28 DNS razvile su reznice tretirane s 2% IBA, no istovremeno je samo 50% reznica razvilo korijenov sustav. Najveći postotak ukorjenjivanja ( $91,7\%$ ) postignut je kod reznica tretiranih 1% IBA. Tretmani IBAom (1% i 2%) utjecali su pozitivno na morfološke karakteristike adventivnog korijena, no tretman 2% IBA rezultirao je smanjenim postotkom ukorjenjivanja reznica. Mutui i sur. (2010) navode da je tretman IBA od  $4 \mu\text{L L}^{-1}$  supstrata izazvao razvoj korijena kod 100% reznica pelargonija, dok je tretman od  $12 \mu\text{L IBA L}^{-1}$  supstrata značajno smanjio postotak daljnjeg razvoja induciranog korijenja. Isti autori smatraju da se tijekom 4 tjedna ukorjenjivanja u reznicama tretiranim s  $12 \mu\text{L IBA L}^{-1}$  supstrata nakupila fitotoksična količina IBA. King i sur (1995) navode da je adventivno korijenje u nekim stadijima razvoja izuzetno osjetljivo na povćanu koncentraciju auksina. Razlog negativnog utjecaja visoke koncentracije auksina na ukorjenjivanje reznica pelargonija može ležati i u intenzivnoj aktivaciji procesa rasta stanica koju uzrokuje visoka koncentracija IBA te brzog iscrpljivanja zaliha ugljikohidrata. Li i Leung (2000) navode da je za inicijaciju i razvoj adventivnog korijenja najvažnija adekvatna zaliha ugljikohidrata u zoni regeneracije korijena.

## Zaključci

Razvoj adventivnog korijenja reznica pelargonija pod značajnim je utjecajem tipa supstrata i tretmana IBAom. Nije utvrđen interakcijski utjecaj supstrata i tretmana različitim koncentracijama IBA na morfološke karakteristike i postotak ukorjenjivanja reznica pelargonija. Najveći korijenov sustav 28 DNS razvile su reznice uzgajane u Substratu 2,  $291,3 \text{ cm}$  ukupne duljine,  $39,6 \text{ cm}^2$  površine i  $0,70 \text{ cm}^3$  volumena, te reznice tretirane s 2% IBA,  $327,7 \text{ cm}$  ukupne duljine,  $37,8 \text{ cm}^2$  površine i  $0,64 \text{ cm}^3$  volumena, no reznice uzgajane u tim tretmanima postigle su najmanji prosječni postotak ukorjenjivanja  $58,3\%$  (Substrat 2) i  $50,0\%$  (2% IBA). Najveći postotak ukorjenjivanja reznica postignut je u supstratu Valentin,  $100\%$  te kod tretmana 1% IBA,  $91,7\%$ . Statistički značajne razlike između supstrata Substrat 2 i Valentin, te između tretmana IBA 2% i 1%, 28 DNS utvrđene su samo za ukupnu duljinu korijena. Stoga supstrat Valentin i tretman 1% IBA možemo smatrati najpogodnijim za proizvodnju presadnica pelargonija ukorjenjivanjem reznica.

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# Conservation and morphological characterization of bottle gourd for ornamental use

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## Abstract

This study describes the intraspecific variation of *Lagenaria siceraria* (bottle gourd) germplasm accessions, plant, fruit and seed morphology, maintained ex situ at the Institute for field crops, Novi Sad, Serbia. Conservation work aimed to develop a representative core collection of *Lagenaria siceraria* germplasm, African, New World and Asian landraces, to guide future studies and breeding for its ornamental use. Although far from *Lagenaria siceraria* origins, existing diversity in Serbia is a result of introduction and adaptation of germplasm to diverse ecological conditions, owing to natural selection as well as farmer preferences, in accordance with *Lagenaria siceraria* morphologic traits, often very rare or unique, particularly in fruit size and shape. This variation can be associated with the wide range of ornamental uses that favour different shape and size of fruits.

Key words: *Lagenaria siceraria* (Molina) Standl., fruit, variability, collection

## Introduction

Cucurbitaceae family is one of the economically most significant families, supplying edible, nutritious fruits to humanity (Bisognin, 2002). Plants of this family, whilst possessing similar characteristics of the sprouting segments, are characterised by great genetic diversity in fruit shape, fruit length and texture of fruit, resulting in variability and wide range of applications. Bottle gourd, or *Lagenaria siceraria* (Mol.) Standl, is one of the most significant representatives of *Cucurbitaceae*. Its systematic affiliation is: Cucurbitaceae family, *Cucurbitoideae* sub-family, tribe *Benincaseae* Ser., subtribe *Benincasinae* (Ser.) Jeffr., genus *Lagenaria* Ser. *Lagenaria* variety comprises six species, of which only *Lagenaria siceraria* (Molina) Standl. (syn.: *L. vulgaris* Ser.; *L. leucantha* (Duch.) Rusby) is cultivated (Esquinas-Alcazar and Gulick, 1983). Colloquial names for this variety are “sudovnjača”, “nategača” and “ajduk” (Berenji, 1982; 1988). Bottle gourd, of African origins, was widely spread across the world well before Columbus discovered America, attributed to spontaneous dispersion of bottle gourd through ocean currents (Whitaker et al., 1961) towards western hemisphere, including eastern coastal locations (Summit and Widess, 1996). Bottle gourd can be easily distinguished from other pumpkin varieties, due to its white flowers, specific shape of seeds and leaves, as well as the fruit peel structure (Cutler and Whitaker, 1967). The name “*lagenaria*” is derived from Latin word “*lagena*” for bottle, whilst *siceraria* stems from Latin “*sicera*,” for drinking utensil. Tropical Africa is cited in literature as the primary genocentre of this plant origin (Sing, 1990). Cultivation of this variety is widespread in most Central African countries (Achu et al., 2005; Achigan-Dako et al., 2006; Zoro Bi et al., 2006).

Bottle gourd is characterised by differently shaped fruits that can be used as utensils or decorative ornaments, whilst younger juicy fruits are edible and nutritious (Berenji, 1992, 1999, 2000). Prasad and Prasad (1979) have created unique bottle gourd varieties in India, primarily for human consumption. It has been used in varied and specific ways in cultures of different nations. Scientists believe that, of all currently known plants,

bottle gourd is the only species that had been used worldwide in prehistoric times.

Bottle gourd variability has been studied by many authors, including Heiser, 1979; Decker Walters et al., 2001; Marimoto and Mvere, 2004; Marimoto et al., 2005; Achigan Dako et al., 2008, etc. In 2005, studies in India demonstrated significant variability of their regional collection. Sivaraj and Pandravada (2005) cite that 54 analysed genotypes showed variability in quantitative and qualitative characteristics.

Owing to the essential role of bottle gourd in cultures of many nations, it is not surprising that the fruits have also been used in religious and ceremonial rituals. After discovery of terracotta utensils, the use of bottle gourd in cookware declined, but not ceased completely, as thick outer skin of these plants is still used for this purpose, particularly by indigenous peoples of tropical and subtropical regions.

In Serbia, bottle gourd had significant presence in rural life, primarily in household and agricultural uses. More recently, its role in vegetable cultivation as a rootstock for watermelon grafting, and in art as a decorative ornament, is becoming more prominent. Even though in Serbia it is rare to find large fields under bottle gourd crop, this is one of the most popular species in India and some other parts of the world (Sivaraj and Pandravada, 2005).

The aim of this study is to analyse morphological variability of bottle gourd fruit and seeds and to select the parent varieties to be used in cross-breeding for decorative purposes.

### Material and methods

Materials used in experimental procedures are taken from the Institute of Field and Vegetable Crops Novi Sad bottle gourd genotype collection. The specimens in the collection originate from Serbia, US, Canada, Italy, Croatia and Hungary.

Bottle gourd seeds were germinated at 25°C, between two sheets of paper. Germinated seeds were sown into a substrate. Outdoor planting was performed on May 12, 2009. Thirty six genotypes, each represented by five plants, were included in the experiment.

The distance between individual plants and genotypes was 60 cm and 160 cm respectively.

The quantitative and qualitative fruit and seed characteristics of interest for the study were assessed and evaluated using standard descriptive measures. The plant height, and leaf length and width were measured using a metric tape measure. The mass of fruit and 100 seeds was measured using technical scales accurate to 0.01 g. The collected data was processed using one-directional variance analysis in STATISTICA 9.0 software.

### Results and discussion

The collection demonstrated significant variation in fruit shape, colour, texture, length, weight and circumference; seed length and thickness; weight of 100 seeds, leaf length and width, as well as stem length (Table 1). Surface texture is of particular interest, as it can be smooth, wrinkled, and can sometimes contain warts; thus further studies can be directed in that direction, when considering decorative bottle gourd characteristics.

The longest fruit (137.7 cm) and leaves (22.64 cm) were found in genotype LAG 63, whilst the circumference and mass was the greatest for genotype LAG 47, measuring 84 cm and 4.6 kg respectively. LAG 47 also had the widest (12 mm) and thickest (3.7 mm) seeds. The shortest fruit (9.4 cm), of smallest circumference (17.26 cm), as well as mass (0.102 kg) was measured for genotype LAG 84 .

A very important feature of bottle gourd is fruit shape. The collection is the most common form of pear shaped fruit with 13 genotypes followed by an elongated shape fruit with 12 genotypes (Table 2). Other forms are represented in smaller numbers. Skin texture of fruit in 36 genotypes is smooth and only in three genotypes skin texture is with warts. This feature can be very interesting and breeding work in this direction would be made on further research.

**Table 1 Morphological characteristics of fruit and seed of bottle gourd germplasm collection**

Variable	Range	Mean value ± Standard Error	Standard deviation	Coefficient of variation
Plant height (m)	2.8-3.25	3.07 ± 0.01	0.12	3.88
Fruit weight (kg)	0.099-4.599	1.37 ± 0.06	0.8	58.1
Fruit length (cm)	8.7-140	42.93 ± 2.08	27.95	65.09
Handle length (cm)	4-22	10.38 ± 0.28	3.78	36.44
Width of leaves (cm)	17.75-30.25	23.63 ± 0.21	2.79	11.81
The length of leaves (cm)	14.05-22.85	18.57 ± 0.17	2.23	12.00
Volume of fruit (cm)	16-89	47.58 ± 1.18	15.81	33.23
Seed length (mm)	8-20.2	16.2 ± 0.2	2.71	16.74
Seed width (mm)	5-12	7.17 ± 0.11	1.43	19.92
Thickness of seed (mm)	2-3.7	2.73 ± 0.04	0.53	19.35
100-seed mass (g)	9.8-29.84	22.09 ± 0.37	5.0	22.65

**Table 2. Diversity of fruit morphological characters of bottle gourd**

Character	No of genotypes	Frequency (%)
Shape of fruits		
Pear shaped	13	36.1
Long	12	33.3
Conic	3	8.3
Oval	3	8.3
Globular	2	5.6
Discus shaped	2	5.6
Elongated curvilinear	1	2.8
Fruit Color		
Light green	29	80.6
Dark green	7	19.4
Texture of fruit		
Smooth	3	8.3
With warts	33	91.7
Gloss of fruits		
Mate	9	25
Medium	26	72.2
Brilliant	1	2.8
The presence of stem		
Present	36	100

## Conclusions

Studies of bottle gourd fruit morphological characteristics enable further research and attempts to produce varieties with unusual shapes and colours. Significant variability in fruit shape enables a wide spectrum of uses of this variety. From the largest species that can be used as tableware, to the miniature fruits displayed as decorative ornaments. Bottle gourd fruits are probably the most variable species by size and shape compared to any other variety. Fruit can be pear shaped, disc shaped, globular, elongated curvilinear, conical, oval etc. The fruit length also shows significant variation, from miniature fruits only a few centimetres long, to those longer than one meter. Proportionally to the fruit size, morphological seed characteristics are also subject to significant variability; the 100-seed weight from one fruit can vary in 9.8-29.84 g range.

This paper presents research results that show significant variability in quantitative and qualitative bottle gourd properties, which can be further used in cross-breeding and producing fruits of variable characteristics.

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# The effect of plant density on bulb quality and yield of spring garlic (*Allium sativum*)

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## Abstract

The research on the effect of plant density on bulb quality and yield of spring garlic domestic cultivar 'Labud' was carried out in two-year field experiment (2009 and 2010). Spring garlic is planted in five densities: 300000 plants ha<sup>-1</sup> (G1), 450000 plants ha<sup>-1</sup> (G2), 600000 plants ha<sup>-1</sup> (G3), 750000 plants ha<sup>-1</sup> (G4) and 900000 plants ha<sup>-1</sup> (G5). The present paper shows the results of garlic yield and its components (number of cloves per bulb, clove and bulb mass). The average bulb mass was 16.54 g, the lowest value was recorded at G4 density (13.73 g) and the highest one at G1 (21.23 g). The average two-year garlic yield was 9100 kg ha<sup>-1</sup>. The lowest yield per hectare was achieved at G1 plant density (6228 kg), and the highest one in the densest planting G5 (12547 kg). The plant density positively influenced the yield and quality of spring garlic. Considering the densest plantings the yield was the highest, but the bulb quality was the lowest. Spring garlic bulbs of high quality and good yield were produced at plant density of 600000 plants per hectare.

Key words: garlic, plant density, yield components

## Introduction

Garlic (*Allium sativum* L.) is traditionally grown on about 8500 ha in the Republic of Serbia. The two varieties of garlic are distinguished depending on planting date - spring and autumn. The spring garlic production is predominant. Domestic populations and cultivars are mainly grown. The yields are relatively low and range from 2.5 to 3 t ha<sup>-1</sup>. Realised production does not meet the demands of home market, so it is greatly imported. About half a million euros is spent annually on garlic importation.

Successful garlic growing depends on various factors. Climatic and soil conditions are especially important. In order to use these factors effectively, it is very important that appropriate (optimal) plant density is used. It is of the greatest importance for using of light. Having that in mind, very dense plantings are undesirable because of great mutual plant shading. For that reason the lowest leaves of the plant, which are least exposed to light, have lower photosynthesis, often below the compensation point. In such circumstances, there is a decrease of both yield and quality as well as of economic justification of the production itself.

The useful results were obtained by Gorbatenko and Kiver (1986) while investigating the effect of plant density on an average bulb mass and standard bulb yield. It was shown that plant densities higher than 800,000 plants per hectare significantly decreased both above mentioned factors. According to Duranti and Barbieri (1986) garlic in dense plantings achieves high yields, but its quality decreases and susceptibility to sicknesses increases, especially in conditions of irrigation. Experiments conducted by Pandey et al. (1992) show that the largest bulbs (3.23 cm) and the highest yield (13.1 t ha<sup>-1</sup>) are obtained when plant density was 700000 plants ha<sup>-1</sup>. Arboleya et al. (1994a) investigated garlic using four plant densities, from 112000 to 500000 plants ha<sup>-1</sup>, and results show that the highest yield was achieved at the densest planting (8.1 t ha<sup>-1</sup>). The same authors (Arboleya et al., 1994b) studied the effect of five different plant densities on garlic yield in another experiment and came to the conclusion that the highest yield of good quality was in garlic plant



densities of 560000 plants ha<sup>-1</sup>. Ahmad and Iqbal (2002) determined that garlic was greatly effected by plant density, which is logical since very different plant densities were used, having in mind that the densest planting comprised 2000000 plants ha<sup>-1</sup>. Garlic was the most productive at the densest planting, with achieved yield of 14 t ha<sup>-1</sup>. Investigating the effects of plant density (Moravčević, 2008) in garlic cultivar 'Piros', bulbs had a higher mass at sparse plantings, but the yield was higher at denser plantings. The values obtained for bulb mass averagely range from 14.51 g (G5) to 19.63 g (G1), and regarding yield, values range from 5.78 t ha<sup>-1</sup> (G1) to 12.45 t ha<sup>-1</sup> (G5). Optimal results in these researches were achieved at plant density of 600000 plants ha<sup>-1</sup>.

The aim of this paper was to define the optimal plant density for garlic growing in Serbian agroecological conditions.

### Material and methods

Garlic was investigated on family farm (the municipality of Šabac, the village of Zminjak). The investigation was carried out in the years 2009 and 2010. The variations of the experiment (plant densities) were arranged in a randomised block design with four replications. The size of elementary plot was 4m<sup>2</sup> (2 × 2 m). Standard agrotechnics was applied. Garlic was planted in both years in March (16 and 20). Cloves were planted at inter-row spacing which was constant (25 cm), whilst the in-row spacing varied and ranged from 4.4 cm to 13.3 cm. The following plant densities were used: 300000 plants ha<sup>-1</sup> (G1), 450000 plants ha<sup>-1</sup> (G2), 600000 plants ha<sup>-1</sup> (G3), 750000 plants ha<sup>-1</sup> (G4) and 900000 plants ha<sup>-1</sup> (G5).

The domestic garlic cultivar 'Labud', which belongs to spring garlic type, was used. It is medium early garlic cultivar, moderately large, forming flat round bulbs, of expressed strength. It was selected at Institute of Field and Vegetable Crops, Novi Sad.

Yield and its components are shown in the paper. Components comprise the number of cloves per bulb, clove and bulb mass. Observed parameters were determined on bulbs in the time after the harvest (picking). Garlic was picked on July 23 in both experimental years.

During the experiment in 2009, favourable conditions included moderate, well distributed precipitations (about 188 mm), unlike 2010, when from March to July the rainfall of 400 mm was recorded. It should be pointed out that the second year was warmer. The soil on which the garlic was grown was cambisol.

The results were statistically processed by variance analysis and shown in Tables. The test of the least significant difference (LSD) was used.

### Results and discussion

Taking into account the whole experiment and both years of research, the average number of cloves per bulb was 7.8 (Table 1), and individual values ranged between 6.9 and 8.4 (densities G5 and G1, respectively). Further analysis of this parameter shows that a greater number of cloves per bulb were formed in sparser plantings.

Investigating from year to year, a higher influence of plant density was achieved by this parameter in 2009, when 8.7 cloves per bulb were recorded. Statistically significant differences occurred only between plantings of G1 and G5 densities.

Table 1 The effect of plant density on the number of cloves per bulb

Plant density [plants ha <sup>-1</sup> ]	Number of cloves per bulb		Average
	Year		
	2009	2010	
300000 (G1)	9.5	7.3	8.4
450000 (G2)	9.0	7.3	8.1
600000 (G3)	8.5	6.8	7.6
750000 (G4)	8.8	6.8	7.8
900000 (G5)	7.5	6.3	6.9
Average	8.7	6.9	7.8
LSD 0.05	1.73	1.26	1.21
0.01	2.43	1.76	1.65

The number of cloves per bulb depends on genotype and conditions in the course of garlic vegetation as well as on the temperature at which planting material is stored (Rahim et al., 1988). There are the results which show that in arid years the number of cloves per bulb decreases (Gvozdanović-Varga, 2005).

Clove mass for both years averagely was 2.20 g (Table 2). The lowest values for clove mass (1.91 and 1.99 g) were obtained at the densest plantings (G4 and G5), and the highest values were obtained at G1 and G2 densities, ranging from 2.65 to 2.39 g. Those differences are statistically significant.

**Table 2 The effect of plant density on clove mass**

Plant density [plant ha <sup>-1</sup> ]	Clove mass [g]		Average
	Year		
	2009	2010	
300000 (G1)	2.75	2.55	2.65
450000 (G2)	2.43	2.35	2.39
600000 (G3)	2.18	1.98	2.08
750000 (G4)	1.93	1.90	1.91
900000 (G5)	2.02	2.23	1.99
Average	2.26	2.15	2.20
LSD	0.05	0.28	0.23
	0.01	0.39	0.35

Densities had different impacts on clove mass in both years of experiment. As a rule, considering all densities in 2009 higher values were obtained for this parameter, except for G5 density (the densest planting). Statistically significant differences were recorded at the same levels as in two-year average. Clove mass and the number of cloves are characteristics which are negatively correlated (Gvozdanović-Varga, 2005) and represent the main quantitative bulb characteristic which defines garlic uses.

Average bulb mass for the whole experiment was 16.54 g (Table 3). The greatest bulb mass was obtained at the most sparsest planting (G1, 21.23 g), whilst in dense plantings (G4 and G5) it was 13.73 and 14.34 g, respectively. The differences were statistically significant.

**Table 3 The effect of plant density on bulb mass**

Plant density [plant ha <sup>-1</sup> ]	Bulb mass [g]		Average
	Year		
	2009	2010	
300000 (G1)	24.85	17.60	21.23
450000 (G2)	20.68	16.28	18.48
600000 (G3)	17.43	12.45	14.94
750000 (G4)	15.75	11.70	13.73
900000 (G5)	15.63	13.05	14.34
Average	18.87	14.22	16.54
LSD	0.05	3.41	2.48
	0.01	4.79	3.76

**Table 4 The effect of plant density on garlic yield**

Plant density [plant ha <sup>-1</sup> ]	Yield [kg]		Average
	Year		
	2009	2010	
300000 (G1)	7.335	5.121	6.228
450000 (G2)	9.064	7.141	8.102
600000 (G3)	10.189	7.162	8.675
750000 (G4)	11.387	8.509	9.948
900000 (G5)	13.697	11.396	12.547
Average	10.334	7.866	9.100
LSD	0.05	1.613	1.489
	0.01	2.261	2.155

During the year 2009, bulb mass was noticeably higher and reached the average value of 18.87 g, but as the density increased, the average bulb mass decreased. Regarding both years, statistical difference was observed only at the sparsest planting (G1) in comparison with other densities.

Plant density, besides other influences, can significantly influence bulb mass of garlic, which is confirmed by numerous reference sources. Muhina (1980) noticed that higher yields can be achieved at the densest plantings, but the bulb mass and their market value decrease (they are small and inconsistent). Gorbatenko and Kiver (1986) determined that denser plantings decreased average bulb mass and standard bulb yield.

The average garlic yield for the whole experiment was 9100 kg ha<sup>-1</sup> (Table 4). It is obtained from the values which range from 6228 (G1) to 12547 kg ha<sup>-1</sup> (G5). In general, higher yields were obtained in 2009. The maximum yield (13697 kg) was achieved at the density of 900000 plants ha<sup>-1</sup>. Regarding both experimental years, statistically significant differences in yield were achieved between the sparsest and the densest plantings.

Garlic achieves higher yields if it is grown in denser plantings. The densities which are considered as the most favourable for high yields in garlic production, range from 450000 to 880000 plants ha<sup>-1</sup> (Arboleya et al., 1994a, 1994b; Karaye and Yakubu, 2006; Kilgori et al., 2007, Moravčević, 2008).

### Conclusion

The density influenced the quality and yield of garlic bulbs. Increasing plant density resulted in significant increase of yield, whereas the quality of individual bulbs deteriorated. The experiment has shown that spring garlic for fresh consumption, should be grown in moderate densities which do not exceed 600000 plants per hectare.

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# Effect of planting method and picking frequency on spice pepper yield

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## Abstract

The aim of our research was to determine the particular plant density suitable for spice pepper hybrids and in elaborating the trellis system and the pruning method under plastic cover. We studied the effect of picking frequency and trellis type on yields and fruit quality. Containers in the first 3 treatments were arranged in twin rows (90+60x32cm plant spacing). In the case of the other treatments a single row arrangement was applied (150x16cm plant spacing). Plants were pruned to 2 stems and 4 of them were planted on each m<sup>2</sup>, in 4 repeats. Based on the results, the planting of 1 plant per container had more favourable influence on fruit number and yields than the planting method of 2 plants per container.

Key words: plastic cover, plant density, pruning method, trellis system, spice pepper

## Introduction

Due to climate change traditional spice pepper growing (in field, direct seeded or transplanted) involves increasing risks both in terms of yield and quality. Production under plastic cover can result earlier onset of picking, increased number of pickings, better quality (purity, in the first place), better (and cheaper) post harvest maturation and therefore in a ground product of higher quality.

The crucial issue of production technology is *plant density*. Plant number per square meter has determinant influence on the amount of light that plants receive, on the feasibility of plant care operations and on the health condition of plants, i.e. plant protection (Bosland and Votava, 2000). According to Somogyi et al. (2008) a density of 5-6 plants per square meter is recommended. On the other hand, in the knowledge of those green pepper variety types that have a similar habit to that of spice pepper and the similar demands of the former (Gyúró and Szóriné, 2005; Zatykó and Márkus, 2006), also a plant density of 4-4.5-5 plants per m<sup>2</sup> can be sufficient. The *pruning method* and the *trellis system* are correlated with plant density and have determinant influence on the amount of light that plants receive, the micro-climate, plant protection and the number of pickings. In the intensive growing of green pepper under unheated greenhouse conditions it is the two stem pruning that has become widespread (Dasgan and Abak, 2003; Gyúró and Szóriné, 2005), in contrast to the less intensive technology where a cordon trellis system is used (Zatykó, 2000, Durovka et al., 2006). Cordon cultivation involves less plant care, but therefore plants form a dense canopy, and this way of picking and plant protection are more difficult (Nicole and Canliffe, 2002). On the other hand, the increased number of fruits can be more favourable in the case of the spice pepper having fruits of smaller weight (Kapitány, 2004). The increased number of picking increases total yields as with the removal of ripen fruits plants are relieved and therefore are permitted to develop and mature other fruits at high quality (Durovka et al., 2006).

Composition parameters are influenced by several production technology factors, starting from fertilizer application to the timing of harvest (Belakbir et al., 1998; Bosland and Votava 2000; Anchondo et al., 2001; Irinyi and Kapitány, 2004; Irinyi and Slezák, 2006a,b.; Gyökös et al., 2009).

The main objective of our research work consists in determining the particular plant density suitable for spice pepper hybrids and in elaborating the trellis system and the pruning method. It is also among the aims to adjust the unheated greenhouse production technology of green pepper to the demands of spice pepper

plants having a strongly different habit and to the harvestability of biologically mature fruits. In the first year of the series of experiments over several years we studied the effect of picking frequency and trellis type on yields and fruit quality. In this publication we discuss the issues of yields and the temporal pattern of fruit ripening.

### Material and methods

The experiment was set up at the Experimental and Training Farm of the Faculty of Horticulture, Corvinus University of Budapest, in a high roof plastic greenhouse, using the (indeterminate) variety Délibáb in container growing.

Main technological parameters of the experiment:

Seedlings growing was carried out in KITE trays with 96 cells (400 plants/m<sup>2</sup>), in seedling soil POT 20, with sowing date 1<sup>st</sup>Apr. Planting-out took place on the 20<sup>th</sup>May.

Treatments:

SP1/1: 1 plant/container (2 stems/container), harvests at two week intervals,

SP2/1: 1 plant/container (2 stems/container), harvests at four week intervals,

SP3/1: 1 plant/container (2 stems/container), one picking,

SP1/2: 2 plants/container (4 stems/container), harvests at two week intervals,

SP2/2: 2 plants/container (4 stems/container), harvests at four week intervals,

SP3/2: 2 plants/container (4 stems/container), one picking.

Containers in the first three treatments (SP1/1, SP2/1, SP3/1) were arranged in twin rows (90+60x32 cm plant spacing) and stems were trained vertically. In the case of the other treatments (SP1/2, SP2/2, SP3/2) a single row arrangement was applied (150x16 cm plant spacing) where plants were trained in a V shape.

Four independent replications were used.

Composition of container soil: 48% fen peat, 32% fluvial sand, 10% raised bog peat and 10% perlite. We used black buckets having rigid walls, with a fill volume of 10 litres.

Plants had two stems and 4 of them were planted on each m<sup>2</sup>.

Drip irrigation and fertigation were possible in accordance with plant requirements.

In the course of plant care operations after the two stem shaping pruning the main shoots were wound around the string and only branching lateral shoots were broken off 2-3 internodes above the soil surface.

A preventive plant protection was used in the plastic tunnel against eventual infection by aphids, greenhouse whitefly, cotton bollworm, trips and powdery mildew. (Consequently, no yield loss from pest was observed.)

Picking dates according to the respective treatments are included in Table 1.

At the pickings, in order to observe vegetative plant development, the longer main stem of each plant was measured.

Pickings were carried out in the state of biological maturity of fruits. We registered the number and total weight of fruits picked per plot, separating the healthy and ill (Ca deficient) fruits from each other. In the investigations, calculations were made using the healthy fruits.

Table 1 Picking dates (Budapest, 2010).

Treatment	04.08.	18.08.	01.09.	15.09	29.09.	13.10.	27.10.
SP1/1	X	X	X	X	X	X	X
SP2/1	X		X		X		X
SP3/1					X		
SP1/2	X	X	X	X	X	X	X
SP2/2	X		X		X		X
SP3/2					X		

**Results and conclusions**

Though no statistical difference can be observed between the treatments with the planting type 1 plant/container, the highest yield, both in terms of fruit number and weight, was produced by the treatment SP1/1 (harvests at two week intervals) (Figures 1 and 2). In this treatment, per square meter yield was as high as 130 fruits in number and 2.8 kg in weight. In the case of the treatment SP2/1 where harvests occurred at four week intervals, fruit number was slightly increased, but yields were lower than in the former treatment. The treatment SP3/1 with one picking produced almost the same fruit number (111 fruits per m<sup>2</sup>) as the treatment SP1/1 till the same date (29<sup>th</sup> Sept) with five pickings. Considering fruit weight, it was inferior to the former two treatments, amounting to 2.1 kg/m<sup>2</sup>.

Increase of plant number per container resulted in the decrease of total fruit weight. In terms of fruit numbers, statistical difference was observable between the treatments SP1/1 and SP 1/2 which is well illustrated by Figure 2. It was these two treatments where the highest and the lowest number of fruits were picked. The treatment SP2/2 picked at four weeks intervals the highest fruit number 96 fruits per m<sup>2</sup> and yield (2 kg/m<sup>2</sup>) of the treatments with 2 plants per container. The treatment SP1/2 had the lowest fruit number of all the treatments and the fruit number of the plants picked at two week intervals was inferior to 90 fruits per m<sup>2</sup> Also the lowest yield was registered for this treatment: 1.7 kg/m<sup>2</sup>. The fruit number of the treatment SP3/2 with one picking was almost the same as that of the treatment SP2/2 (93 fruits per m<sup>2</sup>). Yields, on the other hand, were lower: 1.8 kg/m<sup>2</sup>. In terms of total fruit weight significant difference was found between the treatment SP 1/1 (1 plant/container) and the treatments SP 1/2, SP 2/2 and SP 3/2 (2 plants/container).

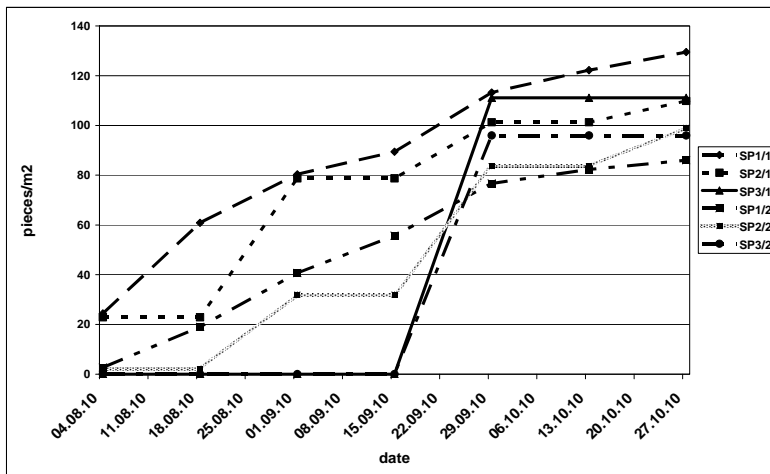


Figure 1 Effect of pickings on fruit number

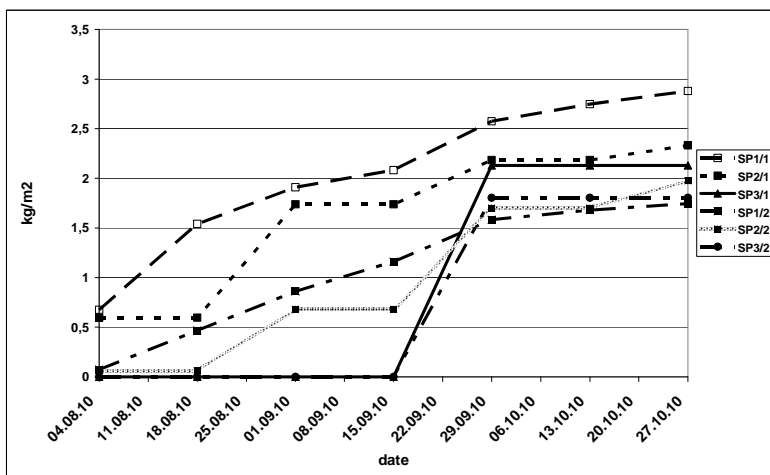


Figure 2 Effect of pickings on yields

In terms of average fruit weight, in the case of the arrangements 1 plant/container and 2 plants per container, the higher fruit weights were produced by the harvests with two week intervals (figure 3). The fruits picked at

4 week intervals did not result in significantly lower yields. The planting of 1 plant per container had favourable effect on average fruit weight.

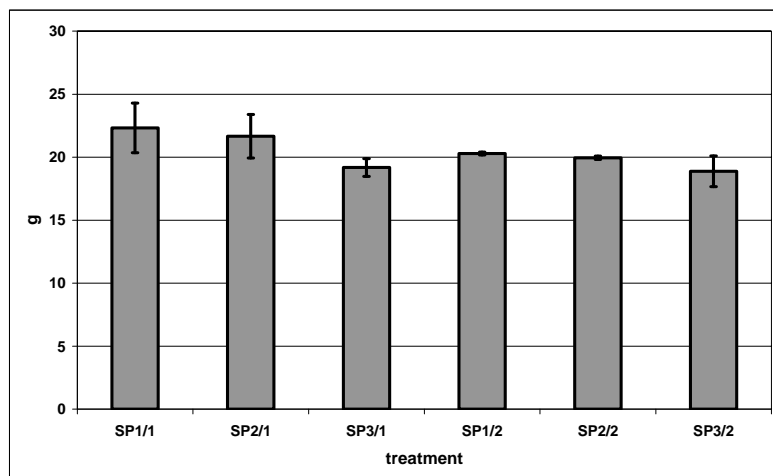


Figure 3 Average fruit weights per treatment

Based on the results, the planting of 1 plant/container had more favourable influence of fruit number and yields than the planting method with 2 plants per container. On the other hand, statistical results confirm that the frequency of harvests has stronger effect on fruit number and yields than the type of planting (1-2 plants/container).

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# Yield of early sweet corn

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## Abstract

The trial was carried out with the aim to find out how the time of propagation and transplanting influence the growing season of sweet corn along with some major properties relevant to quality. The following technological variations were compared with the help of the variety 'Spirit' (normal sweet, very early ripening): transplanted plants with floating row cover (with early planting date), direct seeded plants with no row cover with 2 seeding dates); early, direct seeded plants with row cover. The 21 day transplant growing period reduced the growing period by 20 days, compared to the technology used in the existing practice of production and by 6 and 8 days compared to early seeded, covered and not covered treatments, respectively. The covering in the case of early, direct seeded treatment produced favorable effect on ear weight and length compared to not covered seeded treatments.

Key words: growing season, earliness, seedlings, fleece covering.

## Introduction

Currently, Hungary is not considered as a major country on the markets of most vegetables in terms of quantity. The only exception is the sweet corn. Based on its present growing area, the sweet corn is the vegetable which is grown on the greatest area in Hungary and after the sudden and sharp decline in 2003 this plant returned in a rise after 2006. With a growing area of over 30000 hectares, Hungary is presently the first in the EU (Tömpe 2006). Production is mostly carried out in accordance with the demands of the processing industry and foreign buyers in the framework of the so-called systems of production on order. The exact timing, which is based on the knowledge of the growing period of the cropped variety, is an essential element in production, being indispensable for ensuring an adequate product quality and for making an efficient use of processing capacities.

Considering the production technology elements, a number of researchers studied or are currently studying the sowing time of sweet corn. As early as in the beginning of the 20<sup>th</sup> century some researchers (Cserháti, 1901) highlighted the importance of the sowing date. Ripening can occur earlier when sowing earlier and using high quality seeds as compared to normal or late sowing. I'só (1969b) and Pásztor (1966), after their multi-year sowing date trial, concluded the following: in the case of an earlier sowing, seed germination will be more protracted, but from the point of view of fruit maturing it was more favourable than late sowing. The greatest influence on early corn development is exerted by moisture and temperature, therefore early sowing is recommended on lighter soils. Early sowing is also recommended by Aldrich (1970) for the reason that the roots will penetrate deeper this way, from where they can get water even in periods of drought. The more intensive vegetative growth also takes place during the period of shorter daytime and this way the plants will be smaller and less prone to lodge. Several techniques with the purpose of early fresh market shipments are known: seedling growing or direct seeding with temporary plant covering (Kurucz, 1998, Hodossi, 2004).

Direct seeded sweet corn under fleece cover showed earlier ripening and gave better yields in the experiments of Kassel (1990). The plots under fleece cover reached harvest maturity 12 days earlier as compared to the plots with no cover. Besides, a greater number of missing plants was observed in the plots with no cover. As a result of the greater plant number and the better ear set per plant, yields were much

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higher in the plots with fleece cover.

According to another solution in use, the seeds were sown in 10 to 14 cm deep seed trenches and latter were covered with floating row cover. The cover was removed 22 to 24 days after sowing. In that case, earlier emergence by 8 to 10 day and advantage in growth and development was occurred (Hodossi and Kovács, 1996).

The most widespread method of seedling production is the use of soil blocks (Pereczes 1999) which can also significantly increase earliness. According to the trials of Kurucz (1998), seedling growing advanced harvest by 2 weeks. According to Hodossi (2004) 10 to 12 day earliness can be achieved by planting seedlings grown in soil blocks and 6 to 8 day earliness by seedlings grown in trays.

The trial was carried out with the aim to find out how the time of propagation and transplanting influence the growing season of sweet corn along with some major properties relevant to quality.

### Material and methods

The experiment was set up in 2008 on an area equipped for irrigation at the Experimental Farm of the Faculty of Horticulture of the Corvinus University of Budapest. The results of the analysis of the soil sample collected at the beginning of 2006 from the trial area prior to direct seeding are shown in Table 1.

**Table 1 Soil analysis results**

pH (H <sub>2</sub> O)	Salt,%	Humus,%	K <sub>A</sub>	P <sub>2</sub> O <sub>5</sub> , mg kg <sup>-1</sup>	K <sub>2</sub> O, mg kg <sup>-1</sup>	CaCO <sub>3</sub> ,%
8.3	0.035	1.31	<30	293	205	<1

The pH-value of soil was considered as calcareous. The nutrient content in nitrogen was low, in phosphorus very good and in potash good.

The test variety was 'Spirit', a normal sweet corn with a very early growing period (85 days). Average plant height is 159 cm, ear height is 37 cm, average ear length is 19.6 cm and average ear weight is 245 g, on the base of variety trials carried out by the Central Agricultural Office (Kovács 2002).

The following treatments were applied during the experiment (with the date of planting or seeding):

P1 = covered plants grown from transplants (Apr 8)

P2 = uncovered plants grown from seeds (Apr 8)

P3 = covered plants grown from seeds (Apr 8)

P4 = uncovered direct seeding, control (Apr 21)

For the purpose of seedling growing, the seeds were sown on March 16 in trays with rigid walls. For seedling growing a commercial mix (white peat 10-20 mm, PG Mix 1 kg m<sup>-3</sup> + micro nutrients, bentonite 40 kg m<sup>-3</sup>, pH 5.5-6.5) was used. The seedlings were grown for 3 weeks and were planted out at the stage of 3 to 4 leaves. At the two propagation times the treatments P1 and P3 were covered with Novagryl floating row cover, having a weight of 19 g m<sup>-2</sup> (using the small tunnel technique) in order to enhance earliness. The floating row cover was removed on May 13.

The corn stand was created to contain 60607 plants per hectare, according to the recommendations of the owner of the variety, at a spacing of 110 + 40 × 22 cm in twin rows. Each plot had an area of 6 × 7 m (8 parallel rows and 30 seeds sown in each row). Number of replications: 4. No farmyard manure was applied, and fertilization was done by top dressing with N. In order to avoid salt damage, N was applied as 34% ammonium nitrate in the dose less than 50 kg ha<sup>-1</sup>.

During the experiment, plant growth rates were studied and the time of the occurrence of the major phenological stages was recorded. For this purpose, regular observations (every 3 to 5 days) were carried out:

- tassels appearance (by 50% of the plants),
- beginning of tasseling (pollen shed has begun on the axes of tassels),
- 50% female flowering (silks have reached a length of 2 cm on half of the ears),
- milk stage (harvest).

## Yield of early sweet corn

During the harvest, the ears together with the husks, were collected from the two central twin rows. After that, 20 representative ears from each row were selected and the following measurements were carried out:

- un-husked ear weight (g),
- total ear length (cm).

The statistical analysis of the results was carried out by using the programme RopStat 1.1. When the standard deviations were identical, the mean values were compared by pairs using the Tukey-Kramer test, while in the case of the non identical standard deviations the means were compared using the Games-Howell test (Vargha, 2007).

## Results and discussion

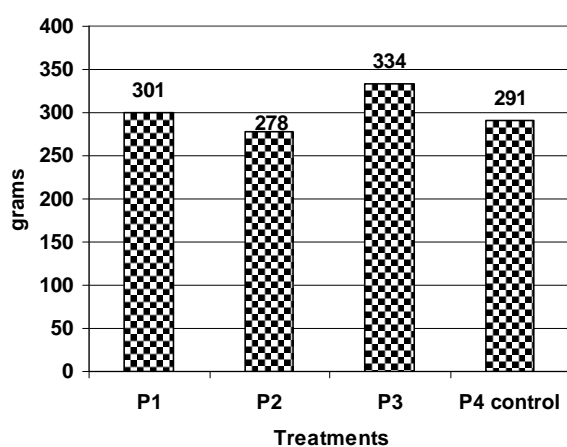
The occurrence of the different phenological stages is illustrated by Table 2.

**Table 2 Days of occurrence of generative phenophases (the day of direct seeding or transplanting = 0)**

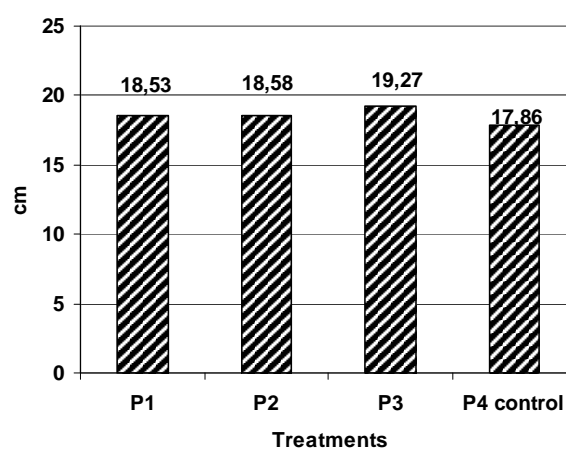
Treatments	Appearance of tassels	Beginning of tasseling	50% female flowering	Milk stage
P1 (Apr 8)	46 (May 24)	49 (May 27)	52 (May 30)	72 (Jun 19)
P2 (Apr 8)	57 (Jun 5)	64 (Jun 12)	71 (Jun 19)	86 (Jul 3)
P3 (Apr 8)	54 (Jun 2)	57 (Jun 5)	64 (Jun 12)	84 (Jul 1)
P4 control, (Apr 21)	49 (Jun 9)	59 (Jun 19)	61 (Jun 22)	79 (Jul 9)

The growing season of the treatment P4 (recommended according to the existing practice of production) was in accordance with the data recorded by the National Institute for Agricultural Quality Control. The beginning of harvest was delayed by 20 days, when compared to the treatment P1 and by 6 and 8 days when compared to the treatments P2 and P3, respectively.

The unhusked ear weight, one of the major yield parameters, is illustrated in Figure 1.



**Figure 1 Unhusked ear weight**



**Figure 2 Total ear length (cm)**

The average ears weight obtained from the treatment P3 (covered plants grown from seeds) was significantly higher (at  $p < 0.01$  level) as compared to the other treatments. The average unhusked ear weight of the P1 treatment (covered plants grown from transplants) was significantly higher (at  $p < 0.01$  level) compared to the uncovered treatments P2 and P4.

The data concerning, an important characteristics for market appeal (total ear length) are shown in Figure 2. Studying the data of total ear length, it was found that the lengths of the latter, direct seeded treatment P4 (control) were also significantly lower (at  $p < 0.01$  level) than the lengths obtained at the other treatments (P1, P2 and P3). The average total ear length of the P3 treatment (covered plants grown from seeds) was significantly higher (at  $p < 0.01$  level) compared to the other treatments. No difference was found between the ear length of the treatments P1 and P2.

## Conclusions

Based on the results obtained in one-year experiment, it can be concluded that the growing season was significantly reduced in the transplanted treatments compared to the later and direct seeded (control) treatment. Harvest time occurred 20 days earlier in the case of the treatment of early transplanting and with floating row cover (P1), while 12 and 14 days earlier in case of the treatments of early, direct seeded, with and without covered P2 and P3 treatments, respectively. At the same time, the floating row cover did not produce any important shortening in the growing season between treatments P2 and P3. The ear length of the early transplanted treatment P1 was significantly superior compared to the control treatment (P4), but the longest ears were collected from the earlier seeded, covered (P3) treatment. The covering in case of direct seeded treatment P3 produced favourable effect on length of ears.

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# Deficit irrigation strategies for production of tomato in greenhouse conditions

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## Abstract

The effects of partial root drying (PRD) and deficit irrigation (RDI) on tomato (cultivar 'Amati') yield and fruit quality were researched and compared to full irrigation (FI). Under PRD and RDI tomato plants received 60% of the water that was applied to FI. At harvest, the effects of RDI, PRD and FI on total yield, fruit quality (total soluble solids, titrable acidity and antioxidant activity) and water use efficiency (WUE) were assessed. These results showed that with both deficit irrigation techniques is possible to increase WUE without reduction of tomato yield. Comparison between deficit irrigation techniques showed an increase in antioxidative activity in tomato fruits under PRD and indicated that PRD method could be more beneficial irrigation method than RDI.

Key words: regulated deficit irrigation, partial root drying, tomato, yield quality, water use efficiency

## Introduction

Among environmental factors drought is a major limiting factor of tomato productivity and therefore tomato successful production in many areas of the world requires irrigation. However, as a consequence of global climate changes and environmental pollution, water available for irrigation is often reduced. Recent results have demonstrated that regulated deficit irrigation (RDI) and partial root drying (PRD) are new deficit irrigation strategies which may decrease demand for agricultural use of water. The application of these techniques to different crops, including tomato, has demonstrated benefits in terms of improved water-use efficiency and a stable yield, in addition to an increased yield quality (FAO, 2002; Davies et al., 2000). Both deficit irrigation methods are based on understanding of the physiological responses of plants to water supply and water deficit (Morison et al., 2008). In regulated deficit irrigation (RDI) the entire root zone is irrigated with an amount of water less than the potential evapotranspiration during specific periods of the crop cycle (English and Raja, 1996). Partial root drying (PRD) is a further development of RDI. Under PRD only half of the root zone is irrigated while the other half is allowed to dry out. The treatment is then reversed, allowing the previously well-watered side of the root system to dry while irrigating the previously dry side. The principle behind PRD is that irrigating part of the root system keeps the leaves hydrated. When exposing the remaining part of the roots to soil drying, synthesis and transport of chemical signals (particularly ABA) from roots to the shoot via the xylem is triggered (Loveys et al., 2000). Effects of PRD on plant physiology are different from RDI because wet roots under PRD sustain shoot and fruit turgor important for growth (Mingo et al., 2003). Triggering partial stomatal closure under PRD irrigation may prevent excessive water loss and lead to better water balance of the plants, and this also may prevent the metabolic inhibition of CO<sub>2</sub> assimilation that otherwise would occur if drought stress was allowed to develop extensively (Chaves et al., 2002). PRD or RDI research has been focused mainly on tomato yield and water-use efficiency with comparatively less research to characterize the effects of these techniques on fruit quality. One of the very important tomato fruit characteristic is antioxidant activity. Tomato fruit is significant dietary source of important natural antioxidant compounds including carotenoids, flavonoids and other

phenolic compounds. By removing free radicals these compounds might reduce the risk of the developments of chronic diseases, such as cardiovascular disease and cancer (Middleton et al., 2000). Antioxidants are also very important for plants reactions to stress conditions, including drought, because they are acting as oxygen scavenging systems able to detoxify the various forms of activated oxygen generated during stress conditions (Noctor and Foyer, 1998). The aim of presented results was to assess the effects of RDI and PRD techniques on tomato yield, WUE and fruit quality with the special emphasis on fruit antioxidant activity. This could be important not only for saving water for irrigation of tomato but also for production of food with greater human health benefits.

### Material and methods

Tomato experiment was carried out in a commercial greenhouse at a local market gardener "Salate Centre" located 10 km north of Belgrade. Greenhouse design was typical for Serbia with the size of 400 m<sup>2</sup> (width 8 m and length 50 m), covered with a polyethylene film and unheated. Experimental soil in the greenhouse was classified as humogley. Planted species was *Lycopersicon esculentum* L., hybrid cultivar 'Amati'. Tomato uniform seedlings were planted into greenhouse soil on the end of April in single rows each having 90 plants of 50 cm spacing in rows. When plants were in the phenological phase of first truss formed (middle of May) three irrigation treatments were tested: regulated deficit irrigation (RDI), partial root drying (PRD) and full irrigation (FI). The irrigation ended on the end of August when plants were in the growth stage 88 (growth stage code 808) (BBCH, 2001). Plants in FI treatment were irrigated every two or three days to a volumetric soil water content of 35%, although PRD and RDI plants received 60% of the water that was applied to FI. The water amount supplied in the period between middle of May and the end of August to FI, RDI and PRD treatments was 103.4 l, 60.4 l and 57.4 l per plant, respectively. The irrigation was provided by drip system (one line for FI and RDI and two for PRD). Switching of water from one to another side in PRD treatment was done for a period of approximately 5 to 7 days. Irrigation timing in all treatments was determined according to the soil moisture data measured by profile probe (PR2/6, Delta-T Device, Ltd, UK). Tomato fruits were harvested when a stage of ripeness had been reached. Yield was expressed as t FW per ha. Tomato quality was characterized on the basis of fruit FW data by measuring total soluble solids (TSS), titrable acidity (TA) and antioxidant activity (AA). Hand-held refractometer (Reichert Analytical Instruments, Depew NY) was used for measuring soluble solids concentration in fruits extracts. Titrable acidity of tomato ethanolic extract was determined by volumetric titration with NaOH and expressed as µmol citric acid content per g FW. The same extract was used to measure sugars with a refractometer. Antioxidant activity of tomato fruits ethanolic extract was evaluated according to Rotino et al. (2005) against ABTS<sup>•+</sup> radical cation using the modification of the method of Böhm et al. (2002). Results were expressed as TEAC in µmol of Trolox per 100 g of sample fresh weight (Kequan and Liangli, 2006). Water use efficiency (WUE) was calculated as the ratio between yield (fruit FW) and the amount of used irrigation water. Data were processing and analysing by Statistica 7.1 data analyses software system (Stat.Soft, Inc., Tulsa, USA, 2004).

### Results and discussion

Results of a tomato experiment are presented in Table 1 and Table 2. The data in Table 1 showed that yield wasn't slightly higher in FI irrigation (48.71 t FW ha<sup>-1</sup>) comparing to the RDI and PRD irrigated plants (48.58 and 43.41 t FW ha<sup>-1</sup>). Although almost all studies confirmed that both PRD and RDI might be successfully applied as water saving strategy, there is a discrepancy in published results concerning the feasibility of these techniques to maintain yield. There are reports in the literature demonstrated that under PRD yield of tomato was maintain and improved in both processing tomatoes (Zegbe-Dominguez et al., 2003, 2004) and fresh market tomato (Kirda et al., 2004). On the contrary, there are also results showing an depressing input on tomato yield of plants under PRD or RDI (Tahi et al., 2007). The phenological stages of tomato or other vegetables may react differently to RDI or PRD and, therefore, scheduling of both technique should be done taking into account the stages in which the vegetables are particular vulnerable to the soil water deficit. Reproductive tomato growth, especially flower and fruit set phases, are a more sensitive phenological stage to water deficit than is vegetative growth (Srinivasa et al., 2000).

Results of this research also showed that RDI and PRD tomato plants produced more fruit biomass per m<sup>-3</sup> water (61.85 and 56.02 kg FW m<sup>-3</sup>) compared to control plants (34.90 kg FW m<sup>-3</sup>) and, therefore, it is clear that an significant increases in crop WUE have been achieved (Table 1). These results confirmed beneficial

effect of both techniques in increasing WUE in tomato similarly to other studies (Davies et al., 2002; Fernández et al., 2006; Tahi et al., 2007; Zegbe-Dominguez et al., 2003).

**Table 1** Treatments mean differences in total yield (Y) and water use efficiency (WUE) in tomato greenhouse experiment where the full irrigation (FI), regulated deficit irrigation (RDI) and partial root drying (PRD) methods were applied

Treatment	Y (t FW ha <sup>-1</sup> )	WUE (kg FW m <sup>-3</sup> )
FI	48.71	34.90 <sup>A</sup>
RDI	48.58	61.87 <sup>B</sup>
PRD	43.41	56.02 <sup>B</sup>

<sup>A,B</sup> - significantly differed after LSD<sub>0.05</sub>.

On the basis of the biochemical analysis (Table 2), it was found out that RDI, PRD and control plants fruit did not differ significantly in statistical terms regarding total soluble solids (4.7, 5.1 and 5.1 °Brix) and titrable acidity (20.1, 19.9 and 19.6 citric acid  $\mu\text{mol g}^{-1}$  FW). Similar improvement in tomato fruit quality under PRD was obtained in earlier results with other tomato cultivar (Stikić et al, 2003). Statistically significant differences were found in antioxidant activity, due to fruits of PRD plants had higher antioxidant activity (50.87  $\mu\text{mol TEAC } 100\text{g}^{-1}$  FW) compared to the fruits of RDI and control plants (43.65 and 33.33  $\mu\text{mol TEAC } 100\text{g}^{-1}$  FW).

In literature there are no data on the effect of PRD on antioxidant activity in yield components (fruits, tubers, seeds) of agricultural crops. Only available data on the effects of PRD irrigation are those of Aganchich et al. (2007) who showed an increase in activity of several antioxidant enzymes in PRD and RDI (regulated deficit irrigation) irrigated olives. According to these authors this increase can be an important protection mechanism of the olive plant against an oxidative stress that might occur under these PRD and RDI irrigation treatments.

**Table 2** Treatments mean differences in total soluble solids (TSS), titrable acidity (TA) and antioxidant activity (AA) in tomato greenhouse experiment where the full irrigation (FI), regulated deficit irrigation (RDI) and partial root drying (PRD) methods were applied

Treatment	TSS (°Brix)	TA (citric acid $\mu\text{mol g}^{-1}$ FW)	AA ( $\mu\text{mol TEAC } 100\text{g}^{-1}$ FW)
FI	5.10	19.60	33.33 <sup>A</sup>
RDI	4.70	20.10	43.65 <sup>A</sup>
PRD	5.10	19.90	50.87 <sup>B</sup>

<sup>A,B</sup> - significantly differed after LSD<sub>0.05</sub>

## Conclusions

Experimental results showed that with both deficit irrigation techniques (RDI and PRD) is possible to save irrigation water and increase water-use efficiency, without reduction of tomato yield. The increase of the antioxidant activity under PRD is very desirable characteristic that could be beneficial from the aspects of health-promoting value of tomato fruits. Further research of both techniques and application to much more tomato cultivars will allow assessment of potential practical impacts of these techniques for tomato production in the areas with restricting water resources.

## Acknowledgements

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# Development of sweet pepper growing technology in clay pebbles

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## Abstract

In 5 year experiments, the applicability of clay pebbles in sweet pepper soilless culture and finding the optimal technological solution were studied. The frequent low dose irrigations with one dripper per plant and buckets bored with holes in the side or vertical containers seemed to be the most suitable. The highest yield was produced by the single stem pruning method and it was seen that using this pruning method as many as 2 or 3 plants can be planted in customary containers of 10 litres. In the case of the double stem pruning method a 5 litres container was suitable with one plant per container.

Key words: *Capsicum annuum* L., soilless culture, substrate, container, plastic tube

## Introduction

In soilless growing systems the growing media is one of the most important factors of successful production. The main demands to 'artificial' growing media are that they should contain no harmful materials, should not influence the composition of the applied nutrient solution, should ensure the necessary environmental conditions for roots (first of all, the proper air/water ratio) and should preserve these favorable characteristics possibly in a uniform manner all through the growing season (Kovács, 2000). As a result of the headway of environment conscious thinking, growers must probably choose between the utilization of materials with continuously renewing sources (e.g. coconut coir) or the repeated application of the same reusable media. Researchers have been looking for suitable media for decades (Andreas, 1993; Raviv et al., 2002) and researches keep involving an ever greater number of materials nowadays (Tompos and Gyúró, 2005; Jakusné and Forró, 2005).

The first relevant Hungarian experiment with the expanded clay pebbles was carried out by Imre, which conducted a trial in the early 1990s with the pepper hybrid variety 'HRF' in a soilless system, using zeolite and clay pebbles as a growing media and a peat-based soil mix as the control. He concluded that all the media tested were suitable for production purposes if setting up an adequate fertigation system. He received similar results in the experiment conducted with the pepper variety 'Mazurka' in which he compared the effect of rockwool, perlite and duroplast foam (Imre, 1994).

Sweet pepper is the most important greenhouse vegetable in Hungary, so the aim of 5 year research work was to elaborate the soilless growing technology of white-fruited pepper in clay pebbles, suited to the Hungarian conditions.

## Material and methods

The trials were set up at the Experimental Farm of the Faculty of Horticulture (Budapest, Soroksár), in Filclair type unheated plastic house. The tested hybrid variety was the white-fruited pepper 'Hó'.

The applicability of the product Liapor Hydro KK (marked as H4/8KK) was studied and the rockwool (Grodan Master) was used as control in the individual experiments. The experiments were directed on a

number of growing technology elements with the purpose of the optimal technological solution selection. The most important of these elements were: irrigation frequency and location of the medium, placement and number of drippers, position of drainage holes in the containers, growing medium volume per plant, pruning method and reusability of clay pebbles. During the experiments following treatments were tested:

1. Irrigation frequency experiment (clay pebbles used for the first time):
  - a) T1-1 = H4/8KK, in buckets with holes drilled on the bottom, using automatic irrigation, 10 litres of medium per plant;
  - b) T1-2 = H4/8KK, in buckets with holes drilled on the side wall, using automatic irrigation, 10 litres of medium per plant;
  - c) T1-3 = H4/8KK, in buckets with holes drilled on the bottom, using manual irrigation, 10 litres of medium per plant;
  - d) T1-4 = H4/8KK, in buckets with holes drilled on the side wall, using manual irrigation, 10 litres of medium per plant.
2. Growing media location (clay pebbles used for the first time, containers of 10 litres, automatic irrigation):
  - a) T2-1 = H4/8KK, in plastic tubes;
  - b) T2-2 = H4/8KK, in buckets with holes drilled on the bottom;
  - c) T2-3 = H4/8KK, in buckets with holes drilled on the side wall;
  - d) T2-4 = Rockwool (1 m), in plastic tubes.
3. Placement and number of drippers experiment (clay pebbles used for the first time, plastic tubes of 15 litres, 3 plants per tube, automatic irrigation):
  - a) T3-1 = H4/8KK, 1 dripper per plant in a soil block (A);
  - b) T3-2 = H4/8KK, 2 drippers per plant in a soil block (B);
  - c) T3-3 = H4/8KK, 5 drippers per tube, 1 dripper in each block + 2 drippers between the soil blocks in the tube (C) (A).
4. Growing media volume per plant and pruning method (clay pebbles used for the first time) in buckets with holes drilled in the side wall:
  - a) T4-1 = H4/8KK, 10 litres per container with 2 plants (5 litres per plant), 2 stem pruning;
  - b) T4-2 = H4/8KK, 10 litres per container with 2 plants (5 litres per plant), 1 stem pruning;
  - c) T4-3 = H4/8KK, 10 litres per container with 3 plants (3.3 litres per plant), 2 stem pruning;
  - d) T4-4 = H4/8KK, 10 litres per container with 3 plants (3.3 litres per plant), 1 stem pruning;
  - e) T4-5 = H4/8KK, 5 litres per container with 1 plant (5 litres per plant), 2 stem pruning;
  - f) T4-6 = H4/8KK, 10 litres per container with 1 plant (10 litres per plant), 2 stem pruning.
5. Growing media reusability (plastic tube of 15 litres, 3 plants per tube):
  - a) T5-1 = H4/8KK, 1st year;
  - b) T5-2 = H4/8KK, 2nd year;
  - c) T5-3 = H4/8KK, 2nd year (heat treated);
  - d) T5-4 = H4/8KK, 3rd year;
  - e) T5-5 = H4/8KK, 3rd year (heat treated);
  - f) T5-6 = H4/8KK, 3rd year (heat treated twice);
  - g) T5-7 = H4/8KK, 4th year;
  - h) T5-8 = Rockwool, 1st year.

Seeds were sown in the last week of February and in the first part of March. Planting was done in the first half of April while the harvest period lasted from the end of May to the second part of October. Seedlings were raised in peat or in rockwool blocks, depending on the used growing media in the experiment. Plants were arranged in a 90+60x33 cm pattern, except for the experiment on container root medium and pruning method. In that case growing was carried out at the same shoot number per square meter, according to the following container arrangement: T4-1 = 90+60x66 cm (2 plants together); T4-2 = 90+60x33 cm (2 plants

together); T4-3 = 90+60x99 cm (3 plants together); T4-4 = 90+60x50 cm (3 plants together); T4-5 = 90+60x33 cm (1 plant).

In each trial 1 dripper per plant was used, except for the experiment on the number and dripper placement (T3-2; T3-3 treatments). The arrangement made in this trial is illustrated in Figure 1.

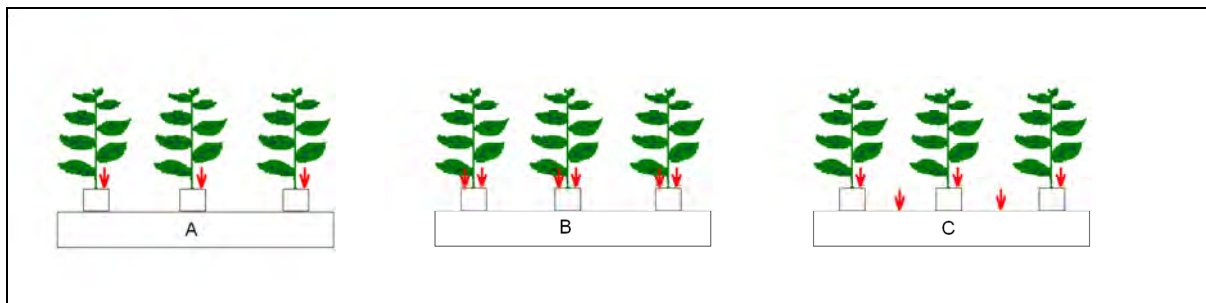


Figure 1. Placement of drippers

Outlet for drain water was provided by cutting 3-4 cm openings on both ends of the tubes, at 3 cm from soil surface. In the experiments with containers a total of 6 holes 5 mm in diameter were made on the bottom or on the sides. Holes were placed at 6 cm from the buckets bottom, in a circular design.

For plants nutrition, the formula and nutrient solution concentration recommended for pepper growing on rockwool were used. Irrigation frequency and duration were set in accordance with plant development. Irrigation was made more frequently compared to the rockwool systems. The water dose of single irrigation (the irrigation norm) was initially identical with that recommended for the rockwool technology, but on the other hand it was reduced by the end of the growing season.

For the trial on medium reusability, the heat-treated substrate was kept at a temperature of 105-110 °C over 1 hour prior to planting. Heat treatment was applied only in the beginning of 2005 in the treatments T5-3 and T5-5 and in both years in the treatment T5-6.

At each harvest the fruits were sorted into quality categories, in conformity with market requirements. In the case of the tested 'Hó' F1 variety these categories correspond to the following classes:

- Extra - healthy fruits weighted over 100 g;
- 1<sup>st</sup> class - healthy fruits weighted from 80 to 100 grams;
- 2<sup>nd</sup> class - healthy fruits weighted from 60 to 80 grams;
- 3<sup>rd</sup> class - healthy fruits weighted from 40 to 60 grams;
- unmarketable fruits (including the strongly deformed or blotched ones, mainly with Ca deficiency, and the ones under 40 grams).

Harvest dynamic, in accordance with the production practice, was such as to conform with the plant development dynamics as well to the pre-harvest pesticide sprayings intervals. Fruits were harvested at the commercial maturity stage.

The program Robstat\_Prof was used in the statistical analyses. The comparison of the treatments, as it was not possible to test the normal distribution with the majority of the parameters considering the dimensions of the experiment (4 treatments, 4 repetitions), begun with variance analyses (O'Brien's Test, Levene's Test) not requiring normality. Depending on the results obtained either the F test or robust methods (James-, Welch-, Brown-Forsythe Test) were used for global comparison. The analysis of the treatments in pairs was carried out with the Tukey-Kramer method in the case of equal variances and with the Games-Howell method in the case of unequal variances (Vargha, 2008). In the variance analysis it was examined the differences on  $p < 0.05$  level.

## Results and discussion

Fruit yields achieved in 2005, during the experiments concerning irrigation frequency, growing media type and location (buckets or tubes), placement and number of drippers per plant, growing media volume per plant and pruning method and growing media reusability are shown in Table 1.

Table 1. Pepper fruit yield

Treatment	Total		Extra +1 <sup>st</sup> class		Unmarketable	
	fruit number/m <sup>2</sup>	fruit yield, kg/m <sup>2</sup>	fruit number/m <sup>2</sup>	fruit yield, kg/m <sup>2</sup>	fruit number/m <sup>2</sup>	fruit yield, kg/m <sup>2</sup>
T1-1	166.41 <sup>b*</sup>	13.67a	85.61a	8.65a	4.80b	0.17b
T1-2	188.38 <sup>a</sup>	15.36a	94.70a	9.57a	5.81b	0.27b
T1-3	93.51 <sup>c</sup>	6.03b	18.55b	1.72b	11.23b	0.49b
T1-4	123.54 <sup>d</sup>	7.91b	25.88b	2.49b	21.73a	0.97a
T2-1	197.64 <sup>a</sup>	16.00ab	95.96ab	9.56ab	6.73a	0.35a
T2-2	166.41 <sup>a</sup>	13.67b	85.61b	8.65b	4.80a	0.17a
T2-3	188.38 <sup>a</sup>	15.36ab	94.70ab	9.57ab	5.81a	0.27a
T2-4	209.43 <sup>a</sup>	17.84a	115.15a	11.97a	8.42a	0.42a
T3-1	231.20 <sup>a</sup>	18.36a	90.53a	9.66a	4.13a	0.28a
T3-2	218.07 <sup>a</sup>	18.01a	103.60a	10.72a	3.40a	0.28a
T3-3	208.40 <sup>a</sup>	16.91a	86.87a	8.98a	5.13a	0.42a
T4-1	207.82 <sup>c</sup>	16.37c	81.27b	8.42b	3.95a	0.26b
T4-2	290.61 <sup>a</sup>	23.66a	122.50a	13.04a	8.08a	0.55a
T4-3	183.28 <sup>c</sup>	14.36c	69.66b	7.21b	3.86a	0.24b
T4-4	250.09 <sup>b</sup>	20.50b	109.80a	11.49a	7.32a	0.55a
T4-5	207.96 <sup>c</sup>	15.91c	71.15b	7.47b	4.64a	0.22b
T4-6	189.99 <sup>c</sup>	15.24c	76.79b	7.96b	2.72a	0.19b
T5-1	231.20 <sup>a</sup>	18.36a	90.53ab	9.66ab	4.13a	0.28b
T5-2	196.09 <sup>bc</sup>	14.46bc	71.15c	7.35c	4.24a	0.32b
T5-3	197.00 <sup>bc</sup>	15.36bc	71.00c	7.44c	4.67a	0.33b
T5-4	172.73 <sup>c</sup>	13.31c	60.68cd	6.14c	3.85a	0.26b
T5-5	177.82 <sup>c</sup>	13.79c	66.42cd	6.76c	2.87a	0.15b
T5-6	183.73 <sup>bc</sup>	13.59c	55.81d	5.73c	1.06a	0.05b
T5-7	213.78 <sup>ab</sup>	16.08b	77.16bc	7.84bc	1.33a	0.09b
T5-8	216.01 <sup>ab</sup>	17.76ab	93.84a	9.97a	8.58a	0.64a

\* Identical letters placed beside the averages designate (column by column, by experiment) the treatments that are identical at the 95% probability level according to our statistical calculations.

## Conclusions

In the case of using clay pebbles in container growing the most favourable is to bore holes on the side of the buckets and it is definitely advisable to use automated irrigation with frequent small doses irrigations. This method produces the significantly highest total yield and also the amount of the extra and 1st class fruits.

Compared to container growing, the placing of clay pebbles in horizontal plastic tubes (1 m length, 3 plants per tube) can produce even more favourable results.

The placing of more than 1 dripper per plant in the plastic tube and thereby the application of more nutrient solution does not result with significant yield increase and it is not recommended to increase the number of drippers in order not to waste nutrient solution.

In container growing, the single stem pruning method produces better yield results. Therefore, if enough seedlings are available for planting, a double plant number and also the trellis system is high enough to train up longer shoots, this technological variant is recommended. The 10 litres growing media volume per plant can be halved or reduced to one third in the case of the single stem pruning (planting of 2 or 3 plants in the same bucket) and in the case of the two-stem pruning method it is a possible solution to plant individual plants in 5 litres containers.

Relative to the reusability of the medium, no clear results were obtained. Besides the medium used for the first time, also the one used for the fourth time produced favourable yield results. The plants grown on clay pebbles used for the second and third year achieved statistically lower yields. The heat treatment applied (a temperature of 105-110°C over 1 hour) did not have clear influence.

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# Utjecaj sorte i gnojidbe dušikom na prinos i sadržaj nitrata u vršnom cvatu brokule

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## Sažetak

Prekomjerna dušična gnojidba može smanjiti kvalitetu cvata brokule zbog nakupljanja štetnih nitrata. U gnojidbenom poljskom pokusu sa tri hibridne sorte brokule ('Ironman', 'Marathon' i 'Parthenon') testirane su četiri razine gnojidbe dušikom (0, 60, 120 i 240 kg·ha<sup>-1</sup>). Istraživanje je provedeno u Zagrebu u ljetno-jesenskom roku uzgoja 2009. godine. Tijekom višekratnih berbi utvrđeni su broj, masa i prinos tržnih vršnih cvatova brokule te sadržaj nitrata. Velik, statistički jednak prinos u rasponu 15 do 16,9 t·ha<sup>-1</sup>, uz sadržaj nitrata manji od 500 mg·kg<sup>-1</sup> svježe mase, ostvarile su kombinacije 'Marathon' × 240 i 120 kg N·ha<sup>-1</sup>, 'Parthenon' × 120 kg N·ha<sup>-1</sup> i Ironman × 240 kg N·ha<sup>-1</sup>.

Ključne riječi: *Brassica oleracea* var. *italica*, amonijev nitrat, masa tržnog cvata.

## Effect of cultivar and nitrogen fertilization on the broccoli top inflorescence yield and nitrate content

### Abstract

Excessive nitrogen fertilization can reduce the quality of broccoli inflorescence due to the accumulation of detrimental nitrate. In the fertilization field trial with 3 hybrid broccoli cultivars ('Ironman', 'Marathon', 'Parthenon') four levels of nitrogen fertilization (0, 60, 120, 240 kg N·ha<sup>-1</sup>) were tested. The research was conducted in Zagreb during the summer-autumn growing period in 2009. Number, weight, yield and nitrate content of marketable top inflorescence were determined during multiple harvests. High, statistically equal yields in range from 15 to 16,9 t·ha<sup>-1</sup>, with nitrate content lower than 500 mg·kg<sup>-1</sup> fresh weight, were achieved by the combinations 'Marathon' × 240 and 120 kg N·ha<sup>-1</sup>, 'Parthenon' × 120 kg N·ha<sup>-1</sup> and 'Ironman' × 240 kg N·ha<sup>-1</sup>.

Key words: *Brassica oleracea* var. *italica*, ammonium nitrate, marketable inflorescence mass

### Uvod

Prinos svih poljoprivrednih kultura u znatnoj mjeri ovisi o količini pristupačnih hraniva u tlu, a najznačajniji utjecaj na količinu prisutnih hraniva u tlu ima gnojidba (Lončarić i sur., 1999). Dušik se smatra esencijalnim biljnim hranivom koje najviše ograničava biljnu proizvodnju. Ćustić (1996) navodi važnost poznavanja optimalne potrebe povrtnih vrsta za dušikom, obzirom na značajnost utjecaja na tvorbu aminokiselina, visinu prinosa te osobito akumulaciju štetnih nitrata. Ipak, ističe da gnojidba dušikom uzrokuje povećanje prinosa do određene razine. Brokula za ostvarenje visokog prinosa zahtijeva dobru opskrbljenost lako pristupačnim hranivima, posebice dušikom. Prema Lešić i sur. (2004) gnojidba brokule ovisi o sorti i načinu uzgoja. Tako je pri proljetnom i rano-jesenskom roku uzgoja sorti kraće vegetacije, za prinos od oko 12 t·ha<sup>-1</sup>,

potrebno 200 kg N, 80 kg P<sub>2</sub>O<sub>5</sub>, 215 kg K<sub>2</sub>O te 25 kg MgO. Obzirom da brokula razvija veliku vegetativnu masu, više od polovice navedenih hraniva ostaje u biljnim ostacima nakon berbe. Obzirom da je dušik u biljci lako pokretljiv i brzo se premješta iz starijih organa u mlađe, nedostaci se uočavaju na najstarijim listovima (Kastori, 1983). Višak dušika nepovoljno utječe na produktivnost biljaka, uzrokuje stvaranje velike lisne mase tamnozeleno boje, krhkost te neotpornost biljaka na bolesti i polijeganje zbog pojačane tvorbe parenhimskog tkiva. Također, smanjena sinteza šećera i prekomjerno nakupljanje nitrata, negativno utječu na kvalitetu i održivost tako proizvedenog povrća. Radi sprečavanja pojave nepoželjnih simptoma viška dušika EFSA (2008) preporučuje raspoređivanje ukupno planirane doze dušika u više navrata tijekom vegetacije. Brokula, kao cikla, kupus, celer, salata, radič i špinat, može imati značajan sadržaj nitrata, više od 1000 mg·kg<sup>-1</sup> svježe mase, ovisno o količini i primjeni dušične gnojidbe, intenzitetu svjetlosti, dnevnoj temperaturi te tipu tla (EFSA, 2008). Za optimalan vegetativni rast i produkciju kvalitetnih cvatova, mnogi autori navode velike potrebe brokule za dušikom, kao i utjecaj takove gnojidbe na biljku. Sorensen (1999) je ustanovio pozitivan utjecaj gnojidbe dušikom na prinos brokule jer se najveći prinos (16 t·ha<sup>-1</sup>) ostvaruje pri velikoj dozi dušika (400 kg N·ha<sup>-1</sup>), dok se primjenom 210 kg N·ha<sup>-1</sup> ostvaruje manji prinos (11 t·ha<sup>-1</sup>). Coulombe i sur. (1999) također navode velike potrebe brokule za dušikom, ali i da prevelika količina ovog hraniva rezultira pojavom šuplje stabljike i smanjenom otpornosti biljaka na bolesti, čime izravno utječe na smanjenje tržišnog prinosa. Goodless i sur. (1997) te Feller i Fink (2005) iznose podjednaku potrebu brokule za dušikom (300 do 465 kg·ha<sup>-1</sup>), ali ističu problem potencijalnog ispiranja dušika uslijed primjene prevelikih količina dušika pri sadnji, budući da mlade biljke u početnim fazama rasta ne mogu usvojiti obilne količine dušika iz tla. Greenwood i sur. (1980) preporučuju manje doze dušika (175 do 252 kg N·ha<sup>-1</sup>) kao i Everaarts (1994) koji navodi da doza od 196 kg N·ha<sup>-1</sup> ostvaruje prihvatljivu masu vršnog cvata (216 g) uz manju pojavu cvatova s fiziološkim poremećajem smeđenja cvata. S nižom koncentracijom dušika povezuje se visoki udio suhe tvari koji rezultira čvršćim tkivom i smanjenom osjetljivosti biljaka na bakterijske bolesti. Također, Toth i sur. (2004) pri gnojidbi s 200 kg N·ha<sup>-1</sup> ostvaruju prinos brokule (11,81 do 14,51 t·ha<sup>-1</sup>) koji je jednak ili veći od europskog standarda (12,0 t·ha<sup>-1</sup>). Wojciechowska i sur. (2005) proučavali su utjecaj dušične gnojidbe i folijarne prihrane ureom na komponente prinosa brokule te nisu utvrdili statistički značajni utjecaj doze dušika na prinos i kvalitetu brokule.

Navedeno ukazuje na potrebu istraživanja utjecaja sorte i gnojidbe dušikom na prinos i sadržaj nitrata vršnog cvata brokule u različitim rokovima uzgoja, u cilju izdvajanja kombinacija koje istovremeno karakteriziraju veliki prinos i prihvatljiv sadržaj nitrata.

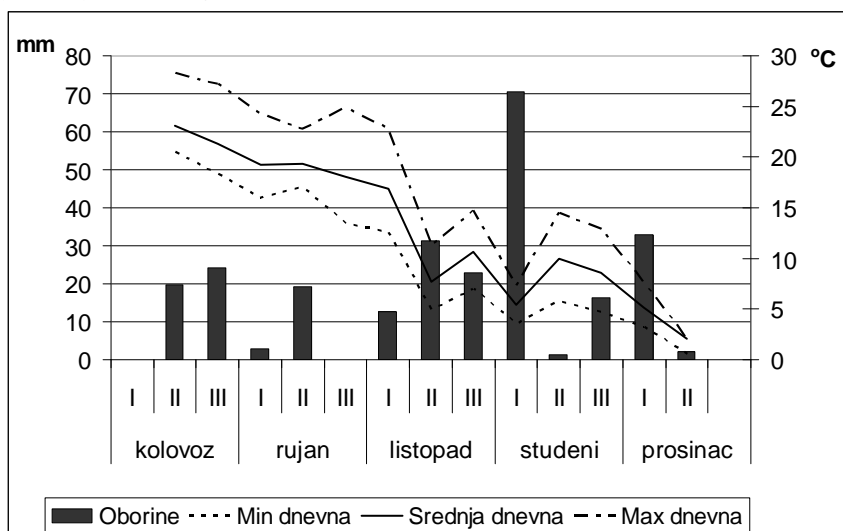
### Materijal i metode

Istraživanje je provedeno u ljetno-jesenskom roku uzgoja 2009. godine na lokaciji Zagreb-Petruševac. Poljski pokus sa tri sorte ('Ironman', 'Marathon' i 'Parthenon') postavljen je po metodi slučajnog bloknoeg rasporeda u 4 ponavljanja. Testirane su četiri razine gnojidbe dušikom (0, 60, 120, i 240 kg N·ha<sup>-1</sup>). Presadnice s razvijena 4 do 5 listova sađene su 7. kolovoza na razmak 0,6 × 0,5 m čime je ostvaren sklop od 3,3 biljke·m<sup>-2</sup>. Na osnovnu parcelu površine 12 m<sup>2</sup> sađeno je 40 biljaka. Temeljem rezultata kemijske analize tla utvrđena je dobra opskrbljenost humusom i osnovnim hranivima pa je gnojidba određena prema ciljanom prinosu od 12 t·ha<sup>-1</sup>. Osnovnom gnojidbom pred sadnju osigurana je potreba brokule za fosforom i kalijem (80 kg P<sub>2</sub>O<sub>5</sub> i 215 kg K<sub>2</sub>O) dok je dušik u navedenim dozama osiguran prihranama amonijevim nitratom u tri navrata: 22. kolovoza., 2. rujna, 11. rujna. Prilikom prihrane gnojivo je inkorporirano u tlo. Berba vršnog cvata započela je 13. listopada, a završila je 26. studenog, odnosno, trajala je 74 dana. Ovisno o meteorološkim prilikama i dinamici razvoja cvatova, provodila se svaka 3 do 4 dana. Tijekom višekratnih berbi utvrđivani su broj, masa i prinos tržišnih vršnih cvatova. Sadržaj nitrata u vršnom cvatu određen je standardnom analitičkom metodom. Utjecaj sorte i gnojidbe na istraživane parametre utvrđen je analizom varijance, a prosječne vrijednosti su uspoređene LSD testom na razini signifikantnosti  $P \leq 0,05$  i  $P \leq 0,01$  (SAS, 1999).

### Rezultati i rasprava

Temperaturni uvjeti za uzgoj brokule u ljetno-jesenskom roku 2009. godine bili su izuzetno povoljni tijekom prva dva mjeseca vegetacije, od sadnje 7.8. do druge dekade listopada, a manje povoljni u nastavku listopada i tijekom studenog (grafikon 1). Dekadne temperature u kolovozu (23,1 i 21,4 °C), rujnu (19,2 do 18 °C) i listopadu (16,9 °C), odgovarale su optimalnoj temperaturi za rast i razvoj brokule koja je prema Lešić i sur. (2004) 20 do 24 °C početkom vegetacije, a kasnije 15 do 18 °C. Vrijednosti dekadne temperature tijekom

druge i treće dekade listopada i u studenom bile su 7,7 i 10,7 °C te 5,5, 9,9 i 8,6 °C, odnosno, nešto niže od optimalnih. Tijekom vegetacije brokule zabilježeno je 221 mm oborina (grafikon 1), što je prema Lešić et al. (2004) svega 50% ukupnih potreba. Oborine su bile relativno dobro raspoređene, izuzev tijekom rujna kada je zabilježeno svega 22,2 mm oborina.



Grafikon 1. Meteorološki uvjeti tijekom ljetno-jesenskog roka uzgoja brokule, Zagreb, 2009.

Analizom varijance utvrđen je opravdani utjecaj istraživanih faktora i njihove interakcije na promatrane parametre, masu, prinos i sadržaj nitrata tržnog vršnog cvata brokule, a u tablici 1. prikazani su rezultati testiranja razlika između srednjih vrijednosti. Najveću masu tržnog vršnog cvata ostvarila je sorta 'Parthenon' (509 g), značajno veću nego sorte 'Marathon' i 'Ironman' (444 i 436 g). Navedene vrijednosti su veće 15 do 20% u odnosu na rezultate Katušić (2009) iz ljetno-jesenskog roka uzgoja 2007. godine kada su navedene sorte ostvarile manju masu (429, 350 i 371 g). Sirić (2010) u ljetno-jesenskom roku uzgoja tijekom 2008. godine navodi nešto veću masu cvata testiranih sorata 'Parthenon' (448 g), 'Marathon' (372 g) i 'Ironman' (351 g), koja je ipak bila za 12 do 20% manja u odnosu na ostvarene u ovom istraživanju. Toth i sur. (2007) u ljetno-jesenskom roku uzgoja kod sorte 'Marathon' zabilježili su značajno manju masu vršnog cvata (282 g). Obzirom na razinu gnojidbe dušikom, relativno najveća masa tržnog vršnog cvata (469 i 514 g) ostvarena je pri najvećim dozama gnojidbe (120 i 240 kg N·ha<sup>-1</sup>), ali bez statističke razlike u odnosu na masu cvata (455 i 416 g) ostvarenu pri gnojidbi sa 60 i 0 kg N·ha<sup>-1</sup>. Iako su kombinacije sorte 'Parthenon' sa 120 i 240 kg N·ha<sup>-1</sup> ostvarile relativno najveću masu cvata (513 i 602 g), pripadale su istom rangu kao i sedam kombinacija s rasponom mase od 444 do 485 g. Statistički najmanju masu (389 i 379 g) ostvarile su kombinacije sorte 'Ironman' i 'Marathon' s 0 kg N·ha<sup>-1</sup>. Sorta 'Parthenon' ostvarila je najveći prinos tržnog vršnog cvata (16,8 t·ha<sup>-1</sup>), značajno veći nego sorte 'Marathon' i 'Ironman' (14,7 i 14,4 t·ha<sup>-1</sup>). Slične rezultate navode Katušić (2009) i Sirić (2010) za ljetno-jesenski rok uzgoja 2007. i 2008. godine kada su sorte 'Parthenon', 'Marathon' i 'Ironman' ostvarile prinos od 12,5, 10,6 i 9,8 t·ha<sup>-1</sup>, odnosno, 14,8, 12,3 i 11,6 t·ha<sup>-1</sup>. Obzirom da je najveći prinos tržnog vršnog cvata (17,0 i 15,5 t·ha<sup>-1</sup>) postignut pri gnojidbi s najvećim istraživanim dozama dušika, dobiveni rezultati su sukladni navodima autora (Sorensen, 1999; Coulombe i sur., 1999; Goodless i sur., 1997; Feller i Fink, 2005) o pozitivnom utjecaju gnojidbe dušikom na prinos brokule. Kombinacije sorte 'Parthenon' i gnojidbe sa 120 i 240 kg N·ha<sup>-1</sup> realizirale su najveći, statistički jednak prinos vršnog cvata (16,9 i 19,8 t·ha<sup>-1</sup>). Dok kombinacija 'Parthenon' × 240 kg N·ha<sup>-1</sup> ima opravdano veći prinos od ostalih istraživanih kombinacija, 'Parthenon' × 120 kg N·ha<sup>-1</sup> pripada istom rangu kao i sedam kombinacija s rasponom vrijednosti prinosa od 14,6 do 16,9 t·ha<sup>-1</sup>. Značajne razlike između sorti u akumulaciji nitrata ukazuju da je to svojstvo sortna odlika. Najveći sadržaj nitrata (638,3 mg·kg<sup>-1</sup> svježe tvari) ustanovljen je kod sorte 'Parthenon', opravdano veći nego kod sorti 'Ironman' i 'Marathon' (591,9 i 467,0 mg·kg<sup>-1</sup> svježe tvari).



Tablica 1. Utjecaj sorte i gnojidbe dušikom na masu, prinos i sadržaj nitrata tržnog vršnog cvata brokule, Zagreb, ljeto-jesen 2009.

Tretman	Tržni vršni cvat		
	Masa (g)	Prinos (t·ha <sup>-1</sup> )	Sadržaj nitrata (mg NO <sub>3</sub> ·kg <sup>-1</sup> svježe tvari)
Parthenon	509 a*	16,8 a	638,3 A**
Marathon	444 b	14,7 b	467,0 C
Ironman	436 b	14,4 b	591,9 B
Gnojidba dušikom (kg·ha <sup>-1</sup> )			
0	416 b	13,7 b	527,6 C
60	455 b	15,0 b	563,5 B
120	469 ab	15,5 ab	565,2 B
240	514 ab	17,0 a	606,7 A
Sorta × Gnojidba dušikom			
Parthenon × 0	479 bc	15,8 bc	522,5 G
Parthenon × 60	444 bcd	14,6 bcd	570,0 E
Parthenon × 120	513 ab	16,9 ab	438,0 I
Parthenon × 240	602 ab	19,8 a	1022,5 A
Marathon × 0	379 d	12,5 d	650,3 C
Marathon × 60	465 bcd	15,3 bcd	530,3 F
Marathon × 120	479 bc	15,8 bc	350,0 K
Marathon × 240	455 bcd	15,0 bcd	337,5 L
Ironman × 0	389 cd	12,8 cd	410,0 J
Ironman × 60	457 bcd	15,1 bcd	590,3 D
Ironman × 120	414 cd	13,7 cd	907,5 B
Ironman × 240	485 bc	16,0 bc	460,0 H

Različita slova u stupcima pokazuju značajne razlike temeljem LSD testa na razini signifikantnosti P≤0,05\* i P≤0,01\*\* za istraživane faktore i interakcije

Opravdano najveći sadržaj nitrata zabilježen je pri gnojidbi s najvećom dozom dušika, dok je značajno manji, a statistički jednak, kod varijanata s dozama gnojiva 120 i 60 kg N·ha<sup>-1</sup>, a najmanji pri varijanti bez gnojidbe. Najvećim sadržajem nitrata (1022,5 i 907,5 mg·kg<sup>-1</sup> svježe tvari) ističu se dvije kombinacije 'Parthenon' × 240 kg N·ha<sup>-1</sup> i 'Ironman' × 120 kg N·ha<sup>-1</sup>, a koji je sukladan mogućim vrijednostima za brokulu koje navodi EFSA (2008). Ostale kombinacije imale su sadržaj nitrata u izuzetno povoljnom rasponu od 337,5 do 650,3 mg·kg<sup>-1</sup> svježe tvari.

## Zaključci

Ustanovljen je značajan utjecaj genetskog čimbenika i gnojidbe dušikom na promatrane komponente prinosa vršnog cvata brokule. Kombinacije 'Marathon' × 240 i 120 kg N·ha<sup>-1</sup>, 'Parthenon' × 120 kg N·ha<sup>-1</sup> i 'Ironman' × 240 kg N·ha<sup>-1</sup> ističu se kvantitativnim i kvalitativnim svojstvima obzirom na velik, statistički jednak prinos u rasponu od 15 do 16,9 t·ha<sup>-1</sup> i izuzetno povoljan sadržaj nitrata, manji od 500 mg·kg<sup>-1</sup> svježe mase.

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# Collecting, characterisation and conservation of autochthonous germplasm of *Diplotaxis* sp. in Slovenia

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## Abstract

Paper aims at presenting the situation of the *Diplotaxis* sp. collection in the Slovene Gene Bank of Agricultural Plants i.e. its establishment, description of accessions and their multiplication.

At present the collection consist of 19 autochthonous accessions from different parts of Slovenia. The main morphological traits of all the accessions were described. The observations revealed that plants with different characteristics are present in the majority of accessions and that some accessions are composed of different species. The success of multiplication in isolation cages was poor, probably due to high self-incompatibility and absence of pollinators.

To complete the collection of wild growing *Diplotaxis* germplasm some regions of the country remain to be examined. First observations indicate that there is quite some variability within the collected germplasm and that it is worth of further evaluation and potential breeding. The maintenance of the collection will require more attention.

Key words: wild rocket, genetic resources, evaluation, multiplication, preservation

## Introduction

The collective name 'rocket' indicates different species of the *Brassicaceae* family belonging to *Eruca* and *Diplotaxis* genera (IPGRI, 1999). Growing wild only some species from the genus *Diplotaxis* can be found in Slovenia while species from genus *Eruca* are not occurring (Martinčič et al., 2007). Genus *Diplotaxis* includes about 30 species (Martinez-Laborde, 1997) among which *Diplotaxis tenuifolia*, *Diplotaxis muralis* and *Diplotaxis viminea* are native also to Slovenia (Martinčič et al., 2007). According to Martinez-Laborde (1997) this three species belong to the same, so-called *D. tenuifolia*, group which is characterized by seedless beak, mostly brochidodromous petals and some additional phytochemical characters. In Slovenia *D. muralis* and *D. tenuifolia* are spread throughout the country while *D. viminea* is limited to the submediterranean region. All three species appear on more or less the same habitats i.e. roadsides, waste places, along the walls, in the fields,... (Martinčič et al., 2007).

The collections of *Diplotaxis* germplasm can be found at different institutions but a complete picture is difficult to draw. The status of rocket genetic resources collections was reviewed in the frame of Rocket Genetic Resources Network which was established in the middle of 90<sup>th</sup> within the IPGRI project Underutilized Mediterranean Species. At that time the only good collection of *Diplotaxis* species was maintained at the Universidad Politecnica of Madrid, Spain. Some other genebanks possessed just a few samples. Stimulated by the Network activities some of the participating institutions intensified their efforts to better collect and safeguard *Diplotaxis* genetic resources (Pignone, 1997). At the present the collections of *Diplotaxis* genetic resources are part of The International Minor Leafy Vegetables Database which covers all known European collections as well as main collections from outside Europe (ECPGR, 2010). All together 380 accessions of different *Diplotaxis* species from five countries are listed in the Database. The most extensive is still the Spanish collection that contributes more than 80% of the accessions, while 18 accessions are part of the Slovene collection. Different species of genus *Diplotaxis* are included in collections; the most frequent is *D. tenuifolia*.

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The collection of *Diplotaxis* in Slovene Gene Bank of Agricultural Plants at the Agricultural Institute of Slovenia was set up with the aim to preserve and assess the diversity of biological and agronomical characteristics of wild rocket germplasm in Slovenia and estimate its potential for commercial breeding.

In this paper we present the collecting of rocket resources in Slovenia, the first characterization of collected accessions and the attempt of their multiplication.

### Material and methods

Collecting was conducted occasionally from the year 2005 on. Sampling sites were selected randomly on the basis of our observations during traveling and fieldwork. Larger groups of plants were usually observed by the roadsides, field/vineyard path and railway track. At the time of ripening the seeds were stripped off the dry siliqua of several plants. Collected seed was later air dried, cleaned and stored at 4 °C in the seed bank of Gene Bank of Agricultural Plants at the Agricultural Institute of Slovenia.

Characterization of collected accessions was carried out in the years 2008 and 2010. Shortened UPOV (2008) guidelines for wild rocket (TG/244/1) were used to describe the main morphological (leaf attitude, leaf color and its intensity, leaf length and leaf division) and phenological (time of flowering) characteristics. The taste was additionally evaluated in 2010. In 2008 plants were grown in polystyrene trays filled with peat substrate on floating system in greenhouse (sowing on 27<sup>th</sup> March and characterization at the end of May). In 2010 plants were grown in the soil in a plastic house (sowing 12<sup>th</sup> March and characterization at the end of April and beginning of May).

Multiplication was attempted in the years 2009 and 2010. In 2009 seeds of each accession were sown to the open field on 22<sup>nd</sup> of April. Unfortunately only few plants per accession grew up to flowering stage due to low germination and attack of flea beetles after the emergency. In 2010 the plants used for characterization were left to seed. Before the beginning of flowering the plants were covered with isolation cages holding about 100 plants each. Approximately once a week the plants were shaken with a stick to enhance the fertilization. At the time of ripening seeds were collected regularly.

### Results and discussion

Collecting of *Diplotaxis* germplasm around Slovenia in the past 6 years resulted in altogether 19 accessions stored in the seed bank. At present almost half of the accessions is from Primorska region. Although some regions still remain to be examined it can be stated, that in Slovenia *Diplotaxis* is rarely found at altitudes higher than 500 m asl. Only one of those accessions of *D. muralis*, *D. tenuifolia* and *D. viminea* from The International Minor Leafy Vegetables Database for which the information about the attitude of collecting site is given, was found higher than 500 m asl - the sample of *D. tenuifolia* stored in Germany and originating from Bulgaria. Seed for our collection was mostly collected in October and November when the highest abundance of ripe seed was at disposal. The amount of collected seed varied between the accessions and ranged from 0.4 to 53.0 g. Passport data and amount of seeds collected per accession are presented in Table 1. The germination of collected seed was low what caused problems at first attempts of characterization and multiplication. Also other authors report on low germination of seeds collected from wild growing populations of *Eruca* and *Diplotaxis*. They attribute it to harvesting of not yet fully mature seeds which is obliged by dehiscent siliques of these species (Pignone, 1997), environmental factors during seed formation and maturation enhancing seed dormancy and deteriorating its viability (Pita-Villamil et al., 2002) and secondary dormancy (Martinez-Laborde et al., 2007).

Characterization revealed that we managed to collect all three species of *Diplotaxis* growing wild in Slovenia i.e. *D. tenuifolia*, *D. muralis* and *D. viminea*. Some accessions are composed of different species. Different types of plants are present in almost all the accessions what made the characterization more challenging. Most of the plants had semi-erect leaf attitude and medium long leaves. Only one accession exhibited horizontal leaf attitude. Leaf color was generally medium green. At some accessions some plants showed reddish nervature coloring. Most of the accessions were medium to late flowering. Interestingly, accessions differed also in the leaf taste - from pleasant slightly pungent and bitter to unpleasant herbaceous or very pungent taste. The main characteristics of each accession are shown in Table 2.

Multiplication of *Diplotaxis* was associated with quite some problems. Firstly, the allogamous nature of the genus requires the multiplication in complete isolation (Pignone, 1997). Secondly the fertilization of plants in

isolation was very poor and consequently the seed production was very low. Some variation in the success of fertilization was observed between the accessions. The reason for low fertilization was probably high level of self-incompatibility even though some other authors reported encouraging results on rocket multiplication in isolation even at lower number of plants (Pignone, 1997). On the other side Bhandari and Chandel (1997) stated that maintenance of rocket germplasm is rather difficult because of the self-incompatibility and that the multiplication of cross-pollinated species in general is difficult and expensive. Beside that frequent regeneration has to be avoided because of the risk of the genetic drift and the strengthening of the self-incompatibility. Beside the self-incompatibility the reason for low fertilization could also be the absence of insects in isolation. Thirdly, at the time of seed maturity regular inspection and seed collection is essential to minimize the loss of seed what implies a lot of labour. Similar was exposed also by Pignone (1997), while on the other side the protocol for *Eruca* multiplication in Leafy Veg project (Anonymus, 2009) suggests cutting of all plants at harvest maturity and putting them into bags.

**Table 1. Passport data and amount of collected seed of *Diplotaxis* accessions stored in Gene Bank of Agricultural Plants at the Agricultural Institute of Slovenia**

Accession number	Year of collecting	Collecting location			Amount of seed (g)	
		habitat	longitude	latitude		
Dx-1	2005	vineyard	4590--N	01364--E	80	3.3
Dx-2	2005	vineyard	4587--N	01384--E	100	2.3
Dx-3	2005	vineyard	4585--N	01348--E	170	1.8
Dx-4	2006	roadsides	4608--N	01450--E	300	28.7
Dx-5	2006	field path	4559--N	01373--E	10	3.5
Dx-6	2006	field path	4559--N	01373--E	10	5.8
Dx-7	2006	roadsides	4557--N	01376--E	60	1.7
Dx-8	2007	roadsides	4587--N	01390--E	100	17.9
Dx-9	2007	roadsides	4589--N	01394--E	280	6.8
Dx-10	2007	roadsides	4637--N	01413--E	500	24.4
Dx-11	2007	roadsides	4596--N	01428--E	350	0.4
Dx-12	2007	roadsides	4596--N	01428--E	350	19.7
Dx-13	2007	railway track	4639--N	01566--E	250	13.5
Dx-14	2007	roadsides	4596--N	01428--E	350	53.0
Dx-15	2007	roadsides	4639--N	01566--E	250	37.6
Dx-16	2007	railway track	4653--N	01589--E	220	20.1
Dx-17	2007	railway track	4641--N	01591--E	220	16.0
Dx-18	2007	railway track	4645--N	01567--E	260	0.8
Dx-19	2008	roadsides	4577--N	01401--E	280	10.1

**Table 2. Main characteristics of *Diplotaxis* accessions stored in Gene Bank of Agricultural Plants at the Agricultural Institute of Slovenia**

Accession number	Leaf attitude	Leaf length	Time of flowering	Taste
Dx-1	erect	medium	early (10%), medium (90%)	pleasant
Dx-2	semi erect	short	early	herbaceous
Dx-3	semi erect	short to medium	early to very early	herbaceous, pungent
Dx-4	semi erect	short	medium	very pungent
Dx-5	erect to semi erect	medium	medium	herbaceous
Dx-6	erect to semi erect	short to medium	early to medium	pleasant
Dx-7	semi erect	short to medium	early	herbaceous
Dx-8	semi erect	short to medium	late	pungent
Dx-9	semi erect	short to medium	late	pungent
Dx-10	semi erect	short to medium	late	pungent
Dx-11	horizontal	medium to long	late	pungent
Dx-12	erect to semi erect	short to medium	late	very pungent
Dx-13	semi erect	short to medium	late	pungent
Dx-14	semi erect	short to medium	late	pungent
Dx-15	semi erect to horizontal	short to medium	late	herbaceous
Dx-16	semi erect	short to medium	late	herbaceous to pleasant
Dx-17	semi erect	short to medium	late	herbaceous
Dx-18	erect	short to medium	late	herbaceous
Dx-19	semi erect	short to medium	medium	pungent

## Conclusions

To complete the collection of wild growing *Diplotaxis* germplasm some regions of the country still remain to be examined.

First observations indicate that there is quite some variability within the collected germplasm and that it is worth of further evaluation, selection and potential breeding.

To ensure adequate amounts of seed and to avoid the risk of the genetic drift and the strengthening of the self-incompatibility the maintenance of the collection will require more attention and the multiplication of *Diplotaxis* in isolation will need to be studied dipper.

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# Utjecaj omjera iona $\text{NO}_3^-:\text{NH}_4^+$ na vegetativna svojstva i prinos rajčice te populaciju *Bemisia tabaci*

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## Sažetak

Cilj rada bio je utvrditi utjecaj različitih omjera  $\text{NO}_3^-$  i  $\text{NH}_4^+$  iona (92:8, 75:25 i 55:45) na vegetativna i generativna svojstva rajčice te populaciju duhanovog štitastog moljca. Omjeri  $\text{NO}_3^-:\text{NH}_4^+$  iona nisu utjecali na visinu i promjer stabljike te broj listova rajčice. Biljke tretirane s omjerom 55:45 razvile su više plodova, ali manje prosječne mase. Iste biljke ostvarile su dva puta veći rani prinos u usporedbi s omjerom 92:8, dok se ukupni prinos nije razlikovao. Značajne razlike u pojavi vršne truleži zabilježene su u tretmanima s višim koncentracijama  $\text{NH}_4^+$  iona (75:25 i 55:45). Koncentracije  $\text{NH}_4^+$  iona veće od 8%, smanjile su populaciju duhanovog štitastog moljca.

Ključne riječi: duhanov štitasti moljac, hidroponski uzgoj, kamena vuna, *Lycopersicon esculentum* Mill., vršna trulež

## Influence of $\text{NO}_3^-:\text{NH}_4^+$ ions ratio on tomato vegetative traits, yield, and *Bemisia tabaci* population

### Abstract

The objective of this study was to determine the influence of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  ions ratios (92:8, 75:25 i 55:45) on tomato vegetative growth and yield and population of tobacco whitefly.

Applied  $\text{NO}_3^-:\text{NH}_4^+$  ratios did not affect tomato plant height, stem diameter and leaves number. Plants fertigated with ions ratio 55:45 developed more fruits, but with less average mass. Same plants had early yield two-fold higher than 92:8, however total yield did not show significant differences. Plants treated with increasing concentrations of  $\text{NH}_4^+$  ions had significantly more fruits affected with blossom end root (BER) and lower population density of tobacco whitefly.

Key words: BER, hydroponic, *Lycopersicon esculentum* Mill., rockwool, tobacco whitefly

### Uvod

Nitratni oblik ( $\text{NO}_3^-$ ) prevladava kao glavni izvor dušika (N) za rast biljaka dok amonijski oblik ( $\text{NH}_4^+$ ) može biti štetan za rast mnogih vrsta ako se koristi kao jedini izvor N. Najveće vrijednosti rasta postižu se kod korištenja oba oblika N, a optimalni omjeri ovise o ukupnoj količini N (Marschner, 1995). Dušik je poželjan u obliku  $\text{NH}_4^+$  iona posebno kod sprečavanja ispiranja N, kao i nakupljanja štetnih količina  $\text{NO}_3^-$  u jestivim dijelovima biljke. Utjecaj ishrane  $\text{NH}_4^+$  ionom u nekim uvjetima (visoka temperatura) može izazvati slabiji generativni i vegetativni rast, a zbog toga je korištenje većih količina amonijskih gnojiva ili omjera N iona

povezano s pojavom i intezitetom vršne truleži. Utjecaj ovih faktora na pojavu vršne truleži indirektno se veže uz opskrbu plodova  $\text{Ca}^{2+}$  iako se to ne može uzeti kao primaran i neovisan faktor (Saure, 2001). U standardnoj hranivoj otopini za hidroponski uzgoj rajčice omjer  $\text{NO}_3^-$  i  $\text{NH}_4^+$  iona je oko 92:8. Siddiqi i sur. (2002) utvrdili su da postotak  $\text{NH}_4^+$  iona do 50% ukupnog N nema negativan utjecaj na rani vegetativni rast rajčice, ali da dugotrajnije korištenje rezultira visokim postotkom pojavljivanja vršne truleži. Duhanov štitasti moljac (*Bemisia tabaci*) jedan je od najznačajnijih štetnika u svijetu, posebno pri uzgoju u zaštićenim prostorima. Ovaj kozmopolitski i polifagni štetnik nađen je na preko 500 biljnih vrsta gdje se hrani floemskim sokom te izlučuje mednu rosu koja uzrokuje stvaranje čađavice i gubljenje kvalitete proizvoda. Pojava *B. tabaci* prvi je put zabilježena u Hrvatskoj 2000. godine (Žanić, 2001). Količina dušika u biljkama, kao posljedica dušične gnojidbe jedan je od faktora koji utječe na pojavu štitastih moljaca na kultiviranom bilju. Jauset i sur. (1998) utvrdili su da biljke rajčice opskrbljene s većim dozama dušika imaju veći broj odraslih jedinki i jaja cvjetnog štitastog moljca *Trialeurodes vaporariorum*.

Cilj ovog rada bio je utvrditi utjecaj tri omjera N iona na parametre vegetativnog i generativnog rasta rajčice kao i na gustoću populacije i raspored odraslih jedinki *B. tabaci*.

### Materijali i metode

Pokus je postavljen od ožujka do srpnja u stakleniku Instituta za jadranske kulture u Splitu (43°30'17.17" N, 16°29'49.71" E) po slučajnom bloknom rasporedu u 3 ponavljanja.

Sjeme rajčice [*Lycopersicon esculentum* (Miller)] cv. Belle posijano je 17. ožujka u organski supstrat (Brill Type 4, Njemačka) Nakon nicanja, biljčice su pikirane u kocke kamene vune dimenzija 7,5 x 7,5 x 6, cm (KRAN-IZOL s.r.o., Češka Republika). Presadnice s razvijenih pet listova su 29. travnja presađene na ploče kamene vune (7.5 x 20 x 100 cm), u dvoredne trake na razmak 50 cm u redu, 40 cm između redova i 140 cm između traka. Rajčice su prihranjivane standardnom hranivom otopinom za uzgoj u kamenoj vuni (Sonneveld i Kreij, 1999) s ukupnom količinom dušika od 205 mg L<sup>-1</sup> N i omjerom  $\text{NO}_3^-$ :  $\text{NH}_4^+$  iona 92:8%. Sedam dana nakon sadnje, 6. svibnja, primijenjena su još 2 tretmana s različitim omjerima  $\text{NO}_3^-$ : $\text{NH}_4^+$  iona (75:25 i 55:45), dok se ukupna količina dušika nije mijenjala.

Ispuštanje *B. tabaci* obavljeno je 13 dana od početka tretiranja kada su utvrđene razlike indeksa koncentracije klorofila u listu izmjerene N-tester klorofil metrom (Hydro) na fiziološki najmlađem potpuno razvijenom listu (4. list od vrha biljke). Populacija *B. tabaci* uzgojena je na biljkama mente, te su tri zaražene biljke postavljene po svakoj repeticiji tijekom dva dana. Gustoća populacije štetnika utvrđena je na četiri biljke unutar svakog ponavljanja te su sve biljke podijeljene na tri etaže s ukupno 15 listova, tj. svaka etaža (gornja, srednja i donja) je imala 5 listova. Osmog dana nakon zaraze (DNZ), metodom okrenutog lista, na 16 biljaka po tretmanu izbrojane su odrasle jedinke na 15 označenih listova, počevši od najmlađeg lista. Plodovi su ubirani dinamikom kako su sazrijevali (blaga crvena boja). Obavljeno je sedam berbi, od 25. lipnja do kraja pokusa. Utvrđeni su masa i broj plodova, rani i ukupni prinos, kao i broj plodova oštećenih vršnom truleži. Dobiveni podaci utjecaja omjera nitratnih i amonijskih iona na vegetativne i generativne parametre te gustoću populacije duhanovog štitastog moljca obrađeni su analizom varijance (ANOVA) pomoću statističkog programa StatView (SAS Institute, USA). Nakon signifikantnog F-testa, srednje vrijednosti su uspoređene LSD testom na razini signifikantnosti  $P \leq 0.05$ .

### Rezultati i rasprava

Tijekom 35 dana od početka tretiranja nisu uočene razlike u promjeru i visini stabljike, broju listova i dužini internodija (tablica 1). Dobiveni rezultati su sukladni s rezultatima Siddiqi i sur. (2004) i Heeb i sur. (2005) koji također nisu zabilježili signifikantne razlike u rastu i biomasi izdanka rajčice u odnosu na primjenu gnojiva s različitim omjerima  $\text{NO}_3^-$  i  $\text{NH}_4^+$  iona.

Broj plodova po biljci ubranih u prve četiri berbe (rani prinos) nije se značajno razlikovao (tablica 2), premda je kod biljaka tretiranih s omjerom N iona 55:45 ubrano 4,3 puta više plodova nego na kontrolnim biljkama. Prosječna masa ploda u ranom prinosu značajno se razlikovala među tretmanima i bila u rasponu od 95,3 do 197,5 g (tablica 2). Povišene koncentracije  $\text{NH}_4^+$  iona utjecale su na smanjenje mase ploda i povećanje pojave vršne truleži te su kod omjera 55:45 svi su plodovi bili oštećeni (tablica 2). Rani prinos se nije značajno razlikovao među tretmanima iako je bio dva puta veći kod omjera 55:45 u usporedbi s kontrolom. Broj plodova po biljci ubranih tijekom plodonošenja nije se razlikovao, dok su značajne razlike zabilježene u



## Utjecaj omjera iona NO<sub>3</sub><sup>-</sup>:NH<sub>4</sub><sup>+</sup> na vegetativna svojstva i prinos rajčice te populaciju Bemisia tabaci

prosječnoj masi ploda između tretiranja 55:45 i ostala dva tretiranja (tablica 2). Postotak vršne truleži među svim tretmanima značajno se razlikovao, te je kao i kod ranog prinosa rastao s povišenjem koncentracije NH<sub>4</sub><sup>+</sup> iona (tablica 2). Heeb i sur. (2005), također navode kako povećanje koncentracije NH<sub>4</sub><sup>+</sup> iona utječe na veću pojavu vršne truleži. Dobiveni rezultati upućuju na zaključak, kako se veći broj plodova, ali manje prosječne mase uslijed povećanja NH<sub>4</sub><sup>+</sup> iona može pripisati ubrzanju zriobi zbog oštećenja plodova vršnom truleži.

**Tablica 1. Vegetativni parametri biljaka rajčice uzgajanih uz primjenu 3 omjera dušičnih iona NO<sub>3</sub><sup>-</sup>: NH<sub>4</sub><sup>+</sup> (92:8, 75:25 i 55:45) nakon 36 dana tretmana**

Tretman	Vegetativni parametri			
	Promjer stabljike (mm)	Broj listova	Visina stabljike (cm)	Dužina internodija (cm)
92:8	13,2	25,3	172,6	6,8
75:25	12,2	25,0	178,8	7,1
55:45	12,8	24,9	180,6	7,1
Signifikantnost	ns	ns	ns	ns

**Tablica 2. Utjecaj omjera dušičnih iona NO<sub>3</sub><sup>-</sup>: NH<sub>4</sub><sup>+</sup> na broj plodova, masu ploda, prinos i postotak plodova oštećenih vršnom truleži u ranom i ukupnom prinosu rajčice.**

NO <sub>3</sub> <sup>-</sup> : NH <sub>4</sub> <sup>+</sup>	Komponente prinosa							
	Rani prinos				Ukupni prinos			
	Broj plodova po biljci	Masa ploda (g)	Prinos (g/biljci)	Vršna trulež (%)	Broj plodova po biljci	Masa ploda (g)	Prinos (g/biljci)	Vršna trulež (%)
92:8	0,29	197,5 A	54,3	0 A	8,38	166,3 a	1380	6,1 C
75:25	0,67	120,2 B	75,6	65 B	9,17	152,0 a	1340	29,9 B
55:45	1,25	95,3 B	112,3	100 C	10,25	128,7 b	1310	53,8 A
Signifikantnost	ns	** 1	ns	**	ns	*	ns	**

1 \* P < 0,05; \*\* P < 0,01; ns - nije signifikantno

Utjecaj tri omjera N iona i etaže biljke na distribuciju odraslih jedinki *B. tabaci* prikazan je u tablici 3. Osam dana nakon zaraze signifikantno veći broj jedinki zapažen je na biljkama pri omjeru 92:8, nego pri omjeru 55:45. U istom razdoblju najviše kukaca naselilo je listove srednje etaže, dok su mladi, mekani i dlakavi listovi gornjeg sloja bili manje atraktivni. Isti je slučaj i s listovima donje etaže što se može pripisati nižim temperaturama tijekom istraživanja, a što se slaže s radom Jauseta i sur. (1998).

**Tablica 3. Broj odraslih jedinki *B. tabaci* po listu 8 dana nakon zaraze pri tri NO<sub>3</sub><sup>-</sup>:NH<sub>4</sub><sup>+</sup> (92:8, 75:25 and 55:45) omjera i u ovisnosti o etaži biljke (gornja, srednja i donja)**

Tretmani	Odrasle jedinke (kom/listu)
NO <sub>3</sub> <sup>-</sup> : NH <sub>4</sub> <sup>+</sup>	
92:8	7.69 a <sup>1</sup>
75:25	6.65 ab
55:45	6.22 b
Etaža biljke	
Gornja	4.55 b
Srednja	12.53 a
Donja	3.48 b
Signifikantnost	
NO <sub>3</sub> <sup>-</sup> : NH <sub>4</sub> <sup>+</sup> (N)	***
Etaža	***
N x etaža	ns

1 a, b P < 0,05; \*\* P < 0,01; \*\*\* P < 0,001 i ns - nije signifikantno

## Zaključci

Primijenjeni omjeri dušičnih iona NO<sub>3</sub><sup>-</sup>:NH<sub>4</sub><sup>+</sup> u hranivoj otopini u hidroponskom uzgoju rajčice nisu utjecali na vegetativni rast rajčice. Povišenje koncentracije NH<sub>4</sub><sup>+</sup> iona je signifikantno djelovalo na smanjenje prosječne mase plodova i povećanu pojavu vršne truleži ploda te je opravdano smanjilo gustoću populacije *B.*

*tabaci*. Činjenica, da 25%  $\text{NH}_4^+$  iona izaziva manju pojavu vršne truleži, a 45% smanjenje broja štetnika, može biti iskorištena u daljnjem radu.

### Zahvala

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# The effect of weather conditions on barley yield in Serbia during 2000-2007

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## Abstract

This study evaluates grain yield variations in barley in Serbia over 2000-2007 as affected by precipitation and temperature regimes. The average yield was lowest in 2003 (1.7 t ha<sup>-1</sup> Central Serbia, 1.8 t ha<sup>-1</sup> Vojvodina) and highest in 2004 (3.2 t ha<sup>-1</sup> and 4.3 t ha<sup>-1</sup>, respectively). In 2003 (October-June), total precipitation was 323 mm (26% below the long-term average-LTA), and mean daily air temperature was 0.4°C above LTA. The highest average barley yield was 3.7 t ha<sup>-1</sup> in 2004 (Central Serbia 3.2 t ha<sup>-1</sup>, Vojvodina 4.3 t ha<sup>-1</sup>), when precipitation totalled 544.5 mm (October-June), being 110 mm above LTA, and the average air temperature rose 0.1°C above LTA.

Key words: barley, grain yield, precipitation, air temperature

## Introduction

After maize and wheat, barley is the most commonly cultivated field crop in Serbia. According to data from the National Bureau of Statistics for the 2000-2007 period, barley was cultivated on 110,124 ha of land, yielding 2.8 t ha<sup>-1</sup> (Central Serbia: 54,840 ha, yield of 2.4 t ha<sup>-1</sup> and Vojvodina: 55,284 ha, yield of 3.2 t ha<sup>-1</sup>). Molnar et al. (2001) and Paunović et al. (2007, 2008) report that weather conditions induce substantial variations in both yield and technological quality of barley grain. The objective of this study was to evaluate barley yield variations over 2000-2007 in terms of precipitation and temperature regimes. Analogous studies on wheat were conducted by Knežević et al. (2007) and Paunović et al. (2010), and those on maize by Jelić et al. (2009) and Kovačević et al. (2010).

## Material and methods

Data provided by the Serbian Bureau of Statistics (Statistical Yearbooks: 2001-2008) and the National Weather Service were used in the study. Observations with respect to specific weather conditions (grain yield, amount of precipitation and mean air temperatures during October-June) were recorded for analysis of yield variations in barley over years (2000-2007). Barley yields and harvested area are given for Central Serbia and Vojvodina, and weather data are provided for Kragujevac and Novi Sad. The analysis covered 87.7% of Serbian territory.

The Republic of Serbia occupies an area of 88,361 km<sup>2</sup>. The total agricultural land in 2007 was 5,053,000 ha (65.3% arable land, 28.8% meadows and pastures, 5.9% vineyards and orchards).

Central Serbia occupies an area of 55,968 km<sup>2</sup> or 63.3% of the state territory. It comprises 17 administrative districts. The relief of Central Serbia is mostly mountainous, marked by different soil types and temperate continental climate in lowland and upland regions and mountain climate in the highlands (Kopaonik, Zlatibor, Zlatar, Rudnik, Stara Planina). The middle part of Central Serbia is covered by the Šumadija region (spreading between the Sava and Danube rivers in the north, the Velika Morava in the east, the Zapadna Morava in the south, and the Kolubara and Dičina in the west).

Vojvodina occupies an area of 21,506 km<sup>2</sup> or 24.3% of the state territory. It comprises 7 administrative districts. The relief of Vojvodina is mostly lowland, except in Srem and southeastern Banat dominated by

Mts. Fruška Gora and Vršачki Breg, respectively. Soils of above-average fertility are found in Vojvodina, with calcereous chernozem being the predominating soil type. Vojvodina has a temperate continental climate, characterised by mid-European i.e. Danube precipitation regimes and very high non-uniformity in precipitation distribution across months.

### Results and discussion

Depending on the year, barley area in the Republic of Serbia ranged from 93,520 ha to 130,755 ha, with annual yields averaging between 1.8 t ha<sup>-1</sup> and 3.7 t ha<sup>-1</sup>. The harvested area of barley in Serbia is rather uniformly distributed across Vojvodina and Central Serbia, with the yields in Vojvodina being 12.5% higher on average than those in Central Serbia (Tab. 1). The average barley area in Central Serbia and Vojvodina was 54,840 ha and 55,284 ha respectively. The yields ranged from 1.7 t ha<sup>-1</sup> to 3.2 t ha<sup>-1</sup> in Central Serbia and from 1.8 t ha<sup>-1</sup> to 4.3 t ha<sup>-1</sup> in Vojvodina.

The lowest average yield of barley in Serbia during the period of analysis was obtained in 2003: 1.8 t ha<sup>-1</sup> or 35.7% below the 8-year average (2000-2007). The highest average yields were reported for 2004: Central Serbia 3.2 t ha<sup>-1</sup> and Vojvodina 4.3 t ha<sup>-1</sup>.

The unfavourable effect of weather conditions on barley yield during the 2002/2003 growing season (Tab. 3: average values for two locations) showed specificity in terms of substantial deviation of total precipitation and mean air temperature from the 30-year average value (1961-1990: Tab. 2).

The total amount of precipitation (October-June) was 323 mm or 20.2% below the average value, whereas the measured air temperature was 8.8°C or 0.8°C above the average. February was an extremely cold month, the mean air temperature being -3.4°C or 5.7°C below the average value. During March-May, the rainfall amount was 61 mm or 38% of the average value, and the average air temperature was 12.3°C or 1.1°C above the average. In June, the amount of precipitation was insufficient (39 mm: long-term average 74.5 mm) and mean air temperature was extremely high (23.7°C or 4.4°C above the average value).

Over 2000-2007, during barley growing season (October-June), Novi Sad received an average of 481 mm of precipitation and had an average air temperature of 9.1°C. At the same time, the precipitation in Kragujevac was lower by 61 mm, and air temperature was 0.2°C higher than in Novi Sad. As compared to the long-term average (1961-1990: Tab. 2), mean air temperatures during 2000-2007 were 0.8°C higher on average (average values for Novi Sad and Kragujevac: Tab. 3).

Paunović (2008) analysed the effect of weather conditions on yield components and grain yield of five cultivars of two-row spring barley under the environmental conditions of Šumadija over a period of three years. Under deficient soil and air moisture, at high temperatures during barley spike emergence, grain yield was found to decrease by 18-35%, depending on cultivar tolerance to both water and air temperature stress. The higher amount of precipitation, particularly in May and June (161 mm) caused a substantial increase in plant height associated with active uptake of soil nitrogen. The nitrogen had an indirect effect on stem elongation and lodging. Plant lodging led to protein accumulation in the grain of two-row barley (an average of 13.15% for all the cultivars), with the lowest 1000-kernel weight (38.8 g) and lowest content of first-class grain (85.01%) being recorded.

Table 1. Harvested acreage and grain yields of barley

Year	Harvested acreage (ha) and grain yields (t ha <sup>-1</sup> ) of barley					
	Serbia (total)		Central Serbia		Vojvodina	
	ha	t ha <sup>-1</sup>	ha	t ha <sup>-1</sup>	ha	t ha <sup>-1</sup>
2000	107410	2.3	51219	1.8	56191	2.8
2001	131056	3.2	56022	2.7	75034	3.6
2002	130755	2.7	59311	2.4	71444	2.9
2003	109626	1.8	57832	1.7	51794	1.8
2004	109862	3.7	59017	3.2	50845	4.3
2005	104917	3.0	53762	2.6	51155	3.3
2006	93520	2.9	51419	2.4	42101	3.6
2007	93844	2.8	50134	2.4	43710	3.2
x	110124	2.8	54840	2.4	55284	3.2

The effect of weather conditions on barley yield in Serbia during 2000-2007

Table 2. Long-term average (1961-1990) for precipitation and air temperatures

		1961-1990: precipitation (mm) and mean air temperatures (°C)								
		Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June
Novi Sad (Serbia)										
mm	48	50	43	36	29	39	47	59	81	432
(°C)	11.2	5.4	1.6	0.1	1.8	6.3	11.2	16.7	19.4	8.2
Kragujevac (Serbia)										
mm	48	47	44	36	35	40	55	64	68	437
(°C)	11.4	5.9	2.1	0.9	2.8	6.7	11.2	16.2	19.9	8.6

Table 3. Precipitation and mean air temperatures for Novi Sad and Kragujevac

Harvest	Month of barley growing season									Σ
	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	
Novi Sad Weather Bureau										
Precipitation (mm)										Σ
2000	36	104	139	16	8	32	25	40	32	448
2001	8	23	54	38	29	76	156	79	237	699
2002	10	71	28	8	28	10	30	85	28	303
2003	66	24	42	49	22	9	9	22	31	300
2004	83	29	21	53	43	18	119	88	97	610
2005	50	143	34	30	42	40	33	38	136	582
2006	49	20	67	31	44	73	66	70	104	482
2007	17	17	40	48	51	79	0	99	71	423
8	52	54	53	34	33	42	55	65	92	481
Mean air temperature (°C)										Σ
2000	11.6	4.1	1.2	-1.7	3.9	6.8	14.4	18.5	22.0	9.5
2001	13.9	10.4	3.3	3.0	4.1	10.2	10.9	17.8	18.0	10.2
2002	14.1	3.6	-3.4	0.2	6.7	8.6	11.1	19.1	22.0	9.1
2003	12.1	9.5	0.5	-1.9	-4.5	5.6	11.3	20.6	24.2	8.6
2004	9.8	7.7	2.1	-1.2	2.4	6.4	12.0	15.0	19.5	8.2
2005	13.5	6.5	2.6	0.1	-3.7	4.3	11.8	17.2	19.4	8.0
2006	11.6	5.3	2.1	-1.3	0.9	5.7	12.7	16.5	19.7	8.1
2007	13.3	7.6	2.8	6.1	5.8	8.9	13.4	18.5	22.1	10.9
8	12.5	6.8	1.4	0.4	1.9	7.1	12.2	17.9	20.1	9.1
Kragujevac Weather Bureau										
Precipitation (mm)										Σ
2000	36	47	78	26	38	19	29	35	21	329
2001	8	24	26	21	33	37	155	45	109	458
2002	10	64	28	17	20	26	64	39	57	325
2003	66	32	39	59	20	3	37	42	48	346
2004	83	29	37	86	60	21	52	50	61	479
2005	50	105	20	37	67	45	69	70	51	514
2006	49	55	48	28	39	116	86	29	85	535
2007	17	14	55	45	32	63	4	119	25	374
8	40	46	41	40	39	41	62	54	57	420
Mean air temperature (°C)										Σ
2000	11.8	5.2	2.1	-1.5	3.8	7.0	15.1	18.2	21.8	9.3
2001	13.5	10.8	4.8	4.1	4.1	11.0	10.8	17.4	18.5	10.5
2002	13.8	4.6	-2.4	-0.1	7.0	8.9	10.9	18.4	21.6	9.1
2003	12.2	9.7	1.1	0.7	-2.4	5.8	10.8	19.9	23.3	9.0
2004	10.6	8.9	2.2	-0.9	3.0	7.1	12.8	14.5	19.8	8.7
2005	14.6	6.9	3.2	1.4	-1.8	4.7	11.6	16.5	19.3	8.5
2006	11.5	5.7	3.4	-1.6	1.3	6.0	12.7	16.6	19.8	8.4
2007	13.3	7.6	3.4	6.3	6.4	9.1	12.1	18.3	22.9	11.0
8	12.7	7.4	2.2	1.0	2.7	7.4	12.1	17.4	20.9	9.3

A similar effect of weather conditions was observed in other major field crops.

Josipović et al., 2005, and Šoštarić and Josipović, 2006 reported an average maize yield in Eastern Croatia of 6.69 t ha<sup>-1</sup> during three favourable years and a 24% lower yield (5.11 t ha<sup>-1</sup>) in three unfavourable years. The amount of precipitation in May-August was 285 mm and 235 mm during favourable and unfavourable years respectively (3-year average values). The respective values of total precipitation in July were 65 mm and 40 mm.

Jelić et al. (2009) analysed maize yield variations in Serbia (Kragujevac and Zaječar regions) and Croatia (Osijek-Baranja and Zagreb counties), focusing on the effect of precipitation and temperature regimes. The year 2000 was particularly unfavourable for maize. The amount of precipitation over a period of three months (June-August) in Kragujevac were 71 mm or as low as 35% of the long-term average, and those in Osijek - 78 mm or 37% of the average. Mean air temperatures were 22.9°C (Kragujevac) and 22.6°C (Osijek) or 2.5°C and 2.3°C above the average value, respectively. As a result of drought- and high temperature-induced stress, maize yields were as low as 1.78 t ha<sup>-1</sup> (Kragujevac region) and 3.96 t ha<sup>-1</sup> (Osijek-Baranja county).

Savić et al. (2009) examined the effect of weather conditions on grain yield in seven winter wheat cultivars grown in Central Šumadija over 2005-2007. They reported a significant effect of weather conditions on grain yield in all cultivars. The average grain yield was highest in 2005 (4607 kg ha<sup>-1</sup>) characterised by total precipitation being above the long-term average (1961-1990) and precipitation distribution (October-June) favouring the development and growth of winter wheat.

Kovačević et al. (2010) suggested that grain yield variations of maize grown in Croatia (Eastern and Northwestern Croatia) and Serbia (Central Serbia and Vojvodina) during an eight-year period were largely due to weather conditions. Average yields during the period ranged from 3.86 t ha<sup>-1</sup> to 6.92 t ha<sup>-1</sup> (Republic of Croatia - RC), and from 3.2 t ha<sup>-1</sup> to 5.8 t ha<sup>-1</sup> (Republic of Serbia - RS). During the two "unfavourable years" (2000 and 2003), maize yields were 3.9 t ha<sup>-1</sup> (two-year average) in RC and 2.8 t ha<sup>-1</sup> in RS. The yields during the two "favourable years" (2005 and 2006) were 6.7 t ha<sup>-1</sup> (RC) and 5.5 t ha<sup>-1</sup> (RS). Maize yields during favourable years were on average 72% (RC) and 97% (RS) higher than in unfavourable years.

Paunović et al. (2010) reported that the effect of weather conditions on wheat yield was evident in Serbia and Croatia during 2000-2007. The lowest average wheat yield was produced in 2003: 2.29 t ha<sup>-1</sup> (RS) and 2.96 t ha<sup>-1</sup> (RC), being 34% (RS) and 28% (RC) below the average. The unfavourable effect of weather conditions on wheat in 2002/2003 (average values for Novi Sad, Kragujevac, Osijek and Zagreb) showed specificity in terms of substantial deviation from the long-term average (I<sub>ta</sub>: 1961-1990). The amount of precipitation (October-June) was 349 mm or 28% below the I<sub>ta</sub>, and mean air temperature was 8.8°C or 0.8°C higher.

## Conclusion

Weather conditions during the growing seasons (October-June) of 2000-2007 had a significant effect on barley yield in Serbia. The adverse effect of weather conditions should be mitigated by an adequate choice of cultivars that are more tolerant to drought and have a shorter growing period, which enables the plant to undergo its development stages more rapidly. In that way, negative effects of drought and high temperatures could be avoided. The negative effect of precipitation deficiency and global warming can be mitigated by the use of cultivation operations, primarily good soil tillage involving retention of autumn and winter precipitations and timely high-quality sowing.

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# Učinak dušika i zasušivanja na svojstva biljke kod ozimih sorti ječma

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## Sažetak

Cilj rada bio je istražiti učinak sorte, vodnog stresa i ishrane dušikom (N) na morfološka i gospodarska svojstva ječma. Istraživanja ukazuju na suodnos vodnog stresa, ishrane dušikom (razine = 5 mmol/L N; N10 = 10 mmol/L N; N15 = 15 mmol/L N) i sorte. Vodni stres je imao značajan negativan učinak na broj vlati, broj listova, količinu klorofila, ukupnu masu biljke i lista. Ustanovljen je pozitivan učinak ishrane u uvjetima stresa, iako je učinak ishrane na istraživana svojstva jači u uvjetima uzgoja bez vodnoga stresa. Utvrđeno je da sorte Vanessa i Spartak pod utjecajem vodnog stresa najbolje održavaju osmotski potencijal i relativni sadržaj vode (RWC) u biljci, pokazujući najmanje razlike između najznačajnijih morfoloških svojstava u uvjetima vodnog stresa i bez stresa.

Ključne riječi: ječam, vodni stres, ishrana, dušik, sorta

## Effect of nitrogen and water deficiency on the properties of plants in the winter barley varieties

### Abstract

The aim of the present study was to investigate the effect of variety, water stress and nitrogen (N) nutrition on agronomic and morphological traits of barley. Results indicate the relationship between water stress, nitrogen nutrition (level N5, N10, N15) and variety. Water stress had a significant negative effect on the number of tillers, number of leaves, the amount of chlorophyll, total plant and leaf weight. There was a positive effect of nutrition in stress conditions, although the effect of nutrition on traits was stronger in growing conditions without water stress. It was found that varieties Vanessa and Spartak influenced by water stress performed better compared to other varieties in maintaining osmotic potential and RWC in plants, showing the lowest differences between the most important morphological traits in water stress and stress-free conditions.

Key words: barley, water deficiency, nutrition, N, variety

## Uvod

Na negativne učinke suše u proizvodnji ječma koja se sve češće javlja i u vlažnijim područjima zapadne Europe, te u aridnim i semiaridnim područjima jugoistočne Europe ukazuju Ceccarelli i sur. (1998.) te Lalić i sur. (2007.). Prema Bray i sur. (2006.) gubitak prinosa zrna uzrokovan abiotskim stresom kod ječma može iznositi i do 75%. Autori navode da su najčešći abiotski stresovi uzrokovani sušom i visokim temperaturama u fazi nalijevanja zrna, a koji utječu na intenzitet i trajanje nalijevanja zrna, te mogu izazvati prisilnu zriobu. Autori naglašavaju i negativan učinak abiotskog stresa, naročito suše u ranijim fazama razvoja žitarica. Optimizirana ishrana biljaka ječma, naročito s dušikom (N), u vegetacijskoj fazi razvoja Zadoks GS 21-30 (od početka busanja do početka vlatanja) i Zadoks GS 30-51 (od početka vlatanja do početka klasanja) značajno utječe na formiranje uroda zrna, ali određuje i namjensku kakvoću ječma. Stoga je cilj ovoga rada bio istražiti reakciju kultivara u vegetacijskoj fazi Zadoks GS -30-50 na vodni stres u suodnosu s ishranom N te kako se odražava navedeni suodnos na gospodarska i morfološka svojstva kod različitih sorti ječma.

## Materijali i metode

U stakleničkom pokusu koji je obavljen na Institutu za jadranske kulture i melioraciju krša u Splitu učinak zasušivanja i različitog stanja N u tlu analiziran je u vegetacijskoj fazi razvoja usjeva Zadoks GS 30-51 prema Zadoks i sur., (1974), odnosno od početka vlatanja do početka klasanja. Pokus je postavljen kao trofaktorijelni pokus u 6 ponavljanja prema slučajnom bloknom rasporedu s kultivarom, vodnim stresom i razinom dušika kao faktorima. Pokus je postavljen s pet kultivara ječma Bingo, Titan, Barun, Vanessa i Spartak. Sjetva je obavljena 14. kolovoza u sjetvene ploče s 350 sjetvenih mjesta volumena 30 ml u substrat Brill tip 4. Nakon presađivanja, biljke su zalijevane vodovodnom vodom u količini 200 ml po biljci. Nakon nekoliko dana biljke su spojene na sustav navodnjavanja kapanjem pomoću kapaljki (TORO company) kapaciteta 3 L razdijeljene na 2 biljke i zalivene hranjivom otopinom s 3 razine dušika (N5; N10; N15) do zasićenja: N5 = 5 mmol/L N; N10 = 10 mmol/L N; N15 = 15 mmol/L N. U svim slučajevima se nastojao zadržati omjer  $\text{NO}_3^-/\text{NH}_4^+$  odnosno udio  $\text{NH}_4^+$  iona oko 20%. Sljedećih 45 dana obavljano je navodnjavanje 2 puta tjedno u količini (zasićena masa lonca - trenutna masa lonca) + 20% extra. Provedena je zaštita usjeva od bolesti i štetnika.

Postupak vodnoga stresa proveden je u trajanju od 8 dana, a do pojave venuća na biljkama. Nakon 8 dana vodnog stresa, kada su na zasušivanim kombinacijama bili izraženi znakovi venuća, izvršeno je navodnjavanje cjelokupnog pokusa kako bi se povratio turgor u biljkama. Sedam dana nakon prestanka zasušivanja na 30 biljaka (5 po repeticiji) utvrđeni su: visina biljke, broj izboja, broj listova, masa nadzemnog dijela biljke, masa listova i površina plojke listova, suha masa nadzemnog dijela biljke i listova, izmjeren je sadržaj klorofila pomoću ručnog klorofil metra (Hydro N tester).

Relativni sadržaj vode (RWC) određen je 4. i 8. dan nakon početka zasušivanja na uzorcima središnjih dijelova potpuno razvijenog mladog lista površine oko 1 cm<sup>2</sup>. Uzorci za mjerenje osmotskog potencijala uzeti su 4., 6. i 8. dan od početka zasušivanja, a mjerenje osmotskog potencijala provedeno je na instrumentu Vapro Osmometer 5520 (Wescor Inc, USA), te su očitani rezultati izraženi u mmol/kg.

Podatci su obrađeni korištenjem procedura PROC GLM, PROC MEANS u SAS 9.1 software-u (SAS Institute Inc, 2007).

## Rezultati rada i rasprava

Staklenički pokusi ukazuju na sinergiju stanja hraniva (prihrana N5, N10, N15) s morfološkim svojstvima biljke, te na sinergiju i suodnos vodnoga stresa, kultivara i prihrane (Tablice 1, 2 i 3). Vodni stres imao je značajan negativan učinak na broj vlati, broj listova, količinu klorofila, ukupnu masu biljke i lista. Kod tretmana vodnim stresom biljke s gnojidbom N15 ostvarile su sličnu ili višu visinu biljke i broj listova kao kod gnojidbe N5 bez vodnog stresa. Međutim, svojstvo mase biljke, mase lista, mase suhe biljke i mase suhog lišća, te količina klorofila bili su izraženiji kod N5 gnojidbe bez vodnoga stresa nego kod svih tretmana gnojidbe u uvjetima vodnoga stresa. U pokusu uočavamo pozitivan učinak ishrane u uvjetima stresa, iako je on izraženiji u uvjetima uzgoja bez vodnoga stresa. Navedeni učinak vodnoga stresa i gnojidbe različiti su kod ispitivanih sorti ječma, a najviše razlike u masi biljke, masi lista, masi suhe biljke i masi suhog lista imala je sorta Bingo u uvjetima vodnog stresa u odnosu na uvjete bez stresa (Tablica 1, 2).

Suša, salinitet, ekstremne temperature i oksidativni stres često su međusobno povezani, dovode do morfoloških, fizioloških, biokemijskih i molekularnih promjena koje štetno utječu na rast i produktivnost biljaka (Serrano i sur.,2001). Pojava abiotskog stresa, naročito nedostatka vode u fazi razvoja biljke busanja (Zadoks GS -20-30) i vlatanja (Zadoks GS -30-50) značajno utječe na rast biljaka, izgradnju osnovnih komponenti uroda zrna i kakvoće zrna. Bertholdsson (1999) iznosi da razlike u razvoju korijena i iskorištenju vode, razlike u ritmu porasta, morfologiji biljke i komponentama prinosa utječu na urod zrna i varijabilnost u količini bjelančevina u zrnu. Gonzales i sur. (1999) ukazuju na sinergiju između udjela formirane biomase i nižeg uroda zrna kod slabije prilagodljivih genotipova izloženih stresu nedostatka vode. Osmotski potencijal biljke i RWC u biljci ukazuju da sorte Vanessa i Spartak bolje održavaju osmotski potencijal i RWC u biljci u odnosu na ostale ispitivane sorte, te su ostvarile i najmanje razlike u osmotskom potencijalu između uvjeta uzgoja pod vodnim stresom i uvjeta uzgoja bez stresa (Tablica 4). U uvjetima vodnoga stresa gnojidba dušikom pokazala je tendenciju povećanja osmotskog potencijala, te smanjenja RWC u odnosu na uvjete bez vodnoga stresa. U oplemenjivanju ječma, u cilju povećanja otpornosti na vodni stres ciljeve oplemenjivanja treba usmjeriti na stvaranju sorata s većom upojnom moći i kapacitetom pohrane vode, te na implementaciju pojedinih mehanizama za sprečavanje gubljenja vode putem isušivanja listova (Gonzales i sur., 1999; Ivandic i sur., 2000).

Tablica 1. Vrijednosti istraživanih svojstava ječma

Sorta	Vodni stres	Gnojid. tretman	Masa bilj (gr)	Visina bilj. (cm)	Broj listova	Masa lista (gr)	Biljka suho (gr)	Lišće suho (gr)	Sadržaj klorofila (N tester)
BARUN	A	N5	37.00	63.80	66.80	22.13	5.64	3.85	32.58
	A	N10	49.31	62.60	84.20	29.66	5.66	4.01	37.72
	A	N15	54.93	63.40	95.00	35.23	6.39	4.40	37.60
	B	N5	69.62	64.20	86.20	43.53	8.30	5.66	33.52
	B	N10	68.82	64.00	97.60	42.35	7.59	5.14	39.60
	B	N15	96.74	66.00	115.20	61.55	9.37	6.30	34.70
BINGO	A	N5	38.15	57.00	68.40	22.89	5.38	3.73	37.74
	A	N10	39.31	60.00	68.20	23.12	5.84	3.95	37.04
	A	N15	48.44	63.60	87.00	29.34	6.32	4.54	30.30
	B	N5	62.42	62.30	87.60	40.14	7.43	5.10	39.16
	B	N10	65.14	64.00	92.80	40.79	8.30	5.57	38.48
	B	N15	97.26	66.40	126.00	62.43	10.39	6.91	37.60
SPARTAK	A	N5	37.36	52.80	60.40	22.94	6.12	4.03	38.32
	A	N10	49.51	62.20	77.40	29.24	6.80	4.72	34.04
	A	N15	58.25	59.60	85.20	38.21	7.59	5.34	35.66
	B	N5	60.65	61.80	80.80	37.94	8.27	5.67	42.76
	B	N10	75.38	66.80	97.00	47.40	8.40	5.68	39.20
	B	N15	99.84	63.40	129.00	65.89	9.94	7.01	40.58
TITAN	A	N5	37.91	59.20	68.60	22.24	4.29	2.87	32.46
	A	N10	42.55	59.20	82.60	24.11	5.50	3.80	35.74
	A	N15	47.97	62.60	90.40	27.80	6.13	4.35	32.68
	B	N5	59.97	60.00	87.60	38.31	7.35	5.22	35.52
	B	N10	64.00	62.80	93.00	39.89	7.67	5.21	36.34
	B	N15	76.04	63.40	104.20	48.90	9.75	6.82	35.62
VANESSA	A	N5	44.39	63.60	86.40	26.05	6.15	4.23	33.78
	A	N10	51.06	62.60	97.60	31.39	7.41	4.94	38.60
	A	N15	54.72	66.20	100.20	34.09	7.86	5.63	32.44
	B	N5	75.85	68.00	107.80	47.45	10.54	7.20	35.74
	B	N10	74.89	66.00	109.60	47.51	9.54	6.44	37.20
	B	N15	66.72	67.00	91.40	41.30	8.69	6.38	38.76

A-vodni stress; B-bez vodnog stresa

Učinak dušika i zasušivanja na svojstva biljke kod ozimih sorti ječma

Tablica 2. Prosječne vrijednosti istraživanih svojstava ječma

Sorta	Vodni stres	Visina bilj (cm)	Broj vlati	Broj listova	Masa bilj. (gr)	Masa lista, gr	Sadržaj klorofila	Masa biljka suho (gr)	Masa lišća suho, (gr)
BARUN	A	63.27	15.47	82.00	47.08	29.00	35.97	5.90	4.09
	d	1.47	3.33	17.67	31.31	20.14	-0.03	2.52	1.61
	B	64.73	18.80	99.67	78.39	49.14	35.94	8.42	5.70
BINGO	A	60.20	14.33	74.53	41.97	25.11	35.03	5.85	4.07
	d	4.03	5.07	27.60	32.97	22.67	3.39	2.86	1.79
	B	64.23	19.40	102.13	74.94	47.79	38.41	8.71	5.86
SPARTAK	A	58.20	14.00	74.33	48.37	30.13	36.01	6.84	4.69
	d	5.80	5.40	27.93	30.25	20.28	4.84	2.04	1.42
	B	64.00	19.40	102.27	78.62	50.41	40.85	8.87	6.12
TITAN	A	60.33	14.20	80.53	42.81	24.72	33.63	5.31	3.67
	d	1.73	3.00	14.40	23.86	17.65	2.20	2.95	2.07
	B	62.07	17.20	94.93	66.67	42.37	35.83	8.26	5.75
VANESSA	A	64.13	16.53	94.73	50.06	30.51	34.94	7.14	4.93
	d	2.87	1.33	8.20	22.43	14.91	2.29	2.45	1.74
	B	67.00	17.87	102.93	72.49	45.42	37.23	9.59	6.67

Tablica 3. Prosječne vrijednosti istraživanih svojstava

Gnojidbeni tretman	Vodni stres	Visina bilj (cm)	Broj vlati	Broj listova	Masa biljke (gr)	Masa lista gr	Sadržaj klorofila (N tester)	Masa biljka suho (gr)	Masa lišća suho, (gr)
N5	A	59.28	13.16	70.12	38.96	23.25	34.98	5.51	3.74
N10	A	61.32	14.92	82.00	46.35	27.50	36.63	6.24	4.28
N15	A	63.08	16.64	91.56	52.86	32.93	33.74	6.86	4.85
N5	B	63.26	15.52	90.00	65.70	41.47	37.34	8.38	5.77
N10	B	64.72	18.40	98.00	69.65	43.59	38.16	8.30	5.61
N15	B	65.24	21.68	113.16	87.32	56.01	37.45	9.43	6.44
N5		61.27 b	14.34 c	80.06 c	52.33 b	32.36 b	36.16	6.95 b	4.76 b
N10		63.02 a b	16.66 b	90.00 b	58.00 b	35.55 b	37.40	7.27 b	4.94 b
N15		64.16 a	19.16 a	102.36 a	70.09 a	44.47 a	35.59	8.14 a	5.65 a
	A	61.23 b	14.91 b	81.23 b	46.06 b	27.89 b	35.11 b	6.20 b	4.29 b
	B	64.41 a	18.53 a	100.39 a	74.22 a	47.03 a	37.65 a	8.70 a	5.94 a

"a...d" - Duncan's Multiple Range Test za  $P \leq 0,05$

Tablica 4. Vrijednosti relativnog sadržaja vode (RWC) i osmotskog potencijala

Sorta /Gnojidba	Vodni stres	Osmotski potencijal, mmol/kg 1.mjerenje	Osmotski potencijal, mmol/kg 2.mjerenje	Osmotski potencijal, mmol/kg 3.mjerenje	RWC% (30.10.)	RWC% (4.11.)
BARUN	A	612.33	614.47	1295.33	85.08	32.97
	B	644.33	589.67	553.87	89.70	84.11
BINGO	A	639.73	561.40	1202.80	87.01	32.37
	B	620.27	570.20	580.47	88.76	87.40
SPARTAK	A	604.53	583.33	1046.87	87.65	39.66
	B	613.27	551.20	526.87	91.34	85.80
TITAN	A	599.80	599.80	1203.27	86.80	31.84
	B	693.73	578.80	590.73	86.96	84.15
VANESSA	A	555.87	571.67	911.27	86.26	39.51
	B	569.60	531.00	515.33	90.94	86.77
N5	A	668.12	603.28	1088.64	84.73	42.79
N10	A	589.68	560.64	1128.96	86.59	32.68
N15	A	549.56	594.48	1178.12	88.36	30.34
N5	B	685.48	613.04	586.12	90.04	86.00
N10	B	597.56	557.48	538.80	89.66	85.23
N15	B	601.68	522.00	535.44	88.93	85.72
N5		676.80 a	608.16 a	837.38	87.39	64.39 a
N10		593.62 b	559.06 b	833.88	88.12	58.96 b
N15		575.62 b	558.24 b	856.78	88.65	58.03 b
	A	602.45	586.13	1131.91 a	86.56 b	35.27 b
	B	628.24	564.17	553.45 b	89.54 a	85.65 a

"a...d" - Duncan's Multiple Range Test za  $P \leq 0,05$

## Zaključak

Vodni stres je imao značajan negativan učinak na broj vlati, broj listova, količinu klorofila, ukupnu masu biljke i lista. Učinak ishrane s N u uvjetima stresa je bio pozitivan, ali ishrana N nije značajnije umanjila učinak stresa.

Sorte Vanessa i Spartak bolje su održavale osmotski potencijal i RWC u biljci u uvjetima stresa u odnosu na ostale sorte. Učinak vodnoga stresa i ishrane s N razlikovao se kod ispitivanih sorti ječma. Najveće razlike u masi biljke, masi lista, masi suhe biljke i masi suhog lista u uvjetima vodnog stresa u odnosu na uvjete bez stresa imala je sorta Bingo.

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# Urod i komponente uroda zrna kragujevačkih sorti ozimog ječma

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## Sažetak

U radu su prikazani rezultati istraživanja kragujevačkih ozimih kultivara ječma (Rekord, Jagodinac, Maksa i Grand). Pokus je postavljen na pokusnom polju Centra za strna žita, Kragujevac tijekom dvije vegetacijske sezone. Istraživan je urod zrna (t/ha), masa 1000 zrna (g) i hektolitarska masa (kg/hl). Najviši prosječan urod zrna ostvario je kultivar Maksa (5,502 t/ha). Prosječna vrijednost hektolitarske mase bila je najveća za kultivar Maksa (69,86 kg/hl), a najmanja za kultivar Grand (62,37 kg/hl). Najveća masa 1000 zrna utvrđena je kod kultivara Maksa. Ustanovljene značajnosti sa stanovišta utjecaja godine na prosječne vrijednosti uroda zrna statistički su bile signifikantne.

Ključne riječi: ozimi ječam, kultivar, urod zrna

## Yield and components yield grain in Kragujevac of winter barley varieties

### Abstract

This paper presents the results of Kragujevac winter barley varieties (Rekord, Jagodinac, Maksa and Grand). The experiment was conducted at the experimental field of the Center for Small Grains, Kragujevac during two growing seasons. Investigated the grain yield (t/ha), 1000 grain weight (g) and hectoliter mass (kg/hl). The highest average grain yield was obtained with variety Maksa (5.502 t/ha). The average value for the test weight was highest in cultivar Maksa (69.86 kg/hl), and lowest at Grand variety (62.37 kg/hl). Maximum 1000 grain weight was determined at the cultivar Maksa. Revealed significance from the standpoint of impact on the average grain yield were statistically significant.

Key words: grain yield, variety, winter barley

### Uvod

Ječam je najrasprostranjenija žitarica na svetu, a najznačajniji je za hladnija i vlažnija područja, gdje se ne može uzgajati kukuruz za zrno. Jedan od osnovnih zadataka selekcije, za unapređenje proizvodnje ječma je stvaranje genotipova visokog potencijala rodosti izraženog preko komponenata uroda u odgovarajućim uvjetima vanjske sredine. Kao krajnja komponenta i složeno svojstvo, urod zrna je na prvom mjestu i ispred kvalitete i otpornosti na bolesti i stresne uvjete, bez obzira na svrhu uporabe. Agronomska vrijednost sorte ne ovisi samo o njenom genetskom potencijalu na urod, nego i o njenoj sposobnosti da ostvari svoj genetski potencijal pod različitim uvjetima proizvodnje (Mladenov i sur., 1998).

Ječam se koristi kao važna komponenta u proizvodnji piva i slada, važna i kvalitetna komponenta u hranidbi domaćih životinja, djelomično u prehrani ljudi i kao komponenta u prerađivačkoj industriji. Najvišim

dijelom (oko 60%) proizvedene količine zrna ječma se koriste u hranidbi domaćih životinja. U obrocima za svinje ječam se može koristiti bez ikakvih ograničenja kao jedini, ili osnovni izvor energije. U hranidbi peradi ječam se koristi u manjoj količini, jer može izazvati poremećaje u probavljanu hrane. Obilna i duža hranidba krava muzara ječmom može dovesti do nadima (Malobabić, 1997; Mladenović i sur., 2009.). Kao najkvalitetnija ratarska krmna biljka ječam služi i kao krmna jedinica u balansiraju obroka za hranidbu domaćih životinja.

Cilj rada je ustanoviti razlike i istražiti specifičnosti istraživanih kultivara ječma za urod, hektolitarsku masu i masu 1000 zrna, s obzirom na uvjete vegetacijske sezone.

## Materijal i metode

### Materijal i poljski pokusi

Tijekom vegetacijske sezone 2007./2008. i 2008./2009. godine, istraživana su četiri kultivara ozimog ječma, koji su uzgajani u pet ponavljanja u Centru za strna žita u Kragujevcu. Istraživani su kultivari Rekord, Jagodinac, Maksa i Grand. Pokus je postavljen po potpuno slučajnome rasporedu s pet ponavljanja. Veličina osnovne parcelice iznosila je 3,0 m<sup>2</sup>. Primijenjena je uobičajena tehnologija za proizvodnju ječma, s tim što je sjetva obavljena u optimalnom roku u drugoj polovici listopada. Gnojdbom je u jesen dodano 400 kg/ha gnojiva NPK 8:24:16, a u proljetnoj prihrani 200 kg/ha KAN-a. Analizirana su slijedeća svojstva: urod zrna, hektolitarska masa i masa 1000 zrna.

Na osnovu ostvarenih rezultata istraživanja izračunati su uobičajeni varijacijsko statistički pokazatelji: prosječne vrijednosti, greška aritmetičke sredine i standardna devijacija. Statistička obrada podataka napravljena je u modulu Analyst programa SAS/STAT (SAS Institut, 2000.).

### Zemljišni i vremenski uvjeti

Prije početka izvođenja pokusa uzeti su uzorci tla s pokusnih površina i izvršena je kemijska analiza tla. Na temelju dobivenih rezultata utvrđeno je da tlo pripada tipu smonice, s relativno visokim udjelom gline i nepovoljnih je fizičkih svojstava. Sadržaj humusa u površinskom sloju tla je nizak (2,68-2,87%), a supstitucijska i ukupna hidrolitička kiselost su dosta visoke (pH u H<sub>2</sub>O=6,01, u KCl=4,78). Tlo je srednje osigurano ukupnim dušikom (0,12-0,14% N) i lako pristupačnim kalijem (11-16 mg/100 g tla K<sub>2</sub>O), dok je sadržaj lakopristupačnog fosfora bio nizak (ispod 10 mg/100 g tla P<sub>2</sub>O<sub>5</sub>).

Područje Kragujevca se nalazi na nadmorskoj visini od 186,0 m i karakterizira se umjerenom kontinentalnom klimom čija je opća karakteristika neravnomjeran raspored oborina po mjesecima (Tablica 1.). Tijekom godine najveća količina oborina je u proljetnim mjesecima što se povoljno odražava na vegetaciju biljaka. Rast temperatura od ožujka praćen je povećanjem oborina, koje dostižu maksimum u svibnju. Od početka srpnja do rujna područje Kragujevca karakterizira umjereno sušni period.

Tablica 1. Srednje mjesečne temperature zraka i količina oborina (Kragujevac)

Godina	Mjeseci												Prosjeck/ suma
	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	
Srednje mjesečne temperature zraka (°C)													
2007-08	23,2	15,6	10,8	4,5	0,6	6,1	6,3	9,1	12,1	18,2	22,8	24,8	12,8
2008-09	20,9	15,8	13,1	8,5	4,4	2,5	4,5	8,1	12,6	17,3	21,8	22,4	12,7
Prosjeck 1961-04	22,7	16,6	12,5	6,9	1,9	0,5	2,4	7,1	11,6	16,9	20,0	22,0	11,8
Količina oborina (mm)													
2007-08	82,1	45,8	92,8	110,4	28,1	45,3	32,1	62,9	3,6	118,4	25,3	10,1	656,9
2008-09	41,4	50,2	31,3	30,6	29,7	36,6	13,0	53,2	30,1	13,1	65,7	51,5	446,4
Prosjeck 1961-04	58,5	62,7	45,4	48,9	56,6	58,2	46,6	32,4	51,9	57,6	70,4	71,5	660,7

Podaci u tablici 1. za razdoblje istraživanja (2007/09.), jasno ukazuju da su se godine u kojima su izvedena istraživanja po meteorološkim uvjetima razlikovale od višegodišnjeg razdoblja karakterističnog za Kragujevac. Prosječna temperatura zraka u 2007/08. i 2008/09. godini bila je veća za 1°C, odnosno 0,9°C a



## Urod i komponente uroda zrna kragujevačkih sorti ozimog ječma

količina oborina u istim godinama istraživanja manja za 3,8 mm, odnosno za 214,3 mm od višegodišnjeg prosjeka i sa vrlo neravnomjernim rasporedom oborina po mjesecima. Proljetni mjeseci travanj, svibanj i lipanj bili su umjereno sušni, što se nepovoljno odrazilo na uzgajane usjeve. U travnju 2007/08. godine je palo 3,6 mm oborina, a u 2008/09. godini 30,1 mm što je za 48,3 mm, odnosno 21,8 mm manje od višegodišnjeg prosjeka. U svibnju 2007/08. godine je palo 118,4 mm oborina što je za 60,8 mm više od višegodišnjeg prosjeka, dok je u 2008/09. godini za 44,5 mm palo oborina manje od višegodišnjeg prosjeka. U lipnju 2007/08. i 2008/09. godine količina vodenog taloga je bila manja od prosjeka. Polazeći od činjenice da su dovoljne količine oborina u ovim mjesecima vrlo bitne za uspješnu proizvodnju strnih žitarica nameće se zaključak da godine u kojima su izvedena istraživanja nisu bile povoljne za uzgoj ječma.

### Rezultati i rasprava

Prosječne vrijednosti uroda zrna, hektolitarske mase i mase 1000 zrna kod istraživanih kragujevačkih kultivara ječma uzgajanih u Centru za strna žita u Kragujevcu, tijekom dvije vegetacijske sezone 2007-08. i 2008-09. god., prikazani su u tablici 2.

Tablica 2. Prosječne vrijednosti istraživanih svojstava kultivara ječma (2005.-2007. god.)

Svojstva	Kultivar	2007/2008			2008/2009			Prosjeak / Average		
		$\bar{X}$	S	$S_{\bar{x}}$	$\bar{X}$	S	$S_{\bar{x}}$	$\bar{X}$	S	$S_{\bar{x}}$
Urod zrna, (t/ha)	Rekord	5,820	0,604	0,270	4,772	0,497	0,222	5,296	0,756	0,240
	Jagodinac	5,908	0,699	0,313	3,512	0,253	0,113	4,710	1,357	0,429
	Maksa	6,004	0,343	0,153	5,000	0,290	0,130	5,502	0,608	0,192
	Grand	5,544	0,098	0,044	3,490	0,042	0,019	4,517	1,085	0,343
Hektolitarska masa, (kg/hl)	Rekord	68,90	0,526	0,235	67,79	0,425	0,190	68,34	0,738	0,234
	Jagodinac	69,21	0,646	0,289	60,17	1,446	0,647	64,69	4,880	1,543
	Maksa	70,95	0,923	0,413	68,77	1,178	0,527	69,86	1,522	0,481
Masa 1000 zrna, (g)	Grand	66,97	0,936	0,419	57,78	2,727	1,219	62,37	5,211	1,648
	Rekord	46,56	1,596	0,714	44,36	2,714	1,214	45,26	2,304	0,728
	Jagodinac	43,76	1,519	0,679	42,97	1,373	0,614	43,36	1,427	0,451
	Maksa	51,36	1,831	0,819	48,85	1,934	0,865	50,10	2,214	0,700
	Grand	40,36	1,506	0,673	37,96	1,493	0,667	39,16	1,897	0,600

Urod istraživanih genotipova ječma pokazivao je znatno variranje ovisno o godini istraživanja (Tablica 2.). U prvoj godini istraživanja (2007-08.), kultivar Maksa je ostvario najviši urod zrna (6,004 t/ha), zatim Jagodinac (5,908 t/ha), dok je najniži urod imao kultivar Grand (5,544 t/ha). U drugoj godini istraživanja (2008-09.), urod kod kultivara Maksa bio je najviši i iznosio je 5,000 t/ha, dok je nešto niži ostvario Rekord (4,772 t/ha). Znatno niži urod postigli su kultivari Jagodinac i Grand (3,512 i 3,490 t/ha). Prosječan urod zrna u promatranom dvogodišnjem razdoblju bio je najviši kod kultivara Maksa i iznosio je 5,502 t/ha, dok je najniži urod zrna ostvario kultivar Grand (4,517 t/ha). Znatno variranje uroda zrna ovisno o utjecaju genotipa i godine istraživanja, utvrdili su i Perić, 1982; Jelić i sur., 2002. i Đekić i sur., 2010.

Hektolitarska masa zrna kao njena kvalitativna karakteristika nije se znatno razlikovala u ovisnosti o istraživanom genotipu i godini istraživanja (Tablica 2.). Kultivar ječma Maksa ostvario je najveću hektolitarsku masu u obje vegetacijske sezone u odnosu na ostale istraživane kultivare ječma. Prosječna dvogodišnja vrijednost iste kod kultivara Maksa iznosila je 69,86 kg/hl, kod Rekorda 68,34 kg/hl, Jagodinca 64,69 kg/hl, dok je najnižu prosječnu dvogodišnju vrijednost hektolitarske mase ostvario kultivar Grand (62,37 kg/hl). Zrno istraživanih kultivara ječma odlikuje se dobrim fizičkim svojstvima, posebno hektolitarskom masom i masom 1000 zrna. Ostvarene prosječne vrijednosti ovih svojstava u istraživanju bile su nešto niže u odnosu na vrijednosti do kojih su došli Jelić i sur., 2002. i Đekić i sur., 2010.

U obje godine istraživanja (2007-08. i 2008-09.), kultivar Maksa ostvario je najveću prosječnu masu 1000 zrna (51,36 g i 48,85 g) u odnosu na ostale istraživane kultivare ječma. Najnižu prosječnu vrijednost mase 1000 zrna kako u prvoj, tako i u drugoj godini istraživanja ostvario je kultivar Grand (40,36 g i 37,96 g). Masa 1000 zrna je sortna karakteristika i otuda se između različitih genotipova konstatira veće variranje (Jelić i sur. 2002, Đekić i sur. 2010).

Tablica 3. Analiza varijance pokazatelja fizičkih svojstava za istraživane kultivare ječma

Parametar	$F_{exp}$	
	Kultivar	Godina
Urod zrna, (t/ha)	1,755	21,180*
Hektolitarska masa, (kg/hl)	2,472	6,160
Masa 1000 zrna, (g)	4,434	2,951
	$F_{3;0,05}=9,28;$ $F_{3;0,01}=29,46$	$F_{1;0,05}=10,13;$ $F_{1;0,01}=34,12$

Na osnovu analize varijance (Tablica 3.), može se zaključiti da postoje značajne razlike u urodu zrna u odnosu na vegetacijsku sezonu ( $F_{exp}=21,180^*$ ), dok između istraživanih kultivara ječma razlike nisu bile signifikantne. Kod istraživanih kultivara ječma nisu ustanovljeni značajni učinci genotipa i godine na hektolitarsku masu i masu 1000 zrna.

### Zaključak

U provedenim istraživanjima od istraživanih kultivara ječma navedene odlike, odnosno viši urod, hektolitarsku masu i masu 1000 zrna ostvario je kultivar Maksa. Kultivari Rekord i Jagodinac postigli su zadovoljavajuće rezultate, dok je najslabije rezultate ostvario kultivar Grand. Analizom varijance procijenjeni su značajni učinci godine za urod zrna, dok utjecaj genotipa na urod zrna, hektolitarsku masu i masu 1000 zrna nije bio opravdan.

Na osnovu ostvarenih rezultata može se zaključiti da kultivare nije dobro procjenjivati uzimajući u obzir samo parametre stabilnosti, nego treba promatrati i njihovu razinu rodosti. Takvim pristupom moguće je povećati pouzdanost procjene i preporuke kultivara za uvođenje u proizvodnju na određenom području. Strukturu sjetve treba temeljiti na više od jednoga kultivara kako bi se umanjio rizik koji nosi nepredvidivost svake pojedine vegetacije, bez obzira na pouzdanost kriterija izbora sortimenta za sjetvu u pojedinoj godini.

### Napomena

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# Effect of cultivar and year on yield and grain quality of two-row winter barley

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## Abstract

Grain yield and quality components were evaluated in six two-row winter barley cultivars. Comparative studies were conducted during 2005–2008 on the experimental field of the Small Grains Research Centre, Kragujevac. Data were subjected to a two-factor analysis of variance. Means were separated using Fisher's LSD test. The cultivars showed significant differences in grain yield, 1000-kernel weight and germination energy, and no substantial differences in protein and extract contents. Grain yield was highest in cv. Record and lowest in cv. NS-331. Grain yield, 1000-kernel weight and germination energy were substantially affected by growing conditions (year) and the genotype-year interaction.

Key words: malting barley cultivar, grain yield, quality traits

## Introduction

Grain yield and quality of barley are major traits of barley genotypes expressed through the synthesis of a series of individual traits and environmental conditions under which plants develop. Selection for improved barley production should be focused on creating genotypes that will have a high yield potential i.e. exhibit all desirable agronomic and technological traits under different agroenvironmental conditions.

Grain yield has changed during the last century, with yield increases mostly resulting from the development of plant selection and breeding techniques that lead to the genetic yield potential of newly created winter barley cultivars of above 11 t/ha (Pržulj et al., 2009).

Yield increase is associated with improvement of the genetic basis of cultivars and use of adequate production technology. An annual yield increase in two-row barley is 1.1%, being largely due to an increase in certain yield components such as kernel weight and kernel number per spike, increase in total biomass or improved harvest index (Pržulj et al. 2000.; Madić et. al. 2006.; Paunović et. al. 2007.)

Apart from high yield, 1000-kernel weight and good biotic and abiotic stress resistance, malting barley cultivars should have a low content of chaff and proteins and a high starch content. Thousand-kernel weight and hectolitre weight are among initial major indicators of grain quality; hence the positive correlation between malt extract yield and grain size (Paunović et al. 2006).

Protein content is the initial indicator of qualitative analysis of barley grain. Malting barley should have a low content of proteins (below 11.5%), soluble ones in particular, since a high content of soluble proteins gives a saturated taste to the beer produced and makes the colour and taste of beer difficult to control.

Apart from the genetic factors (choice of cultivar), an increase in protein content was substantially affected by environmental factors such as inadequate use of nitrogen fertilisers, water deficiency, high temperatures during the kernel filling stage, etc. (Maksimović et al., 2001). Furthermore, many studies suggest differences in grain yield stability and adaptability of cultivars to environmental and growing conditions, as well as different cultivar responses to biotic and abiotic stresses (Lalić et al. 2010).

Production technology should be strictly adhered to in order to fully implement the genetic potential for grain yield and quality in malting barley (Malešević and Starčević 1992; Pržulj and Momčilović 2002; Paunović et al. 2008).

### Material and methods

Six cultivars of two-row winter barley, including Premium, Jagodinac, Record, NS-331, Crystal and NS-293, were analysed for grain yield and quality components.

A comparative field trial was conducted over a period of three years (2005-2008) on the experimental field of the Small Grains Research Centre, Kragujevac. The trial was set up in a randomised block design with 5 replications and the plot size of 5 m<sup>2</sup>. The cultivation operations employed during the trial were as usual in malting barley production.

Grain yield was determined on each plot and expressed in t/ha at 14% moisture content. Thousand-kernel weight, germination energy (%), protein content and malt extract yield were assessed four months upon harvest under laboratory conditions.

Grain protein content (% d.m.) was determined by Kjeldahl method and malt extract yield (% d.m.) by Bishop formula.

The results on yield and grain quality were subjected to a two-factor analysis of variance (SPPS, 1995). The significance of differences between individual means was tested by Fisher's LSD test.

### Results and discussion

Grain yield of barley is a complex trait of tremendous economic importance resulting from the effect of genotype and environment throughout the life cycle of the plant. It is particularly difficult to develop cultivars that will exhibit solely positive traits under distinct growing conditions, and resistance to biotic and abiotic stress factors (Pržulj et al. 1998.; Knežević et al. 2004.) The analysis of variance for grain yield showed significant differences among the cultivars, with the highest and lowest yield being obtained with cvs. Record and NS-331, respectively. Yield was significantly affected by both environmental conditions (year) and the genotype-year interaction.

An analysis of the interactive effects between genotypes and year reveals a similar tendency of cvs. Jagodinac, Record, NS-331 and NS-293 to respond to environmental conditions, as well as significant deviation of cv. Crystal (Table 1). The significance of the interactions is induced by the different behaviour of cv. Crystal, given the fact that its yield in the third year was comparable to that obtained in the second year, suggesting no response to improved environmental conditions.

The mean values within columns on years and cultivar-year interaction denoted with the same small letter are not significantly different at 95% according to LSD test

Thousand-kernel weight is a grain size trait related to the suitability of barley for malting production. Malting barley is of good quality if its 1000-kernel weight is above 38 g (Gaćeša et al. 1992). The highest 1000-kernel weight was produced in cv. Record and the lowest in cv. Jagodinac. The analysis of variance suggested significant differences among cultivars in this trait. Environmental conditions over the years also produced statistically significant effect, with significant interaction effects between cultivar and year being observed. Thousand-kernel weight was substantially lower in cvs. Premium, Jagodinac, Crystal and Record during the first year of the study as compared to cv. NS-293, but showed an increasing tendency in the second and third years. Cultivars Record and NS-293 stood out among the other cultivars as having a substantially higher 1000-kernel weight (Table 1). The strongest response to variable environmental conditions was exhibited by cv. Crystal, whereas the least variations, irrespective of the conditions, were observed with cvs. Record and NS-293. Similar responses were given by cvs. Jagodinac, Premium and Crystal. Substantial effects of production conditions on technological quality parameters were reported by Pržulj et al. (2000), Lookhart et al. (2001) and Knežević et al. (2004).

In view of malt being defined as the germinated barley, maltsters expect barley to germinate ten days after harvest and retain its viability for 365 days irrespective of storage conditions (Gaćeša et al. 1992.; Pržulj et al. 2000.). Certain grain traits, such as dormancy and hydrosensibility, are desirable agronomic traits though undesirable in technological terms; therefore, breeders are required to satisfy production and storage

requirements, on the one hand, and malting requirements, on the other (Pržulj et al. 2010). The cultivars displayed significant differences in germination energy, whereas the year effect had no substantial effect. Germination energy was highest in cv. Jagodinac and lowest in cv. Crystal. The lowest variation across years was observed in cv. Jagodinac. Conversely, cvs. Record and Premium exhibited significantly higher values in the second and third years. The analysis of the cultivar-year interaction effect indicates a specific response of each cultivar to germination energy. All cultivars were found to possess the required germination energy of above 90%.

Grain protein content is among key parameters of malting barley. The cultivars tested did not significantly differ in the trait, nor did environmental conditions produce any significant effect. This suggests that all of the tested cultivars can serve as equally valuable raw materials in the brewing industry. The choice of the most favourable cultivar can be determined by other production traits.

Malt extract yield determines the amount of beer produced after malting. The highest value for the trait was obtained with cv. NS-293, and the lowest with cv. Premium, which suggests differences between the two cultivars. Environmental conditions were not found to have any significant effect on this trait (Table 1).

**Table 1. Grain yield and quality components of winter barley cultivars over a three-year period**

		Grain yield $\text{tha}^{-1}$	1000-kernel weight (g)	Germination energy (%)	Protein content (%)	Malt extract yield (%)
Cultivars (A)	Premium	6.9ab	43.78bc	94.9b	10.64	80.28b
	Jagodinic	6.8 ab	43.60c	96.7a	10.24	80.78ab
	Record	7.0a	49.32a	94.5b	11.11	80.46ab
	NS-331	6.4b	45.57b	93.9b	10.28	80.44ab
	Crystal	6.8 ab	48.76a	92.9bc	10.93	80.82ab
	NS-293	6.6ab	48.74a	94.3c	10.82	81.08a
Years (B)	2005	5.6 c	44.55b	94.6	10.82	80.51
	2006	7.0 b	47.17a	94.3	10.52	80.78
	2007	7.8 a	48.16a	94.7	-	-
Premium	2005	5.2 g	41.70gh	92.0fg	10.78	80.00
	2006	7.1 cde	45.09ef	95.4cde	10.50	80.56
	2007	8.2a	44.60f	97.5a	-	-
Jagodinic	2005	5.7 g	40.30h	96.8abc	10.27	80.90
	2006	6.9 cde	45.48def	95.8abc	10.20	80.7
	2007	7.9 ab	45.10ef	97.4ab	-	-
Record	2005	5.5 g	48.43bcd	91.4g	11.39	80.41
	2006	7.2 b-e	49.62abc	95.2cde	10.83	80.51
	2007	8.3 a	50.07abc	96.8abc	-	-
NS-331	2005	5.6 g	43.82fg	95.8abc	10.39	80.98
	2006	6.5 ef	44.82f	93.8ef	10.18	81.18
	2007	6.8cde	48.09bcd	92.8fg	-	-
Crystal	2005	5.8 fg	43.79fg	96.0abc	11.19	80.13
	2006	7.4 bcd	50.41ab	91.2g	10.68	80.75
	2007	7.2 bcd	52.08a	91.6g	-	-
NS-293	2005	5.6 g	49.50abc	95.6b-e	10.88	80.62
	2006	6.6 de	47.64cde	94.6de	10.75	81.03
	2007	7.4 bc	49.10bc	92.6fg	-	-
ANOVA	Cultivar (A)	*	**	**	ns	*
	Year (B)	**	**	ns	ns	ns
	AxB	**	**	**	ns	ns

\*,\*\*, significant at 95 or 99% for cultivars according to LSD test and ANOVA results (F-test) respectively

## Conclusion

The three-year study suggests that grain yield of all of the cultivars tested was above 6 t/ha, being the highest in cv. Record and lowest in cv. NS-331. Grain yield was significantly affected by environmental conditions (year) as well as by the genotype-year interaction.

The analysis of variance showed significant differences in 1000-kernel weight. Cultivars Premium, Jagodinac, Crystal and Record exhibited substantially lower kernel weight in the first year, but an increasing tendency in the second and third years.

The strongest response to variable environmental conditions was exhibited by cv. Crystal, whereas the least variations, irrespective of the conditions, were observed with cvs. Record and NS-293. The analysis of the effect of the cultivar-year interaction reveals a specific response of each cultivar to germination energy. All cultivars were found to have germination energy of above 90%.

Environmental conditions had no significant effect on grain protein content and malt extract yield. This suggests that all of the tested cultivars can serve as equally valuable raw materials in the brewing industry.

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# Učinak dušika i zasušivanja na neka svojstva biljke pšenice

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## Sažetak

Cilj istraživanja bio je proučiti utjecaj genotipa i vodnog stresa pri različitim koncentracijama dušika na najznačajnija svojstva biljke i korijena u ranijim fazama razvoja pšenice. Za tu svrhu postavljen je staklenički mikropokus s pet genotipova pšenice, dvije razine opskrbe vodom i tri razine koncentracije dušika. Utvrđeno je da su se broj zelenih listova, ukupna masa biljke, masa zelenih listova, masa stabljike i površina zelenog lista povećavali dodavanjem dušika i vode. Broj i masa otpalih listova povećavali su se dodavanjem dušika, ali su se smanjivali dodavanjem vode. Statistički značajne interakcije zabilježene su najčešće između dušika i vode te između genotipa i dušika.

Gljučne riječi: pšenica, dušik, voda, stres, korijen

## Nitrogen and water stress effect on some wheat plant traits

### Abstract

The aim of this research was to study the influence of genotype and water stress, varying nitrogen concentrations, on the most important plant and root traits in the early stages of wheat growth. Greenhouse experiment was set-up with five genotypes, two levels of water supply and three nitrogen concentrations.

It was found that number of green leaves, plant weight, green leaf weight, stem weight and green leaf area were increased as nitrogen was increased and water was added. Number and fallen leaf weight were increased as we added nitrogen, but decreased by adding water. Statistically significant interactions were only found for nitrogen x water and genotype x nitrogen.

Key words: wheat, nitrogen, water, stress, roots

### Uvod

Jedan od najvažnijih oplemenjivačkih ciljeva u Poljoprivrednom institutu Osijek je pronalaženje genotipova pšenice posebno prilagođenih za uzgoj u Republici Hrvatskoj. Osobita pozornost poklanja se stvaranju genotipova koji osiguravaju stabilne prinose i u godinama s nepovoljnim klimatskim uvjetima (npr. suše nakon sjetve). Kako bi se ovaj cilj mogao ostvariti nužno je identificirati morfo-fiziološka svojstva ključna za daljnji razvoj biljke. Istraživanja su pokazala kako postoje genetske razlike u tolerantnosti na vodni stres i usvajanju dušika (Van Sanford i MacKowan, 1986), no mehanizmi koji uvjetuju ove razlike nisu u potpunosti razjašnjeni.

Cilj istraživanja je bio utvrditi koja su to vegetativna svojstva biljke pšenice u ranim fazama razvoja najviše izložena vodnom stresu i na koji način opskrba dušikom utiče na njih.

### Materijal i metode

Pokus je postavljen kao trofaktorijelni pokus u tri ponavljanja prema slučajnom bloknom rasporedu s pet genotipova pšenice (Alka, Felix, L84-2004, Srpanjka, Zlata), vodnim stresom (0-nenavodnjavano i 1-navodnjavano) i tri razine dušika (5, 10 i 15 mmol/L hranjive otopine) kao glavnim faktorima.

Sjetva je obavljena 10. rujna 2009. godine u stakleniku Instituta za jadranske kulture i melioraciju krša u Splitu u sjetvene ploče s 350 sjetvenih mjesta (volumena 30 mL) u substrat Brill tip 4. Posijano je po 200 zrna svakog genotipa nakon čega je zaliveno vodovodnom vodom. Nakon 4 dana biljke su počele nicati, te su do 8. dana svakodnevno navodnjavane vodovodnom vodom. Biljke s razvijenim listom dužine 5-10 cm presađene su 8. dan nakon sjetve u lonce promjera 14 cm (volumena 1000 mL). Korištena je smjesa supstrata Brill tip 4 i kvarcnog pijeska (granulacija 0,3 - 1,2 mm) u omjeru 1:2 (750 ml), dok je na dno lonca stavljeno 250 ml krupnog pijeska (granulacije 1-2 cm). Lonci s biljkama razmješteni su u četveroredne trake na razmak 70 cm između traka te 14 cm između i unutar reda. Biljke su zalivene vodovodnom vodom u količini 200 ml po biljci.

Biljke su spojene na sustav navodnjavanja kapanjem pomoću kapaljki (TORO company) kapaciteta 3 L/h i zalivene Hoagland-ovom hranjivom otopinom s 3 nivoa dušika (5, 10 i 15 mmol/L N) treći dan nakon sadnje. Zalijevanje je obavljano tri puta tjedno, u dva obroka po 100-150 mL hranjive otopine (drenaža 20%), ovisno o vremenskim prilikama i stadiju razvoja biljke.

Induciranje vodnog stresa (zasušivanje) počelo je 72 dana nakon sadnje i trajalo je deset dana (do točke venuća), nakon čega su biljke ponovno navodnjavane do povrata turgescencije u biljci. Devedeseti dan nakon sadnje na tri biljke po tretiranju izmjereni su: broj i masa (g) zelenih i otpalih listova, masa (g) stabljike i cijele biljke, površina (cm<sup>2</sup>) zelenih i suhih listova, te dužina (cm) i površina (cm<sup>2</sup>) korijena.

Statistička obrada podataka urađena je u SAS/STAT(R) 9.2 statističkom programu

(SAS Institute, 2009. SAS/STAT(R) 9.2 User's Guide, Second Edition).

### Rezultati i rasprava

U Tablici 1. prikazana je statistička značajnost učinaka temeljem analize varijance, ovisno o izvoru varijabiliteta, za analizirana svojstva. Od izvora varijabiliteta, najčešće statistički značajan učinak imali su dušik (za sva svojstva) i voda (osim za svojstva korijena).

Statistički značajna interakcije Genotip x Dušik zabilježena je jedino za masu i površinu zelenog lista. Od ostalih interakcija jedino je interakcija Dušik x Voda bila značajna za većinu analiziranih svojstava (Tablica 1).

Tablica 1. Značajnost efekata (Pr>F) za analizirana svojstva ovisno o izvoru varijabiliteta

Svojstvo	Izvor varijabiliteta							
	Rep	Dušik	Genotip	Genotip x Dušik	Voda	Dušik x Voda	Genotip x Voda	Genotip x Dušik x Voda
Broj zelenih listova	ns1	***2	***	ns	***	ns	ns	ns
Broj otpalih listova	ns	**2	*2	ns	***	ns	ns	ns
Masa zelenih listova	ns	***	**	*	***	***	ns	ns
Masa otpalih listova	ns	**	ns	ns	***	*	ns	ns
Masa stabljike	ns	***	**	ns	***	**	ns	ns
Ukupna masa biljke	ns	***	**	ns	***	**	ns	ns
Površina zelenog lista	*	***	**	*	***	***	ns	ns
Površina otpalog lišća	ns	*	ns	ns	***	**	ns	ns
Dužina korijena	ns	**	ns	ns	ns	ns	ns	ns
Površina korijena	ns	*	ns	ns	ns	ns	ns	ns

<sup>1</sup> ns- nije statistički značajno.

<sup>2</sup> \*, \*\*, \*\*\*- statistički značajno na razini vjerojatnosti p=0.95, 0.99 i 0.999.



## Učinak dušika i zasušivanja na neka svojstva biljke pšenice

Na osnovi dobivenih rezultata utvrdili smo da su se analizirana svojstva mijenjala neovisno o genotipu. Tako su se broj zelenih listova, ukupna masa biljke, masa zelenih listova, masa stabljike i površina zelenog lista povećavali s porastom koncentracije N i navodnjavanjem.

Broj i masa otpalih listova su se povećavali dodavanjem dušika, ali su padali dodavanjem vode. Za površinu otpalih listova, te dužinu i površinu korijena nisu uočene slične pravilnosti (Tablica 2).

Tablica 2. Prosječne vrijednosti analiziranih svojstava biljke neovisno o genotipu pšenice

Svojstvo	5 mmol/L N		10 mmol/L		15 mmol/L	
	0 <sup>1</sup>	1 <sup>2</sup>	0	1	0	1
Broj zelenih listova	58	86	69	115	80	135
Broj otpalih listova	37	25	69	34	73	38
Masa zelenih listova (g)	23.5	29.4	37.0	54.7	41.8	85.2
Masa otpalih listova (g)	4.2	2.5	12.7	3.6	16.1	4.9
Masa stabljike (g)	12.5	17.3	25.3	29.8	30.0	49.0
Ukupna masa biljke (g)	40.2	49.1	75.0	88.1	87.9	139.1
Površina zelenog lista (cm <sup>2</sup> )	1030.3	1275.6	1477.4	2173.7	1591.6	3314.0
Površina otpalog lišća (cm <sup>2</sup> )	197.7	212.7	546.6	147.8	543.3	210.1
Dužina korijena (cm)	17600.3	16694.9	13743.2	13051.9	10537.8	14332.6
Površina korijena (cm <sup>2</sup> )	2156.9	2350.4	1948.2	1924.2	1235.6	1791.9

1 - nenavodnjavano; 2 - navodnjavano.

Positivni učinak vode pri različitim koncentracijama dušika bio je najizraženiji pri 15 mmol/L za masu (povećanje 103.9%) i površinu zelenih listova (povećanje 108.2%). Nešto slabiji učinak bio je zabilježen za masu stabljike (63.4%) i ukupnu masu biljke (58.3%) (Tablica 3).

Tablica 3. Relativni učinak vode (%) na analizirana svojstva biljke pšenice ovisno o dušiku, a neovisno o genotipu

Dušik (mmol/L)	Voda <sup>1</sup>	Masa			Površina			Korijen	
		Zelenih listova	Otpalih listova	Stabljike	Ukupno biljke	Zelenog lista	Suhog lista	Dužina	Površina
5	0	100	100	100	100	100	100	100	100
	1	124.8	60.2	138.5	122.3	123.8	107.6	94.9	109.0
10	0	100	100	100	100	100	100	100.0	100
	1	147.7	28.2	117.9	117.4	147.1	27.0	95.0	98.8
15	0	100	100	100	100	100	100	100.0	100
	1	203.9	30.2	163.4	158.3	208.2	38.7	136.0	145.0

10 - nenavodnjavano; 1 - navodnjavano.

Primjena različite koncentracije dušika imala je najizraženiji učinak (u odnosu na kontrolnu varijantu) na masu otpalih listova (302.4 i 383.3%) i masu stabljike (202.4 i 240.0%) kod nenavodnjavanih biljaka. Kod navodnjavanih biljaka najizraženiji učinak primjene dušika bio je na masi zelenih listova (186.1 i 289.8%), kao i na ukupnoj masi biljke (179.4 i 283.3%). Negativan učinak primjene dušika uočen je za svojstva površine otpalog lišća kod navodnjavanje varijante (-30.5 i -1.2%), te neovisno o količini vode, kod dužine korijena (-21.9 i -40.1; -21.8 i -14.1%) i površine korijena (-9.7 i -42.7; -18.1 i 23.8%) (Tablica 4).

Tablica 4. Relativni učinak dušika (%) na analizirana svojstva biljke pšenice ovisno o vodi, a neovisno o genotipu

Dušik (mmol/L)	Voda <sup>1</sup>	Masa			Površina			Korijen	
		Zelenih listova	Otpalih listova	Stabljike	Ukupno biljke	Zelenog lista	Suhog lista	Dužina	Površina
N5	0	100.0	100.0	100.0	100.0	100	100	100	100
N10	0	157.4	302.4	202.4	186.6	143.4	276.5	78.1	90.3
N15	0	177.9	383.3	240.0	218.7	154.5	274.8	59.9	57.3
N5	1	100.0	100.0	100.0	100.0	100	100	100	100
N10	1	186.1	144.0	172.3	179.4	170.4	69.5	78.2	81.9
N15	1	289.8	196.0	283.2	283.3	259.8	98.8	85.9	76.2

10 - nenavodnjavano; 1 - navodnjavano.

Ovi rezultati su u podudarnosti s rezultatima drugih autora (Ehdaie i sur., 2010), koji navode da dušik i dodane količine vode u fazama ranog porasta povećavaju biomasu pšenice. No, vezano uz utjecaj genotipa na svojstva korijena pšenice rezultati se ne podudaraju s rezultatima drugih autora (Ehdaie i Waines 2006), koji su utvrdili genetsku varijaciju za svojstva korijena. Ovakav rezultat je vjerojatno ovisio o izboru eksperimentalnog materijala.

### Zaključci

Na osnovi provedenih istraživanja uočeno je da postoji određena genetska varijabilnost za analizirana svojstva. Također, utjecaj dušika i vodnog stresa kao glavnih faktora varirao je ovisno o analiziranim svojstvima, a statistički značajne interakcije zabilježene su najčešće između dušika i vode te između genotipa i dušika.

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# Quality traits of international wheat cultivars grown under Kosovo condition

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## Abstract

Wheat cultivars grown today in Kosovo were originally developed and released in former Yugoslavia or other European countries. In the present study 7 winter wheat were tested for their quality traits (protein and gluten content, dough mixing and extension characters and SDS sedimentation test) during growing season 2009-2010. Highest values for most quality traits were recorded for the cultivars 'Luna' and 'Lenta', originating from Croatia. Regarding agronomic traits the best performance for grain yield indicated cultivars 'Pobeda' and 'Evropa' from Serbia, whereas for 1000 kernel weight best performance had cultivar 'Luna'. The study demonstrated, that within these 7 international wheat cultivars, cultivar 'Luna' is best adapted to Kosovo growing conditions providing a relatively high yield but excellent quality traits. It is suggested, that Kosovar farmers should increase the cultivation of 'Luna' within the next years in order to increase both wheat quality and wheat production. However, creation of domestic wheat cultivars adapted to its prevalent growing condition remains still a big challenge for Kosovar experts and companies.

Key words: winter wheat, quality traits, bread making quality, yield, Kosovo

## Introduction

Common wheat (*Triticum aestivum* L.) is the most important food crop in the world and it is the only material suited for the production of leavened bread and associated products. The baking quality deepens on both genetic (cultivar) and environmental (geographical origin /climate, fertilization) factors. One of the most important criteria is the loaf volume resulting from baking test. High protein content has a positive effect on the loaf volume (Finney, 1985, Pomeranz, 1988) and it is an important factor in defining the price of wheat lot. However, protein content is strongly influenced by environmental factors (Pechanek et al. 1997). Wheat cultivars grown today in Kosovo, which were originally developed and released in neighbouring countries and are, therefore, not best adapted to the Kosovo growing condition.

Very often, farmers and millers in Kosovo are faced with problems caused by import of the wheat cultivars with low quality for bread production. Therefore, the objective of study was evaluation of the quality traits of international wheat cultivars grown under Kosovo condition. Outcome results will help directly the farmers to choose the best cultivars for sowing and indirectly would help the millers and bakeries to produce quality flour and quality bread, respectively.

## Material and methods

Seven wheat cultivars of different origin 'Evropa', 'Pobeda' and 'Renesanca' (Serbia), 'Justus' and 'Brutus' (Austria), 'Lenta' and 'Luna' (Croatia), 'Isengrain' (French), were used in the field trial in the year 2009-2010. Experiment was located in Viti, which lies between 500 and 600 meter above sea level and is characterised by an annual mean rainfall of 640 mm and an annual mean temperature of 10°C. In this trial the randomised block design was used. Sowing was carried out using the seed machine "Reform", seed density was 275 kg ha<sup>-1</sup>, plot size was 60 m<sup>2</sup> (3mx20m) and for each cultivar three replications were used. Fertilisation followed the

usual standards for wheat production in Kosovo by applying 60 N, 60 P and 60 K (kg ha<sup>-1</sup>) before sowing and 60 N in mid-March. For yield (YLD) estimation was harvested 1 m<sup>2</sup> for each sample and consequently threshed in a stationary thresher, whereas the rest of the wheat plants were harvested by standard thresher.

1000 kernel weight (TKW) and test weight (TW) were analysed at the laboratory of Faculty and Veterinary in Prishtina, protein content was determined by near-infrared transmittance spectroscopy at the BOKU Vienna, dough rheological characteristics were determined on 200 g flour samples using a Brabender Farinograph (DDT, dough development time; DST, dough stability; DSO, dough softening and QN, quality number) and Extensograph apparatus (R<sub>max</sub>, maximum dough resistance to extension; E', dough extensibility; DE, dough energy) at the laboratory of M & Sillos Mill in Xerxa, Kosovo. SDS-sedimentation test was determined in the laboratory of Saatzucht Donau, Probstdorf, Austria, according to Dick & Quick (1983) using a 1 g whole-meal flour, milled with a Cyclotec mill equipped with a 1 mm sieve. Chopin Alveograph properties and wet gluten were analysed at the private laboratory for cereals processing (Versuchsanalt für Getreideverarbeitung, VFG) in Vienna. Results were statistically by one way ANOVA and Tukey HSD test analysed.

### Results and discussion

Overall average grain yield of the evaluated cultivars in the year 2010 was 1950 kg ha<sup>-1</sup>. The reason for low yield was the unfavourable weather condition (high amount of precipitation) prevailed during flowering and grain filling phases, which directly affected the grain yield and grain quality. Among the cultivars the best performance for grain YLD indicated cultivars 'Pobeda' and 'Evropa', followed by cultivars 'Lenta' and 'Isengrain'; however the differences were not significant (Fig. 1). Regarding agronomic traits a significant differences were achieved for TKW and TW. For TKW the best performance had cultivars 'Luna', 'Pobeda' and 'Renesanca', whereas for TW the best performance had cultivars 'Lenta' and 'Pobeda' (Fig 2). By all graphics means with the same letter are not significant from each other.

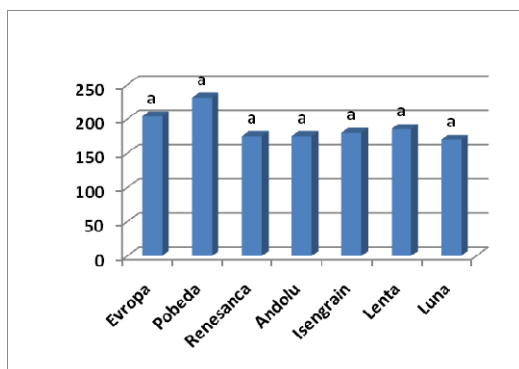


Figure 1. Grain yield (g m<sup>-1</sup>)

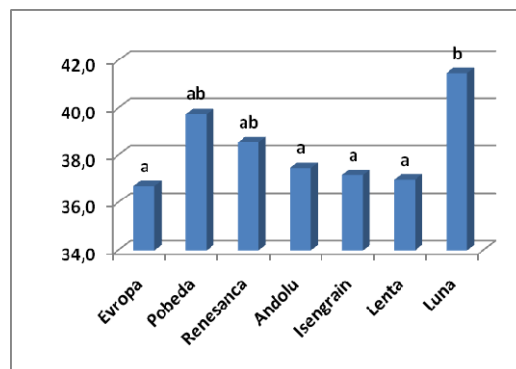


Figure 2. 1000 kernel weight (g)

Significant results were achieved for protein content, SDS-sedimentation test and almost quality traits carried out by Brabender Farinograph, Extensograph and Chopin Alveograph. For protein content, SDS-Sedimentation test, DDT and 'W of Chopin' cultivars 'Lenta' and 'Luna' were superior, whereas cultivars 'Evropa' 'Pobeda', 'Renesanca', 'Andolu' and 'Isengrain' had middle till inferior performance. (Fig. 3, 4, 5). It seems that cultivars from Croatia are best adapted to Kosovo growing condition. A high quality of Croatian cultivars is defined through its glutenin subunits composition for 'Luna' 1/7+9/5+10 und 'Lenta' 1/7+9/2+12. It is well known that protein bands 7+9/ 5+10 are responsible for very good quality and protein bands 7+9 / 2+12 are responsible for relatively good quality (Gröger et al. 1997a). Classification criteria of the cultivars into quality groups are different from county to country. For example in francophone countries the Chopin Alveograph is commonly used to determine the bread making quality of wheat (AACC, 1990).

## Quality traits of international wheat cultivars grown under Kosovo condition

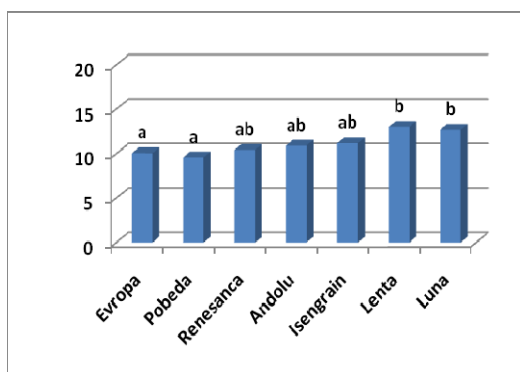


Figure 3. Protein content (%)

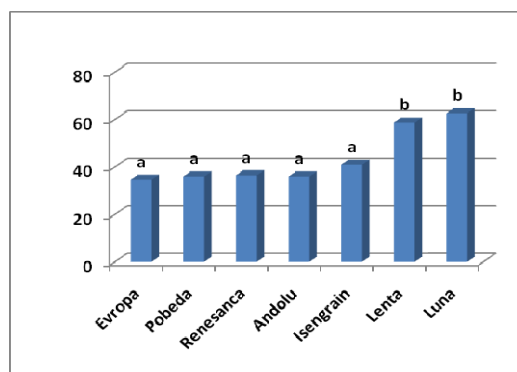


Figure 4. SDS Sedimentation test (ml)

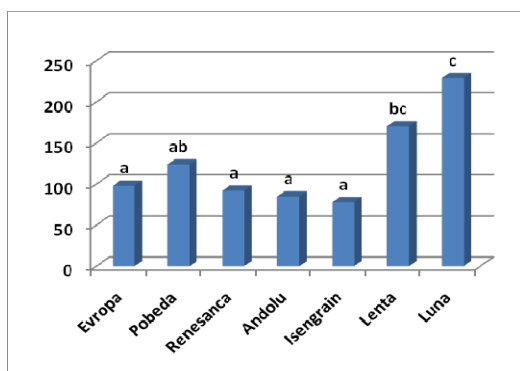


Figure 5. W of Chopin

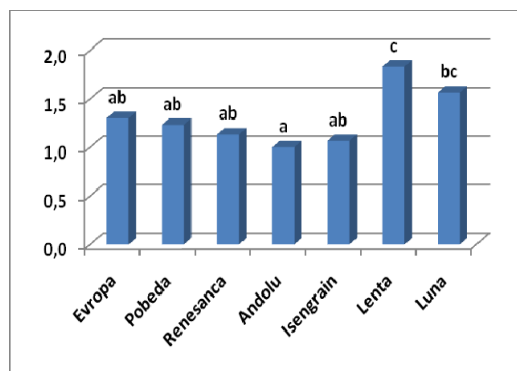


Figure 6. Dough development time (min)

The main trait derived from Chopin Alveograph is “W of Chopin”, which express the amount of the energy required to inflate the dough bubble to bursting point (Fig. 5). Cultivars, with the “W of Chopin” value 150-250 may be used as improver wheat and cultivars with value higher as 250 are high quality wheat with high protein level and excellent bread making quality. According to this trait “W of Chopin” in our study, only cultivars from Croatia ‘Luna’ can be classified as high quality wheat and ‘Lenta’ can be classified and used as improver wheat (Fig. 5). In many Western and Eastern European countries wheat cultivars are classified into quality groups based on Faringraph traits, protein content or SDS sedimentation test (Pelshenke, 1933, Fuchs 1954, Belderok, 1977, Oberfoster et al, 1994, Gröger et al, 1997 a). Based on these criteria and according to its performance, these 7 wheat cultivars grown under Kosovo condition in vegetation season 2009/2010 can be classified into quality group as follows: ‘Luna’=B1/B2, ‘Lenta’=B1/B2, ‘Andolu’=B2/C1, ‘Evropa’=C1, ‘Pobeda’=C1, ‘Renesanca’=C1 and ‘Isengrain’=C1. This indicates that cultivars from Serbia had a low bread making quality, but they were relative good in YLD.

A Pearson correlation was carried out. Generally, the positive correlation between protein content and dough development time (DDT)  $r=0,566^{**}$ , dough stability (DST)  $r=0,843^{**}$ , dough softening (DSO)  $r=-0,698^{**}$  and dough energy (DE)  $r=0,515^{*}$ , were recorded. Relation between protein content and mixing characters are well established (Feil, 1997, Triboi & Triboi-Blondel, 2002). In the present study no correlation between yield and protein content was found, however, the correlation between yield and DSO was positive  $r=0,442^{*}$ .

## Conclusion

It can be summarized that cultivars ‘Luna’ and ‘Lenta’ from Croatia are best adapted wheat cultivars presently available for growing in Kosovo. ‘Luna’ showed both agronomic and quality traits superior to the other cultivars, whereas cultivar ‘Lenta’ was best performed in regard to quality parameters. It is suggested, that Kosovan farmers should increase the cultivation of ‘Luna’ within the next years in order to increase both wheat production and wheat quality. It is an outmost need of Kosovo to start with the wheat breeding and to create its own cultivars adapted to Kosovo growing condition. Not always, foreigner cultivars adapted on its

region are suitable for growing in other regions. Therefore, creation of new cultivars for Kosovo, can boost Kosovar wheat production and wheat quality in the nearest future

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# Impact of changes in climate conditions on the technological quality of wheat

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## Abstract

The aim of this paper was to describe the impact of changes in climate conditions on the technological quality of wheat. Average wheat flour samples have been tested by Standard methods for the determination of technological wheat quality with extensograph, farinograph, amylograph and alveograph. Obtained results showed that in period of ten years climate conditions caused differences in wheat technological quality.

Key words: wheat, technological quality, climate conditions

## Introduction

Wheat is grown under a wide range of environmental conditions where climatic factors such as temperature and moisture combined with agronomic inputs such as fertilizer exert diverse effects on plant growth and metabolism. The manifestation of those effects in the developing kernel impacts the value of the crop by influencing yield, grain characteristics and flour quality (Altenbach et al., 2003). Also, the effect of an environmental factor depends on the developmental stage of the plant (Triboi et al., 2006). Grain quality is a function of grain composition (Triboi et al., 2000), and quality vary considerably as a result of environmental conditions during grain-fill (Dupont and Altenbach, 2003).

The aim of this research was to define possible consequences of changes in climate conditions on the technological quality of wheat.

## Material and methods

Analyzed samples originated from ten wheat production years: 2001-2010, which were characterized by very different climate conditions. The samples were collected from numerous locations of Serbia and their parts used to form average year samples.

Average wheat flour samples have been tested by Standard methods for the determination of technological wheat quality: rheological examinations with extensograph, farinograph, amylograph and alveograph (ICC Standard No. 114/1, ICC Standard No. 115/1, ICC Standard No. 126/1 and ICC Standard No. 121). Laboratory test baking method was applied according to Torbica et al (2007).

## Results and discussion

We considered the impact of changes in climatic conditions in the territory of Serbia on the technological quality of wheat *Triticum aestivum* during the past ten years. Generally, in this period altered technological wheat quality can be considered depending on extremely hot days and exceptionally large amounts of rainfall, as well as their indirect consequences. High temperatures in the period from May to July, as well as during the harvest, have been notified in 2004 and 2009 years. Extremely large amounts of rainfall and harvest interrupted by rain were characteristic of the 2005, 2009 and 2010 years.

Development of field molds and insects are the indirect influence of climatic conditions. In Serbia, as well as the most Mediterranean countries, during the past ten years the intensive attacks of wheat bugs have been typical. Especially, in Serbia it was characteristic for 2004 year. Direct and indirect climate impacts have contributed to the trade and technological wheat quality in Serbia. The good trade quality did not mean the good technological wheat quality and vice versa. Until 2010, according to standard parameters, wheat possessed good to excellent trade quality, but poor and problematic technological quality. However, the wheat from harvest in 2010 was estimated on the basis of standard parameters as poor quality - trade and technological.

The average values of usual technological quality parameters of dough made from wheat flour, showed the trend of reducing during the last decade. Also, the same parameters were characterized by very broad ranges, which indicate uneven technological quality of wheat in Serbia. Figures 1, 2 and 4 show the average values of extensogram (Fig. 1), farinogram (Fig. 2) and amylogram (Fig. 4) parameters in the period from 2001 to 2010 year. Average energy values obtained by extensograph are generally low (except in 2006) from the standpoint of the required energy values for bread making. It was found that during that period, low energy values were not a consequence of small amounts of protein and Zeleny sedimentation values as a measure of their quality (Mastilović et al., 2005; Torbica et al., 2010b). Also, the average parameters values of farinogram during the same period (Fig. 2) show that the average value of the water absorption was almost unchanged, while in the last five years the average values of the degree of softening were increased. On this way the flour quality number gradually reduced, which ranked flours in the lower categories within the quality group (A1 is the best, C2 is the worst).

Based on the standard interpretation of extensogram and farinogram parameters values could be concluded that bread making is impossible or that bread quality will be unacceptable. However, the practice denied it. Moreover, in the year 2004 the flour samples which could not register energy at extensogram could be divided into two groups by bread making properties. The first group of flour samples had destroyed proteins structure as a result of attacks of wheat bugs, and even though with additives could not possible to produce bread. Another group of flour samples was due to heat stress had increase in amount of gliadin in relation to common values. Altered ratio of gliadin and glutenin caused extremely increased extensibility of dough, but with the addition of additives to these flour samples producing of bread was possible (Torbica et al., 2007). Based on experience of examined time period can be concluded that the energy values of the extensogram can not be interpreted as in previous decades in the evaluation of technological wheat quality. An example of similar bread making properties of two flour samples with quite different energy values on extensogram, work of deformation on alveogram and similar values of maximum viscosity at amylogram is shown in Figure 3.

The values of maximum viscosity measured at amylograf show decreasing trend (Fig. 4) and it can not be interpreted as in previous decades in the estimation of technological wheat quality like as in the case of energy on extensogram. It was found that in the examined time period low values of maximum viscosity at amylogram were caused by two different impacts of climate conditions. Those impacts were heat stress (which caused a disturbance in the synthesis of wheat starch) (Torbica et al., 2010a) and prolonged heavy rainfall (Mastilović et al., 2005; Torbica et al., 2010b).

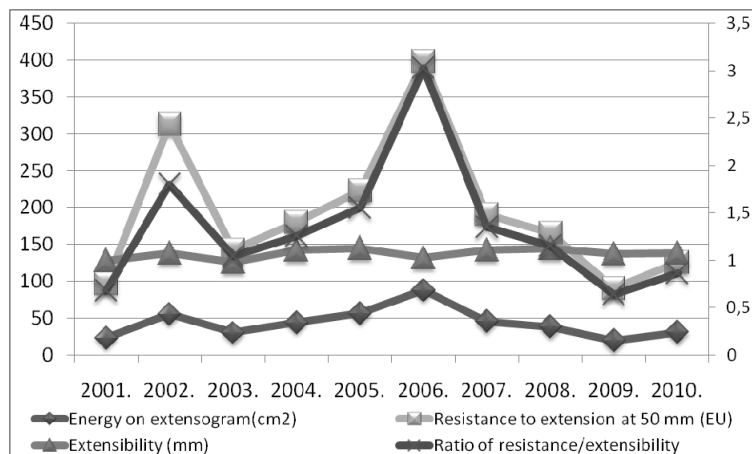


Figure 1. Values of extensogram parameters of average flour samples measured by extensograph



Impact of changes in climate conditions on the technological quality of wheat

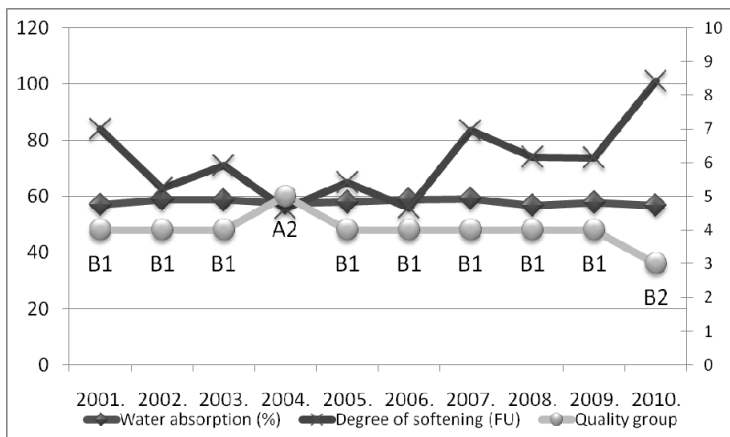
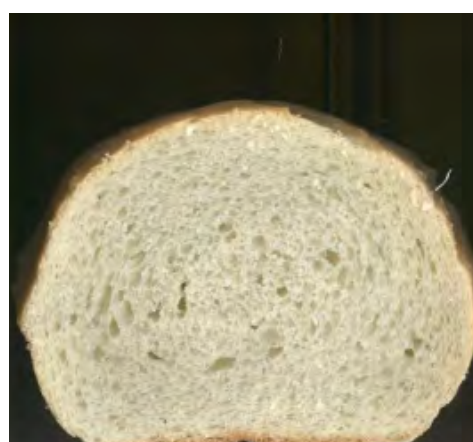


Figure 2. Values of farinogram parameters of average flour samples measured by farinograph



a)



b)

Figure 3(a,b). Photos of bread samples (a) from dough with E=28 cm<sup>2</sup>, W=115 10-4J i 315 AU and (b) from dough with E=56 cm<sup>2</sup>, W=159 10-4J i 285 AU

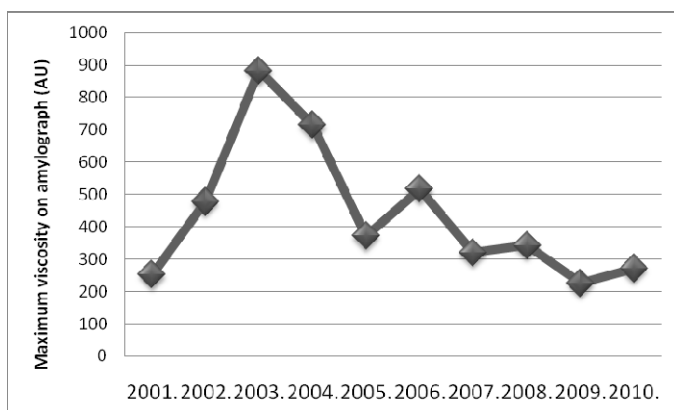


Figure 4. Values of amylogram parameters of average flour samples measured by amylograph

An example of similar bread making properties of two flour samples with quite different values of the maximum viscosity at amylogram is shown in Figure 5. The different values of the maximum viscosity of these flour samples were caused by the difference in the amount of rainfall at their grown wheat areas (a-wheat-from localities with high rainfall; b-wheat with localities with low rainfall). Bread produced from flour sample with a low value of the maximum viscosity (155 AU) in relation to the bread produced from flour sample with a higher value of maximum viscosity (370 AU) had a slightly lower specific volume (6.20 in comparison to 6.56 ml/g), slightly better elasticity, darker color of the crust and finer pores.



Figure 5. Photos of bread samples a) from flour sample which maximum viscosity at amylograph was 155 AU and (b) from flour sample which maximum viscosity at amylograph was 370 AU

### Conclusion

Technological quality of wheat was under strong influence by changes in climatic conditions at territory of Serbia in last decade. There are more than one climatic changes which caused the same effect on processing wheat quality, and on contrary there are different effects on wheat quality which are caused by the same climatic condition. Based on obtained results of analysis in examined time period, it is clear that values of the usual wheat quality parameters can not be interpreted as in previous decades in the predicting of technological wheat quality.

### Acknowledgements

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# Influence of climate conditions at damage starch content of wheat

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## Abstract

The effect of weather conditions and sprout kernels content at damage starch content of wheat was examined in our experiment. Wheat samples were examined by determination of sprout kernel content and Falling Number, whereas starch damage content was determined on wheat flour samples.

Statistical analyses showed that exist significant differences between production year in damage starch content and Falling Number value, which could be explained by difference in climate conditions in those productions years. Weather conditions influence on reduction of starch damage content on the group of twelve wheat samples of which nine showed that it was statistically significant. The other five samples did not show the same trend of reduction of damage starch content.

Key words: damage starch, wheat, Falling Number, climate condition

## Introduction

During wheat milling, a portion of the starch granules sustains mechanical damage. The level of the damage varies with the severity of grinding and the hardness of the wheat (Hoseney, 1994). Damaged granules differ from sound granules in two important aspects: they are significantly more susceptible to attack by  $\alpha$ -amylase and they have an increased ability to bind water (Evers and Stevens, 1985). A certain level of starch damage is desirable because it optimizes hydration and promotes fermentation activity during breadmaking. However, excessive starch damage can overly hydrate the dough and allows accelerated enzymatic action. Thus, it might result in sticky dough and cause problems with slicing and handling of the bread (Ranhotra et al., 1993). Also, In flour used for cookies and cakes, where minimal water absorption is required and  $\alpha$ -amylase susceptibility is not a factor, minimal starch damage is desirable (Evers and Stevens 1985). Hence the level of starch damage is an important quality index for the evaluation of hard and soft wheat flours.

Methods currently used for the determination of damaged starch are based on enzymatic and iodometric assays (Lin and Czuchajowska, 1996). Enzymatic methods depend on the increased susceptibility of damaged granules to be attacked by alpha-amylases. The resultant products are measured volumetrically or spectrophotometrically. Iodometric methods depend on the increased reactivity of damaged granules with iodine and the reaction is measured amperometrically or colorimetrically (Morgan and Williams, 1995).

The wet conditions that prevailed at harvest time in many locations led to sprouting of the wheat. Sprout damage is associated with high levels of  $\alpha$ -amylase, which, during dough mixing and fermentation processes, degrades starch. This leads to a reduced water holding capacity of the dough, thereby necessitating a decrease in baking absorption. Sticky doughs can also result, leading to handling problems, a more open and coarse crumb structure, and gummy crumb (Dexter and Edwards, 1997). One of the ways for measurement of  $\alpha$ -amylase activity in wheat grains and flour to detect sprout damage is Falling Number.

The aim of this work is to show how damage starch content of wheat flour depends of weather conditions and sprout kernels.

## Materials and methods

Samples of seventeen wheat varieties, grown under the same cultivation conditions in 2008 and 2009 years, which were differ in climate conditions, were examined.

Sprout kernel content in wheat samples was determined according to Regulation of methods of physical and chemical analysis for quality control of grain, milling and bakery products, pasta and quickly frozen dough (Službeni list SFRJ, br.74, 1988). Damage starch content in wheat flour samples, which was extracted from wheat kernels at Bühler MLU 202 mill, was examined according to official enzymatic AACC Method 76-31. Falling Number was determined according to ICC Standard No. 107/1.

Mean values of Damage starch content and Falling Number, were tested by ANOVA, whereas differences among individual mean values were determined by *Duncan* test at significance level of 0.05. Softver *STATISTICA* 8.0 were used for statistical calculation.

## Results and discussion

It is mentioned above that climate conditions influence on bread-making quality. Climate conditions just before and during harvest in 2008 and in 2009 were quite different. June 2008

(for the Republic of Serbia) was warm and dry with rainfall below seasonal norm for this month. At mid-June started an increase in temperature, therefore at the end of the month it reached a value which were above or quite above the seasonal norm (Torbica et al., 2008). June 2009 was relatively warm but stormy with large amounts of rainfall, especially at the last ten days of the month. In the first decade of July the rain was falling almost every day, and in some places there was heavy rainfall which were followed by storm wind and the hailstone (Torbica et al., 2009).

It has been found that climate conditions influence at existence of sprout kernel in wheat samples and it was in accordance with findings of Dexter and Edwards (1997). Therefore, sprout kernels were not found in every wheat sample which was harvested in 2008 year. However, most of the wheat samples, which were harvested in 2009 year, poses sprout kernels (variety: Dragana, Arija, Ljiljana, Pobeda, Nevesinjka, Dama, NS 40S, Kantata, Rapsodija, Simonida, Etida and Renesansa; and sprout kernel content: 0.36%, 0.22%, 0.27%, 0.28%, 0.08%, 0.42%, 0.72%, 0.24%, 0.12%, 1.70%, 0.56% and 0.68%, respectively). Average sprout kernel content in wheat samples did not reach average values of 1.15% for Republic of Serbia according Torbica et al. (2009), probably due to lower amounts of rainfall during harvest for area where wheat samples were grown.

Statistical analyses showed that exist significant differences between production year in damage starch content and Falling Number value, which could be explained by difference in climate conditions in productions years. The results in table 1 show that damage starch content of the most wheat samples (Vojvodina, Angelina, Dragana, Arija, NS Rana 5, Pobeda, Nevesinjka, Dama, NS 40S, Kantata, Etida and Renesansa) was statistically increased ( $p < 0.05$ ) in 2009 year when it was compared to the results from 2008 year. Also, three wheat samples (Evropa 90, Rapsodija and Simonida) showed increase in damage starch content when compared the results in 2009 and in 2008 year, but it was not statistically significant. However, two varieties (Ljiljana and Bastijana) showed decrease in damage starch content when compared to the results in 2009 and in 2008 year. Also, it was not statistically significant.

The Falling Number results segregate wheat samples in three groups (Table 1). First group (Vojvodina, Dragana, Arija, Ljiljana Pobeda, Bastijana, Nevesinjka, Evropa 90, NS 40S, Kantata, Rapsodija, Simonida and Etida), in which value of Falling Number in 2009 year was significantly lower ( $p < 0.05$ ) in comparison to the results in 2008 year. The reason for this decrease is likely due existing of sprout kernels in the most of the examined wheat samples (Dragana, Arija, Ljiljana Pobeda, Nevesinjka, NS 40S, Kantata, Rapsodija, Simonida and Etida). Second group (Angelina, NS Rana 5 and Dama), showed statistically significant increase ( $p < 0.05$ ) in Falling Number value when were compared to the results in 2009 and in 2008 years. However, third group of only one sample (Renesansa) did not show change of Falling Number value in two different growing years.

## Conclusion

It could be concluded that nine wheat samples (Vojvodina, Dragana, Arija, Pobeda, Nevesinjka, NS 40S, Kantata, Etida and Renesansa) showed statistically confirmed increased ( $p < 0.05$ ) of damage starch content in second production year as well as statistically significant decreased ( $p < 0.05$ ) of Falling Number values. Also, three wheat samples (Evropa 90, Rapsodija and Simonida) which showed increase in damage starch content in second year exhibit statistically significant decrease ( $p < 0.05$ ) of Falling Number values. It could be concluded that weather conditions influenced on reduction of starch damage content in these two groups of samples. However, two wheat samples (Ljiljana and Bastijana) showed decrease in damage starch content in second production year; even though Falling Number values have the similar trend of statistically significant decrease. Moreover, group of three wheat samples (Angelina, NS Rana 5 and Dama) which showed statistically confirmed increased ( $p < 0.05$ ) of damage starch content in second production year, exhibits statistically significant increase ( $p < 0.05$ ) of Falling Number values. It could be concluded that these five samples did not show the same trend of reduction of damage starch content as twelve examined samples.

For better understanding influence climate conditions on starch damage content in wheat it is necessary to continue investigation, especially to find samples from areas with extreme rainfall during harvest.

**Table 1. Damage starch content and Falling Number of wheat varieties in two different production years.**

Production year	Varieties	Damage starch content mean (%)	Falling Number mean (s)
2008	Vojvodina	7.32 <sup>l</sup>	387.8 <sup>mn</sup>
	Angelina	7.02 <sup>kl</sup>	257.5 <sup>f</sup>
	Dragana	7.39 <sup>l</sup>	396.0 <sup>n</sup>
	Arija	6.65 <sup>ijk</sup>	325.8 <sup>j</sup>
	Ljiljana	5.70 <sup>bcd</sup>	357.8 <sup>l</sup>
	NS Rana 5	5.5 <sup>bcd</sup>	330.5 <sup>j</sup>
	Pobeda	5.37 <sup>abc</sup>	387.5 <sup>mn</sup>
	Bastijana	5.81 <sup>cdefg</sup>	340.8 <sup>k</sup>
	Nevesinjka	5.57 <sup>bcd</sup>	443.8 <sup>o</sup>
	Dama	5.95 <sup>defgh</sup>	230.3 <sup>e</sup>
	Evropa 90	5.80 <sup>cdefg</sup>	386.0 <sup>m</sup>
	NS 40S	5.20 <sup>ab</sup>	307.8 <sup>i</sup>
	Kantata	4.98 <sup>a</sup>	250.5 <sup>f</sup>
	Rapsodija	5.36 <sup>abc</sup>	494.3 <sup>p</sup>
	Simonida	5.82 <sup>cdefg</sup>	309.8 <sup>l</sup>
	Etida	6.08 <sup>efgh</sup>	328.8 <sup>j</sup>
Renesansa	5.77 <sup>cdef</sup>	218.8 <sup>d</sup>	
2009	Vojvodina	9.81 <sup>o</sup>	363.5 <sup>l</sup>
	Angelina	8.06 <sup>m</sup>	270.8 <sup>g</sup>
	Dragana	9.67 <sup>o</sup>	204.0 <sup>c</sup>
	Arija	7.41 <sup>l</sup>	273.8 <sup>g</sup>
	Ljiljana	5.35 <sup>abc</sup>	332.8 <sup>ijk</sup>
	NS Rana 5	6.06 <sup>efgh</sup>	379.5 <sup>m</sup>
	Pobeda	6.60 <sup>ijk</sup>	308.5 <sup>i</sup>
	Bastijana	5.67 <sup>bcd</sup>	289.5 <sup>h</sup>
	Nevesinjka	6.43 <sup>hij</sup>	266.3 <sup>g</sup>
	Dama	6.81 <sup>jk</sup>	328.3 <sup>j</sup>
	Evropa 90	6.22 <sup>fghi</sup>	315.5 <sup>i</sup>
	NS 40S	6.42 <sup>hij</sup>	167.8 <sup>b</sup>
	Kantata	7.29 <sup>l</sup>	217.5 <sup>d</sup>
	Rapsodija	5.84 <sup>cdefg</sup>	333.5 <sup>jk</sup>
	Simonida	5.96 <sup>defgh</sup>	252.8 <sup>f</sup>
	Etida	8.72 <sup>n</sup>	111.0 <sup>a</sup>
Renesansa	6.29 <sup>ghi</sup>	217.0 <sup>d</sup>	

### Acknowledgement

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# The evolution of *Septoria tritici* attack to winter wheat in ARDS Simnic area

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## Abstract

*Septoria tritici* blotch is one of the most important foliar diseases which affected wheat worldwide. The increase in the economic importance of *Septoria tritici* blotch was largely due to the widespread and rapid replacement of local wheat cultivars with early-maturing, semidwarf cultivars that were susceptible to the pathogen. Twenty-five winter wheat cultivars were evaluated for their reaction to *Septoria tritici* attack considering their susceptibility and specific stature. Depending on these the cultivars behavior was different. It was observed that the distance between first emerging three to four leaves are similar for short and tall cultivars. In the next growth stages for tall cultivars *Septoria* progress was lower comparatively with shorter ones because the closeness of the upper leaves to the lower leaves facilitates contact between newly emerging leaves and splashed pycnidiospores. SPC was low for the cultivars for which *Septoria* progressed only to basal or to the middle leaves, even these cultivars recorded different attack degree values. The correlation coefficient between plants height and disease progress height (cm) was -0.73 showing that disease progress height is higher as plant height is low.

Key words: *Septoria tritici*, wheat, yield, disease severity

## Introduction

*Septoria* is the name commonly applied to more than 1000 species of fungi, most of which are plant parasites. Approximately 100 species are parasitic on cereals and grasses. Many of them are economically important on crops other than cereals (Scharen and Sanderson, 1985). There are two major *septoria* diseases that cause problems in wheat in many parts of the world. These are *Septoria tritici* blotch (syn. *Septoria* leaf blotch) incited by the fungus *Septoria tritici* (telemorph: *Mycosphaerella graminicola*) and *Septoria nodorum* blotch (syn. *Septoria* glume blotch of wheat) caused by the fungus *Septoria (Phaeosporia) nodorum* (telemorph: *Leptosphaeria nodorum*). Both diseases cause serious yield losses (Rajaram and Dubin, 1977; Eyal, 1981). Even if in normal years yield losses ranged from 3

% to 5% (Barbulescu, 2001), have been reported that yield losses attributed to heavy incidences of *septoria* diseases ranged from 31% to 53% (Eyal, 1981). Under severe epidemics, the kernels of vulnerable wheat cultivars are shriveled and are not fit for milling. The increase in the economic importance of *Septoria tritici* blotch was largely due to the widespread and rapid replacement of local wheat cultivars with early-maturing, semidwarf cultivars that were susceptible to the pathogen. Cultivars with adequate resistance are now replacing the original introductions. Changes in cultural practices have also significantly contributed to the increase in disease incidence. The aim of this research was to evaluate the disease progress with time, considering wheat cultivars susceptibility and specific stature which may provide some explanation as to relationship between disease and plant development and its reflection on yield.



## Material and methods

The experiment was conducted in the Breeding and Plant Protection Laboratory field from ARDS Simnic on brown reddish soil (pH 5.6; 1.8% humus). Twenty-five winter wheat cultivars with diverse origin were evaluated for their response to *Septoria tritici* natural infection under field conditions. Plots were fertilized at sowing time with 40 kg/ha of N and 40 kg/ha of P<sub>2</sub>O<sub>5</sub> basal applied and top-dressed with 60 kg/ha of N on early spring (March). The layout was a randomized complete block design in a strip-plot system with three replications. Plot size was 10 m<sup>2</sup>. Seeding was on October 15<sup>th</sup> 2009 using a seed rate of 550 grains/ m<sup>2</sup>. To observe the effects of infection on yield, the disease was evaluated also between medium milk (growth stage 75) and late milk (growth stage 77). Growth stages of plants were recorded according to the Zadoks scale (Zadoks et al., 1974) modified by Tottman and Makepeace (Tottman and Makepeace, 1979). Disease evaluation was started when initial necrotic symptoms were noticed in the canopy of the wheat cultivars. Individual leaf-disease rating was averaged to obtain a mean score for each replication. For each score,

percent disease incidence (I) was estimated based on the formula:  $I\% = \frac{n \times 100}{N}$ , where  $n$  is the number of

diseased plants,  $N$  is plants total number/ m<sup>2</sup>. Disease severity (S) was estimated using Bronnimann scale (Bronnimann, 1968), determining the area of dead tissue on the affected plant. The data were used to calculate the attack degree (AD) following formula:  $AD\% = (S\% \times I\%) / 100$  (Savescu et al., 1969). Cultivars susceptibility to *Septoria tritici* pathogen was evaluated using Rosielle scale (Rosielle, 1972). To evaluate disease progress considering plants stature was used Septoria progress coefficient (SPC) following the formula:  $SPC = \text{Disease height (cm)} / \text{Plant height (cm)}$  (Eyal and Ziv, 1974), where disease height (cm) = the maximum height (cm) above ground level at which the pycnidia of *S. tritici* could be found on green plant tissue. This coefficient allows the comparison of infected placement on cultivars with different plant stature. The control was Briana, a Romanian wheat variety created to ARDS Simnic area. Statistical analysis involved analysis of variance procedure (Saulescu, 1967).

## Results and discussions

Epidemics of *Septoria tritici* blotch are associated with favorable weather conditions (frequent rains and moderate air temperatures), specific cultural practices, availability of inoculums, and the presence of susceptible wheat cultivars. First visible symptoms on the leaves were noticed when flag leaf ligule just visible (growth stage 39). Depending wheat stature and susceptibility the cultivars behavior was different. The attack degree ranged from 2.02% (Capo) to 22.64% (Renan) (Table 1). Comparatively with the control, the positive differences recorded by the cultivars Renan, Essential and Renesansa were statistically assured showing them susceptibility to the pathogen attack. The cultivars Cezanne, Aztec, Exotic, Meunier and Capo recorded negative differences statistically assured comparatively with the control and average attack degree value. The usual vertical progress of *Septoria* from lower to upper leaves is affected by the distance between consecutive leaves - the "ladder effect". It was observed that the distance between first emerging three to four leaves are similar for short and tall cultivars. On tall varieties, the distance between each leaf is greater toward the flag leaf. For tall cultivars (Glosa, Boema, Moldova 83, Karlygash) *Septoria* progress was lower comparatively with shorter ones (Flamura 85, Magistral, GK David, Renan, Autan, Martina) (Fig.1). In the dwarf cultivars (70-90 cm) the closeness of the upper leaves to the lower leaves facilitates contact between newly emerging leaves and splashed pycnidiospores. As a result, pycnidia often appear earlier on upper plant parts of dwarf cultivars than they do on leaves of taller cultivars.

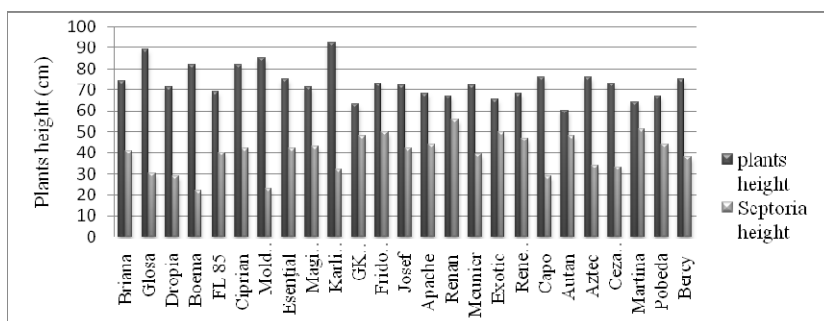
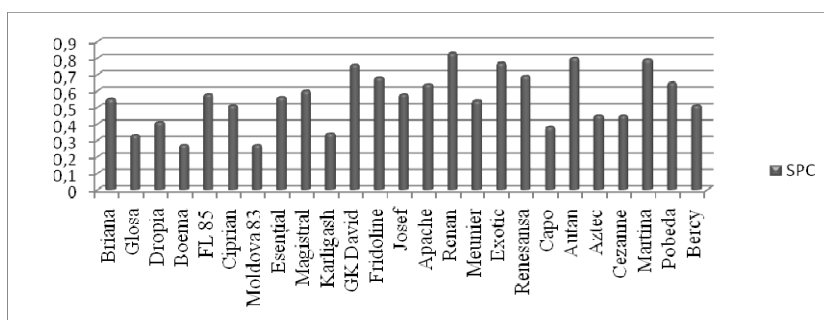
Previous researches showed that under severe epidemics the difference in plant architecture and stature of susceptible cultivars are of no importance to the pathogen (Eyal et al., 1987). It was also observed that in moderate epidemic upper plant parts of dwarf cultivars are more receptive to the pathogen than taller wheats as they are nearer to inoculum sources which coincide to the previous observations done by Eyal (1971).

SPC was low for the cultivars for which *Septoria* progressed only to basal or to the middle leaves, even these cultivars recorded different attack degree values. It was observed that for the same *Septoria* progress height (cm) the attack degree was different due to disease severity percent which was influenced by cultivar susceptibility. It was noticed Renan which recorded the highest attack degree and SPC value, whereas Exotic recorded low attack degree, but high SPC (Fig.2).

Table 1. The attack degree values of *Septoria tritici* blotch in 2009 year

No.	Cultivar	AD% 2009	Diff. ± Control	Signif.	Diff.± Average	Signif.
15	Renan	22.64	9.23	***	12.33	***
8	Esential	19.5	6.09	**	9.19	***
18	Renesansa	18.3	4.89	*	7.99	**
20	Autan	16.19	2.78		5.88	**
12	Fridoline	15.19	1.78		4.88	*
1	Briana	13.41	Mt.		3.1	
11	GK David	13.3	-0.11		2.99	
25	Bercy	12.41	-1		2.1	
13	Josef	11.5	-1.91		1.19	
23	Martina	11.31	-2.1		1	
14	Apache	10.36	-3.05		0.05	
7	Moldova 83	10.13	-3.28		-0.18	
2	Glosa	9.4	-4.01		-0.91	
3	Dropia	8.53	-4.88	o	-1.78	
10	Karlygash	8.48	-4.93	o	-1.83	
9	Magistral	7.66	5.75	o	-2.65	
6	Ciprian	7.07	-6.34	oo	-3.24	
4	Boema	6.9	-6.51	oo	-3.41	
5	FL 85	6.75	-6.66	oo	-3.56	
24	Pobeda	6.71	-6.7	oo	-3.6	
22	Cezanne	6.03	-7.38	oo	-4.28	o
21	Aztec	5.4	-8.01	oo	-4.91	o
17	Exotic	4.48	-8.93	ooo	-5.83	oo
16	Meunier	4.18	-9.23	ooo	-6.13	oo
19	Capo	2.02	-11.39	ooo	-8.29	oo
	Average	10.31				

LSD 5%=4.10; 1%=5.78; 0.1%=8.91

Fig.1. The *Septoria* progress height (cm) for winter wheat cultivars tested in 2009 in ARDS Simnic areaFig.2. The *Septoria* Progress Coefficient (SPC) for winter wheat cultivars tested in 2009 in ARDS Simnic area

The correlation coefficient between plants height and disease progress height (cm) was -0.73 (negative very significant) showing that disease progress height is higher as plant height is low. The yield of winter wheat cultivars ranged from 3350 kg/ha (Meunier) to 5145 kg/ha (Aztec) (Table 2).

Table 2. The yields recorded by winter wheat cultivars attacked by *Septoria tritici* blotch in ARDS Simnic area

No.	Cultivar	Yield Kg/ha	Diff.± Control	Signif.	Diff.± Average	Signif.
21	Aztec	5145	1107	***	895	***
24	Pobeda	4862	824	***	612	**
19	Capo	4776	738	**	526	**
22	Cezanne	4598	560	**	348	*
6	Ciprian	4584	546	**	334	*
20	Autan	4582	544	**	332	*
14	Apache	4471	433	*	221	
11	GK David	4403	365	*	153	
2	Glosa	4355	317	*	105	
17	Exotic	4336	298		86	
5	Flamura 85	4306	268		56	
10	Karlygash	4284	246		34	
9	Magistral	4272	234		22	
23	Martina	4265	227		15	
3	Dropia	4226	188		-24	
7	Moldova 83	4098	60		-152	
13	Josef	4093	55		-157	
1	Briana	4038	Mt.		-212	
18	Rebensansa	4033	-5		-217	
25	Bercy	3948	-90		-302	
4	Boema	3890	-148		-360	o
12	Fridoline	3849	-189		-401	o
8	Esential	3716	-322	o	-534	oo
15	Renan	3596	-442	o	-654	oo
16	Meunier	3530	-508	oo	-720	oo
	Average	4250				

LSD 5%=307; 1%=510; 0,1%=723

Cultivars Renan and Esential were the most affected by *Septoria tritici* attack leading to yield decreases statistically assured comparatively with the control. Despite low attack degree, Meunier recorded low yield probably due to its low adaptation ability in ARDS Simnic area. The correlation coefficient between yield and attack degrees was -0.51 (negative distinct significant).

### Conclusions

In 2009 year in ARDS Simnic area the attack degree of *Septoria tritici* blotch ranged from 2.02% (Capo) to 22,64% (Renan). For tall cultivars (Glosa, Boema, Moldova 83, Karlygash) *Septoria* progress was lower comparatively with shorter ones (Flamura 85, Magistral, GK David, Renan, Autan, Martina) because in the dwarf cultivars the closeness of the upper leaves to the lower leaves facilitates contact between newly emerging leaves and splashed pycnidiospores. SPC was low for the cultivars for which *Septoria* progressed only to basal or to the middle leaves, even these cultivars recorded different attack degree values. The correlation coefficient between plants height and disease progress height (cm) was -0.73 (negative very significant) showing that disease progress height is higher as plant height is low.

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# Prinos sjemena i biomase zrnatog šćira (*Amaranthus* spp.) u ovisnosti o gustoći sklopa

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## Sažetak

Cilj istraživanja provedenih na pokušalištu Agronomskog fakulteta Sveučilišta u Zagrebu tijekom 2008. - 2010. godine bio je utvrditi utjecaj gustoće sklopa na agronomska i morfološka svojstva različitih sorata zrnatog šćira.

U istraživanju su bile tri sorte zrnatog šćira: Plainsman (*Amaranthus hypochondriacus* L.), Olpir (*A. cruentus* L.) i 1008 (*A. hypochondriacus* L.) i četiri gustoće sklopa: 30, 60, 90 i 120 biljaka m<sup>-2</sup> u žetvi. Najveći prinos sjemena u klimatski nepovoljnijim 2008. i 2010. godini ostvarile su sorte Olpir i 1008, dok je u 2009. godini najrodnija bila sorta Plainsman. Značajno najveću masu 1000 sjemenki u 2009. godini ostvarile su sorte Plainsman i 1008, a u 2010. godini sorte Olpir i 1008. Sorte Plainsman i Olpir su u sve tri godine istraživanja imale značajno najveću visinu biljke, a 2008. i 2009. godine i duljinu cvata. Sorte Plainsman i 1008 ostvarile su značajno veći sadržaj bjelančevina u sjemenu u odnosu na sortu Olpir (171,4, 170,8, odnosno 166,7 g kg<sup>-1</sup>). Najveći prinos biomase ostvarile su sorte Plainsman (81,1 t ha<sup>-1</sup>) i 1008 (75,4 t ha<sup>-1</sup>). Gustoća sklopa je značajno utjecala na prinos sjemena zrnatog šćira samo u 2009. god. te je najveći prinos sjemena (1759 kg ha<sup>-1</sup>) ostvaren je kod gustoće sklopa od 30 biljaka m<sup>-2</sup>.

Ključne riječi: zrnati šćir, gustoća sklopa, agronomska i morfološka svojstva

## Grain amaranth (*Amaranthus* spp.) seed and total biomass yield as influenced by plant density

### Abstract

The goal of investigations carried out at the experimental facility of the Faculty of Agriculture in Zagreb during 2008 - 2010 was to determine the impact of plant density upon agronomic and morphological traits of different grain amaranth varieties.

Three grain amaranth species were studied: Plainsman (*Amaranthus hypochondriacus* L.), Olpir (*A. cruentus* L.) and 1008 (*A. hypochondriacus* L.) and four plant densities: 30, 60, 90 and 120 plants m<sup>-2</sup> at harvest. The highest grain yield in the climatically unfavourable 2008 and 2010 was given by the varieties Olpir and 1008 while Plainsman was the highest-yielding variety in 2009 (2423 kg/ha). Varieties Plainsman and 1008 had significantly higher 1000 seed mass in 2009 year and in 2010 varieties Olpir and 1008.

In three trial years, varieties Plainsman and Olpir had higher plant height, and in 2008 and 2009 also the inflorescence length. Varieties Plainsman and 1008 produced a significantly higher grain protein content compared to Olpir (171.4, 170.8, and 166.7 g kg<sup>-1</sup>, respectively). Varieties Plainsman and Olpir had the highest biomass yield in harvest (81.1 and 75.4 t ha<sup>-1</sup>, respectively).

Plant density had a strong influence on grain yield only in 2009. The highest yield was achieved with the plant density of 30 plants m<sup>-2</sup>.

Key words: grain amaranth, plant density, agronomic and morphological traits

## Uvod

U današnje vrijeme se sve više pažnje poklanja kvaliteti hrane i teži što uravnoteženijem obroku. Alternativne žitarice u tome pronalaze svoje mjesto, a među njima i zrnati šćir. Zrnati šćir (*Amaranthus* spp.), odlikuje se visokom nutricionističkom vrijednosti koja proizlazi iz vrlo povoljnog aminokiselinskog sastava bjelančevina u sjemenu. Bjelančevine zrnatog šćira najkvalitetniji su među biljnim vrstama (Bressani i sur., 1993; Bejosano i Corke, 1998). Prinos sjemena zrnatog šćira znatno varira. U agroekološkim uvjetima sjeverozapadne Hrvatske prinos sjemena, ovisno o sorti i roku sjetve, varirao je od 907 do 2351 kg ha<sup>-1</sup> (Pospišil i sur., 2007). Jedna od najprinosnijih sorata šćira je Plainsman koji pripada vrsti *Amaranthus hypochondriacus* L. (Jamriška, 1998). Međutim, Moudrý i Peterka (2001) viši prinos sjemena dobili su sa sortom 1008 (790-4070 kg/ha ovisno o godini istraživanja).

Efikasno korištenje vode, brz rast te mogućnost uzgoja i u lošijim agroekološkim uvjetima čine zrnati šćir pogodnom kulturom za proizvodnju velike količine biomase za hranidbu stoke i proizvodnju biogoriva. Ovisno o sorti i agroekološkim uvjetima prinos zelene mase šćira u fazi cvatnje kreće se od 21,5 do 42,3 t ha<sup>-1</sup>, a prinos suhe tvari od 3,7 do 7,3 t ha<sup>-1</sup> (Pospišil i sur., 2009). U istraživanjima provedenim u Sjevernoj Dakoti prinosi suhe tvari šćira u zriobi varirali su od 6,9 do 9,3 t ha<sup>-1</sup> (Johnson i Henderson, 2002). Ovisno o sorti i agroekološkim uvjetima, ostvaruju se i znatno veći prinosi biomase zrnatog šćira. Peterka i Kalinova (2006) dobili su prinose nadzemne biomase šćira od 75,8 do 92,9 t ha<sup>-1</sup>.

Cilj istraživanja bio je utvrditi utjecaj gustoće sklopa na agronomska i morfološka svojstva tri sorte zrnatog šćira.

## Materijal i metode

Istraživanja su provedena na pokušalištu Agronomskog fakulteta u Zagrebu tijekom 2008. - 2010. godine. U istraživanje su bile uključene tri sorte zrnatog šćira: Plainsman (*Amaranthus hypochondriacus* L.), Olpir (*Amaranthus cruentus* L.) i 1008 (*A. hypochondriacus* L.) i četiri gustoće sklopa u žetvi (30, 60, 90 i 120 biljaka m<sup>-2</sup>). Korekcija na željeni sklop obavljena je prorjeđivanjem kod visine biljaka 15 cm. Pokus je bio postavljen po slučajnom bloknom rasporedu u četiri ponavljanja. Veličina osnovne parcele u sjetvi bila je 14 m<sup>2</sup> (4 reda x 0,70 m razmak redova x 5 m dužina). Za žetvu su korištena dva srednja reda te je veličina parcele u žetvi iznosila 7 m<sup>2</sup>. U 2008. godini predkultura je bila soja, u 2009. uljana repica, a u 2010. pir. Sjetva šćira obavljena je 7.5.2008. godine, 11.5.2009. i 29.4.2010. Gnojidba je obavljena sa 200 kg ha<sup>-1</sup> NPK 10:20:30 u osnovnoj obradi tla. Kontrola korova obavljena je međurednom kultivacijom i ručno. Visina biljaka, duljina cvati te prinos ukupne biomase određeni su neposredno prije žetve. Žetva je obavljena ručno u rujnu. Nakon žetve utvrđeni su prinos i vlaga sjemena te masa 1000 sjemenki. Prinos sjemena preračunat je na 13% vlage. Prinos zelene mase te sadržaj bjelančevina u sjemenu određeni su samo u 2010. godini. Sadržaj bjelančevina u sjemenu određen je metodom po Kjeldahlu (AOAC, 2002). Dobiveni podaci statistički su obrađeni analizom varijance korištenjem MSTAT-C programa (Michigan State University, 1990).

## Rezultati i rasprava

U 2008. i 2010. godini i u prosjeku za tri godine istraživanja sorta Olpir ostvarila je najveći prinos sjemena, 1562, 1323, odnosno 1719 kg ha<sup>-1</sup> (tablica 1). U većem broju istraživanja sorta Plainsman se navodi kao najprinosnija (Jamriška, 1998; Pospišil i sur., 2003; Pospišil i sur. 2007.). Međutim, u ovim istraživanjima ova sorta je ostvarila najviši prinos sjemena samo u klimatski povoljnijoj 2009. godini s boljim rasporedom oborina. U 2009. godini sve sorte su ostvarile značajno veći prinos sjemena u odnosu na druge dvije godine istraživanja. Značajno najniži prinos ostvaren je u 2010. godini koju je karakterizirao nepovoljan raspored oborina tijekom vegetacije zrnatog šćira. Tijekom svibnja, lipnja, kolovoza, a osobito rujna, u vrijeme žetve, pala je veća količina oborina u odnosu na višegodišnji prosjek što se nepovoljno odrazilo na visinu prinosa sjemena.

Gustoća sklopa imala je utjecaja na prinos sjemena samo u 2009. godini kada je značajno viši prinos ostvaren kod najmanje gustoće sklopa (30 biljaka m<sup>-2</sup>), a iznosio je 2531 kg ha<sup>-1</sup> (tablica 1). U prosjeku za sve tri godine istraživanja najviši prinos sjemena zrnatog šćira ostvaren je kod gustoća sklopa od 30 i 60 biljaka m<sup>-2</sup> (1759, odnosno 1701 kg ha<sup>-1</sup>). I u ranijim istraživanjima provedenim u ovim agroekološkim uvjetima, viši prinos sjemena ostvaren je kod manje gustoće sklopa (Pospišil i sur., 2003; Pospišil i sur. 2007.).

**Prinos sjemena i biomase zrnatog šćira (*Amaranthus spp.*) u ovisnosti o gustoći sklopa**

Značajno najveću masu 1000 sjemenki u 2009. godini ostvarile su sorte Plainsman i 1008 koje pripadaju vrsti *A. hypochondriacus* L., 0,718, odnosno 0,715 g, a u 2010. godini sorte Olpir (0,698 g) i 1008 (0,697 g), tablica 1. U prosjeku za sve tri godine istraživanja sorte se nisu razlikovale u masi 1000 sjemenki koja se kretala od 0,675 g kod sorte Plainsman do 0,680 g kod sorte 1008. Haban i sur. (2001) dobili su slične vrijednosti mase 1000 sjemenki kod različitih vrsta zrnatog šćira.

Gustoća sklopa nije imala utjecaja na masu 1000 sjemenki u nijednoj godini istraživanja, a u prosjeku za sve tri godine se kretala od 0,671 g kod gustoće sklopa od 30 biljaka m<sup>-2</sup> do 0,682 g kod 60 biljaka m<sup>-2</sup> (tablica 1).

**Tablica 1. Prinos sjemena i masa 1000 sjemenki istraženih sorata zrnatog šćira kod različitih gustoća sklopa, 2008.-2010. god.**

Varijanta	Prinos sjemena (kg ha <sup>-1</sup> )				Masa 1000 sjemenki (g)			
	2008	2009	2010	Prosjek	2008	2009	2010	Prosjek
Sorta								
Plainsman	1410 b	2423 a	1168 b	1667 b	0,636	0,718 a	0,673 b	0,675
Olpir	1562 a	2271 b	1323 a	1719 a	0,643	0,691 b	0,698 a	0,676
1008	1514 ab	2297 b	1215 ab	1675 c	0,620	0,715 a	0,697 a	0,680
Gustoća sklopa (bilj. m <sup>-2</sup> )								
30	1453	2531 a	1293	1759 a	0,633	0,701	0,680	0,671
60	1571	2243 b	1289	1701 ab	0,642	0,713	0,692	0,682
90	1486	2215 b	1131	1610 c	0,630	0,711	0,700	0,680
120	1471	2332 b	1229	1678 bc	0,627	0,707	0,686	0,674

Vrijednosti označene istim slovom nisu signifikantno različite kod P=5%

Najveći prinos zelene mase u žetvi u 2010. godini ostvarila je sorta Plainsman (81,1 t ha<sup>-1</sup>), a sorta 1008 je bila u istom rangu s ostvarenih 75,4 t ha<sup>-1</sup> (tablica 2.). Iste sorte su ostvarile i najveći prinos biomase na bazi suhe tvari, 15,7 odnosno 13,9 t ha<sup>-1</sup>. Dobiveni prinosi suhe tvari viši su u odnosu na prinose dobivene u istraživanjima Johnsona i Hendersona (2002), a prinosi zelene mase su slični rezultatima dobivenim u istraživanjima Peterke i Kalinove (2006).

**Tablica 2. Prinos biomase u zriobi istraženih sorata zrnatog šćira kod različitih gustoća sklopa u 2010. godini, te sadržaj bjelančevina u sjemenu**

Varijanta	Prinos zelene mase (t ha <sup>-1</sup> )	Prinos suhe tvari (t ha <sup>-1</sup> )	Sadržaj bjelančevina u sjemenu (g kg <sup>-1</sup> )
Sorta			
Plainsman	81,1 a	15,7 a	171,4 a
Olpir	70,5 b	13,3 b	166,7 b
1008	75,4 ab	13,9 ab	170,8 a
Gustoća sklopa (bilj. m <sup>-2</sup> )			
30	76,1	14,8	172,1
60	74,3	13,4	168,1
90	75,5	14,1	169,4
120	76,8	14,8	168,9

Vrijednosti označene istim slovom nisu signifikantno različite kod P=5%

Sorte Plainsman i Olpir su u prosjeku za sve tri godine istraživanja ostvarile značajno najvišu stabljiku (182, odnosno 183 cm) i duljinu cvata (51,6, odnosno 52,1 cm), tablica 3. Gustoća sklopa nije imala utjecaja na visinu biljaka. U trogodišnjem prosjeku najveća duljina cvata ostvarena je kod gustoća sklopa od 30 i 60 biljaka m<sup>-2</sup> što se pozitivno odrazilo i na visinu prinosa.

Tablica 3. Visina biljaka i duljina cvati istraživanih sorata zrnatog šćira kod različitih gustoća sklopa, 2008. - 2010. god.

Varijanta	Visina biljke (cm)				Duljina cvati (cm)			
	2008	2009	2010	Prosjek	2008	2009	2010	Prosjek
Sorta								
Plainsman	166 a	193 a	187 a	182 a	50,1 a	56,7 a	47,9 b	51,6 a
Olpir	162 a	197 a	189 a	183 a	50,3 a	54,6 a	51,4 a	52,1 a
1008	142 b	163 b	170 b	158 b	45,9 b	47,6 b	47,1 b	46,9 b
Gustoća sklopa (bilj. m <sup>-2</sup> )								
30	154	189	186	176	49,2	55,8	51,0	52,0 a
60	161	185	186	177	51,9	52,4	48,9	51,1 ab
90	155	181	179	172	46,7	51,4	47,8	48,6 b
120	158	182	178	173	47,3	52,3	47,5	49,1 b

Vrijednosti označene istim slovom nisu signifikantno različite kod P=5%

### Zaključci

U prosjeku za tri godine istraživanja sorta Olpir ostvarila je najveći prinos sjemena (1719 kg ha<sup>-1</sup>). Najviši prinos sjemena zrnatog šćira ostvaren je kod gustoća sklopa od 30 i 60 biljaka m<sup>-2</sup> (1759, odnosno 1701 kg ha<sup>-1</sup>). Značajno najveću masu 1000 sjemenki u 2009. godini ostvarile su sorte Plainsman i 1008, a u 2010. godini sorte Olpir i 1008. Sorte Plainsman i 1008 ostvarile su najveći prinos ukupne biomase u žetvi. U prosjeku za sve tri godine istraživanja značajno najvišu stabiljiku i duljinu cvata ostvarile su sorte Plainsman i Olpir.

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# Maize as raw material for bioethanol

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## Abstract

Maize is one of the most important naturally renewable sources of carbohydrate raw materials, energy and series of diverse products. Maize can provide both starch (seed) and cellulosic (stover) material for bioethanol production. The aim of this paper is study of the utility of ZP maize hybrids as raw material for bioethanol production. Obtained results show that maize hybrids differ in ethanol yield production. The highest ethanol yield, expressed in% of the theoretical yield, after 34 hours of fermentation was obtained with ZP 434, 90.2% and the lowest one with ZP544, 69.32%. The highest starch-producing hybrid was not the highest ethanol producer. The starch yield and starch recovery are more important traits for ethanol production than starch content. The correlation between these two traits with ethanol yield was 0.37 and 0.57 respectively. The cellulose and hemicelluloses content vary between ZP hybrids from 19.17 to 21.68% and 19.13 to 22.92%, respectively. Study of lignocelluloses of ZP maize hybrids as raw material for ethanol production is in progress.

Key words: bioethanol, lignocellulose, maize hybrids, starch

## Hibridi kukuruza kao sirovina za proizvodnju bioetanol

### Sažetak

Cilj rada je ispitati mogućnost korištenja ZP hibrida kukuruza za proizvodnju etanola. Kukuruz daje škrob (zrno) i celulozu (stabljika) kao sirovinu za proizvodnju bioetanol. Dobiveni rezultati pokazali su da je najveći prinos etanola, izražen u% u odnosu na teoretski prinos, imao hibrid ZP 434 (90,2%), a najniži hibrid ZP 544 (69,32%). Hibrid s najvećim sadržajem škroba nije dao najviše etanola. Prinos i obnovljivost škroba su važnija svojstva za proizvodnju etanola od sadržaja škroba. Koeficijenti korelacije između ova dva svojstva s prinosom etanola bili su 0,37 odnosno 0,57. Hibridi kukuruza su se razlikovali po sadržaju celuloze i hemiceluloze. Sadržaj celuloze je bio od 19,17 do 21,68% a hemiceluloze od 19,13 do 22,92%. Korištenje lignoceluloze ZP hibrida kukuruza kao sirovine za proizvodnju bioetanol je u fazi istraživanja.

Ključne riječi: bioethanol, hibridi, kukuruz, lignoceluloza, škrob

## Introduction

It has become clear that fossil energy sources of the Earth are finite, moreover, their use causes more and more damages to the environment (climate change, air pollution, greenhouse effect, etc.). Bioethanol is the most commonly used biofuel to substitute for gasoline. It can be combined with gasoline in any concentration up to pure ethanol. It is a renewable, environmentally friendly fuel that is inherently cleaner than gasoline. Using ethanol reduces emissions of carbon monoxide by 32.5%, particulate matter, oxides of nitrogen, and other ozone-forming pollutants and greenhouse gas emissions by as much as 35-45 percent (Badger, 2002, Demirbas, 2005, Purwadi, 2006). According to Renewable Fuels Association (RFA) in 2009 ethanol fuel production worldwide reached 73.9 million liters. The world and European production of bioethanol for fuel is constantly increasing, tending to 100 mil L till 2012 (Radosavljević et al, 2009). The consumption of bioethanol in Europe is largest in Germany, Sweden, France and Spain. Europe produces equivalent to 90% of its consumption (Wikipedia, 2010).

The two most widely used crops for ethanol production are sugarcane and maize. The production process consists of conversion of biomass to fermentable sugars, fermentation of sugars to ethanol, and the separation and purification of the ethanol. Maize is one of the most important crops, and as such, one of the most significant naturally renewable carbohydrate raw materials of energy and numerous very different products. According to FAO data in 2009 maize was grown on the area of 159.531.007 hectares (<http://www.fao.org>). The world maize production amounted to 817 million tonnes of grain. The average global yield per hectare has approached the level of five tonnes of grain, while the most developed agricultures have reached the levels of 7-8 tonnes per hectare. The Republic of Serbia is one of more important maize producers not only in Europe but in the world, too. According to FAO data in 2009, maize was grown on areas of approximately 1.208.640ha. The total annual production amounted to 6.396.262 t, with an average grain yield of 5.291 tons per hectare.

The interest in producing ethanol from maize has increased during recent years. There are two ways, i.e. procedures of getting ethanol from maize, wet and dry milling. A 25.3 kg of maize grain can produce from 9.4 to 10.9 L of pure ethanol, depending on the technology used. Currently, ethanol is primarily fermented from the sugar that makes up the starch in grain. But ethanol also can be made from celluloses biomass - plant matter composed primarily of inedible cellulose fibers that form the stems and branches of most plants. Lignocellulosic materials, as excellent energy sources, consist primarily of three components, namely cellulose, hemicelluloses and lignin (Ehara and Saka, 2002). The compositions of these constituents may vary from one plant species to another. The composition within a single plant varies with age, stage of growth and other conditions (Purwadi, 2006). Four biologically mediated steps occur in the course of converting lignocelluloses materials into bio-ethanol: (i) cellulose production, (ii) hydrolysis of the cellulose and other insoluble polysaccharides, (iii) fermentation of soluble cellulose hydrolysates and (iv) fermentation of soluble hemicelluloses hydrolysates. A pretreatment step using steam or dilute sulfuric acid is generally used to separate the biomass into its constituent parts - cellulose, hemicelluloses, and lignin. The cellulose and hemicelluloses are then hydrolyzed to sugars - both five-carbon sugars - xylose and arabinose - and six-carbon sugars - glucose, mannose and galactose. These sugars require specialized microbes or modified yeasts for fermentation. There are three basic types of ethanol-from-cellulose processes—acid hydrolysis, enzymatic hydrolysis, and thermochemical—with variations for each. The most common is acid hydrolysis. Virtually any acid can be used; however, sulfuric acid is most commonly used since it is usually the least expensive (Badger, 2002). The aim of our study was to analyse the fermentable properties of grain as well as suitability of selected ZP maize hybrids for the bioethanol production.

## Material and methods

Grain of five ZP maize hybrids (ZP-341, ZP-434, ZP-505, ZP-544, ZP-704wx) was milled to flour on the Perten Instruments laboratory mill. Grain starch content was analysed by Ewers polarimetric method (ISO, 1997). Starch yield and recovery was determined by Eckhoff et al., 1996. Before ethanol fermentation two-step enzymatic hydrolysis of corn meal by commercially available  $\alpha$ -amylase (from *Bacillus licheniformis*, Termamyl® SC, Novozymes, Denmark) and glucoamylase (SAN Extra® L, Novozymes, Denmark, from *Aspergillus niger*) was done (Nikolić et al., 2009). The maize meal hydrolyzates were good substrates for ethanol fermentation by *Saccharomyces cerevisiae* (collection of BIB-TMF, Belgrade) yeast. The ethanol concentration was determined based on the density of alcohol distillate at 20 °C and expressed in

weight%(w/w), (Official Methods, 2000). Analysis of the content of lignocellulose was performed by the modified Van Soest method (1963).

### Results and discussion

Maize is the most important crop and starch is the most abundant component of the maize kernels. Starch content differs between analysed hybrids. The lowest starch content has hybrid ZP341 (69%) and the highest hybrid ZP704wx, 74.13%, (Table 1). Starch yield is the most important fraction from the wet-milling process (Singh and Eckhoff, 1996) as indicator of millability, or ease with which kernel components are separated by wet milling. In analysed maize hybrids starch yield varied from 61.99 (ZP704wx) to 65.15 (ZP434). Starch recovery as an indicator of the starch extractability of a particular hybrid varied from 83.62 to 93.14%. Starch recoveries were highly correlated with starch yield values ( $r = 0.82$ ).

**Table 1. Starch properties of maize hybrids and ethanol content and yield**

Hybrids	Starch content %	Starch yield	Starch recovery	Ethanol content %	Ethanol yield %
ZP341	69.0 <sup>a</sup>	63.91 <sup>b</sup>	92.63	7.75 <sup>ns</sup>	79.75 <sup>d</sup>
ZP434	69.96 <sup>a</sup>	65.15 <sup>c</sup>	93.14	8.95 <sup>ns</sup>	90.20 <sup>e</sup>
ZP505	71.99 <sup>a</sup>	62.37 <sup>a</sup>	86.64	7.59 <sup>ns</sup>	74.37 <sup>b</sup>
ZP544	73.48 <sup>a</sup>	64.36 <sup>b</sup>	87.59	7.22 <sup>ns</sup>	69.32 <sup>a</sup>
ZP704wx	74.13 <sup>ab</sup>	61.99 <sup>a</sup>	83.62	8.32 <sup>ns</sup>	79.23 <sup>c</sup>
LSD 5%	4.81	0.86		2.04	0.11

<sup>a-e</sup> column means with common superscripts do not differ ( $p > 0.05$ )

Today, ethanol from maize is produced almost exclusively from starch. Starchy materials require a reaction of starch with water (hydrolysis) to break down the starch into fermentable sugars (saccharification). After the two-step enzymatic hydrolysis of five ZP maize hybrids obtained hydrolyzates was subjected to anaerobic fermentation by yeast *Saccharomyces cerevisiae* to produce ethanol. Ethanol content during the fermentation were determined in samples taken before fermentation and after 24 and 34 hour (Drinic et al., 2010).

The highest ethanol content, after 34 hours of fermentation, was obtained from hybrid ZP434, 8.95%, and the lowest from hybrid ZP544, 7.22. Maize hybrids differ in ethanol yield production. The highest ethanol yield (in% of the theoretical yield) achieved after 34 hours of the fermentation, was obtained with ZP 434, 90, 2% (table 1). The lowest ethanol yield of 69.32% was obtained with ZP 544. The similar ethanol yield (approximately 79%) was also detected in the hybrids ZP 704wx and ZP 341. These two hybrids significantly differ in starch content. If compared ethanol yield of ZP 434 with ethanol yield of some another commercial hybrids, ranged from 76.79 to 92.35% (Radosavljević et al., 2001; Nikolić et al., 2009), it can be concluded that ZP434 is very suitable for bioethanol production. The relationship between grain starch and ethanol yield is not completely understood. The highest starch-producing hybrid was not the highest ethanol producer (Dein et al., 2002). Our results indicate that starch yield and starch recovery are more important traits for ethanol production than starch content. Coefficient of correlation between starch yield and ethanol yield and ethanol content was 0.37 and 0.22, respectively. Coefficient of correlation between starch recovery and ethanol content and ethanol yield was 0.30 and 0.57, respectively.

While ethanol is typically produced from the starch contained in grains, it can also be produced from cellulose. Cellulose is the main component of plant cell walls and is the most common organic compound on earth. Maize stover contains principally cellulose and hemicelluloses which are the main source of fermentable sugars for ethanol production. Lignocelluloses content of ZP hybrids plant was analyzed and results are presented in Table 2.

**Table 2. Lignocelluloses content of ZP maize hybrids**

Hybrids	Cellulose %	Hemicelluloses %
ZP341	19.17 <sup>a</sup>	19.13 <sup>a</sup>
ZP434	20.03 <sup>b</sup>	20.43 <sup>b</sup>
ZP505	21.34 <sup>d</sup>	22.73 <sup>d</sup>
ZP544	21.68 <sup>e</sup>	22.92 <sup>d</sup>
ZP704wx	20.41 <sup>c</sup>	20.80 <sup>c</sup>
LSD 5%	0.28	0.23

<sup>a-e</sup> column means with common superscripts do not differ ( $p > 0.05$ )

The conversion of lignocellulosic material to ethanol is generally more complex, compared to starch hydrolysis and fermentation. Cellulose is difficult to convert into fermentable sugars due to its crystalline structure and closed association with lignin and hemicelluloses. Study of lignocelluloses from ZP maize hybrids as raw material for ethanol production is in progress. If sustainable, cost effective, and environmentally compatible agricultural practices are developed and coupled to cellulose conversion technology, maize has potential to provide 20-24 billion gallons of ethanol per year through a combination of starch processing and cellulose conversion (Schwietzke et al, 2009).

### Conclusion

The hybrid ZP 434 is extremely suitable for the production of bioethanol and starch, as it had the highest ethanol yield of 90.2% of the theoretical yield, as well as, the maximum yield (65.15%) and starch recovery (93.14%). The starch yield and starch recovery, as indicators of millability and starch extractability, are more important traits for ethanol production than starch content. How in Serbia is enough maize for other purposes besides the food significant amounts can be used for the bioethanol production.

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# Influence of genotype on maize (*Zea mays* L.) yield and yield parameters in irrigated and N fertilized conditions

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## Abstract

The experiment was set up as split-split plot method with three repetitions in two vegetation seasons (2006-2007) in order to determine the influence of irrigation treatment (A1-control, A2-60% to 100% field water capacity (FWC), A3-80% to 100% FWC), N fertilizer (B1-control, B2-100 kg N ha<sup>-1</sup>, and B3-200 kg N ha<sup>-1</sup>) and genotype (C1= OSSK 596; C2=OSSK 617; C3= OSSK 602; C4 = OSSK 552) on yield and yield parameters (cob length, cob weight, kernel number, kernel weight and number of rows per cob) of maize. Irrigation treatment have very significantly increased yield in both tested years. Also, irrigation treatment increased row number/cob, kernel weight (KW), kernel number (KN), cob weight (CW), (P>0.05) in 2006, CW and KN in 2007 (P>0.01). N fertilization had a very significant (P>0.01) impact on all tested factors in both years of research. Genotype showed very significant impact on all tested factors in year 2006, although in dry vegetation season 2007 statistical significant was showed only to yield and kernel number.

Key words: irrigation, N fertilization, maize hybrids, yield, yield parameters

## Utjecaj genotipa na prinos i parametre prinosa kukuruza (*Zea mays* L.) u uvjetima navodnjavanja i gnojidbe dušikom

### Sažetak

Poljski pokus je postavljen na površinama Poljoprivrednog instituta u Osijeku tijekom dvije vegetacijske sezone (2006-2007) kako bi se istražio utjecaj navodnjavanja (A1-kontrola, A2-60%-100% poljskog vodnog kapaciteta (PVK), A3-80%-100% PVK), gnojidbe dušikom (B1-kontrola, B2-100 kg N ha<sup>-1</sup>, B3-200 kg N ha<sup>-1</sup>) i genotipa (C1= OSSK 596; C2=OSSK 617; C3= OSSK 602; C4 = OSSK 552) na prinos i komponente prinosa kukuruza. U obje vegetacijske sezone najveći prinos je izmjeren na varijantama navodnjavanja A3-80%-100% PVK i gnojidbe B3-200 kg N ha<sup>-1</sup>, dok je prinos varirao po genotipu. Navodnjavanje je značajno utjecalo na povećanje proučavanih komponenata prinosa: broj zrna/klipu, masu zrna, masu klipa, dužinu klipa, broj redova po klipu u 2006. (P>0.05), dok u sušnoj 2007. navodnjavanje je imalo utjecaj na težinu klipa i broj zrna (P>0.01). Gnojidba N je u obje vegetacijske sezone imala vrlo značajan utjecaj na povećanje svih ispitivanih faktora. Najveće vrijednosti ispitivanih svojstava izmjerene su pri B3-200 kg N ha<sup>-1</sup> varijanti gnojidbe. Hibrid je pokazao vrlo značajan utjecaj na ispitivana svojstva 2006., dok se u sušnoj, 2007. značajnost očitovala na povećanje prinosa i broj zrna po klipu.

Ključne riječi: navodnjavanje, gnojidba N, hibridi kukuruza, prinos, komponente prinosa

## Introduction

Maize (*Zea mays* L.) represents important cereal in agricultural production of Croatia. According to central bureau of statistics (2009.) 296 195 ha were sown by maize with average yield from 6.5 t ha<sup>-1</sup>, while in dry vegetation season of 2007-th year, 288 549 ha were sown with average yield 4.9 t ha<sup>-1</sup>. According to Kovačević et al. (2009) this dry periods are the main reason for yield variation among years. Maize belongs to a group of plant who tolerates the drought very well, but the yield is becoming very low during dry periods. The adequate supply of irrigation water and N fertilizer are two main factors affecting directly the plant growth and quality of maize grain (Ibrahim, 2007). According to Eck (1986) water deficit during the vegetative growth reduced kernel numbers but had a small effect on kernel growth. The potential yield of maize is determined by kernel weight. Stone *et al.* (2001) reported that water deficit reduced morphological characteristics of corn plant. Pandey *et al.* (2000) reported that water stress reduced kernel number, kernel weight, and yield as well. Number of kernels per cob is closely associated with yield of maize and yield component that varies markedly with stress (Oktem et al., 2008). Cob length generally depended on genotype and growing environment (Josipović et al., 2007). The aim of this study was to evaluate the effects of water stress, N rate and tested genotype to maize yield and yield parameters - cob length (CL), cob weight (CW), row numbers (RN), kernel number (KN) and kernel weight (KW).

## Materials and methods

Two experiments were carried out during two vegetation (2006-2007) seasons at the trial fields of Agricultural Institute in Osijek. Four maize hybrids have been tested in order to determine the influence of irrigation management, N fertilizer rate and genotype on maize yield and yield parameters. The research was set up as split-split plot method with three repetitions. Soil type on trial fields of Agricultural institute is eutric cambisol (Soil Survey Division Staff, 1993), silt clay loam texture, shallow gley, pH in KCl from 6.5 to 6.9, P<sub>2</sub>O<sub>5</sub> content is from 22.6 to 26.4 mg per 100 grams of soil, K<sub>2</sub>O content is from 30.4 to 36.5 mg per 100 grams of soil. Planned plant density was 58309 plants ha<sup>-1</sup> (spacing between rows 70 cm and distance in the row 24.5 cm). Main treatment includes three irrigation treatments A1 was control variant without applied irrigation water, the plants were having water only from natural precipitation, A2 variant - 60% -100% field water capacity (FWC), and A3 variant - 80%-100% FWC. Soil water content has been measured every second day with Watermark (US company) device. Irrigation started when soil water content was 60% of FWC in A2 variant and 80% field water capacity on A3 variant. Maize crops were irrigated with self propelled sprinkler system. Three rates of the nitrogen fertilizer (B1 - control variant without N fertilization, B2 - fertilization with 100 kg N ha<sup>-1</sup>, and B3 - 200 kg N ha<sup>-1</sup>) were used. Two-thirds of nitrogen were added in autumn and before sowing (urea: 46% N) and the rest (one-third) by two top-dressings at early growth stages (calcium ammonium nitrate: 27% N). Four different genotypes with similar vegetation group (end of FAO 500 and beginning of FAO 600) were tested: C1 = OSSK 596; C2 = OSSK 617; C3 = OSSK 602; C4 = OSSK 552. All four maize hybrids were created on Agricultural institute in Osijek. On the end of vegetation, yield determined by trial harvester and yield parameters were determined from ten average cobs. For the analysis of the weather conditions (precipitation quantity and mean air temperatures), data from Osijek Weather Bureau have been used (2009). For the analysis of variance, an ANOVA was carried out with the General Linear Model (GLM) Statistical Software Package (SAS, 2003) procedure.

Table 1. Monthly mean air t (°C) and rainfall (mm) from 2006-2007 and 30-years mean

Month	Mean air temperatures (°C)			Precipitation quantities (mm)		
	2006	2007	61-90	2006	2007	61-90
April	12.9	13.7	11.3	95.5	0.7	54.1
May	17.0	19.0	16.5	79.3	48.5	58.9
June	20.5	22.7	19.4	92.5	60.6	83.5
July	24.8	24.8	21.1	15.3	31.7	66.6
August	20.5	23.5	20.3	122.6	89.0	59.6
September	17.9	14.8	16.6	8.7	71.2	51.8
Mean	18.9	19.7	17.5	414	302	368

In two tested years (2006 and 2007) climate conditions were quite different regarding the precipitation quantities and mean air temperatures. In both tested years air temperatures during the vegetation season

(April-September) where higher compare to the 30-year mean (1961-1990), for 1.4 °C in year 2006, and 2.2 °C in year 2007. Vegetation season 2007 was characterized with 302 mm of rainfall which is for 66 mm below the 30-years mean (368 mm). According to this, irrigation practice becomes very important agricultural measure as supplementary character for accomplishing high yields.

### Results and discussion

The average values of maize yield and yield parameters: cob weight (CW), cob length (CL), kernel weight (KW), kernel number (KN) and yield was given in Table 2 for both years (2006 and 2007) of experiments. In both of tested years, highest yield was measured at A3 (80% to 100% FWC) variant of irrigation: 2006 - 9618 kg ha<sup>-1</sup>, and in year 2007 - 10777 kg ha<sup>-1</sup>. Result is comparable to many authors who also reported yield increasing under the irrigation treatment (Josipović et al., 2010; Pepo et al., 2008; Dagdelen et al. 2008; Pandey et al. 2000; Plavšić, 2006). Irrigation treatment in year 2006 showed significant (P>0.05) impact on all tested factors with the exception of cob length (CL). While, very significant impact (P>0.01) irrigation treatment showed at: kernel number (KN), kernel weight (KW), cob weight (CW) and yield as well. KN and RN where increased with the highest amount of applied irrigation water (KN: A1-564; A3 - 584 in 2006, and A1 - 650; A3 - 655 in 2007).

**Table 2. Influence of irrigation treatment, N fertilization and genotype on yield and yield parameters: Cob length (CL), cob weight (CW), row numbers (RN), kernel numbers (KN), kernel weight (KW); FWC-field water capacity**

Year	2006	2007	2006	2007	2006	2007	2006	2007		
	A1 - control		A2-60%-100% FWC		A3-80% - 100% FWC		Mean			
Y	8536	8426	9263	9165	9618	10777	9139	9456		
CW	210.5	148	205.4	153	215.9	157	210.6	152.6		
CL	19.26	21.2	19.17	21.2	19.16	21.6	19.196	21.33		
RN	14.87	15.4	14.54	15.4	14.79	15.6	14,73	15.46		
KN	564	650	572	651	584	655	573.33	652		
KW	184.9	127.8	181	133.2	189.7	137.1	185.2	132.7		
Influence of N fertilization										
	B1 - control		B2-100 kg N a <sup>-1</sup>		B3-200 kg N ha <sup>-1</sup>		Mean			
Y	8333	8942	9129	9285	9955	10140	9139	9455.66		
CW	187.7	144	217.5	152	226.8	162	210.66	152.66		
CL	18.03	20.9	19.59	21.3	19.95	21.7	19.07	21.3		
RN	14.47	15.5	14.79	15.5	14.94	15.4	14.73	15.46		
KN	520	638	587	659	613	659	573.33	652		
KW	164.8	124.3	191.3	132.2	199.6	141.6	185.23	171.73		
Influence of genotype										
	C1		C2		C3		C4		Mean	
Y	9144	8782	9247	10020	9505	9559	8659	9461	9206	9455
CW	216	151.1	207	153.7	227.9	153.4	191.4	153.6	211	152.9
CL	20.0	21.23	19.7	21.38	18.73	21.17	18.28	21.51	19.2	21.32
RN	14.3	15.36	14.5	15.58	15.25	15.49	14.74	15.44	14.7	15.47
KN	596	643	584	661	552	664	564	642	574	652.5
KW	191	130.7	182	133.6	197.5	133.6	169.4	132.9	185.3	132.7

Results are comparable to Pandey et al. (2000), Yazar (1999) and Khan (2001) whose results are showing that water deficit reduced kernel numbers, that kernel number per cob is moisture dependent, and that the kernel number per cob is primary effect of water deficit on maize grain yield. KW increased with the highest amount of applied water (A1-184.9; A3-189.7) which is comparable to Dagdelen et al. (2008) and Oktem (2008) whose results are also showing that KW is significant affected by irrigation treatment, meaning that highest amount of applied water leads to larger KW. Increased amount of applied water leads to increasing of CW (A1-210.5; A3-189.7 in 2006, A1-128; A3:137 in 2007). Nitrogen fertilization had very significant impact on all tested factors (Table 3), P>0.01 for CL, KN, KW, CW, and yield as well. All tested factors where increased under N fertilization treatment in both years of experiment with the exception of RN in dry year 2007. Both N treatment 100 kg N ha<sup>-1</sup> and 200 kg N ha<sup>-1</sup> resulted with the increasing of tested factors. The



result is comparable to Namakka et al. (2008) who reported significantly increasing of CW and CL as well by application of N fertilizer.

**Table 3. LSD test of significance for tested features**

Year	CL		RN		KN		KW		CW		Y		
	05	01	05	01	05	01	05	01	05	01	05	01	
A	2006	n.s.	n.s.	0.25	n.s.	11.9	15.8	4.75	6.32	5.22	6.95	161	214
	2007	0.45	n.s.	0.26	n.s.	n.s.	n.s.	3.32	4.41	3.68	4.89	178	237
B	2006	0.35	0.48	0.25	0.33	11.9	15.8	4.75	6.32	5.22	6.95	161	214
	2007	0.45	0.59	n.s.	n.s.	13.9	18.6	3.32	4.41	3.68	4.89	178	237
C	2006	0.41	0.54	0.28	0.38	13.7	18.3	5.48	7.30	6.03	8.03	185	247
	2007	n.s.	n.s.	n.s.	n.s.	16.13	21.48	n.s.	n.s.	n.s.	n.s.	206	274

A-irrigation treatment; B-N fertilization; C-genotype. CL-cob length; RN-row numbers; KN-kernel numbers; KW-kernel weight; CW-cob weight; Y-yield.

In vegetation season 2006 hybrid showed very significant impact on all tested factors ( $P > 0.001$ ), while in dry year 2007 genotype was significant only to yield and KN. Hybrid C2 = OSSK 617 showed good resistance to drought and resulted with the highest yield in both years of research ( $10\ 020\ \text{kg ha}^{-1}$ ). While C4 = OSSK 552 hybrid resulted with the lowest yield ( $8\ 659\ \text{kg ha}^{-1}$ ).

### Conclusion

It can be concluded that water stress have influence on maize yield and yield parameters as well. Highest irrigation and N treatment resulted with the highest yield, and most of yield parameters. Tested genotypes reacted differently to drought stress, lack of nitrogen fertilizer doses, and so the given results regarding yield parameters can be used as selection criteria to create a hybrid resisting to drought.

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# Evaluation of NPK fertilizers and bacterial inoculants influence on soil dehydrogenase activity and microbial biomass and yield of maize

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## Abstract

The aim of this study was to evaluate the influence of an application of different rates of mineral fertilizers and their combination with associative N-fixing *Klebsiella planticola* and *Enterobacter* spp. and sampling period on microbial biomass carbon and dehydrogenase activity in Cambisol and grain yield of maize.

The values of the studied parameters of the soil microbial activity were significantly higher in the variants where combination of bacterial inoculants and lower rates of mineral fertilizers was applied, as well as in the second sampling period. Mentioned combination also resulted in higher grain yield of maize comparing to the application of lower rates of the pure NPK nutrients.

Key words: microbial biomass, dehydrogenase activity, NPK fertilizers, N-fixing bacteria, maize

## Introduction

The studies in the field of fertilization are mostly focused on the increase of the yield of crops whereas the traits of the cumulative effect of fertilizers (the change of biological and chemical soil properties, the content of biogenic elements and heavy metals etc.) have often been disregarded. Regardless of its major role in crop productivity and soil fertility, the application of mineral fertilizers (particularly nitrogen) may induce a series of negative consequences, from the microbiological, economic and ecological aspects (Acosta-Martinez and Tabatabai, 2000).

The coefficient of nitrogen utilization by crops is low (30-60%) and is being reduced even more with the increase of nitrogen fertilizers rates. The problems concerned can be overcome by partial replacement of these fertilizers by application of microbial inoculants, in order to inhibit or stimulate certain cellular processes, including mineralization ones, thus leading to the improvement of physico-chemical and biological soil properties. (Milošević et al., 2003).

Having in mind the above mentioned, the aim of this investigation was to examine the influence of different rates of mineral fertilizers [composite NPK (15:15:15)] and their combination with selected soil bacterial inoculants, and sampling period on microbial biomass carbon and dehydrogenase activity in Cambisol and grain yield of maize.

## Material and methods

The investigation was conducted on Mladenovac experimental station of Institute of Soil Science, located 55 km from Belgrade in Serbia, during 2006. Mean monthly temperature and precipitation sum for the investigated period are presented in Table 1.

The studied soil type was Cambisol. The experiment was set up in a randomized block design with three

replicates, based on the following variants: control ( $\emptyset$ , non-fertilized soil); 60 kg·ha<sup>-1</sup> N and P<sub>2</sub>O<sub>5</sub>, and 40 kg K<sub>2</sub>O ha<sup>-1</sup> (N1); 120 kg·ha<sup>-1</sup> N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (N2); *Enterobacter* sp. strains + 60 kg·ha<sup>-1</sup> N and P<sub>2</sub>O<sub>5</sub>, and 40 kg K<sub>2</sub>O ha<sup>-1</sup> (ES+N1); *Enterobacter* sp. strains + 120 kg·ha<sup>-1</sup> N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (ES+N2); *Klebsiella planticola* + 60 kg·ha<sup>-1</sup> N and P<sub>2</sub>O<sub>5</sub>, and 40 kg K<sub>2</sub>O ha<sup>-1</sup> (KP+N1); *K. planticola* + 120 kg·ha<sup>-1</sup> N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (KP+N2). Maize (hybrid ZP-341, FAO 300) was used as a test plants.

Nitrogen fertilizer was applied in the form of urea with 46% N, phosphorus - in the form of monoammonium phosphate with 52% P<sub>2</sub>O<sub>5</sub> and 11% N, and potassium - as 40% potassium salt (KCl).

Table 1. Mean monthly temperature and precipitation summ for the study year.

Month	Year 2006		Mean 1990-2006	
	Temperature (°C)	Precipitation (mm)	Temperature (°C)	Precipitation (mm)
January	-0.5	43.2	1.8	41.9
February	1.9	59.1	3.7	36.8
March	6.5	104.4	8.0	42.8
April	13.7	97.0	12.8	54.6
May	17.4	42.3	18.2	51.4
June	20.2	137.8	21.6	94.8
July	24.7	23.3	23.2	66.1
August	20.9	120.6	23.1	60.1
September	19.2	24.3	17.6	63.8
October	15.2	20.9	13.1	53.8
November	8.9	24.5	7.4	55.6
December	4.3	51.9	2.3	61.5
Mean	12.8	-	12.7	-
Total	-	749.3	-	683.2

The pure culture of an associative N-fixing bacterium *K. planticola* was obtained from the stock culture of the Microbiology Laboratory of Faculty of Agronomy (Čačak, Serbia), while the *Enterobacter* strains (KG-75 and KG-76) were obtained from the stock culture of the Microbiology Laboratory in the Center for Small Grains (Kragujevac, Serbia), where they have been isolated from the rhizosphere of wheat.

Pure liquid inoculums of *K. planticola* and *Enterobacter* spp. were made using fermentors with suitable nutrient broth and incubated with aeration for 48 h at 28°C ± 1. The inoculation of the soil under young, 2-3 leaves formed plants of maize, was carried out using plastic haversack sprinkler with 300.00 cm<sup>3</sup>/m<sup>2</sup> of diluted liquid bacterial inoculum, previously made by adding the tap water in the pure bacterial liquid inoculum.

For the purpose of microbiological analyses the soil samples were taken three times during vegetation period of maize (intensive plant growth stage - 7-8 leaves, milk-waxy maturity stage, full grain maturity stage), from the plough layer (0-20 cm).

The following soil chemical parameters were analyzed: soil acidity - potentiometrically, using glass electrode pH meter; available phosphorus and potassium - spectrophotometrically and flame-photometrically, using Al-method by Egner-Riehm; humus content, using Tiurin's method, modified by Simakov; soil total N, using elemental CNS analyzer, Vario model EL III (Džamić et al., 1996; Nelson and Sommers, 1996).

Microbial biomass carbon (MBC) was measured using the chloroform fumigation incubation method, based on CO evolution (Jenkinson and Powlson, 1976). Soil dehydrogenase activity (DHA) was assayed under standard conditions (24 hours of incubation at 30°C ± 1) by measuring the intensity of the red-coloured triphenyl formazan extinction, formed by reduction of 2, 3, 5 - triphenyltetrazolium chloride, spectrophotometrically (Thalman, 1968).

The microbiological data obtained were analyzed by the method of the analysis of variance, using SPS Statistica 6.0 Software. The significance of the differences between the study factors was compared by the LSD test at  $P < 0.05$  and  $P < 0.01$ . The grain yield of maize was calculated at 14% moisture.

## Results and discussion

The main chemical characteristics of the study soil sampled before the trial was set up are presented in Table 2. The soil is characterized by acid reaction, high available potassium and medium available phosphorus, humus and total nitrogen supply.

**Table 2. Main chemical characteristics of the studied Cambisol.**

Parameter		Mean	Standard deviation	Range
pH	nKCl	4.06	0.05	4.00-4.10
	H <sub>2</sub> O	4.90	0.03	4.87-4.92
P <sub>2</sub> O <sub>5</sub> (mg 100 g <sup>-1</sup> )		15.73	0.31	15.51-16.09
K <sub>2</sub> O (mg 100 g <sup>-1</sup> )		25.30	0.30	25.08-25.65
Humus (%)		2.19	0.01	2.18-2.19
Total N (%)		0.136	0.005	0.132-0.141

The values of MBC and DHA in the soil depended on the fertilization variant used, as well as the sampling period studied (Tables 3 and 4). The analysis of the experimental data showed that the highest and statistically highly significant ( $P < 0.01$ ) level of DHA and MBC inhibition in the soil was determined in the variant with high rates of NPK nutrients (N2) during all studied vegetation periods of maize. Opposite to this, the highest and statistically highly significant ( $P < 0.01$ ) stimulation of DHA and MBC in the soil was affected by applied combination of the microbial inoculants used and low rates of NPK fertilizers (variants ES+N1 and KP+N1).

**Table 3. The effect of fertilization variant (A) and sampling period (B) on average dehydrogenase activity ( $\mu\text{g TPF}\cdot 10\text{ g}^{-1}$  of an air-dry soil) in Cambisol under maize**

Variants (A)		Ø	N1	N2	KP+N1	KP+N2	ES+N1	ES+N2	$\bar{X}$ B
Sampling period (B)	I	83.43	82.70	39.30	100.03	49.20	108.70	51.67	73.58
	II	93.47	90.13	39.07	126.27	60.07	128.13	62.33	85.64
	III	90.70	84.17	34.67	112.87	51.50	115.33	55.20	77.78
$\bar{X}$ A		89.20	85.67	37.68	113.06	53.59	117.39	56.40	79.00
LSD			A			B			
0.05			2.33			1.22			
0.01			3.09			1.62			

**Table 4. The effect of fertilization variant (A) and sampling period (B) on average microbial biomass C ( $\text{mg}\cdot\text{kg}^{-1}$  of an absolutely dry soil) in Cambisol under maize**

Variants (A)		Ø	N1	N2	KP+N1	KP+N2	ES+N1	ES+N2	$\bar{X}$ B
Sampling period (B)	I	54.90	48.28	22.83	77.56	29.63	93.94	35.03	51.74
	II	62.40	53.86	38.17	98.65	39.56	113.99	40.96	63.94
	III	56.64	50.89	19.69	85.05	37.65	103.35	39.91	56.17
$\bar{X}$ A		57.98	51.01	26.90	87.09	35.61	103.76	38.63	57.28
LSD			A			B			
0.05			10.33			5.40			
0.01			13.74			7.18			

Similar to our studies, results of the previous studies indicate that long-term application of high doses of mineral fertilizers significantly decrease microbiological activity in soil by decreasing soil pH and increasing N content in soil (Aciego Pietri and Brookes, 2008; Wang et al., 2009). Other findings (Csitári and Hoffmann, 2005) point out that different fertilizer treatments influence soil biological parameters significantly, but there is no linear correlation between them and the quantity of fertilizer active agents. Stimulative effects of the combine usage of the associative N-fixing bacteria and low rates of NPK nutrients on soil MBC and DHA were also reported in previous studies (Raičević et al., 2006).

According to our studies, the values of MBC and DHA depended significantly on sampling period studied. The highest values of MBC and DHA in the soil were determined in the second sampling period, which was statistically highly significantly more ( $P < 0.01$ ) comparing to the other two vegetation periods of maize. The highest values of the studied parameters of soil fertility in the second sampling period is, probably, due to a better distribution of precipitation during summer in the year studied. Similar to this, Nagaraja et al. (2002) reported that an increase in soil moisture status during the wet periods of the year resulted in higher biological activity.

Concerning the grain yield of maize (Figure 1), the highest increase was obtained by combined application of microbial inoculants used and high rates of mineral NPK fertilizers, although it should be noted that with combined usage of microbial inoculants and low rates of mineral NPK fertilizers was obtained higher yields comparing to the application of lower rates of mineral NPK fertilizers in conditions of agricultural production typical for this study. Similar results for both constataions were also obtained in previous researches (Dobbelaere et al., 2001; Dalla Santa et al., 2004).

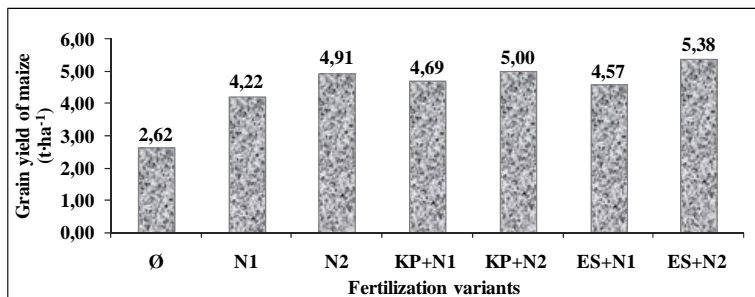


Figure 1. The effect of the fertilization variants on the grain yield of maize (t · ha<sup>-1</sup>).

## Conclusions

The studies indicate that bacterial inoculants can be used to supplement the use of urea-N, reducing the amounts of NPK fertilizers used and positively affecting on dynamics and direction of the soil microbial processes. The combined usage of microbial inoculants and low rates of mineral fertilizers also resulted in higher maize yields comparing to the application of lower rates of the pure NPK nutrients in the studied agroecological conditions.

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# Influence of fertilization on the evolution of maize yields

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## Abstract

The research is focused on the influence of nitrogen and phosphorus fertilizing to maize yield in long term trails in irrigated conditions during 2004-2010 years. The analysis of variance emphasized that the organic fertilizers efficiency was strongly influenced by climatically conditions. The results showed also that maize yields and yield increases were conditioned and limited by specific traits, especially using of mineral and organic fertilizing.

Key words: fertilization, yields, maize

## Introduction

One of the most important technological conditions to obtain high yields is fertilizing. This was always in the attention of the researchers, because of its positive effects on the yield increase and for its detrimental effects to soil, water and human health (Dornescu, 1992; Partal and Zaharia, 2008). The previous studies focused on the fertilizing effects emphasized yield fluctuations depending on crop, cultivar, climatically conditions, soil and its natural fertility (Frye and Thomas, 1991; Petcu et al., 2003; Ciobanu and Ciobanu, 2005; Sin and Partal, 2010). The lowest yields recorded on unfertilized plots in long time trials showed that soil natural fertility decrease during the time (Yang et al., 2004). The optimization of plants nutrition is necessary in sustainable agriculture systems leading to soil conservation and higher net inputs. To touch this goal an experiment was carries out during 2004-2010 to Experimental Agricultural Station Moara Domneasca to study the influence of mineral and organic fertilizers to maize yield.

## Material and methods

The researches were done on long time trails in irrigated conditions on preluvosoil to Agricultural Station Moara Domneasca. The variants were: Factor A - phosphorus fertilizer with 4 rates: 0, 40, 80, 120 kg/ha P<sub>2</sub>O<sub>5</sub> basal applied and Factor B - organic fertilizers: unfertilized, plant debris (3-5 t/ha wheat stows), manure (20 t/ha applied annually in autumn). Factor C - nitrogen fertilizer with 5 rates: 0, 50, 100, 150, 200 kg/ha N. The data were statistically evaluated using analysis of variance procedure (Saulescu and Saulescu, 1967) and response curves.

## Climatic conditions

The climatically were variable during experimental period. It was observed that climatically conditions linked with technological ones influenced strongly the yield. For the experimental period (2004-2010) the rainfalls were variable comparatively with the multiannual average value recording two years with heavy rains, two droughty years and three normal years. Water stress was noticed during summer/autumn period influencing crop development. Heavy rains characterized the year 2005 (+ 490 mm over multiannual average value). It was observed that air temperatures were up to 1 °C over multiannual average value. Thus, in 2007 and 2009 years the high air temperatures during summer months linked with water stress leading to yield decreases

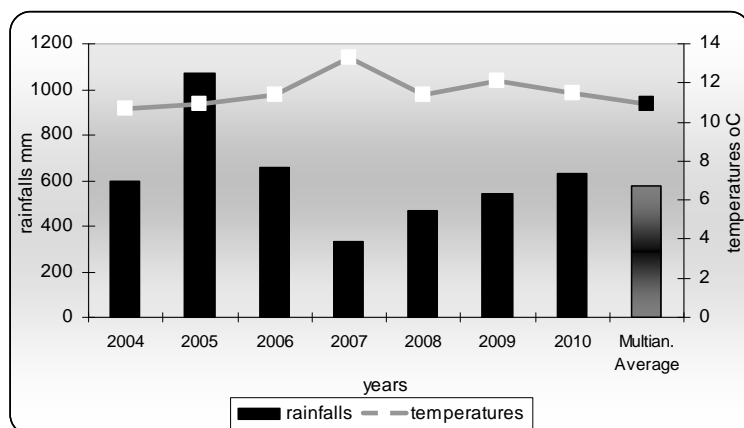
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## Influence of fertilization on the evolution of maize yields

(Fig. 1).



**Fig. 1.**The evolution of the rainfalls and air temperatures during

2004-2010 years to Moara Domneasă area

### Results and discussion

The analysis of variance emphasized distinct significant values both experimental variants and their interactions on the basis of F test (Table 1) which comparatively with experimental error showed that yields had fluctuations form year to year as a result of the influence of climatically and fertilizing conditions. It was observed that organic fertilizers efficiency was strongly influenced by rainfalls and their distribution during crop growth stages.

**Table 1.** ANOVA for maize average yields on 7 years (2004-2010)

Factor	SP*	GL*	S <sup>2</sup>	F <sub>c</sub>	F <sub>t 5%</sub>	F <sub>t 1%</sub>
A - year	4525	7	661	2308**	2.49	3.64
Error a	6.02	21	0.30			
B - phosphorus fertilizer	107	3	36.1	160**	2.74	4.08
AB	68	21	3.20	14.20**	1.72	2.15
Error b	16.3	72	0.23			
C - organic fertilizers	154	2	77.0	420**	3.00	4.60
AC	106	14	7.60	41.80**	1.70	2.09
BC	11.3	6	1.90	10.30**	2.09	2.80
ABC	65	42	1.50	8.40*	1.39	1.59
D - nitrogen fertilizer	2025	4	507	2790**	2.37	3.32
AD	440	28	15.8	87.00**	1.46	1.74
BD	11.9	12	0.99	5.50**	1.75	2.18
ABD	52.0	84	0.62	3.40**	1.27	1.39
CD	65.5	8	8.20	45.10**	1.94	2.51
ACD	60.9	56	1.09	6.01**	1.33	1.49
BCD	19.2	24	0.80	4.45**	1.52	1.79
ABCD	100	168	0.61	3.35**	1.00	1.00
Error c	244	1340	0.19			

SP - sum of squares

GL - degree of freedom

The average yields decrease significantly depending on climatically conditions. Thus, the lowest yield values recorded in 2004 and 2007 years. Yield increases due to manure application ranged from 1.75 t/ha to 2.40 t/ha comparatively with unfertilized plots and from 0.9 t/ha to 1.90 t/ha comparatively with plant debris plots (Fig.2).

Considering maize yield increase, one of the limited factors is represented by nitrogen. Thus, it was observed the very significant influence of unilateral nitrogen fertilization to average yields. The yield increases ranged from 1.5 t/ha to 3.0 t/ha. The gradually nitrogen rates to 150 kg/ha N assured significant yield increases. When were applied higher nitrogen rates (over 150 kg/ha N) yield increases weren't significant (Fig.3).

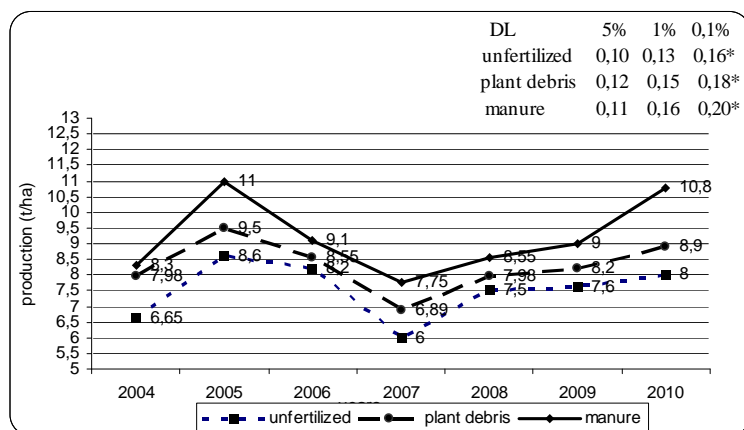


Fig. 2. The influence of climatically fluctuation on maize average yield

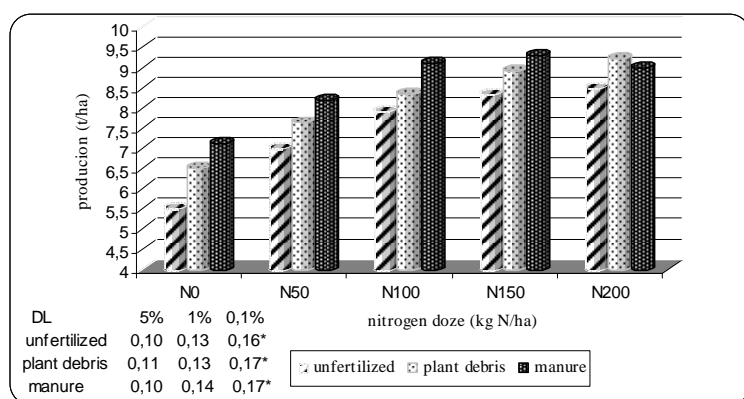


Fig. 3. The influence of nitrogen fertilizing on maize average yield (2004-2010)

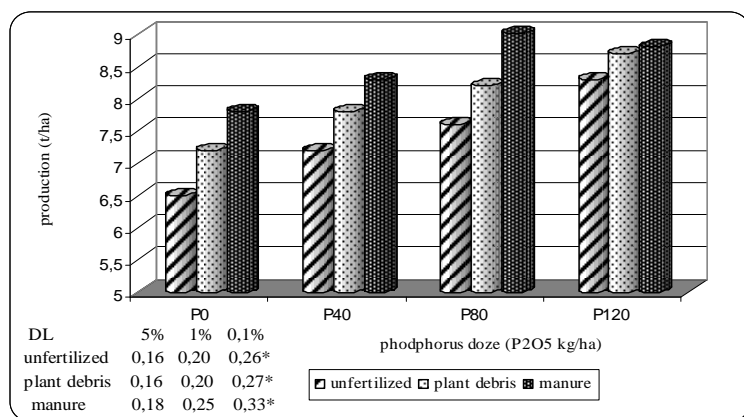


Fig. 4. The influence of phosphorus fertilizing on maize average yield (2004-2010)

Analysing maize average yields can be observed the very significant influence of phosphorus fertilizing. The yield increases due to unilateral phosphorus fertilizing ranged from 0.7 t/ha to 1.8 t/ha. The yield increases were very significant when phosphorus fertilizers were applied on the plots fertilized previously with manure. Using 80 kg/ha P<sub>2</sub>O<sub>5</sub> the yield was 9.0 t/ha (Fig.4).

On the long time unfertilized plots the yields ranged from 4.40 t/ha to 7.10 t/ha. When were applied economical nitrogen rates the yields ranged from 7.65 t/ha to 11.30 t/ha and the yield increase ranged from 2.06 t/ha to 4.30 t/ha comparatively with unfertilized plots. The economical nitrogen rates were between 130-160 kg/ha N. When the nitrogen fertilizer is unilateral applied yield increases ranged from 11 kg grains/N kg to 12 kg grains/N kg, whereas the nitrogen fertilizing applied on the plots fertilized previously with phosphorus determine yield increases which ranged from 11 kg grains/NP kg to 18 kg grains/kg NP. It was observed that in climatically favourable years the coefficient of nitrogen efficiency increase to 54%.

Table 2. The influence of nitrogen and phosphorus fertilizing on maize yield (t/ha)

Specification	Maize crop						
	2004	2005	2006	2007	2008	2009	2010
Control (N <sub>0</sub> P <sub>0</sub> )	5.05	7.00	4.70	4.40	6.50	6.05	7.10
N <sub>0</sub> P <sub>80</sub>	5.25	7.53	5.05	5.22	6.90	6.90	7.88
N <sub>50</sub> P <sub>80</sub>	6.23	8.77	6.90	6.48	7.75	7.55	8.90
N <sub>100</sub> P <sub>80</sub>	7.05	10.78	8.77	7.30	8.68	8.43	10.55
N <sub>150</sub> P <sub>80</sub>	8.30	11.95	9.00	8.10	9.30	9.44	11.85
N <sub>200</sub> P <sub>80</sub>	8.00	11.70	9.00	8.00	9.10	9.15	11.40
Economically efficient yield (t/ha)	7.70	11.30	8.80	7.65	8.90	8.80	11.10
Economically nitrogen doses (kg/ha)	140	160	160	130	150	145	160
Yield increase beside N <sub>0</sub> P <sub>0</sub>	2.06	4.30	4.10	3.25	2.40	2.75	4.00
Yield increase for 1 kg N	17.0	24.0	18.0	11.0	19.0	19.0	23.0
Yield increase for 1 kg NP	12.0	18.0	17.0	11.0	16.0	15.5	17.0
Nitrogen efficiency coefficient (%)	35.0	54.0	40.0	25.0	45.0	42.0	53.0

### Conclusions

The yields for the same fertilizing variant ranged from 2.67 t/ha to 3.73 t/ha depending on the influence of climatically conditions especially to the nitrogen fertilizers efficiency. Organic fertilizers determine a depression of optimal nitrogen doses leading to yields which ranged from 0.9 t/ha to 2.40 t/ha. To obtain the best efficiency of nitrogen and phosphorus fertilizers these must be applied until the end of May because in the next growth stages maize plants record the highest water and nutrients consumption. The coefficients of nitrogen efficiency ranged from 25% to 54%. The highest value was recorded in the years with heavy rains. leading to high yields. To establish the fertilizers amount necessary to assure plants development considering its genetic potential represent the main way to increase the efficiency and to avoid soil pollution.

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# The influence of seed treatments on germination and initial growth of maize seedlings

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## Abstract

Seed coating with protective substances, as fungicide and insecticides is very important practice in maize seed production. Some fungicides and insecticides could stimulate or reduce germination and initial growth of seedlings. The aim of this study was to investigate different seed treatments of fungicide (fludixonil + metalxil-M) and insecticides (tiametoxam and imidacloprid) on germination and initial growth of six maize inbred lines. Applied pesticides generally elevated the germination percentage, while fresh matter of root and shoot varied, depending on the genotype. Furthermore, all applied treatments induced increase in dry matter in root and shoot, what can be related to a decrease in hydrolysis, parallel to increase in biosynthesis, in general. The observed seed coating treatments induced increase in maize inbreds germination, as well as it stimulated fresh and dry matter accumulation *via* increasing of biosynthesis. Adequate pesticide combination depends on genotype.

Key words: maize, germination, seedlings, growth, insecticide, fungicide

## Introduction

Contemporary seed production is inconceivable without seed coating with protective substances, as fungicides and insecticides. They provide seed storage during some period without negative influence of present microorganisms (Protić et al., 2004; Mrđa et al., 2009). On the other hand, some fungicides and insecticides could act as suppressors or stimulators of germination (Lomović et al., 2000; Stevanović et al., 2009). In seedlings, observed effect could prolong during some time, inducing poorer growth, with less fresh and dry matter accumulation in root and shoot (Singh et al., 1982; Kunkur et al., 2007; Moore and Kroger, 2010). Toxic or stimulant effects of seed coating fungicides and insecticides could be expressed by cytological aberrations (Singh et al., 1979), higher production of plant hormones (Singh et al., 1982), what could have as consequence unequal distribution of seed matter into root and shoot (Dragičević et al., 2008).

The aim of this study was to investigate different seed treatments with fungicide and insecticides on germination and initial growth of maize inbred lines.

## Material and methods

The seeds of six maize inbred lines (PL A 680 - L1, PL 173/4 - L2, PL 357/3 - L3, PL 217 - L4, PL 17/5 - L5 and 255/75 - L6), were treated with fungicide fludixonil + metalxil-M (preparation Maxim XL035-FS) in dose of 1 ml kg<sup>-1</sup> seeds. Applied insecticides were: tiametoxam (preparation Cruiser 350 FS) in dose 9 ml kg<sup>-1</sup> seeds, and imidacloprid (preparation Gaucho 600 FS) in dose of 7 ml kg<sup>-1</sup> seeds, as follows:

Control - without treatments (Ø);

Treatment with fludixonil + metalxil-M (M);

Treatment with fludixonil + metalxil-M and tiametoxam (M+C);

Treatment with fludixonil + metalxil-M and imidacloprid (M+G);

The germination capacity was determined by ISTA Rules, in four replications of 100 uniform seeds (ISTA, 2007), after 7 days. The seeds were weighed before germination. Filter paper towels were used as the germination medium. The following conditions were maintained in the germination cabinet: a temperature of 25 °C, with an 8 h light regime of 1250 lux (simulation of daylight) and a relative humidity of 97%.

The uniformly grown seedlings were separated into four replications of 25 plants and then fractioned into root, shoot and the rest -seed. The roots and the shoots were weighed for fresh matter determination (FM, g) and dried in the ventilation drier at 60 °C to the constant mass for dry matter determination (DM,%).

Based on obtained measurements sum of hydrolysis and biosynthesis were calculated:

$$\Sigma Hy = \text{SeedM} - \text{DM}_{\text{seed rest}}$$

$$\Sigma Bs = \text{DM}_{\text{root}} + \text{DM}_{\text{shoot}}$$

Where  $\Sigma Hy$  is sum of hydrolysis (g);  $\Sigma Bs$  is sum of biosynthesis (g); SeedM is seed weight (g);  $\text{DM}_{\text{seed rest}}$  is dry weight of rest -seed (g);  $\text{DM}_{\text{root}}$  is dry weight of root (g);  $\text{DM}_{\text{shoot}}$  is dry weight of shoot (g);

The data of fresh matter, dry matter, hydrolysis and biosynthesis were expressed with standard deviation.

### Results and discussion

The germination percentage was in general elevated by influence of applied pesticides (Figure 1). Only for L4 possible toxicity was noticed, by lowering the germination percentage, similar to results of Singh et al. (1979) and Lomović et al. (2000). Treatment with fludixonil + metalxil-M induced increased germination on average 4%, evidencing positive impact of fungicide against possible fungus activity (Protić et al., 2004). Meanwhile, fludixonil + metalxil-M and imidacloprid show better results for L1, L3 and L5, increasing germination percentage up to 9%, which was opposite to the results of Mrđa et al. (2009), attained on sunflower.

The applied treatments induced variations in root and shoot FM, dependently on genotype. In general, application of insecticide and fungicide increased root and shoot FM (Figure 1), except for L1, where pesticide application decreased FM, similar to results of Singh et al. (1979) and Moore and Kroger (2010), which discussed phytotoxicity of some insecticides to crops. The best results in the increase of FM were obtained on root level, with application of fludixonil + metalxil-M and tiametoxam (L6 up to 54% increase in comparison to control) and on shoot level, with application of fludixonil + metalxil-M and imidacloprid (L6 up to 37% increase in comparison to control).

Furthermore, all applied treatments induced increase of root and shoot DM, in comparison to control (Figure 2), evidencing a better utilization of seed matter (Dragičević et al., 2008). The application of fludixonil + metalxil-M increased root DM of L1, L2 and L3, up to 1.21%, while combination of fludixonil + metalxil-M and tiametoxam was more effective for L5 and L6, increasing root DM up to 2.01%. At shoot level fludixonil + metalxil-M and imidacloprid induced DM increase for L1, L3, L4 and L5, up to 0.92%. Obtained results are in agreement with results of Siddiqui and Zaman (2004), and Kunkur et al. (2007), where positive impact of fungicides and insecticides seed treatments on DM accumulation was observed.

The differences in growth of seedlings of examined inbreds, influenced by applied pesticides could be better understood on hydrolysis and biosynthesis level (Figure 3). Namely, relatively poor growth, expressed through low shoot and root FM of L2 (Figure 1), with no remarkable influence of applied pesticide treatments could be connected to a highest hydrolysis level among all inbreds (Figure 3) and lowest biosynthesis. High hydrolysis and low biosynthesis levels are evidence of high deprivations of dry matter, giving poor growth potential to a specified seedling (Dragičević et al., 2008). In general, pesticide treatments induced decrease in hydrolysis, parallel to increase in biosynthesis. It is important to underline that for L4, as inbred with highest average biosynthesis, the applied seed treatments increased biosynthesis (Figure 3), but mainly on the root level (highest root DM, Figure 2), similar to results achieved by Kunkur et al. (2007) on cotton. On the other hand, highest impact of applied treatments was observed for L5, where biosynthesis was elevated 34.4% in fludixonil + metalxil-M and imidacloprid treatment, and in L6 it was 52.5% higher in treatment with fludixonil + metalxil-M and tiametoxam, indicating stimulation, irrespective to the way of their action (Singh et al., 1979, Singh et al., 1982, Siddiqui and Zaman, 2004).

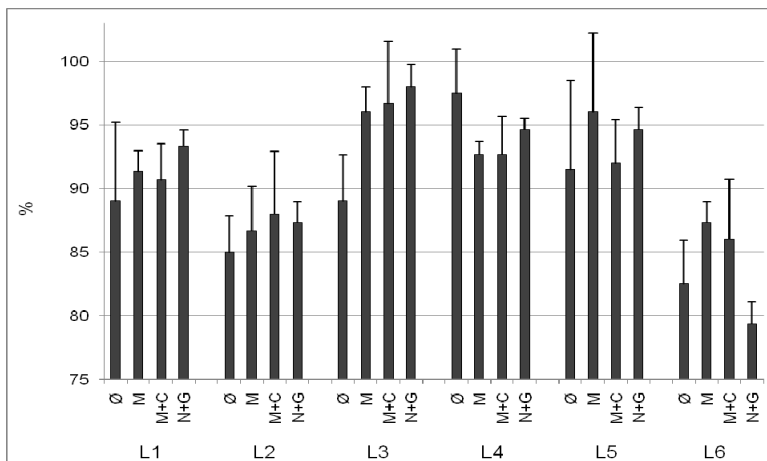


Figure 1. Germination percentage of maize inbred lines (L1-L6), influenced by fludixonil + metalxil-M (M), fludixonil + metalxil-M and tiametoxam (M+C), fludixonil + metalxil-M and imidacloprid (M+G) and control (Ø); Values are mean ± SD.

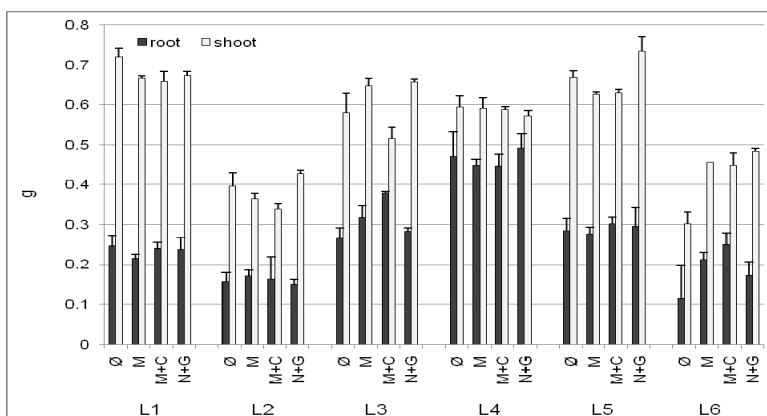


Figure 2. Fresh matter of maize inbred lines (L1-L6), influenced by fludixonil + metalxil-M (M), fludixonil + metalxil-M and tiametoxam (M+C), fludixonil + metalxil-M and imidacloprid (M+G) and control (Ø); Values are mean ± SD.

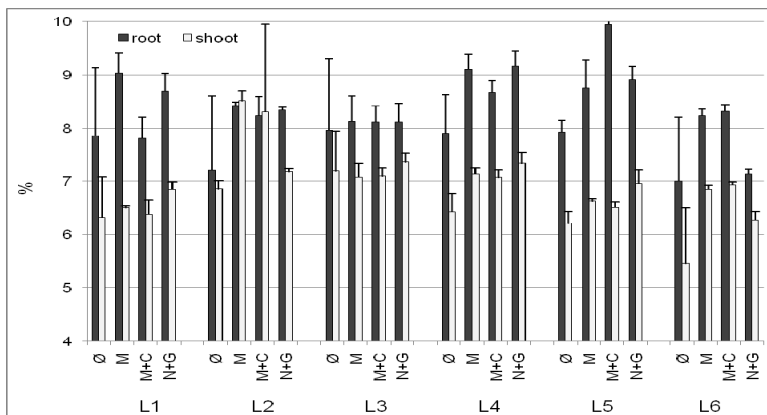


Figure 3. Dry matter of maize inbred lines (L1-L6), influenced by fludixonil + metalxil-M (M), fludixonil + metalxil-M and tiametoxam (M+C), fludixonil + metalxil-M and imidacloprid (M+G) and control (Ø); Values are mean ± SD.

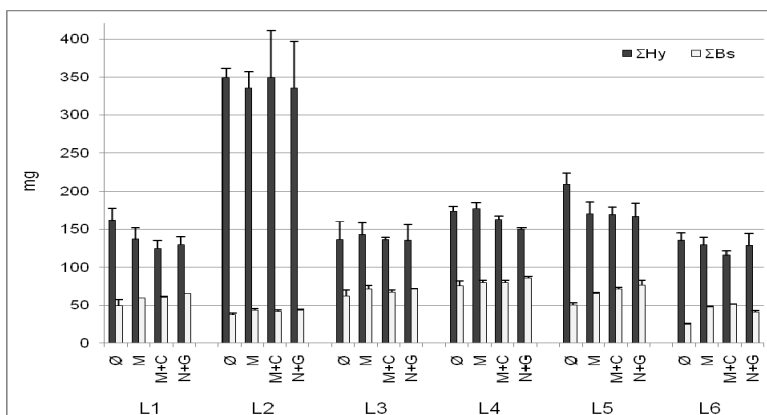


Figure 4. Sum of hydrolysis (ΣHy) and biosynthesis (ΣBs) of maize inbred lines (L1-L6), influenced by fludixonil + metalxil-M (M), fludixonil + metalxil-M and tiametoxam (M+C), fludixonil + metalxil-M and imidacloprid (M+G) and control (Ø); Values are mean ± SD.

## Conclusion

Based on the obtained data it can be concluded that the applied pesticide treatments induced increase in germination of maize inbreds, as well as stimulate fresh matter and dry matter accumulation, through lowering the hydrolysis level and increasing the biosynthesis. Adequate pesticide combination depends on the genotype.

## Acknowledgments

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# Effects of crop rotation on weed infestation in maize crops

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## Abstract

Effects of the crop rotation, as a cropping system on arable areas, were studied on weed infestation in maize crops. Maize as a dominant crop in the sowing structure is most often grown in two cropping systems: maize continuous cropping and the two crops rotation. Soybean as a crop is sown on significantly smaller areas, hence it is an important crop to be used in the future organisation of the contemporary crop rotations. Considering all these facts, it is decided to organise permanent crop rotations in Radmilovac, the experimental model farm of the Faculty of Agriculture in Belgrade-Zemun. The trials with crop rotations with various crops were set up in 1992 and they are still performed. The crop rotation, as a cropping practice, is a complex category with broad effects on the soil and crops. The present study presents results on effects of different cropping systems (crop rotation and continuous cropping) on a weed synusia in maize crops during the two years of investigation (2009 and 2010).

According to obtained results, all crop rotations, from two-crop to six-crop rotation, were a more efficient system for weed suppression than maize continuous cropping.

Key words: weeds, crop rotation, continuous cropping, maize

## Introduction

Weed control on arable areas is just one of segments of the soil maintenance that can significantly increase crop yields per area unit. Making the decision on the selection of weed control measures is based on the crop type, genotype and a growing system for a particular crop. Studies related to cropping systems are a great deal difficult and lasting (Kovačević et al., 2008), and explanation of their effects on weed communities cannot be generalised (Swanton et al., 1999), i.e. other factors have to be considered: different types of tillage, environmental conditions (soil type, moisture) and other weed control measures. A great distribution of maize in the sowing structure contributes to the cultivation of this crop in continuous cropping more often than other crops. Such a growing system, with a frequent application of herbicides of similar or the same activity spectrum, leads to greater weed infestation by species belonging to the family *Poaceae*, especially the most resistant perennial species such as *Sorghum halepense* Pers. (Kovačević, 1993). Molnar, 1990, however, states that the increased abundance of the mentioned weed in continuous cropping is more a result of the herbicides application, and this standpoint is illustrated by studies carried out in Rimski šančevi, Novi Sad, in which a small number of plants of this weed was observed in maize continuous cropping without the herbicides application. Nowadays, maize continuous cropping, with or without herbicide applications, should necessarily be avoided due to very dangerous maize pest *Diabrotica* sp. since the crop rotation is the safest measure for its control (Kovačević et al., 2008).

Beside the direct effect of the crop rotation on the yield, this measure also indirectly affect the manifestation of greater efficiency of other applied cropping practices, especially weed control measures. Kovačević, 2004, emphasises that the crop growth in the crop rotations is not only the most important measure, but sometimes is also the only measure that can properly protect crops from weeds, diseases and pests. Jovanović, 1995, states that the crop rotation with a smaller number of fields (two-field system/two-crop



rotation) has a significant effect on the weed infestation reduction. This is confirmed by results obtained by Kovačević et al., 2008, which show that weed mass measured in the two-crop rotation was significantly lower than the weed mass measured in continuous cropping and other observed crop rotations (three-, four- and six-crop rotation). The advantages of three- and four-crop rotations over the two-crop rotation are in a lower frequency of tillage and thereby in saving energy, mineral nitrogen fertilisers and herbicides, which causes stronger weed infestation in a longer period of time. The effect of the crop rotation on the structure of the weed synusia in maize crops can be physical, allelopathic or both jointly, but in any case this effect is very great (Dražić, 1999).

The objective of this study was to observe a long-term effect of different crop rotations, as cropping systems, on weed infestation in maize crops and on the basis of obtained results to more clearly perceive their role in weed suppression under agroecological conditions of our country.

### Material and methods

The trial with different cropping systems was set up on leached chernozem in Radmilovac, the experimental model farm of the Faculty of Agriculture, Belgrade-Zemun, in 1992 and it has been lasting till today.

Different cropping systems were established:

1. continuous cropping (winter wheat, maize and soybean) and different crop rotations:
2. two-crop rotation (winter wheat-maize)
3. tree-crop rotation (winter wheat-maize-soybean)
4. six-crop rotation (winter wheat-maize-soybean-spring barley+red clover-red clover-sunflower).

The size of the plot under one crop, i.e. the plot in a one-field system, was approximately 10 ares. The hybrid ZP SC 599 was used in the trials. NPK fertilisers were not applied. Seed dressing with KAN in the amount of 250 kg ha<sup>-1</sup> (about 63 kg of pure N fertiliser) was performed in the 3-4-leaf stage of maize. Tillage was done in due time in both years of investigation to the depth of approximately 25 cm. Maize sowing was done by a pneumatic four row seeder. Cultivation measures specific for the conventional maize production were applied during the maize growing season.

Weed samples were drawn in the stage of maize intensive growth on July 3, 2009 and May 27, 2010 in tree replications. Weed species and the number of plants per annual, i.e. perennial weed species were determined per m<sup>2</sup>. Fresh biomass of weed samples, and then after biomass drying, air dry biomass were measured.

Meteorological conditions in the course of trails performance

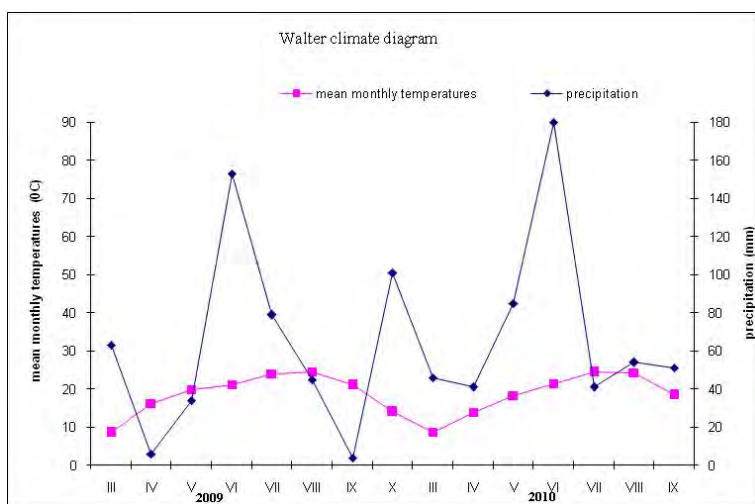


Figure 1. Meteorological data in Belgrade during the period of investigation

The most important meteorological data (temperatures and precipitation) in the experimental field during studies on weed infestation are presented in Figure 1. Total precipitation sums over months of the maize growing season, as seen from Walter climate diagram (Figure 1), were relatively favourable for maize in both years. However, the precipitation distribution was significantly more favourable during the second year of investigation, especially in the initial stages of maize growth and development. The first year of investigation

(2009) was characteristic for two dry spells. The first dry spell during April and May led to delayed maize emergence, and thereby to a weaker competitiveness in relation to weeds. The second dry spell, during August and September, was somewhat longer, but it more affected maize grain yield than weed infestation on the observed area.

### Results and discussion

Tables 1 and 2 present results on effects of different crop rotations and continuous cropping on weed infestation in maize crops. The weed synusia in maize crops in all cropping systems was composed of 14, i.e. 15 weed species in the first, i.e. second year of investigation, respectively. A higher number of weed species, and especially their mass, as well as, a lower number of plants per weed species in the second year are the result of favourable meteorological conditions that equally affected weeds and maize.

**Table 1. The effect of a cropping system on the floristic composition of the weed synusia in maize crops (2009)**

No	Weed species	Continuous cropping	Crop rotation		
			two-crop rotation	three-crop rotation	six-crop rotation
1.	<i>Agropyrum repens</i> (L.) Beauv.		1.32	2.66	6.00
2.	<i>Amaranthus retroflexus</i> L.	6.64		3.32	1.32
3.	<i>Ambrosia artemisiifolia</i> L.	4.00			0.66
4.	<i>Cirsium arvense</i> (L.) Scop.	9.32		0.66	2.66
5.	<i>Chenopodium album</i> L.	8.00	2.66	2.66	4.66
5.	<i>Convolvulus arvensis</i> L.	12.00			
6.	<i>Cynodon dactylon</i> (L.) Pers.	1.32	1.32		2.00
7.	<i>Datura stramonium</i> L.	4.00	1.32	0.66	2.00
9.	<i>Polygonum aviculare</i> L.	2.64	0.66	1.32	
10.	<i>Rubus caesius</i> L.	8.00			
11.	<i>Setaria viridis</i> (L.) P.B.			1.32	
12.	<i>Sinapis arvensis</i> L.	1.32	0.66		0.66
13.	<i>Sorghum halepense</i> (L.) Pers	14.64	4.00	3.32	6.00
14.	<i>Solanum nigrum</i> L.	13.32	6.00	4.00	5.32
Total number of plants per weed species m <sup>-2</sup>		85.20	17.94	19.92	31.28
Total number of weed species		12	8	9	10
Number of plants per annual weed species		39.92	11.30	13.28	14.62
Number plants per perennial weed species		45.28	6.64	6.64	16.66
Fresh biomass g m <sup>-2</sup>		169.44	90.78	121.98	131.58
Air dry biomass g m <sup>-2</sup>		57.24	26.91	29.88	46.92

The 17-, i.e. 18-year continuous cropping is obviously a respectable period for making unambiguous and precise conclusions. Namely, the number of weed species, and especially the number of plants per weed species, have been increasing in maize continuous cropping over years, but the increasing tendency certainly depended on meteorological conditions in particular years. Both years of investigation of maize continuous cropping were characterised by the highest number of weed species and plants per weed species with the dominance of perennial species, due to, first of all, great abundance of plants per species *Sorghum halepense* (L.) Pers and *Convolvulus arvensis* L. The highest number of plants per annual weed species in maize continuous cropping was recorded in species *Solanum nigrum* L., *Chenopodium album* L. and *Amaranthus retroflexus* L. Beside a great number of plants per weed species in maize continuous cropping, the greatest fresh biomass and air dry biomass were also recorded. This was exceptionally contributed by a large number of plants per perennial weed species. Dominant species in crop rotations were the same as in maize continuous cropping, only the increased distribution of perennial species *Cirsium arvense* (L.) Scop. and *Agropyrum repens* (L.) Beauv. was observed in the six-crop rotation.

The field crops cultivation in long-term continuous cropping results in qualitative changes in the structure of anthropogenic weed community, due to the application of selective herbicides that successfully suppress weed species and the vacated spaces are inhibited by resistant and perennial weed species (Dražić, 1999). This statement is in accordance to results obtained in our study. Crop rotations, even two-crop rotations, as a

## Effects of crop rotation on weed infestation in maize crops

crop rotation with the smallest number of fields, positively affected the weed infestation reduction (Kovačević et al., 2010). The number of weed species and the number of plants per weed species were lower in two- and three-crop rotations in both years than in maize continuous cropping and the six-crop rotation. In the simplest, the two-crop rotation, narrow- and broad-cast crops are permanently interchanged, which came out as a good solution in weed control, because the possibility of intensive spreading of weeds, especially perennial ones, is constantly discontinued. Small grains with their density and good coverage disturb many weeds, while mechanical tillage measures that are applied after small grains directly destroy weeds and reduce potential weed infestation by provoking their emergence in order to destroy them prior to seed dispersal (Kovačević et al., 2008., 2010).

**Table 2. The effect of a cropping system on the floristic composition of the weed synusia in maize crops (2010)**

No	Weed species	Continuous cropping	Crop rotation		
			two-crop rotation	three-crop rotation	six-crop rotation
1.	<i>Agropyrum repens</i> (L.) Beauv.	4.00			
2.	<i>Amaranthus retroflexus</i> L.	1.00	2.66		1.32
3.	<i>Ambrosia artemisiifolia</i> L.	2.64			1.32
4.	<i>Avena fatua</i> L.				1.32
5.	<i>Capsella bursa-pastoris</i> (L.) Med.			1.32	
6.	<i>Cirsium arvense</i> (L.) Scop.	2.64		4.00	3.33
7.	<i>Chenopodium album</i> L.	2.64	1.32	1.32	1.32
8.	<i>Convolvulus arvensis</i> L.	12.00	2.66	1.32	1.32
9.	<i>Cynodon dactylon</i> (L.) Pers.		1.32	1.32	
10.	<i>Datura stramonium</i> L.	1.32	1.32	0.66	1.32
11.	<i>Polygonum aviculare</i> L.	0.66			
12.	<i>Sinapis arvensis</i> L.			0.66	2.00
13.	<i>Sorghum halepense</i> (L.) Pers.	12.00	3.00	3.33	4.00
14.	<i>Solanum nigrum</i> L.	8.00	2.66	2.00	4.00
15.	<i>Sonchus olerceus</i> L.	2.64	2.66	1.32	
Total number of plants per weed species m <sup>-2</sup>		49.54	17.60	17.25	21.25
Total number of weed species		11	8	10	10
Number of plants per annual weed species		18.90	10.62	7.28	12.60
Number plants per perennial weed species		30.64	6.98	9.97	8.65
Fresh biomass g m <sup>-2</sup>		264.53	123.43	136.90	160.43
Air dry biomass g m <sup>-2</sup>		63.51	40.87	33.33	46.07

The worst characteristic was expressed by the six-crop rotation, because this system encompassed different crops, which were accompanied with different weed synusiae. The greatest number of weed species, as well as, the number of plants per weed species were detected in maize crop grown in the six-row cropping rotation. Furthermore, the greatest weed fresh biomass and air dry biomass were recorded in this cropping system (Tables 1 and 2). The six-crop rotation was more efficient in weed suppression only in relation to maize continuous cropping, which is in accordance with results for wheat obtained by Kovačević et al., 2010. Although maize growth in crop rotations with a greater number of fields results in higher yields (Dolijanović et al., 2006), it does not contribute to the reduction of weed infestation, especially by perennial weeds. In order to get a positive response of the poly-crop rotation to weed infestation, especially to perennial weeds, the rotation should begin with a dense crop (wheat), which should be succeeded with broad-leaf row crops (soya bean, sunflower, sugar beet) and at the end maize could be sown on already clean field (Dražić, 1999). In some crops such as alfalfa and red clover often mowing exhaust many perennial weeds whereby their seed dispersal is reduced.

## Conclusion

According to studies on effects of different cropping systems (crop rotations and continuous cropping) carried out since 1992 till the years of investigation (2009 and 2010) on the weed synusia in maize crops grown on leached chernozem the following can be concluded:

The Weed synusia in maize crops was composed of 14, i.e. 15 weed species in the first, i.e. second year of investigation, respectively, with dominance of terophytes. The perennial species *Sorghum halepense* (L.) Pers and *Convolvulus arvensis* L. and annual species *Solanum nigrum* L., *Chenopodium album* L. and *Amaranthus retroflexus* L. prevailed in the weed synusia in maize crops.

The highest number of weed species, plants per weed species and the greatest weed biomass per m<sup>2</sup> were recorded in maize continuous cropping. Crop rotations, especially two- and three-crop rotations were more efficient in the reduction of the number of plants per weed species and weed mass than continuous cropping and six-crop rotation.

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# Cyclic hydroxamic acid content of different maize varieties in early developmental stages

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## Abstract

Cyclic hydroxamic acids are plant-born chemicals playing important role in the self-defence mechanism of the plant. The species and the varieties produce different amount from these chemicals and the quantity depends on plant age as well as organ. The varieties with higher cyclic hydroxamic acid content have higher ability to protect themselves, especially in early stages of development. Two maize varieties were examined from this point of view: Saaten Union Zamora and an experimental variety, named DASi. The cyclic hydroxamic acid content was measured in various ages and in various organs. The higher cyclic hydroxamic acid content was measured in the youngest leaves of the experimental plants. Much lower cyclic hydroxamic acid content was measured in the roots, than in the shoots. The Zamora variety had higher cyclic hydroxamic acid content compared to DASi. It would be important to survey the cyclic hydroxamic acid content of as many cultivated varieties as possible to better exploit the available natural self-protecting abilities of plants.

Key words: cyclic hydroxamic acid (cHx), maize varieties

## Introduction

Cyclic hydroxamic acids (cHx-s) are secondary metabolites produced mainly by the species of *Poaceae* family (Niemeyer, 1988). The quantity of these chemicals varies widely amongst and within plant species (Woodward *et al.* 1979; Zuniga-Massardo, 1991). The cHx-s are key defence chemicals of cereals: they protect the plants against pathogens and pests, especially in the early stages of development (Niemeyer, 2009). It would be necessary to know more detail the factors determining the cHx-content and cHx-synthesis potential of plants of different varieties to better use of their natural capacities.

## Materials and methods

Two maize varieties were tested for cHx determination purpose: Saaten Union Zamora and an experimental variety, named DASi. These varieties have different genetic base because of their different origin. Plants were cultivated in greenhouse in the experimental station of the Plant Protection Institute of Hungarian Academy of Sciences. Ten plant individuals were grown in soil - gathered from the experimental station - in pots with diameter of 12 centimetres. Pots were regularly watered to 60% of the soil water capacity. Plant samples were collected at the age of 3, 6, 9, 12, 15, 18, 21 and 24 days, respectively. At every age the samples were collected from 4 pots (40 plants all together) in case of both varieties. Plant age was calculated from the emergence of seedling. At the time of sample collection, shoots along with washed and mopped roots were separated and were deposited into deep-freezer to - 77 °C. Samples were kept for a minimum of one week until cHx-determination. The reason of this process was that the cHx-s can naturally be occurred in glycoside form. The glycosidase enzymes and the cHx-glycosides are in different compartments in plant cells. So the cell damage (freezing) needs for the glycosidase enzymes to release the aglucones (free cHx-s) after thawing. The

total, free cHx-content of roots, first, second, third and fourth leaf was measured. The fourth leaf was examined only from fully expanded stage. For measurement of cHx-s method of Long et al. (1974) was used. This method is based on the measurement of the absorbance of the cHx-s' iron (Fe<sup>III</sup>)-complexes. In an average 20 subsamples were examined from each age and mentioned plant part from respective variety. For the evaluation of experimental data the SPSS statistic programme was used.

## Results and discussion

Three factors were examined whether they influence or not on the cHx-content of maize plants: variety (Zamora; DASi), organ (root, 1st, 2nd, 3rd and 4th leaf) and plant age (3, 6, 9, 12, 15, 18, 21 and 24 days old). The first table shows main effects of the factors: plant age, organ and variety separately influence significantly on the cHx-content of maize plants. The interactions of plant age and variety or plant age and organ also influence on the cHx-content. Other interactions also have significant influence on the cHx-content, but the explanation of these interactions would have led to improper conclusions. For example the interaction of variety and organ was excluded from the evaluation because we supposed that there would be no difference between the examined varieties in the distribution of cHx-s in different plant parts.

**Table 1. Effect of plant age (fix factor), organ and variety (random factors) on the cHx-content of maize plants evaluated with General Linear Model (GLM):**

Source	df	F	sig
Intercept	1	26.41	0.004
Age	7	6.12	0.001
Variety	1	80.54	0.000
Organ	4	54.97	0.000
Age x Variety	7	8.20	0.000
Age x Organ	19	110.90	0.000

The second table below illustrates the cHx-content of different organs of the examined varieties at different plant ages. There are no data of the 1st leaf after the age of 15 days because this leaf does already not exist at this age. There are no data of the 3rd leaf at the age of 3 days, because the leaf emerged only after this age. There are also no data in case of 4th leaf till the age of 15-18 days, because the 4th leaf emerges fully only up to this age depending on the variety.

The overall cHx-content of variety Zamora and DASi was significantly different: 403.99 mg/kg fresh weight in case of Zamora and 342.18 mg/kg fresh weight in case of DASi (number of samples = 882; 844).

The first figure below summarises the effect of plant organ and variety on average cHx-content. The root has much lower cHx-content than that of the shoot. Our results confirm the earlier results of other authors: the total cHx-content always lower in the roots, than in the shoots (Tang et al. 1975; Argandona - Corcuera, 1985).

The cHx-content increases from the lower to the upper leaves at both varieties. The first figure also confirms that the variety Zamora generally has higher cHx-content in case of examined organs.

Other authors demonstrated the same results: the cHx-content of the roots and leaves decreases with ageing. Always the youngest leaf has the highest cHx-content (Toldiné Tóth É., 1984; Cambier et al. 1999).

**Table 2. The average cHx-content (mg/kg fresh weight  $\pm$ SD) of the organs of examined varieties in different plant ages.**

Variety /Age	3 days old	6 days old	9 days old	12 days old	15 days old	18 days old	21 days old	24 days old
Zamora root	286.80 $\pm$ 26.74	271.71 $\pm$ 20.91	224.64 $\pm$ 49.5	207.22 $\pm$ 21.96	186.91 $\pm$ 52.58	181.86 $\pm$ 48.46	177.37 $\pm$ 40.00	122.63 $\pm$ 40.66
DASi root	246.72 $\pm$ 30.74	158.25 $\pm$ 25.72	150.61 $\pm$ 21.25	146.36 $\pm$ 31.07	146.91 $\pm$ 32.23	137.04 $\pm$ 26.5	126.19 $\pm$ 42.07	110.43 $\pm$ 42.35
Zamora 1 <sup>st</sup> leaf	454.81 $\pm$ 33.87	422.03 $\pm$ 31.19	382.98 $\pm$ 31.72	363.58 $\pm$ 23.05	-	-	-	-
DASi 1 <sup>st</sup> leaf	393.80 $\pm$ 59.47	348.54 $\pm$ 32.91	322.88 $\pm$ 22.83	276.20 $\pm$ 33.96	-	-	-	-
Zamora 2 <sup>nd</sup> leaf	552.22 $\pm$ 45.02	476.78 $\pm$ 38.99	450.42 $\pm$ 27.92	448.23 $\pm$ 47.16	432.93 $\pm$ 43.76	422.03 $\pm$ 35.28	395.96 $\pm$ 43.88	361.43 $\pm$ 26.48
DASi 2 <sup>nd</sup> leaf	514.36 $\pm$ 43.14	406.81 $\pm$ 32.19	393.80 $\pm$ 27.79	387.31 $\pm$ 39.99	361.43 $\pm$ 37.38	329.28 $\pm$ 30.24	312.22 $\pm$ 34.05	297.30 $\pm$ 26.16
Zamora 3 <sup>rd</sup> leaf	-	646.94 $\pm$ 32.25	549.99 $\pm$ 28.58	521.02 $\pm$ 37.12	501.06 $\pm$ 32.45	441.67 $\pm$ 40.33	387.31 $\pm$ 51.92	357.13 $\pm$ 27.91
DASi 3 <sup>rd</sup> leaf	-	633.33 $\pm$ 41.91	534.37 $\pm$ 36.75	446.05 $\pm$ 44.46	441.67 $\pm$ 37.18	406.81 $\pm$ 45.82	344.26 $\pm$ 45.9	312.23 $\pm$ 37.32
Zamora 4 <sup>th</sup> leaf	-	-	-	-	797.32 $\pm$ 25.03	640.30 $\pm$ 22.25	451.55 $\pm$ 65.77	380.89 $\pm$ 37.17
DASi 4 <sup>th</sup> leaf	-	-	-	-	-	616.28 $\pm$ 43.82	480.53 $\pm$ 27.80	377.60 $\pm$ 28.90

The second figure below summarises the effect of plant age and variety on cHx-content of maize plants. This figure also confirms the statement that the variety Zamora has higher overall cHx-content than that of DASi at the examined ages.

The average cHx-content not at the youngest plant age is the highest, because the upper leaves have higher cHx-content than the lower ones and the upper leaves emerge at latter stages of development. The shift of the peaks at the age of 15 and 18 days clearly indicates this effect, because the 4th leaf emerged later in case of variety DASi.

The effect of the age is not independent from the examined organ. So the age affects the cHx-content differently in various organs. There are two ages when the cHx-content rises: at the age of 6 days, and at the age of 15 or 18 days. The appearance of data of new leaves with higher cHx-content causes this effect.

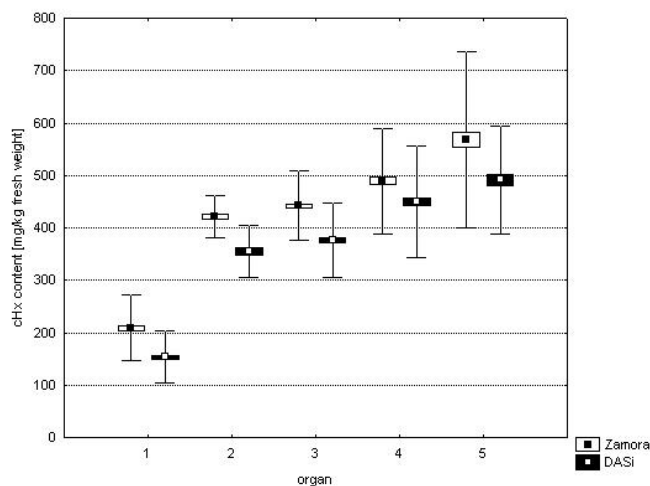


Figure 1. Effect of organ (1-5) and variety on average cHx-content ( $\pm$ SE - box,  $\pm$ SD - line) in maize plants. (1 = root; 2 = 1st leaf; 3 = 2nd leaf; 4 = 3rd leaf; 5 = 4th leaf)

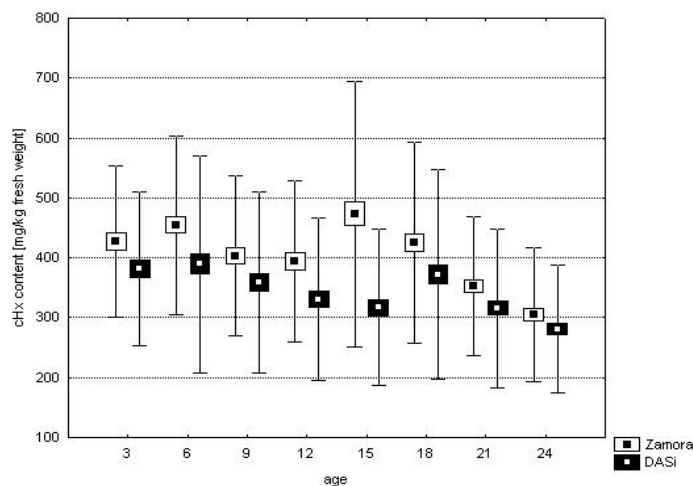


Figure 2. The effect of plant age (3, 6, 9, 12, 15, 18, 21 and 24 days old) and variety on average cHx-content ( $\pm$ SE - box,  $\pm$ SD - line) in maize plants

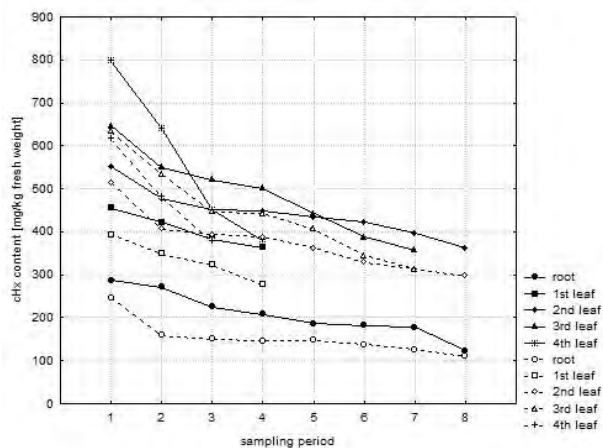


Figure 3. The cHx-content of various organs at various sampling periods (Zamora indicated with continuous line and dark spots; DASi indicated with dashed line and empty spots).

Figure three above illustrates the average cHx-content of various organs separately. The first sampling period was always the first age, when the organ was examined. In case of root, 1st and 2nd leaf the first sampling period is the age of 3 days, in case of 3rd leaf it is the age of 6 days, and in case of 4th leaf it is the age of 15 or 18 days depending on variety.

The cHx-content of the organs decreases with ageing, most quickly in the 4th leaf. This figure also demonstrates the higher cHx-content of variety Zamora.

### Conclusions

1/ Indifferent from the studied variety and plant age the cHx-content in the roots is much lower than in the shoots.

2/ In case of the examined varieties and plant ages the cHx-content in the shoot increases from the lower to the upper leaves, so the youngest leaves have the highest cHx-content.

3/ The cHx-content was highest at the youngest examined age in the different organs of examined varieties, so the elder plants parts had the lowest cHx-content.

4/ Generally the Zamora has higher cHx-content than that of DASi in case of examined organs and plant ages.

Our results completed with other authors' results are strongly suggest to get more information about the cHx-content of the various cultivated varieties of various cultivars of different cHx-producing species, because it is advised to utilize plants self-defence abilities at its highest efficiency by selecting the varieties with higher cHx-content.

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# Influence of nitrogen fertilization and plant density on yield and nitrogen use efficiency of the potato (*Solanum tuberosum* L.)

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## Abstract

The objective of this study was to evaluate influence of different nitrogen rate and in-row seed spacing on yield, tuber size distribution and nitrogen use efficiency characteristics. Field experiment was conducted at the Gospić on private farm during 2009 growth season. The experiment used a split plot arrangement of treatments in randomized complete block design in four repetitions. Main plots were N supply rates (0, 50, 100, 150, 200 i 250 kg N ha<sup>-1</sup>). Sub plots were in-row seed space (25, 30 and 35 cm). Respectively to control, total tuber yield increased by increased N rate up to 150 kg N ha<sup>-1</sup> (20.5 t ha<sup>-1</sup>). As N rate increased ratio of small tubers decreased and the lowest ratio of small tubers (9.86%) was obtained at 150 kg N ha<sup>-1</sup>. The total tuber yield decreased for 22% as in-row space increased from 25 to 35 cm, but ratio of medium and large tubers increased marginally. The increased N rate decreased nitrogen use efficiency (NUE), nitrogen utilization efficiency (NUtE) and nitrogen uptake efficiency (NUpE) significantly respectively to control. Varying in-row seed spacing from 25 cm to 35 cm decreased significantly N use efficiency characteristics (NUE, NUtE and NUpE) too. Because there is no the interaction effect it is necessary to continue investigation to find out the best combination N rate x plant density for potato growers.

Key words: potato, N rate, plant density, yield quality, N use efficiency characteristics

## Utjecaj gnojidbe dušikom i gustoće sklopa na prinos i efikasnost iskorištenja dušika u krumpira (*Solanum tuberosum* L.)

### Sažetak

Cilj ovog istraživanja bio je utvrditi utjecaj različitih doza dušika i razmaka sadnje u redu na prinos krumpira, distribuciju gomolja po veličini i parametre efikasnosti iskorištenja dušika. Poljski pokus je proveden u Gospiću na obiteljskom gospodarstvu tijekom vegetacijske sezone 2009. godine. Pokus je proveden po split-plot metodi u četiri ponavljanja. Glavni faktor su predstavljali gnojidbeni tretmani dušikom (0, 50, 100, 150, 200 i 250 kg N ha<sup>-1</sup>), a podfaktor razmaci sadnje u redu (25, 30 i 35 cm). U usporedbi s kontrolom, ukupni prinos gomolja je povećan s povećanjem doze dušika na 150 kg N ha<sup>-1</sup> (20.5 t ha<sup>-1</sup>). Povećanjem doze dušika udio sitnih gomolja se smanjio. Najmanji udio sitnih gomolja (9,86%) utvrđen je pri gnojidbi s 150 kg N ha<sup>-1</sup>. Povećanjem razmaka sadnje s 25 na 35 cm reduciran je ukupni prinos gomolja za 22%, a povećan je udio srednje-krupnih i krupnih gomolja. Povećanjem doze dušika smanjena je efikasnost iskorištenja dušika (NUE, NUtE) i efikasnost usvajanja dušika (NUpE) signifikantno u usporedbi s kontrolom. Povećanje razmaka sadnje s 25 do 35 cm utjecalo je na

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smanjenje parametara iskorištenja dušika (NUE, NUtE i NU<sub>p</sub>E). Budući da je izostao učinak interakcije faktora nužno je nastaviti istraživanje s ciljem ishođenja najbolje kombinacije doze gnojidbe dušikom i gustoće sklopa za uzgajivače krumpira.

Ključne riječi: krumpir, doza dušika, gusoća sklopa, prinosi, parametri efikasnosti iskorištenja dušika

## Introduction

Nitrogen rate and in-row seed spacing are important economic considerations in the production of potatoes (*Solanum tuberosum* L.) because both are under grower control. The optimum spacing and N rate vary with cultivar, geographic location and climatic conditions (Arsenault et al., 2001). Nitrogen is the mineral nutrient most commonly deficient in agricultural soils. Limited N supply affects an array of physiological processes and causes reduced plant growth, the onset tuberization and final tuber yield (Vos and MacKerron, 2000). Nitrogen supply may also affect quality aspects including tuber size distribution.

Different in-row seed spacing have also important role in nitrogen uptake as well as in yield and tuber quality (Oliviera, 2000). Total yields in some cultivars increase with increase in nitrogen supply and plant density (Arsenault et al., 2001). With reduced within-row seed spacing, shoot branching, root growth and average tuber size will be reduced, but total yield per hectare will be increased (Vander Zaag et al., 1990, Hasse et al., 2007). Arsenault and Malone (1999) was noted that increase in within-row spacing result with reduced yield and tuber number but increased tuber size.

Potatoes require high amounts of N fertilizer because they have a shallow, inefficient rooting system (Sattelmacher et al., 1990). In the economically relevant range of N supply potato is a crop with a relatively low apparent nitrogen recovery, about 50% (Vos, 2009). Enhancing fertilizer efficiency in potato is particularly important because relatively high N are necessary to compensate for an inefficient rooting system and extreme sensitivity to deficiencies. At sufficient N supply variation in N use efficiency is due largely to a difference in N uptake efficiency, whereas at deficient N supply, that is mainly due to difference in utilization of accumulated N (Moll et al., 1982). Nitrogen use efficiency (NUE) variation in potato crop was reported by Errebhi et al., 1999 and Zebarth et al. 2004a. Variation in NUE was attributed to variation in both NUtE and NU<sub>p</sub>E (Zebarth et al., 2004a). Nitrogen efficiency indices decrease with increasing N level, especially under dry soil condition (Huggins and Pan, 1993). Nitrogen nutrition and cultivars can also influence NUE. With increasing fertilizer N rate NUE and NUtE decreasing (Zebarth et al., 2004a). Increasing fertilizer N rate from 0 to an optimal rate had no effect of NU<sub>p</sub>E in 2 years with adequate soil moisture supply, but decreased NU<sub>p</sub>E in year with dry soil conditions in spring (Zebarth et al., 2004b). Differences in NU<sub>p</sub>E between potato cultivars were attributed to differences in root morphology (Sattelmacher et al., 1990). Also, different plant densities play an important role on plant N uptake, yield and quality. Varying within-row seed spacing from 0.2 to 0.4 m had little effect on NUE of two potato cultivars (Zebarth et al., 2006). There is scarce information on effect N rate and plant density on NUE. An improved understanding of NUE of potato is needed to increment sustainability of potato N management.

The main objective of this study was to evaluate influence of different nitrogen rates and in-row seed spacing on yield, tuber size distribution and nitrogen use efficiency characteristics.

## Materials and methods

The experiment was conducted in 2009 growth season at the Gospić. Soil properties for 0-30 cm depth were: pH 4.9, with moderate levels of residual N (37.49 kg ha<sup>-1</sup>), 10.2 mg K<sub>2</sub>O/100g and 1.2 mg P<sub>2</sub>O<sub>5</sub>/100g dry soil. The experimental site was cropped to rye prior to testing. In this trial, a range of N fertility treatments designed to cover the spectrum from deficient through to luxury levels were tested. Nutrient levels were amended in accordance with local soil test recommendations for potatoes. Sufficient NPK 7-20-30 was applied to all plots except control (0) as a pre-plant broadcast treatment to raise nutrient soil level to 50 kg N ha<sup>-1</sup>, 140 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> and 210 kg K<sub>2</sub>O ha<sup>-1</sup>. To provide a total N rate of 100, 150, 200 and 250 kg/ha, a additional sufficient broadcast application of the KAN 27% N was done at hilling. A sub plot was obtained by planting four rows of 55 g, sprouted seed tubers cv. Victoria at the three within-row seed spaces (25, 30 and 35 cm). Soil samples were collected by replicate from main plots prior to fertilization for 0-30 cm soil depth to determine soil NO<sub>3</sub>-N and NH<sub>4</sub>-N concentrations and converted to units of kg N ha<sup>-1</sup> as described by

Zebarth and Milburn (2003). Crop N supply was calculated as fertilizer N rate plus soil N supply. Ten hills from the two middle rows within each treatment were harvested and tuber fresh weight yield and tuber size ratio was determined. Twenty tubers (medium and large size) per treatments were used and dry matter and N content are determined. Calculated N use efficiency parameters included NUE (tuber dry mater accumulation/crop N supply), NUtE (tuber dry mater accumulation/tuber N accumulation) and NUpE (tuber N accumulation/crop N supply). Statistical analyses were performed using the GLM procedure of SAS (SAS Institute Inc., Cary NC, Version 8).

### Results and discussion

Fresh tuber yield was increased by N fertilization respectively to control. Tuber yields, averaged across N rates were highest for 150 kg ha<sup>-1</sup> N rate, however all N rates produced the significantly same yields (Table 1). In the northwestern Europe, the economical optimal point of input is commonly in the range of 150-250 kg ha<sup>-1</sup> (Vos, 2009). Poljak et al., (2007) reported a 15,5% increase in fresh tuber yield by the application 250 kg ha<sup>-1</sup> N respectively to untreated control. In this experiment yield increased up to the 150 kg ha<sup>-1</sup> N rate and slowly decreased at the higher N rates. At those levels of input NUE commonly drops to values of 0.5 to 0.6 and this means that 60% of nitrogen added to system remaining in the soil system. Small sized tubers ratio in total fresh tuber yield decreased as N rate increased respectively to control treatment only and this variable were linked to the differences in total yield. In the same time, ratio of the medium and large sized tubers increased little but not significantly. This seems that N applied favorite tuber growth through control of tuber initiation and canopy duration as reported by Vos (2009).

**Table 1. Effect of different N rate and in-row spacing on fresh tuber yield and relative tuber size distribution**

Treatments	Fresh tuber yield (t ha <sup>-1</sup> )	Relative tuber size ratio (%)		
		< 35 mm (small)	35-55 mm (medium)	> 55 mm (large)
N rate (kg ha <sup>-1</sup> )				
0	15,43	15,02	80,41	4,58
50	18,87	10,54	80,94	8,52
100	20,01	10,35	81,01	8,64
150	20,55	9,86	81,62	8,53
200	18,92	10,23	81,40	8,37
250	19,98	10,14	81,67	8,19
LSD (P ≤ 0.05)	2,78	2,99	NS	NS
In-row seed spacing (cm)				
25	21,54	12,75	80,01	7,24
30	18,48	10,75	82,14	7,12
35	16,86	9,58	81,37	9,05
LSD (P ≤ 0.05)	1,73	2,28	NS	NS
Analysis of variance				
N rate (N)	*	*	NS	NS
In-row seed spacing (RS)	**	*	NS	NS
N × RS	NS	NS	NS	NS

NS: Not significant, \* Significant (P ≤ 0.05), \*\* Significant (P ≤ 0.01)

Tuber yield averaged across within-row seed spaces significantly decreased by increasing in-row seed space up to the 35 cm (Table 1). Total fresh tuber yield reduction of the 22% was observed by increasing within-row seed space from 25 to 35 cm. This yield reduction was closely related with significant reduction in small sized tuber ratio. Similar result was reported by Arsenault and Malone (1999) and Oliveira (2000). Varying plant density had strong effect on the reduction of the number of small sized tubers because higher plant density reduced stem branching, root growth and average tuber size, but increased fresh tuber yield per hectare (Vander Zaag et al., 1990). Higher ratio of medium and large sized tubers with reduction of the total tuber yield at the 30-40 cm within-row space was reported by Zebarth et al., 2006. Vander Zaag et al., 1990 reported that reduced within-row space increased total yield, but decreased large sized tuber ratio.

Results showed that nitrogen use efficiency (NUE) were significantly affected by N-rate and in-row seed spacing but interaction effect was not statistically significant. NUE was reduced by fertilizer N application and strongly influenced by NUpE. Nitrogen uptake efficiency (NUpE) reflects the efficiency of the crop in

obtaining N from the soil and explains the effects of soil factors. Increased NUpE has been proposed as a strategy to increase NUE by Zebarth et al., 2008. Results showed that potato NUpE was affected by N fertilizer rates and in-row seed spacing (Table 2). The highest (0.67 kg kg<sup>-1</sup>) and lowest (0.24 kg kg<sup>-1</sup>) NUpE observed for the control and 250 kg N ha<sup>-1</sup>, respectively (Table 2). This study showed that was a clear relationship between NUpE and NUE in all N rates and variation in NUtE contributed lower to variation in NUE among the N rate and in row seed space. These results were similar to reports of Zebarth et al. 2004a and 2004b. In conclusion, the effect of fertilizer N rate and in-row seed space on NUE was mainly through its effect on NUpE. The increase in-row seed space from 25 to 30 cm significantly decreased NUpE from 0.61 to 0.51 kg kg<sup>-1</sup> and NUE from 47.12 to 38.67 kg kg<sup>-1</sup>, respectively. Results of this study were opposite to results of Zebarth 2006, but similar value was noted by Vos 2009.

**Table 2. Effect of different N rate and in-row spacing on NUtE (tuber dry matter production/tuber N accumulation), NUpE (tuber N accumulation/crop N supply) and NUE (tuber dry matter accumulation/crop N supply)**

Treatments	NUtE kg kg <sup>-1</sup>	NUpE kg kg <sup>-1</sup>	NUE kg kg <sup>-1</sup>
N rate (kg ha <sup>-1</sup> )			
0	77.94	1.30	102.57
50	77.62	0.67	51.89
100	74.08	0.47	34.41
150	73.57	0.35	25.75
200	71.90	0.26	19.19
250	69.34	0.24	16.84
LSD (P ≤ 0.05)	NS	0.15	15.35
In-row seed spacing (cm)			
25	74.99	0.61	47.12
30	74.28	0.51	38.67
35	72.96	0.53	39.53
LSD (P ≤ 0.05)	NS	0.07	6.12
Analysis of variance			
N rate (N)	NS	**	**
In-rowseed spacing (RS)	NS	**	*
N x RS	NS	NS	NS

NS: Not significant, \* Significant (P ≤ 0.05), \*\* Significant (P ≤ 0.01)

The factors that are primarily responsible for the NUpE value on control plot are the amount of soil mineral N at planting, the rate of N mineralization during the season and contributions of N from other sources such as atmospheric deposition and biological fixation. Insufficient root proliferation is likely to reduce NUpE and smaller N uptake per unit applied.

## Conclusions

This study confirmed and extended previous studies which showed that fresh tuber yield is very responsive to N supply and plant density due to an effect on small sized tubers ratio. The highest fresh tuber yield with lowest ratio of small sized tubers was obtained by application 150 kg ha<sup>-1</sup> N. The fresh tuber yield decreased by 22% as in-row seed space increased form 25 to 35 cm. The effect of fertilizer N rate and in-row seed space on NUE was mainly through its effect on NUpE. Higher plant density improved NUpE up to 0.61. Optimal N rate in combination with optimal in-row seed spacing need to be find in further research.

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# Utjecaj gustoće sadnje na prinos i druga produktivna svojstva krumpira

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## Sažetak

U radu su prikazani rezultati proučavanja utjecaja gustoće sadnje na prinos i druga produktivna svojstva krumpira u agroekološkim uvjetima sjevera Crne Gore. Dvogodišnja istraživanja utjecaja različite gustoće sadnje (70 x 36, 70 x 29, 70 x 24 i 70 x 20 cm) na prinos i druge parametre produktivnosti izvedena su 2008. i 2009. godine u okolini Nikšića (Župa).

Rezultati istraživanja pokazuju da je gustoća sadnje značajno utjecala na vegetativni porast krumpira, broj i veličinu formiranih gomolja, što se sve skupa odrazilo i na ukupan prinos. Najveći broj gomolja po m<sup>2</sup> - 42.6, a samim tim i prinos utvrđen je na varijanti s najvećom gustoćom sadnje - 34.1 t / ha. Primjenom najmanje gustoće sadnje postignuto je statistički vrlo značajno povećanje prosječne mase gomolja (94 g) u usporedbi sa svim ostalim ispitivanim varijantama.

Ključne riječi: krumpir, gustoća sadnje, broj gomolja, veličina gomolja, prinos

## The influence of the planting density on yield and other productivity potato traits

### Abstract

In this paper the results of studying the influence of plant density on yield and other productivity features of potatoes in the agro-ecological conditions in central Montenegro are presented.

Two-year investigations of the influence of different planting density (70 x 36, 70 x 29, 70 and 70 x 24 x 20 cm) on yield and other parameters of productivity were done in 2008 and 2009 in the vicinity of Nikšić (Župa).

The results show that the planting density significantly affected the vegetative growth of potato, the number and size of formed tubers, what was reflected in the total yield. The largest number of tubers per m<sup>2</sup> - 42.6, and thus the tuber yield was found in the variant with the highest plant density (70 x 20 cm) - 34.1 t / ha. By applying the least of plant density (70 x 36 cm) achieved a statistically highly significant increase in average tubers weight (94 g) compared with all other tested variants.

Key words: potatoes, plant density, tuber number, tuber size, yield

## Uvod

I pored povoljnih agroekoloških uvjeta za proizvodnju krumpira u Crnoj Gori, ostvareni prinosi po jedinici površine su još uvijek niski (ispod 15 t/ha) i značajno variraju po godinama. Niski prinosi su posljedica ekstenzivne proizvodnje koja se ogleda u uporabi lošeg sadnog materijala, neodgovarajućeg sortimenta i neadekvatne agrotehnike (Milošević i sur., 2000).

Gustoća sadnje krumpira, koja podrazumijeva optimalan broj primarnih nadzemnih izdanaka po jedinici površine, veoma je bitan element tehnološkog procesa proizvodnje krumpira kome se, u cilju postizanja visokih prinosa, mora posvetiti posebna pažnja. Smatra se da u povoljnim agroekološkim uvjetima sadnjom treba osigurati optimalan broj primarnih nadzemnih izdanaka koji se u proizvodnji krumpira za konzum kreće od 12-15, a u sjemenskoj proizvodnji 25-30 izdanaka/m<sup>2</sup>. Cilj sjemenske proizvodnje krumpira je dobiti što veći broj gomolja veličine 28-55 mm za što je potrebno ostvariti najmanje 30 primarnih izdanaka po m<sup>2</sup>. Daljnje povećanje broja stabljika neće voditi povećanju ukupnih prinosa već smanjenju broja krupnih gomolja. S druge strane, smanjenje broja stabljika po hektaru utječe na značajno povećanje krupnih gomolja (Momirović i sur., 2000).

Broj nadzemnih izdanaka i njihova visina, veličina lisne površine i ukupna organska produkcija nadzemnog dijela biljke najčešći su način utvrđivanja veličine organske produkcije i potencijala rodnosti usjeva krumpira (Jovović i sur., 2009). Cilj istraživanja bio je utvrditi optimalnu gustoću usjeva koja će u danim agroekološkim uvjetima dati najveći broj tržišnih gomolja, a samim tim i najveći prinos.

## Materijal i metode rada

Proučavanje utjecaja različite gustoće sadnje na prinos i druge parametre produktivnosti krumpira obavljeno je tijekom vegetacije krumpira 2008. i 2009. u Župi (okolica Nikšića), na kiselu-smeđem zemljištu (tablica 1), na nadmorskoj visini oko 800 m. Poljski pokus izveden je u potpuno slučajnom blok sustavu, u 4 ponavljanja. Površina osnovne parcele iznosila je 21 m<sup>2</sup>. Gnojidba tla za krumpir obavljena je mineralnim gnojivom NPK - 8:16:24, u količini od 1000 kg/ha, a prihrana usjeva krumpira pojedinačnim dušičnim gnojivom KAN-om, u količini od 250 kg/ha. Ostale agrotehničke mjere obavljene su standardno za usjev krumpira.

Tablica 1. Kemijske osobine kiselu-smeđeg tla na pokusnom polju

Dubina (cm)	pH		CaCO <sub>3</sub> (%)	Humus (%)	Topivi mg/100 g	
	H <sub>2</sub> O	nKCl			P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
0-40	5,68	4,68	0,23	4,59	8,6	32,74

Testirana je sorta Kennebec sa 4 različite gustoće sadnje: 70 x 36 cm (G1), 70 x 29 cm (G2), 70 x 24 cm (G3) i 70 x 20 cm (G4). Određivanje broja primarnih izdanaka (pni) i njihove visine obavljeno je u fazi punog cvjetanja krumpira.

Nekoliko dana prije vađenja krumpira izvršeno je uzorkovanje uzimanjem 10 kućica krumpira po svakoj proučavanoj varijanti, a zatim je napravljena kompletna biometrička analiza broja, veličine i mase gomolja. Vađenje krumpira obavljeno je nakon potpunog sazrijevanja cime, a zatim obračunat ukupan prinos po hektaru prema teoretskim kategorijama za gustoću usjeva. Statistička obrada podataka urađena je metodom faktorijalne analize varijance (ANOVA), korištenjem statističkog paketa Statistics 5.5 (Windows, analitički softver), a ocjena razlika između srednjih vrijednosti urađena je LSD testom. Meteorološki podaci tijekom izvođenja pokusa prikazani su u tablici 2.

Tablica 2. Meteorološki uvjeti tijekom vegetacije krumpira 2008. i 2009. godine

Godina	Mjesec				Prosjek
	Svibanj	Lipanj	Srpanj	Kolovoz	
Temperatura zraka (°C)					
2008.	14.9	19.6	22.0	23.0	19.9
2009.	17.0	18.2	21.8	22.3	19.8
Količina oborina (mm)					
2008.	81	86	18	40	Ukupno 225
2009.	73	158	81	51	363

## Rezultati i rasprava

Rezultati istraživanja (tablice 3 i 4) pokazuju da je gustoća sadnje pokazala značajan utjecaj na vegetativni porast krumpira, broj i veličinu formiranih gomolja, kao i na ukupan prinos. Najveći broj primarnih nadzemnih izdanaka (pni), u dvogodišnjem prosjeku (tablica 3), imale su biljke krumpira uzgojene na varijantama s najmanjom gustoćom sadnje  $G_1$  i  $G_2$  (4.6 pni/biljci), dok je najmanje primarnih izdanaka utvrđeno na varijanti  $G_3$  i  $G_4$ , na kojima su gomolji sađeni na manji međuredni razmak - 70 x 24 i 70 x 20 cm (4.1 i 4.2 pni/biljci). Razlika u broju nadzemnih izdanaka između navedenih tretmana ocijenjena je statistički veoma značajnom.

Analizom prosječne visine primarnih stabala krumpira, nisu ustanovljene značajne razlike između proučavanih varijanti za bilo koji nivo vjerojatnosti. Ipak, nešto viša primarna stabla izmjerena su na varijantama  $G_2$  i  $G_1$ , 48, odnosno 47 cm. Statistički opravdane razlike, kada je u pitanju ovo svojstvo, utvrđene su jedino u 2009. godini usporedbom biljaka uzgajanih na tretmanima  $G_2$  i  $G_1$ , s onima na tretmanu  $G_3$ . Kompleks uvjeta koji vladaju u planinskom području djeluje suzdržavajući na pojedina svojstva krumpira. Na većim nadmorskim visinama, u uvjetima relativno nižih temperatura za porast i razvoj nadzemne mase, sve sorte krumpira, u pravilu imaju niže primarne izdanke (Momirović i sur., 2000). Do sličnih rezultata došli smo i u našim istraživanjima.

Tablica 3. Broj primarnih izdanaka po biljci i njihova visina

Parametar	Godina	Gustoća sadnje			
		$G_1$ (70 x 36cm)	$G_2$ (70 x 29 cm)	$G_3$ (70 x 24cm)	$G_4$ (70 x 20 cm)
Broj primarnih izdanaka po biljci	2008.	4.8	5.0	4.0	4.0
	2009.	4.4	4.2	4.3	4.4
	Prosjek	4.6	4.6	4.1	4.2
Visina stabljike (cm)	2008.	37	38	36	36
	2009.	57	58	52	55
	Prosjek	47	48	44	45

Parametar		2008.	2009.	2008-09.
Broj primarnih izdanaka	LSD 0.05	0.151	0.151	0.260
	LSD 0.01	0.209	0.209	0.359
Visina stabljike	LSD 0.05	-	3.256	-
	LSD 0.01	-	4.503	-

Najveći broj gomolja po biljci (tablica 4), dobiven je na tretmanu na kojem su gomolji sađeni u najmanjoj gustoći ( $G_1$ ) - 8.1, dok je najmanje gomolja utvrđeno na parceli s najvećom gustoćom sadnje ( $G_4$ ) - 6 gomolja/biljci. Razlike u prosječnom broju gomolja između tretmana s najmanjom ( $G_2$  i  $G_1$ ) i tretmana na kojem je primijenjena najveća gustoća sadnje ( $G_4$ ) označene su veoma značajnim. Iz rezultata mjerenja se vidi da su gomolji s najvećom prosječnom masom dobiveni na varijanti s najmanjom gustoćom sadnje - 94 g, dok su ostale varijante u tom pogledu bile vrlo ujednačene:  $G_2$  - 80,  $G_3$  - 79 i  $G_4$  - 80 g. Analiza prosječne mase gomolja pokazala je statistički vrlo značajne razlike između varijante  $G_1$  i svih ostalih varijanti. Do sličnih rezultata došli su Jovović i Biberdžić (2010), Dardić i Dimitrić (2009), Bročić i sur. (2000) i dr.

Najveći prinos gomolja izmjeren je na varijanti na kojoj je primijenjena najveća gustoća sadnje ( $G_4$ ) - 34.1 t/ha. Najmanji prinos dale su varijante s najmanjim brojem biljaka po hektaru:  $G_2$  - 30 i  $G_1$  - 30.3 t/ha. Razlike u ostvarenom prinosu između varijante  $G_4$  i svih ostalih tretmana bile su statistički opravdane. Najveća prosječna masa gomolja i ukupan prinos izmjereni su u 2009. godini što se objašnjava činjenicom da je navedena godina bila vlažnija, a uz to je imala i povoljniji raspored oborina. Tako je u 2009. godini, tijekom vegetacije krumpira, palo 363 mm, dok je u istom razdoblju u 2008. godini registrirano 225 mm vodenog taloga. Imajući u vidu da je 2008. godina bila vrlo topla i sušna kao i da je pokus izveden u uvjetima suhog ratarenja, onda su i dobiveni rezultati sasvim očekivani.

Sve proučavane gustoće sadnje imale su približno jednak prinos tržišnih gomolja (gomolji veći od 40 mm):  $G_1$  - 20.8,  $G_2$  - 20.2,  $G_3$  - 21.5 i  $G_4$  - 21.6 t/ha, tako da u tom pogledu nisu ustanovljene statistički opravdane razlike.



## Utjecaj gustoće sadnje na prinos i druga produktivna svojstva krumpira

Zbog relativno loših meteoroloških uvjeta tijekom izvođenja pokusa udio sitne frakcije gomolja bio je veoma visok kod svih proučavanih tretmana i kretao se od 33.1% na tretmanu G<sub>3</sub> do 39.4% na tretmanu G<sub>4</sub>. Tretman G<sub>4</sub> je u usporedbi sa svim ostalim gustoćama sadnje imao značajno veće učešće sitnih, ali i značajno manje učešće krupnih gomolja (7.9%). Veliki broj sitnih gomolja (<40 mm) i njihov visok udio u ukupnom prinosu jasno ukazuju na nedostatak oborina tijekom razdoblja nalijevanja gomolja. Relativno dobro zametanje gomolja nije adekvatno valorizirano ostvarenim prinosima pa bi iz tih razloga bilo veoma interesantno ova istraživanja ponoviti i u uvjetima navodnjavanja.

Tablica 4. Prinos i komponente prinosa krumpira 2008. i 2009. godine

Gustoća sadnje	Broj biljaka po ha	Godina	Veličina gomolja (%)			Gomolja		Prinos		
			< 40 mm	40 - 55 mm	> 55 mm	Prosječan broj po biljci	Broj po m <sup>2</sup>	Prosječna masa (g)	Tržišnih (t/ha)	(t/ha)
70 x 36 cm	39700	2008	43.9	41.5	14.6	8.2	32.5	64	11.7	20.8
		2009	25.0	50.0	25.0	8.1	32	124	29.9	39.8
		Prosjek	34.6	45.7	19.8	8.1	32.2	94	20.8	30.3
70 x 29 cm	49300	2008	36.1	49.4	14.5	8.3	40.8	60	15.6	24.4
		2009	30.4	56.5	13.0	7	34.3	104	24.8	35.7
		Prosjek	33.6	52.6	13.8	7.6	37.6	80	20.2	30
70 x 24 cm	59500	2008	36.5	47.3	16.2	7.4	43.7	63	17.7	27.9
		2009	29.0	62.9	8.1	6.2	36.7	97	25.3	35.6
		Prosjek	33.1	54.4	12.5	6.8	40.2	79	21.5	31.7
70 x 20 cm	71450	2008	47.4	44.7	7.9	5.9	42.1	65	14.1	26.9
		2009	29.5	59.0	11.5	6	43.2	96	29.1	41.3
		Prosjek	39.4	51.1	9.5	6	42.6	80	21.6	34.1

Parametar	2008.		2009.		2008-09.	
	LSD <sub>0.05</sub>	LSD <sub>0.01</sub>	LSD <sub>0.05</sub>	LSD <sub>0.01</sub>	LSD <sub>0.05</sub>	LSD <sub>0.01</sub>
Veličina gomolja < 40 mm	2.638	3.710	2.911	4.026	3.224	4.459
Veličina gomolja 40- 55 mm	3.301	4.565	4.004	5.537	3.241	4.478
Veličina gomolja > 55 mm	2.284	3.159	2.071	2.864	1.545	1.549
Prosje. broj gomolja po biljci	1.176	1.627	1.279	1.768	0.976	1.350
Broj gomolja po m <sup>2</sup>	4.256	5.879	3.081	4.257	3.003	4.152
Prosječna masa gomolja	-	-	3.552	4.913	2.757	3.813
Prinos tržišnih gomolja	1.671	2.310	2.033	2.811	-	-
Prinos	2.178	3.012	2.150	2.973	2.250	3.112

### Zaključci

Na osnovi rezultata dvogodišnjih istraživanja utjecaja gustoće sadnje na prinos i druga produktivna svojstva krumpira može se zaključiti:

- Gustoća sadnje značajno je utjecala na vegetativni porast krumpira, broj formiranih gomolja po biljci, kao i njihovu veličinu.
- Statistički opravdano povećanje broja gomolja po m<sup>2</sup> (42.6), a samim tim i prinosa (34.1 t/ha) dobiveno je na varijanti s najvećom gustoćom sklopa (70 x 20 cm).
- Na varijanti G<sub>4</sub>, u odnosu na varijante G<sub>1</sub> i G<sub>2</sub>, utvrđen je i prosječno najmanji broj gomolja po biljci (6). Isti tretman je u usporedbi sa svim ostalim gustoćama sadnje imao značajno veće učešće sitnih (39.4%), ali i značajno manji postotak krupnih gomolja (7.9%).
- Sadnjom gomolja na najveći razmak (70 x 36 cm) postignuto je statistički vrlo značajno povećanje prosječne mase gomolja (94 g) u usporedbi sa svim ostalim ispitivanim varijantama.

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# Prinos i kvaliteta novih ranih sorti krumpira u Bosni i Hercegovini

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## Sažetak

U trogodišnjim pokusima (2007, 2008 i 2009.) postavljenim na dvije lokacije Butmir (cca 500 m/nv) i Glamoč (cca 900 m/nv) provedena su istraživanja s ciljem utvrđivanja prinosa i kvalitete gomolja nizozemskih ranih sorta krumpira: Matador, Madeleine i Rudolph, a kao standard je korištena sorta Adora. Tijekom vegetacije su praćene i ostale karakteristike kultivara. U trogodišnjem prosjeku sorta Rudolph je ostvarila prinos od 32,79 t/ha. Razlika je visoko značajno viša od standarda za 10,43 t/ha ili za 46%. Sorta Matador je ostvarila 27,72 t/ha. Razlika je, takođe visoko značajno viša i to za 5,36 t/ha ili za 21%. Sorta Madeleine je ostvarila 26,28 t/ha. Razlika je značajno viša i to za 3,92 t/ha ili za 17%. U trogodišnjem prosjeku visoko značajno viši prinos krumpira je ostvaren na lokaciji Butmir i to za 3,59 t/ha ili za 14%, u odnosu na lokaciju Glamoč.

U 2009. godini je ostvaren prinos od 30,96 t/ha. Prinos je visoko značajno viši za 9,13 t/ha ili 42%, u odnosu na 2007. godinu. U 2008.godini je ostvaren prinos od 29,06 t/ha. Prinos je, takođe visoko značajno viši i to za 7,23 t/ha ili za 33%, u odnosu na 2007. godinu.

Sorta Matador ima najviši sadržaj suhe tvari (22,80%) i škroba (17,60%).

Ključne riječi: sorte krumpira, prinos, kvaliteta, lokacija, godina

## Yield and quality of new early varieties of potato in Bosnia and Herzegovina

### Abstract

In three-year (2007-2009) experiments set up at two locations, in Butmir (cca 500m altitude level) and Glamoč (cca 900m altitude level), the researches were being conducted aiming at establishing yield and quality of tuber of the Dutch early varieties of potato being: Matador, Madeleine and Rudolph, and variety of Adora was used as a standard. In the course of vegetation, other characteristics of cultivated varieties were monitored. In the three-year average, the variety of Rudolph realised yield of 32.79 t/ha. The difference is significantly higher than the standard by 10.43 t/ha or by 46%. The variety of Matador realised yield of 27.72 t/ha. The difference is also (very) significantly higher than the standard by 5.36 t/ha or by 21%. The variety Madeleine realised yield of 26.28 t/ha. The difference is considerably higher than the standard by 3.92 t/ha or by 17%. In the three-year average, (very) significantly higher potato yield was realised at the location of Butmir by 3.59 t/ha or by 14%, in comparison to the one at the location of Glamoč.

In 2009 yield of 30.96 t/ha was realised. The yield is (very) significantly higher by 9.13 t/ha or 42%, in comparison to the one in 2007. In 2008 yield of 29.06 t/ha was realised. The yield is also (very) significantly higher by 7.23 t/ha or by 33%, in comparison to the one in 2007.

The variety of Matador has the highest content of dry substance (22.80%) and starch (17.60%).

Key words: potato varieties, yield, quality, location, year

## Uvod

Proizvodnja krumpira u svijetu je u stalnom porastu. Prema podacima FAO iz 2000. godine njegova proizvodnja je iznosila 297 100 000 tona, a procjenjuje se da njegova današnja proizvodnja iznosi preko 322 milijuna tona.

Prema podacima Federalnog zavoda za statistiku iz 2009. godine proizvodnja krumpira u FBiH zauzima drugo mjesto po ukupnim zasijanim površinama. U 2008. godini je proizvedeno 237 375 t, a prosječna proizvodnja 10 t/ha.

Najpovoljnija područja za uzgoj krumpira su između 40-60° sjeverne geografske širine. U Bosni i Hercegovini se uzgaja u svim dijelovima i u različitim agroekološkim uvjetima. Potrebno je permanentno ispitivanje koje rezultira odabirom najpovoljnijih sorata za određeno područje. Po nekim autorima i pored svih primijenjenih agrotehničkih mjera, pravilan izbor sorte može utjecati na prinose i do 50%.

Istraživanja obuhvaćena ovim radom provedena su sa ciljem iznalažanja adekvatnih ranih sorata krumpira za konkretna proizvodna područja.

## Materijal i metode rada

Pokusi su provedena na lokacijama: Butmir (cca 500 m n.v.), Glamoč (cca 900 m n.v.), tokom 2007, 2008. i 2009. godine. Tlo obje lokacije je kisele reakcije (Glamoč pH 6,82; Butmir pH 6,27). Sadržaj humusa (Glamoč 4%; Butmir 0%) i fosfora je u nedostatku (Glamoč 9,9 mg/100g ; Butmir 4,4 mg/100 g), a kalija ima dovoljno za normalan razvoj usjeva (Glamoč 26,8 mg /100 g; Butmir 18,9mg /100 g). Lokacija Butmir se odlikuje ostrim zimama i umjereno toplim ljetima, a lokacija Glamoč svježim ljetima i hladnim zimama.

U istraživanjima je korištena A klasa sadnog materijala tvrtke Agrica iz Nizozemske. Standard je bila rana sorta Adora, žutog mesa i pokožice, ovalnih gomolja. Pokusi su postavljeni po randomiziranom blok sistemu, u 4 ponavljanja, a veličina osnovne parcele iznosila je 15 m<sup>2</sup> (1,5x10 m). Razmak sadnje 75 x 33 cm, sa sklopom od 40.000 biljaka/ha. Primijenjena količina čistih hraniva u obliku mineralnih gnojiva je: 80-100 kg/ha N, 100-120 kg/ha P<sub>2</sub>O<sub>5</sub> i 180-200 kg/ha K<sub>2</sub>O i to u rano proljeće P i K, kao i 60% N, dok je 40% N dodano u prihrani. Obavljeno je jedno okopavanje i nagrtanje usjeva te suzbijanje korova i zaštita usjeva od uzročnika plamenjače (*Phytophthora infestans* Mont de Bary) i krumpirove zlatice (*Leptinotarsa decemlineata*). Tijekom vegetacije vršena su fenološka zapažanja i ocjene ujednačenosti nicanja, ujednačenosti usjeva i prezimljavanja, utvrđivan je broj primjesa, dužina vegetacije, intenzitet napada virusnih i gljivičnih oboljenja, masa, broj i frakcije gomolja na uzorcima od 10 kućica. Nakon sušenja nadzemne mase obavljeno je ručno vađenje krumpira. Dobiveni podaci o prinosu gomolja su obrađeni analizom varijance, uz ocjenu značajnosti 5% i 1%. U trećoj godini pokusa, uzorci s lokacije Butmir su analizirani na kvalitativna svojstva. Standardnom metodom za krumpir (Rajmanova vaga) određen je sadržaj suhe tvari i škroba u gomoljima.

## Rezultati i rasprava

Rane sorte, zbog kraćeg vegetacijskog razdoblja obično daju niže prinose od srednje kasnih i kasnih sorti. Intenzivno formiranje prinosa kod ranozrelih sorti traje oko 28 dana (Potapopov 1971).

Tablica 1. Prinos krumpira po sortama, lokacijama i godinama (t/ha)

Sorta	Lokacija					
	Butmir			Glamoč		
	2007.	2008.	2009.	2007.	2008.	2009.
Adora	22,54	23,40	18,35	16,3	21,6	25,2
Matador	24,97	33,18	40,33	20,4	24,4	31,7
Rudolph	25,90	38,24	36,51	25,2	36,5	35,9
Madeleine	25,45	30,82	31,75	14,1	25,1	30,4
LSD sorti $P=5\%$	0,43	0,28	0,31	0,37	0,94	0,46
LSD sorti $P=1\%$	0,59	0,39	0,18	0,50	1,28	0,62

Visoko signifikantno viši prinos gomolja krumpira je ostvaren kod svih sorata u sve tri godine, kao i na obje lokacije, osim na lokaciji Glamoč 2007. godine kod sorte Madeleine (tablica 1).

Tablica 2. Prinos različitih sorata ranog krumpira (2007.-2009.god.)

Sorta	Prinos (t/ha)	(%)
Adora	22,36	100
Matador	27,72	121
Rudolph	32,79	146
Madaleine	26,28	117
LSD $P=5\%$	3,24	
LSD $P=1\%$	4,51	

U trogodišnjem prosjeku sorta Rudolph ostvarila je prinos od 32,79 t/ha (tablica 2). Ova razlika je visoko značajno viša od standarda i to za 10,43 t/ha ili za 46%. Sorta Matador je ostvarila 27,72 t/ha. Razlika je, takođe visoko značajno viša i to za 5,36 t/ha ili za 21%, u odnosu na standard. Sorta Madeleine je ostvarila 26,28 t/ha. Razlika je značajno viša i to za 3,92 t/ha ili za 17%, u odnosu na standardnu sortu Adoru.

Tablica 3. Prinos krumpira na lokacijama Butmir i Glamoč (2007.-2009. god.)

Lokacija	Prinos (t/ha)	(%)
Butmir	29,08	114
Glamoč	25,49	100
LSD $P=5\%$	2,28	
LSD $P=1\%$	3,19	

U trogodišnjem prosjeku visoko značajno viši prinos krumpira je ostvaren na lokaciji Butmir i to za 3,59 t/ha ili za 14%, u odnosu na lokaciju Glamoč (tablica 3), što se podudara s rezultatima Čota i Herceg, 2004. Ovo je rezultat različitih uvjeta uzgoja na ove dvije lokacije.

Tablica 4. Prinos krumpira u godinama istraživanja (2007.-2009. god.)

Godina	Prinos t/ha	(%)
2007	21,83	100
2008	29,06	133
2009	30,96	142
LSD $P=5\%$	2,80	
LSD $P=1\%$	3,91	

Uočavaju se razlike u prinosu krumpira u ovisnosti o godini (Čota i sur. 2005.). U 2009. godini je ostvaren prinos od 30,96 t/ha i bio je visoko značajno viši za 9,13 t/ha ili 42%, u odnosu na 2007. godinu (tablica 4). U 2008. godini je ostvaren prinos od 29,06 t/ha. Prinos je takođe visoko značajno viši i to za 7,23 t/ha ili za 33% u odnosu na 2007. godinu. Ovo je rezultat različitih klimatskih uvjeta tijekom godina istraživanja.

Tablica 5. Sadržaj suhe tvari i škroba u gomolju različitih sorata krumpira (%)

Sorta	Sadržaj (%)	
	Suha tvar	Škrob
Adora	22,0	16,8
Matador	22,8	17,6
Madeleine	21,4	16,2
Rudolph	21,4	16,2

Sadržaj suhe tvari se kretao od 21,40% kod sorti Madeleine i Rudolph do 22,80% kod sorte Matador (tablica 5). Sadržaj škroba se kretao do 16,2% kod sorte Madeleine i Rudolpha do 17,6% kod sorte Matador.

Istraživanja drugih autora su pokazala da sadržaj suhe tvari i škroba varira u vrlo širokom rasponu. Sadržaj škroba ovisi o sorti (Quasem, 1978.), duljini dana (Jakovljević, 1965.), ishrani s mikro i makroelementima (Stoiljković, 1986.), duljini vegetacije i drugim čimbenicima. Čota i Herceg (2004.) smatraju da kvalitativna svojstva krumpira reagiraju i na najmanje promjene agroekoloških faktora. U sušnim i sunčanim godinama sadržaj škroba je viši, dok je niži, u hladnijim i vlažnijim godinama, s više oblačnih dana i oborina. Sadržaj

suhe tvari i škroba raste s kasnijim sazrijevanjem gomolja (Čota i Herceg, 2002.). Sorte s većim sadržajem suhe tvari i škroba imaju veću hranjivu vrijednost.

### Zaključak

Na osnovu dobivenih rezultata mogu se donijeti sljedeći zaključci:

U trogodišnjem prosjeku sorta Rudolph je ostvarila visoko značajno viši prinos za 46%,

Matador za 21%, a Madeleine značajno viši prinos za 17%, u odnosu na standardnu sortu Adoru.

U trogodišnjem prosjeku visoko značajno viši prinos krumpira je ostvaren na lokaciji Butmir za 14%, u odnosu na lokaciju Glamoč.

U 2009. godini je ostvaren prinos je visoko značajno viši za 42%, u odnosu na 2007. godinu. U 2008. godini ostvaren je takođe visoko značajno viši prinos za 33%, u odnosu na 2007. godinu.

Sadržaj suhe tvari kretao se od 21,40% kod sorti Madeleine i Rudolph do 22,80% kod sorte Matador. Sadržaj škroba kretao se do 16,2% kod sorti Madeleine i Rudolph do 17,6% kod sorte Matador.

Na osnovu ostvarenog prinosa mogu se za lokacije Butmir i Glamoč preporučiti sorte Rudolph, Matador i Madeleine.

Na osnovu kvalitete gomolja krumpira istraživanih sorata na prvom mjestu je Matador, a iza nje su Rudolph i Madeleine.

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# Identification of soluble protein fractions and their subunits in soybeans with black and yellow kernel coat

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## Abstract

In this study the storage proteins, glycinin (11S) and  $\beta$ -conglycinin (7S) fractions and their respective subunits in four soybean varieties with black and yellow color of kernel coat were analyzed. Protein contents were analyzed by sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) coupled with densitometry. Glycinin and  $\beta$ -conglycinin comprise 75, 78, 73 and 82% of the bean storage protein in Fayette, OS 101, Black Tokyo and Болгария variety respectively, and as such account for both quantity and quality of the kernel protein. The 11S concentration of the varieties studied ranged from 52.42 to 60.91% and those of 7S varied from 20.14 to 22.11% of total extractable proteins. The ratio of 11S/7S proteins varied from 2.50 to 2.89. Based on our results, it can be concluded that the color of soybean kernel coat was not in correlation with content of protein fractions and their subunits.

Key words: black and yellow soybean, protein fractions and subunits.

## Introduction

Soybean kernels contain proteins in a concentration of 36-45% on a dry-weight basis. Like many species of the *Leguminosae*, soybean proteins are a complex polymorphic mixture of polypeptides (Nielsen et al., 1997). Soybean protein is one of the important vegetable protein resources due to its functional properties and high nutritional value. Composition and conformation are responsible for soybean protein's functionality. Compositional differences that may alter functionality include the ratio of protein fractions, variations in subunit concentrations within fractions, or differences in amino acid profiles. Soy proteins have four major salt-extractable fractions (2S, 7S, 11S and 15S) that can be isolated on the basis of their sedimentation coefficients. The 11S (glycinin) and 7S ( $\beta$ -conglycinin) proteins represent the majority of the fractions within the soybean (Wagner et al., 1996) which account for 50% and 25% of the total kernel endosperm protein, respectively. The mean glycinin to  $\beta$ -conglycinin ratio has been reported to be 1.6 : 1 (Nielsen et al., 1997), while others have reported even more extreme ratios to 2.5 : 1 (Fehr et al., 2003). This ratio is known to influence the protein quality of soybeans, and greatly affects the functional properties of food products made from soybeans (Poysa et al., 2006). The 15S protein, as glycinin polymer, and 2S protein account for 10% and 20% of the total kernel endosperm protein, respectively. The differences in composition and structure between  $\beta$ -conglycinin and glycinin are exhibited in both nutritional and functional properties. Glycinin contains 3 to 4 times more sulphur containing amino acids than that of  $\beta$ -conglycinin per unit protein and its more available fraction from nutritional point (Kitamura, 1995). Moreover, Yamauchi et al. (1991) investigated functional properties of soybean proteins and reported that glycinin was a better gel former, although  $\beta$ -conglycinin was shown to possess greater emulsifying properties than glycinin. The genetic background of each variety controls kernel composition and how much of the total kernel protein of soybeans is contributed by these two proteins (Nielsen et al., 1989).

The aims of the present study were to screen for differences in genetic variability in storage protein subunit

composition among genotypes with black and yellow kernel coat, by sodium dodecyl sulfate - polyacrilamide gel electrophoresis. A more detailed knowledge of the variability of proteins and protein subunits accumulation among investigated varieties could facilitate ongoing efforts to improve both quantity and quality of soy bean protein.

### Material and methods

Two black (Болгария, Black Tokyo) and two yellow (Fayette, OS 101) soybean (*Glycine max* (L.) Merr.) varieties produced during the 2008 growing season at the Maize Research Institute Zemun Polje (MRIZP), Serbia, were used for experiments. The wholemeal (particle size <500 µm) was obtained by grounding soybean kernels on a Cyclotec 1093 lab mill (FOSS Tecator, Sweden).

Extractable protein composition of the defatted samples was detected by the sodium dodecyl sulfate - polyacrilamide gel electrophoresis (SDS-PAGE) performed according to Fling and Gregerson (1986) on 12.5% separating gels and 5% stacking gels in vertikal electrophoretic unit (LKB, Sweden). The protein content in the supernatant was determined according to the method of Bradford (1976) using bovine serum protein (BSA, Sigma, USA) as a standard. Molecular weights of the polypeptides were estimated by using low molecular weight standards (Pharmacia, Sweden): phosphorylase B (94.0 kDa), bovine albumin (67.0 kDa), ovalbumin (43.0 kDa), carbonic anhydrase (30.0 kDa), soybean trypsin inhibitor (20.1 kDa), and  $\alpha$ -laktalbumin (14.4 kDa). The protein bands on the destained gel were quantitated using SigmaGel software version 1.1 (Jandal, San Rafael, CA). The concentration of soybean proteins and their ration were calculated from the sum of the total area of their subunits and expressed as% of total extractable proteins. Significant differences between genotype means were determined by the Fisher's least significant differences (LSD) test, after the analysis of variance (ANOVA) for trials set up according to the RCB design.

### Results and discussion

Electrophoretic patterns of total extractable proteins from analyzed genotypes are shown in Figure 1. Most detected proteins had soybean variety with yellow kernel coat Fayette i.e. 19. Besides major protein subunits, lipoxygenase (LOX) and Kunitz trypsin inhibitor (KTI), eight polypeptides with molecular weight from 107.3 kDa to 20.1 were detected by SDS-PAGE. The latter was not presented in all varieties. It is interesting that one of the major subunits of glycinin, A7,6 was not detected in kernels of black soybean Black Tokyo (Figure 1, Table 1). The first significant broad band corresponds to LOX in all investigated soybean varieties. The KTI and LOX with molecular weight of approximately 21,000 and 96,000, respectively, were detected as one band (Figure 1). The KTI concentration was higher in kernel of soybean varieties with black color of coat than in kernel of soybean varieties with yellow color of coat and ranged from 2.70 to 4.72% of total extractable proteins. Contrarily, the LOX concentration was higher in kernel of varieties with yellow color of coat (Fayette and OS 101) (Table 1).

The 11S concentration of the varieties studied ranged from 52.42 to 60.91% and those of 7S varied from 20.14 to 22.11% of total extractable proteins (Table 2). Although neither of the soybean proteins is particularly abundant in the sulfur amino acids, the 11S glycinin is superior in its content of cysteine and methionine. In our work, the highest concentration of total 11S proteins was detected in variety Болгария, 60.91% of total extractable proteins (Table 2). Among detected proteins, acidic A<sub>1,2,3,4</sub> and basic B<sub>1,2,3,4</sub> subunits of 11S protein were dominant and ranged from 16.88 to 18.42% and from 12.01 to 13.74% of total extractable proteins, respectively (Table 1). Various subunits of glycinin are considered to play different important roles in tofu gel formation (Fukushima, 1991). In addition, glycinin is an important storage protein that lowers cholesterol levels in human serum (Kito et al., 1993). Concentration of total acidic subunits ranged from 36.23% in kernel of black soybean Black Tokyo to 42.77% of total extractable proteins in kernel of second black soybean Болгария. Also, the highest concentration of total basic subunits was found in kernels of soybean Болгария (18.14% of total extractable proteins). Soybean with yellow color of kernel coat OS 101 had the lowest concentration of total basic subunits (14.99% of total extractable proteins) (Table 2). Furthermore, the  $\alpha$ -subunit of the  $\beta$ -conglycinin is identified as one of the major allergenic proteins in soybean. According to our results, yellow soybean Fayette had the lowest concentration of  $\alpha$ -subunit (6.42%) and second the lowest concentration of  $\alpha$ -subunit (7.95%) compared to other three genotypes (Table 1). Thus, the development of soybean lines with either absent or reduced amount of  $\alpha$  and  $\alpha$  subunits of  $\beta$ -conglycinin will help to improve the soybean protein quality (Manjaya et al., 2007). The results of Poysa et al.



## Identification of soluble protein fractions and their subunits in soybeans with black and yellow kernel coat

(2006) showed that soybean genotypes lacking the  $\alpha$ -subunit of  $\beta$ -conglycinin and the  $A_5A_4B_3$  (G5) of glycinin, and having increased levels of the  $A_3B_4$  (G4) subunit of glycinin produced firmer tofu. In our study, varieties with black color of kernel coat, Black Tokyo and Болгария, had higher concentration of  $\alpha$ - and  $\alpha$ -subunits, and lower concentration of  $\beta$ - subunit than soybean varieties with yellow color of kernel coat (Table 1).

Variation exists in mean protein ratio of 11S and 7S globulins among seven soybean varieties. The ratio of 11S/7S proteins varied from 2.50 to 2.89 among the varieties (Table 2). According to Žilic et al. (2010) the 11S/7S protein ratio ranged from 2.43 to 3.29 in seven Serbian soybean varieties.

**Table 1. The polypeptide composition of different soybean varieties identified by SDS-PAGE (% of total extractable proteins)**

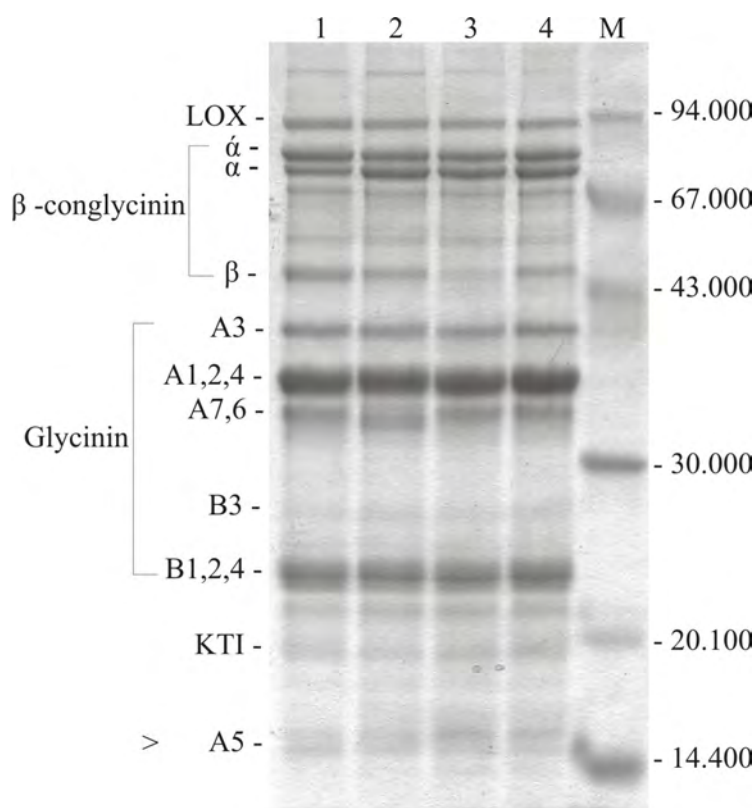
Polypeptides	Soybean varieties			
	yellow		black	
	Fayete	OS 101	Black Tokyo	Болгария
107.300 Dal	2.25 <sup>c</sup>	2.44 <sup>b</sup>	2.80 <sup>a</sup>	2.10 <sup>c</sup>
LOX	5.84 <sup>a</sup>	5.22 <sup>b</sup>	4.83 <sup>c</sup>	4.25 <sup>d</sup>
$\alpha$ '- subunit	7.95 <sup>b</sup>	7.36 <sup>c</sup>	8.58 <sup>a</sup>	8.02 <sup>b</sup>
$\alpha$ - subunit	6.42 <sup>c</sup>	7.87 <sup>b</sup>	8.35 <sup>a</sup>	8.04 <sup>b</sup>
69.700 Dal	3.98 <sup>b</sup>	2.56 <sup>c</sup>	5.15 <sup>a</sup>	3.98 <sup>b</sup>
	1.54 <sup>b</sup>	n.d.	2.41 <sup>a</sup>	n.d.
	1.40 <sup>a</sup>	n.d.	n.d.	n.d.
	1.35 <sup>c</sup>	1.46 <sup>b</sup>	1.91 <sup>a</sup>	n.d.
57.200 Dal	2.64 <sup>d</sup>	4.96 <sup>b</sup>	5.39 <sup>a</sup>	2.91 <sup>c</sup>
$\beta$ - subunit	5.77 <sup>b</sup>	6.88 <sup>a</sup>	4.04 <sup>d</sup>	5.05 <sup>c</sup>
$A_3$ - subunit	7.37 <sup>a</sup>	7.57 <sup>a</sup>	6.96 <sup>b</sup>	5.85 <sup>c</sup>
$A_{1,2,4}$ - subunit	16.91 <sup>c</sup>	16.88 <sup>c</sup>	18.42 <sup>a</sup>	17.71 <sup>b</sup>
$A_{7,6}$ - subunit	8.97 <sup>b</sup>	8.78 <sup>b</sup>	n.d.	9.39 <sup>a</sup>
	1.31 <sup>b</sup>	1.70 <sup>a</sup>	n.d.	n.d.
$B_3$ - subunit	2.13 <sup>d</sup>	2.98 <sup>c</sup>	3.30 <sup>b</sup>	4.40 <sup>a</sup>
$B_{1,2,4}$ - subunit	13.49 <sup>b</sup>	12.01 <sup>d</sup>	12.89 <sup>c</sup>	13.74 <sup>a</sup>
	1.43 <sup>a</sup>	n.d.	n.d.	n.d.
KTI	2.70 <sup>c</sup>	3.91 <sup>b</sup>	4.11 <sup>b</sup>	4.72 <sup>a</sup>
$A_5$ - subunit	6.53 <sup>d</sup>	7.40 <sup>c</sup>	10.85 <sup>a</sup>	9.82 <sup>b</sup>

<sup>a-d</sup> values followed by the same letter within a row are not significantly different according to the list significant difference ( $p < 0.05$ ); n.d.- not detected

**Table 2. Concentration of  $\beta$ -conglycinin, glycinin and their subunits in different soybean varieties (% of total extractable proteins)**

Protein fraction	Soybean varieties			
	yellow		black	
	Fayete	OS 101	Black Tokyo	Болгария
Total 7S ( $\beta$ -conglycinin) ( $\alpha$ ' + $\alpha$ + $\beta$ subunits)	20.14 <sup>c</sup>	22.11 <sup>a</sup>	20.97 <sup>b</sup>	21.11 <sup>b</sup>
Total 11S (Glycinin)	55.40 <sup>b</sup>	55.62 <sup>b</sup>	52.42 <sup>c</sup>	60.91 <sup>a</sup>
Total acid subunit of glycinin (A)	39.78 <sup>c</sup>	40.63 <sup>b</sup>	36.23 <sup>d</sup>	42.77 <sup>a</sup>
Total basic subunit of glycinin (B)	15.62 <sup>c</sup>	14.99 <sup>d</sup>	16.19 <sup>b</sup>	18.14 <sup>a</sup>
11S/7S ratio	2.75 <sup>a</sup>	2.52 <sup>b</sup>	2.50 <sup>b</sup>	2.89 <sup>a</sup>

<sup>a-d</sup> values followed by the same letter within a row are not significantly different according to the list significant difference ( $p < 0.05$ )



**Figure 1. SDS-PAGE patterns of proteins from soybean varieties**

α, α and β indicate subunits of β-conglycinin. A and B indicate acidic and basic polypeptides of glycinin, respectively. LOX-lipoxygenase, KTI-Kunitz trypsin inhibitor, 1- Fayette, 2- OS 101, 3- Black Tokyo, 4- Болгария, M-molecular weight standards

### Conclusions

The results showed that the protein bands were similar among all the soybean varieties. However, concentration of 7S and 11S proteins were statistically different among the soybean varieties. Black soybean Болгария which has the highest concentration of total acid and basic subunits of glycinin, as well as the best 11S/7S protein ratio, could be used as a parent to improve the soybean protein quality. Based on our results, it can be concluded that the color of soybean kernel coat was not in correlation with content of protein fractions and their subunits.

### Acknowledgements

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# Antioxidant properties of soybean with black and yellow kernel coat

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## Abstract

The objectives of this study were to characterize black and yellow soybean varieties for the total phenolic, tannin, proanthocyanidin, flavonoid and tocopherol contents, and to examine antioxidant activity. Also, the content of tocopherols ( $\alpha$ -,  $\beta$ -,  $\gamma$ -, and  $\delta$ -) was detected by using HPLC method. The obtained results suggest that kernel extracts of black soybeans has considerable higher level of all the investigated phenolic classes and about double amount of the total phenolics. The total tocopherols were significantly higher in black than in yellow soybean varieties. Concentrations ranged from 264.3 to 266.7  $\mu\text{g/g}$  and from 216.3 to 246.7  $\mu\text{g/g}$  in black and yellow soybean varieties, respectively.  $\beta$ + $\gamma$ -Tocopherol isomers were dominant in all samples. Correlation between total phenolics, phenolic classes, tocopherols and antioxidant activity detected by DPPH radical scavenging test, was found.

Key words: black and yellow soybean, antioxidants, phenolic compounds

## Introduction

Soybean has been consumed in Asiatic countries for centuries and is now often included in Western diets, because of its beneficial nutritional effects (Sugano, 2005; Taku et al., 2007). These legumes contain complex carbohydrates, vegetable protein, dietary fiber, oligosaccharides, and minerals. Also, soybean is good source of antioxidants. Antioxidants, vitamin E and phenolic compounds, have different beneficial functions in the body, such as the ability to reduce and prevent oxidative damage associated with many diseases, and ageing (Middleton et al., 2000). Polyphenolic compounds that belong to the class of isoflavones, genistein and daidzein are unique to soybeans (Wang and Murphy, 1994). These biologically active compounds may have either weak proestrogenic (agonist) or antiestrogenic (antagonist) effects, and be related to hormone-associated diseases.

A few studies have indicated that soybean varieties with black, brown, green, and yellow seed coats might differ in their antioxidant properties, flavonoid levels, total phenolic contents, and proanthocyanidins (Takahashi et al., 2005; Xu et al., 2007; Astadi et al., 2009), indicating that this may alter their ability to affect health. Black soybeans have been widely used in traditional oriental medicine, unlike yellow soybeans, which have been used mostly as food. A case control study (Do et al., 2007) reported that black soybean consumption reduces the risk of breast cancer in women. Daily intakes of black soybean were also associated with a reduced cardiovascular disease risk (Takahashi et al., 2005). A possible explanation is the fact that black soybeans contain antioxidants, such as anthocyanins, proanthocyanidins, and flavonoids which exert a strong radical-scavenging activity (Pietta, 2000). However, proanthocyanidins, i.e. condensed tannins, as polymeric phenolic compounds form insoluble complexes with proteins (Reddy et al., 1985). These complexes are reported to be responsible for growth depression, low protein digestibility in vitro and in vivo, and decreased amino acid availability (Durigan et al., 1987).

This study aimed to characterize the antioxidant activity and phytochemical composition of soybeans with black and yellow coloured kernel coat.

### Material and methods

Two black (Болгария, Black Tokyo) and two yellow (Fayette, OS 101) soybean (*Glycine max* (L.) Merr.) varieties produced during the 2008 growing season at the Maize Research Institute Zemun Polje (MRIZP), Serbia, were used for experiments. The wholemeal (particle size <500 µm) was obtained by grinding soybean kernels on a Cyclotec 1093 lab mill (FOSS Tecator, Sweden).

For the DPPH test, the soybean extract was prepared by continuous shaking 0.2 g of wholemeal in 10 ml of 70% (v/v) acetone for 30 min at room temperature. After centrifugation (20 min at 20 000 g), supernatant was used for the detection of the DPPH<sup>•</sup> scavenging activity according to the Abe et al. (1998) assay. The results were expressed as an IC<sub>50</sub> value that represents the amount of wholemeal (in mg d.w.) providing 50% inhibition of DPPH<sup>•</sup>. Total phenolics were determined from the same extract according to the Folin-Ciocalteu procedure (Hagerman et al., 2000). The total phenolic content was calculated as a catechin equivalent (CE) from the calibration curve of catechin standard solutions, and expressed in mg/g d.w. Total tannin content was determined by the same procedure used for total phenolics (Hagerman et al., 2000), after removal of tannins by adsorption on an insoluble matrix (polyvinylpyrrolidone, PVPP). Calculated values were subtracted from total phenolic contents and total tannin contents was expressed as mg catechin per g of dry weight. Proanthocyanidins were determined by a butanol-HCl assay (Hagerman et al., 2000), and their content was calculated as leucocyanidin equivalent according to the formula: (A<sub>550nm</sub> × 78.26 × dilution factor) / (% dry weight) given by Porter et al. (1986). Total flavonoid content was determined using colorimetric method described previously (Eberhardt et al., 2000). The results are expressed as milligrams of catechin. HPLC method was used to detect tocopherol contents (Branković, 2006).

Significant differences between genotype means were determined by the Fisher's least significant differences (LSD) test, after the analysis of variance (ANOVA) for trials set up according to the RCB design. Correlations between parameters were examined using the Peterson correlation.

### Results and discussion

Total phenolic content was about two times higher (average 7.50 CE mg/g d.w.) in black soybean varieties Болгария and Black Tokyo than in yellow, Fayette and OS 101 (average 3.72 CE mg/g d.w.) (Table 1). Differences in the content of all phenolic classes were observed. The total flavonoid content was significantly higher in black soybeans than in yellow (0.280 CE mg/g d.w., and 0.064 CE mg/g d.w., respectively). By using Porter assay based on acid catalysed oxidative depolymerization of proanthocyanidins (condensed tannins) into anthocyanidins, we have detected proanthocyanidins only in soybean varieties with black kernel coat, average was about 1.89 mg leucoanthocyanidin per g of dry weight (Table 1). However, Malenčić et al., (2007) reported that the proanthocyanidin content in different soybean genotypes ranged from 1.04 to 3.31 leucoanthocyanidin mg/g dry plant material. As it is shown in Table 1, the tannins content in black soybean varieties was on average six times higher than in yellow soybean varieties.

Like cereals, soybeans and their products are relatively good sources of vitamin E (tocopherols). In addition to their function as cholesterol synthesis inhibitors (Pearce et al., 1992), tocopherols, belonging to the group of antioxidant vitamins, are also able to prevent the formation of free radicals (Frankel, 1989). According to our results, all soybean samples contained α-, β-, γ-, and δ-tocopherols (Table 2). The total tocopherols content was significantly higher (P<0.05) in black than in yellow soybean varieties. Also, soybean varieties with black kernel coat had higher content of α- and β+γ isomers than soybean varieties with yellow color of kernel coat. β+γ-Tocopherol isomers were dominant in all samples. The highest β+γ-tocopherol content was detected in the variety Болгария (179.1 µg/g d.w.), the lowest in kernels of the variety OS 101 (150.6 µg/g d.w.). The amount of δ-tocopherol was 20.92 to 29.91% of the total. The level of α-tocopherol was the lowest in all soybean samples and ranged from 5.91 to 13.58% of the total tocopherols. Although α-tocopherol has a lower antioxidant potency in biological systems than other tocopherols, it has more vitamin E activity in all cells of living tissues. Conversely, γ-tocopherol is the most powerful antioxidant *in vitro* but its *in vivo* activity is low. β- and δ-tocopherols exhibit intermediate properties (Pongracz et al., 1995). Our results are consistent with the results published by Pongracz et al. (1995).

The antioxidant capacity was measured as the DPPH<sup>•</sup> scavenging activity. Black soybean variety Black Tokyo showed the highest DPPH<sup>•</sup> scavenging activity. 1.07 mg of soybean meal was able to scavenge 50% of DPPH<sup>•</sup>. The significant differences (P<0.05) between the DPPH<sup>•</sup> scavenging activity of black soybean varieties Black Tokyo and Болгария, were not detected, but, significant differences were found between black and yellow

varieties. Namely, both yellow soybean varieties OS 101 and Fayette had a low radical scavenging activity ( $IC_{50}$  was 9.44 and 8.57, respectively), (Table 1). The radical scavenging activity and the total phenolic content were closely related ( $r=0.991$ ) (Table 3). Yellow soybean varieties with the lower contents of total phenolics expressed only about 12.4% of the activity of phenolic-rich black varieties. The obtained results are in agreement with earlier findings of Takahata et al. (2001) they reported strong correlation between total phenolic content and antioxidant activity. Also, the radical scavenging activity highly correlated with the content of the total flavonoids, which exert a strong radical-scavenging activity (Pietta, 2000), as well as with other phenolic classes, judging to the calculated correlation coefficients of 0.990, 0.998 and 0.990, for total flavonoids, tannins and proanthocyanidins, respectively (Table 3). The results of Takahata et al. (2001), showed that procyanidins are quite likely to be the predominant compounds responsible for the radical-scavenging activities in the brown soybean seed coat.

**Table 1. The content of total phenolics, tannins, total flavonoids, proanthocyanidins, and DPPH radical scavenging activity in black (Болгария and Black Tokyo) and yellow (Fayette and OS 101) soybean varieties**

Variety	Total phenolics <sup>1</sup>	Tannins <sup>1</sup>	Total flavonoids <sup>1</sup>	Proanthocyanidins <sup>2</sup>	DPPH' scavenging activity ( $IC_{50}$ )
Болгария	7.11 <sup>a</sup>	4.10 <sup>a</sup>	0.257 <sup>b</sup>	1.73 <sup>b</sup>	1.18 <sup>a</sup>
Black Tokyo	7.89 <sup>a</sup>	4.27 <sup>a</sup>	0.303 <sup>a</sup>	2.06 <sup>a</sup>	1.07 <sup>a</sup>
Fayette	3.96 <sup>c</sup>	0.70 <sup>b</sup>	0.076 <sup>c</sup>	n.d.	8.57 <sup>b</sup>
OS 101	3.48 <sup>c</sup>	0.63 <sup>b</sup>	0.053 <sup>c</sup>	n.d.	9.44 <sup>c</sup>

<sup>1</sup>mg CE/g d.w.; <sup>2</sup>mg leucoanthocyanidin/g d.w.; a-c values followed by the same letter within a column are not significantly different according to the list significant difference ( $p<0.05$ )

**Table 2. Tocopherol content in black (Болгария and Black Tokyo) and yellow (Fayette and OS 101) soybean varieties ( $\mu\text{g/g d.w.}$ )**

Variety	$\alpha$ -Tocopherol	$\beta+\gamma$ -Tocopherol	$\delta$ -Tocopherol	Total tocopherols
Болгария	28.1 <sup>b</sup>	179.1 <sup>a</sup>	59.5 <sup>b</sup>	266.7 <sup>a</sup>
Black Tokyo	35.9 <sup>a</sup>	173.1 <sup>a</sup>	55.3 <sup>b</sup>	264.3 <sup>a</sup>
Fayette	14.6 <sup>c</sup>	158.3 <sup>b</sup>	73.8 <sup>a</sup>	246.7 <sup>b</sup>
OS 101	14.6 <sup>c</sup>	150.6 <sup>b</sup>	51.1 <sup>bc</sup>	216.3 <sup>c</sup>

a-d values followed by the same letter within a column are not significantly different according to the list significant difference ( $p<0.05$ )

**Table 3. Correlations between the content of polyphenols, tocopherols and DPPH' scavenging activity of yellow and black soybean varieties**

	DPPH' scavenging activity
Total phenolics	0.991
Tannins	0.998
Total flavonoids	0.990
Proanthocyanidins	0.990
$\alpha$ -Tocopherol	0.953
$\beta+\gamma$ -Tocopherol	0.967
$\delta$ -Tocopherol	0.223

## Conclusions

Antioxidant activity of black soybeans was considerably higher than that of yellow varieties. Each investigated phenolic class contributed to total phenolic content. Positive correlation between content of phenolic classes and tocopherol isomers, with antioxidative activity was found. Black soybeans are better source of natural antioxidants. Also, these data suggest the possibility of developing novel soybean lines with a selected kernel coat color that could be used as bioactive ingredients in functional foods targeting different health problems.

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# Mathematical modeling of total flavonoid compounds extraction from conventionally grown soybeans

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## Abstract

The aim of this study was to investigate the influence of the solvent, the temperature and the extraction time on the extractability of total flavonoid compounds from conventionally grown milled soybeans variety "Ika", mean particles size 0.5796 mm. The influence of different solvents (water; 50, 60, 70 and 80% aqueous ethanol solution) was investigated at 50 °C after 60 min, in order to achieve the highest yield of total flavonoids. The most effective solvent (50% aqueous ethanol solution) was used for the kinetics monitoring and the extraction modelling of total flavonoids. The concentration of extracted total flavonoids was monitored at different temperatures (26 °C, 40 °C, 50 °C, 60 °C, 70 °C and 80 °C) for 120 min, at solid-liquid ratio of 20 mL/g. The concentrations of total flavonoids were determined spectrophotometrically. Various mathematical models (Peleg, Page and Logarithmic) were used to describe the extraction kinetics of total flavonoids. The results showed that the used solvent, temperature and extraction time had a significant impact on the kinetics and the extraction yield of total flavonoids. The highest extraction efficiency was achieved at temperature of 80 °C after 120 min (1.417 mg CE/g<sub>ab</sub>). The yield of total flavonoids increased with the temperature increase, as well as with the prolongation of the extraction process. The results obtained using mathematical models showed good agreement with the obtained experimental results.

Key words: soybeans, solid-liquid extraction, flavonoids, extraction kinetics, modeling

## Matematičko modeliranje ekstrakcije ukupnih flavonoidnih spojeva iz konvencionalno uzgojenog zrna soje

### Sažetak

U radu je ispitivan utjecaj otapala, temperature te vremena ekstrakcije na ekstraktibilnost ukupnih flavonoidnih spojeva iz usitnjenog konvencionalno uzgojenog zrna soje sorte "Ika", srednjeg promjera čestica 0,5796 mm. Cilj istraživanja bio je ispitati utjecaj različitih otapala (voda; te 50, 60, 70 i 80%-tna vodena otopina etanola), pri 50 °C nakon 60 minuta, kojim bi se postigao najveći prinos ukupnih flavonoida. Najučinkovitije otapalo (50%-tna vodena otopina etanola) korišteno je u daljnjem radu, a u svrhu praćenja kinetike i modeliranja ekstrakcije ukupnih flavonoida. Koncentracija ekstrahiranih ukupnih flavonoida praćena je pri različitim temperaturama (26 °C, 40 °C, 50 °C, 60 °C, 70 °C i 80 °C) tijekom 120 minuta, uz omjer kruto-tekuće 20 mL/g. Koncentracije ukupnih flavonoida određene su spektrofotometrijskom metodom. Različiti matematički modeli (Peleg, Page i Logaritamski) korišteni su za opisivanje kinetike ekstrakcije ukupnih flavonoida. Utvrđeno je da korištena otapala, temperatura i vrijeme ekstrakcije imaju značajan utjecaj na kinetiku i prinos ekstrakcije ukupnih flavonoida.

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Dobiveni rezultati pokazali su da je najveća učinkovitost ekstrakcije postignuta pri temperaturi od 80 °C nakon 120 minuta (1,147 mg CE/g<sub>s.tv.</sub>) te da prinos ukupnih flavonoida raste povišenjem temperature i produljenjem trajanja procesa ekstrakcije. Rezultati dobiveni upotrebom ispitanih matematičkih modela pokazali su dobra slaganja s eksperimentalno dobivenim rezultatima.

Ključne riječi: soja, ekstrakcija kruto-tekuće, flavonoidi, kinetika ekstrakcije, modeliranje

### Introduction

Soybeans are worldwide leading crop used for many different products, both edible and non-edible, such are oil and proteins for human nutrition, as well as for livestock feeding. It has become an integral part of modern agriculture and food industry practices (Vratarić and Sudarić, 2008). The flavonoid compounds should be considered as an important feature of soybeans, besides protein and oil content. Soybeans are widely accepted as a “healthy food” and some of their pharmacological effects could be attributed to the presence of these valuable constituents (Malenčić et al. 2007). Flavonoids are a large class of natural products that are widely distributed among the plant kingdom. They are the most represented among polyphenolic compounds and they have important antioxidative and biological properties. Therefore, majority of food safety and nutrition research are focused on this group of compounds. Isoflavones are a subclass of flavonoids that are also described as phytoestrogen compounds, since they exhibit estrogenic activity (Valls et al., 2009). Flavonoids are believed to exhibit series of positive health effects (e.g. anti-cancer, antibacterial, anti-oxidation, immune regulation, etc.). Extraction is an important step in isolation, identification and quantification of phenolic compounds, as well as flavonoid compounds, eventhough there is a lack of standarised extraction methods (Cacace and Mazza, 2003). Solid-liquid extraction is a commonly used isolation method for phenolic (flavonoid) compounds from plant materials (such as soybean). Selection of solvents is one of the most important steps in the extraction process. The most commonly used solvents for the solid-liquid extraction of plant material flavonoid compounds include methanol, ethanol and their liquid mixtures with water and organic solvents (e.g. acetone, ethyl acetate) (Naczka and Shahid, 2004).

The mathematical models are useful engineering tools, which greatly facilitate simulation, optimisation, design and control of processes and contribute to utilization of energy, time, raw material and solvent. The aim of this study was to examine the influence of different solvents (water, and 50, 60, 70, and 80% aqueous ethanol solutions), extraction temperatures (26, 40, 50, 60, 70, and 80 °C), and extraction times (5, 10, 15, 20, 30, 40, 60, 90, and 120 min) on the extractability of total flavonoids from conventionally grown milled soybeans, variety “Ika”.

### Material and methods

**Material.** The extraction was performed on conventionally grown soybeans, variety “Ika,” obtained by the Agricultural Institute of Osijek. The samples were cleaned from impurities (stick, stems, damaged seeds, dirt), milled in a grinder (HR 2860, Philips), and immediately after grinding stored at +4 °C prior to extraction. The soybeans dry matter content was determined by drying the milled soybeans at 105 °C to constant weight. The analysis were done in duplicates and the average dry matter content was noted as percentage. The dry matter content was about 91.9% and was determined in all experimental runs. The total flavonoids concentration was thus expressed on dry basis, which generally provides a more accurate and reliable data comparison. The average particle size ( $d = 0.5796$  mm) was determined using sieve sets (Retsch AS 200, Haan, Germany).

**Extraction.** 1 g of the soybean sample was mixed with 20 ml of solvent in the test tubes. The extraction process was conducted on laboratory scale using a water bath (Julabo SW-23, Germany) for 120 minutes. During the extraction process, the test tubes containing the reaction mixture were incubated in the water bath and shaken for 20 s in 15 min intervals using Vortex (Vibromix 10, Tehnica, Slovenia). All extraction runs were performed in duplicates. The extracts obtained by the extraction were separated from rough particles by decantation and centrifuged (Sigma 2-16, Germany) at 15000 g for 5 minutes. The supernatant was decanted and filled with distilled water to the defined volume (20 ml). The supernatant was used for the determination of total flavonoids content.

**Solvent influence.** The efficiency of total flavonoids extraction using different solvents (water and 50, 60, 70, and 80% aqueous ethanol solutions) at the temperature of 80 °C was examined. **Influence of extraction temperature.** The extraction was performed at different temperatures (26, 40, 50, 60, 70, and 80 °C) using 50% aqueous ethanol solution which proved to be the most effective solvent for the above listed experimental conditions.

**Extraction time influence.** The extraction was performed at different extraction times (5, 10, 15, 20, 30, 40, 60, 90, and 120 min) at the above mentioned extraction temperatures using 50% aqueous ethanol solution as a solvent.

**Total flavonoid content (TFC).** The concentration of total flavonoid compounds in the extracts was determined by the aluminium chloride colorimetric assay (Marinova et al. 2005) as follows: 1 ml of extract was added to 10 ml volumetric flask containing 4 ml of distilled water and 0.3 ml 5% NaNO<sub>2</sub>. After 5 min, 0.3 ml 10% AlCl<sub>3</sub> was added. At 6<sup>th</sup> min, 2 ml of 1 M NaOH was added and the total volume was made up to 10 ml with distilled water. The solution was mixed well and the absorbance was measured against prepared reagent blank at 510 nm. Determination of total flavonoid compounds was carried out in a duplicate and calculated from the calibration curve obtained with (+)-catechin, which was used as a standard and final results were recalculated and expressed as (+)-catechin equivalent per a dry basis of soybeans (mg CE/g<sub>db</sub>).

**Kinetics of solid-liquid-extraction.** The extraction curves (concentration of total flavonoids vs. time) have similar shape as sorption curves (moisture content vs. time), which gives the possibility for using the same mathematical models when describing kinetics.

Therefore, the model proposed by Peleg (1988) was adapted for extraction and used in following form:

$$c(t) = \frac{t}{K_1 + K_2 \cdot t} \quad (1)$$

where  $c(t)$  is concentration of total flavonoids at time  $t$  (mg CE/g<sub>db</sub>),  $t$  - extraction time (min),  $K_1$  - Peleg's rate constant (min g<sub>db</sub>/mg CE),  $K_2$  - Peleg's capacity constant (g<sub>db</sub>/mg CE).

The model proposed by Page was used as follows:

$$c(t) = \exp(-kt^n) \quad (2)$$

where  $c(t)$  is concentration of total flavonoids at time  $t$  (mg CE/g<sub>db</sub>),  $t$  - extraction time (min),  $k$  and  $n$  - constants of Page's model.

Logarithmic model was used as follows:

$$c(t) = a \log t + b \quad (3)$$

where:  $c(t)$  is concentration of total flavonoids at time  $t$  (mg CE/g<sub>db</sub>),  $t$  - extraction time (min),  $a$  and  $b$  - Logarithmic model constants.

**Statistical methods.** Statistica 7.0 (Stat Soft Inc., USA) was used for data analysis. The parameters of modified Peleg's model (constants  $K_1$  and  $K_2$ ) were determined from experimental data using non-linear regression (Quasi-Newton method). The concordance between experimental data and calculated value was established by the correlation coefficient (R) and the root mean squared deviation (RMSD) as follows:

$$\text{RMSD} = \sqrt{\frac{1}{n} \sum_{i=1}^n (\text{experimental} - \text{calculated})^2} \quad (4)$$

## Results and discussion

The results showed (Fig. 1) that the highest concentration of total flavonoids was obtained when using 50% aqueous ethanol solution (1.128 mg CE/g<sub>db</sub>) as a solvent, while further increase of the ethanol concentration significantly contributed to a decrease of the extractability of total flavonoids from the soybean samples. The lowest extraction efficiency was obtained when water was used as a solvent (0,195 mg CE/g<sub>db</sub>). 50% aqueous ethanol solution proved to be the most effective solvent (temperature 50 °C, time 60 min) with the obtained

total flavonoids extraction yield 5,781 times higher than the extraction yield obtained when water was used as the extraction solvent.

The highest concentration of total flavonoids from milled soybeans was obtained when using 50% aqueous ethanol as extraction solvent which is in accordance with the results from other authors (Shi et al. 2003; Jokić et al. 2010).

The aqueous ethanol solution (50, 60, 70, or 80%) was selected as the solvent due to its environmental safety, low cost, and lower toxicity compared to other solvents (e.g. methanol). Although the water represents the best solvent solution when it comes to food industry purposes, due to its polarity it extracts other undesirable macromolecules as well (protein, polysaccharide, etc.) especially at higher temperatures and pressures (Rostagno et al. 2003; Tsao and Deng 2004).

Since 50% aqueous ethanol solution proved to be the most effective solvent, it was used as a solvent in further analysis of kinetics of solid-liquid extraction at different temperatures (26, 40, 50, 60, 70, and 80 °C) during 120 minutes.

The extraction curves (concentration of total flavonoids vs. time) have a similar shape as the sorption curves (moisture content vs. time), and can be described using mathematical models of the mass transfer. Therefore, to describe the extraction kinetics, three mathematical models were used: Peleg's, Page's, and the Logarithmic model. The extraction curves (Fig. 2 a, b and c) indicated the experimental increase in the extraction yield with time. A high initial rate of flavonoids extraction can be observed in the extraction curves, followed by a slower extraction rate, and then asymptotically approaching the equilibrium concentration. Similar trends were obtained for modelling solid-liquid extraction of total polyphenols from grape seeds as well as soybeans seeds (Bucić-Kojić et al. 2007; Jokić et al. 2010).

The constant value, correlation coefficient (R) and the root mean squared deviation (RMSD) were calculated for each mathematical model using Statistica 7.0 non-linear methods. The correlation coefficients were high in all experiments (0.934-0.995), and the root mean squared deviations (RMSD) were in the range from 0.023 to 0.095, which implied a good agreement between the experimental and the calculated data.

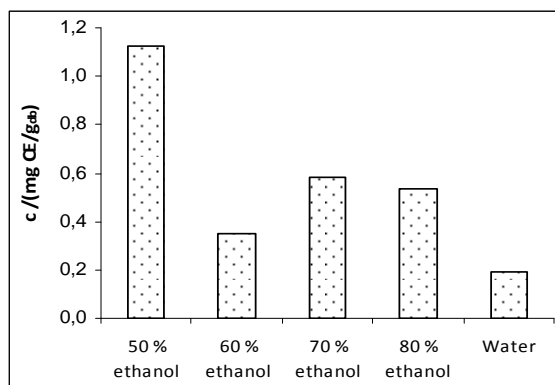


Fig. 1 The effect of the extraction solvent on the extraction yield of total flavonoids from milled soybeans

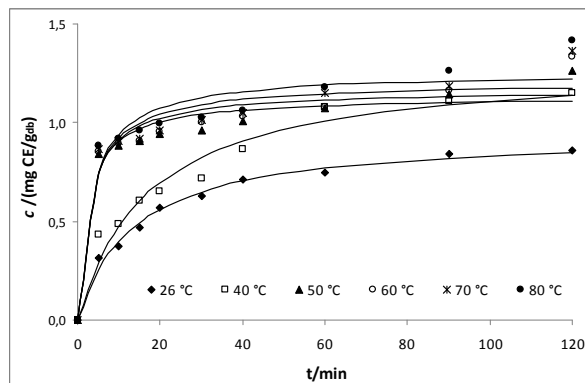


Fig. 2a The temperature influence on the extraction kinetics of total flavonoids: approximation by Peleg's model

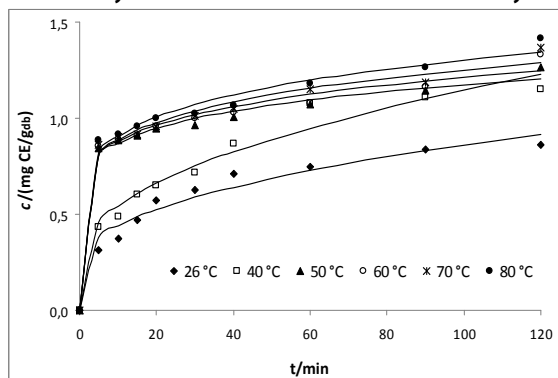


Fig. 2b The temperature influence on the extraction kinetics of total flavonoids: approximation by Page's model

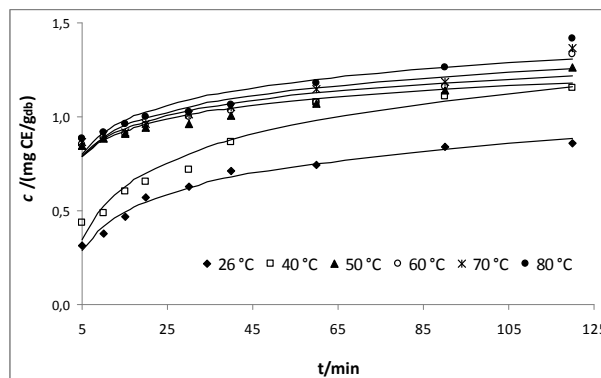


Fig. 2c The temperature influence on the extraction kinetics of total flavonoids: approximation by Logarithmic model

## Conclusion

The results showed that the used solvent, temperature and extraction time had a significant impact on the kinetics and the extraction yield of total flavonoids. The yield of total flavonoids increased with the temperature increase, as well as with the prolongation of the extraction process. 50% aqueous ethanol solution proved to be the most effective solvent (temperature 50 °C, time 60 min) with the obtained total flavonoids extraction yield 5,781 times higher than the extraction yield obtained when water was used as the extraction solvent. The highest extraction efficiency was achieved at temperature of 80 °C after 120 min (1.417 mg CE/g<sub>db</sub>). The mathematical models applied showed a good agreement with the experimental results, which allows their application in modelling and optimisation of solid-liquid extraction process for the extraction of total flavonoids from soybeans.

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# The effect of insufficient nutrition on the development of the sunflower (*Helianthus annuus*, L.) root system

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## Abstract

One of the basic conditions for “physiologically normal” plant growth and development is a good supply of nutrients in the soil. The plant takes up nutrients from the soil solution via the root. The intensity of this uptake is based on a number of factors. One is the size of the root system and particularly the density of the root hairs. In a one-year vegetation experiment we studied how a deficiency of basic macro nutrients (N, P, K, Ca and Mg) affected the development and growth of the root system and aboveground mass of sunflower (*Helianthus annuus*, L.). The experiment was established as a pot experiment in the form of nutrient solutions (hydroponics) with known composition and concentration of ions. The development and growth of the root system in nutrient-deficient conditions was evaluated during the initial stages of sunflower development using the LCR-meter (ELC-131D) which measures the root surface on the basis of electric conductivity. In the experiment we also monitored the aboveground dry matter yield and conducted its chemical analysis. From the results of the pot experiment it was evident that the deficit of macro biogenic elements in nutrient solutions considerably reduced their contents in the plant in the stage of the 4<sup>th</sup> and 8<sup>th</sup> true leaves. Plant growth and development was affected most of all by a deficit of phosphorus which resulted in reduced production of plant biomass in the later stage of development by more than 50%. The effect of insufficient other nutrients was not so marked. The size of the root system was significantly ( $p < 0.01$ ) dependent on both the growth stage of the sunflower plant and on the content of nutrients in the nutrient environment. The electric capacity of the root system increased in time in all the nutrient-deficient treatments. In terms of the macro nutrient deficit the deficit of phosphorus caused the greatest root reduction at all dates of sampling. A statistically significant dependence ( $r = 0.973$ ) was discovered between the size of the active root surfaces and the phosphorus content. On the contrary in the nitrogen-deficient treatment the values of the electric capacity of roots were the highest.

Key words: sunflower, hydroponic, macroelements, root system surface area

## Introduction

The size of the root system is important in the initial stages of plant development. The length of the roots, their surface, diameter and root hairs are important indicators for water and nutrients to be taken up. The size of the root system of crops is affected by a number of factors; among them is indisputably the content of macro biogenic elements in the nutrient environment of the plants. It is possible to identify the size of the root system using a non-destructive method based on the principle of measurements of some electric properties of plants and plant components, one of which is the electrical capacitance. The electrical capacitance method is based on the polarization of biological membranes in the root system, and is dependent on the geometric and dielectric properties of the root system (Dalton 1995; Chloupek et al. 1999).

The electrical capacitance or LCR meter measures the amount of electric charge stored by the root system for a given electric potential (in farads), which is dependent on the active root surface area and root length (Dalton 1995; McBride et al. 2008).

The aim of the study was to obtain knowledge about the influence of macroelements deficiency on the dry weight, the nutrients concentration in plant and on the root system surface area of sunflower.

### Material and methods

Vegetation pot experiments in the form of an aqueous culture with sunflower (*Helianthus annuus*, L.) commenced in the vegetation hall of the experimental laboratories of the Department of Agrochemistry, Soil Science, Microbiology, and Plant Nutrition, Faculty of Agronomy, Mendel University of Agriculture and Forestry in Brno in 2008.

Sunflower variety ES BIBA was sown into a nutrient-free substrate. The seeds were watered on a regular basis and pre-cultivated to the stage of seed leaves (after one week). At this stage the plants were put into vegetation pots with nutrient solutions of different composition (Tab.1) prepared using the method of Hoagland (Laštůvka and Minář, 1967).

**Table 1. Treatments of the experiment and weights of chemicals (g per 1 litre of nutrition solution) according to Hoagland (Laštůvka and Minář, 1967)**

Chemicals	Nutrient solutions (weights of chemicals in g per 1 litre of solution)					
	Complete solution	Nutrition solutions without				
		N	P	K	Ca	Mg
Ca (NO <sub>3</sub> ) <sub>2</sub>	0.821	-	1.231	1.231	-	0.821
KNO <sub>3</sub>	0.506	-	-	-	1.518	0.506
K <sub>2</sub> SO <sub>4</sub>	-	0.871	0.861	-	-	0.436
KH <sub>2</sub> PO <sub>4</sub>	0.136	-	-	-	0.136	0.136
Ca (H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	-	0.117	-	0.117	-	-
CaSO <sub>4</sub> · 2H <sub>2</sub> O	-	0.344	-	-	-	-
MgSO <sub>4</sub>	0.12	0.06	0.241	0.241	0.241	-

The experiment was established in 6 repetitions in 12-litre glass pots with a nutrient solution which were wrapped around in non-transparent film. In each pot the nutrient solutions were aerated at regular time intervals. When the experiment was set up a concentrate of iron was added to all the nutrient solutions (Laštůvka and Minář, 1967). When establishing the aqueous culture the pH value of the solution which was constant during the entire experiment in all the pots was monitored.

In the stage of the 2<sup>nd</sup>, 4<sup>th</sup> and 8<sup>th</sup> true leaves the plants were sampled to determine the size of the root system using the electrical capacitance of the root system (Chloupek, 1977). Due to a lack of plant material in the initial stage of plant development inorganic plant analysis was carried out only in plant matter from samples taken in the stage of the 4<sup>th</sup> and 8<sup>th</sup> true leaves.

The electrical capacitance of the root system was determined using the LCR meter ELC-131D at a frequency of 1 kHz in nF (nanofarad) units in water of constant composition (in a bottle according to Woulf). One electrode was attached to the plant hypocotyl and the other electrode was inserted in a constant position at the bottom of the bottle. Parallel capacity (C<sub>p</sub>) was measured in the circumference where the alternative current passes between the root system and water.

Prior to inorganic analysis of the plant matter the plant samples were dried at a temperature of 60 °C, ground in a grinder and homogenised. This plant matter was subjected to wet mineralisation with H<sub>2</sub>SO<sub>4</sub> (Zbíral, 2005). N concentration was determined using the method according to Kjeldahl and the contents of K, Ca and Mg using the method of atomic absorption spectrometer (AAS) in the apparatus ContrAA 700 (Analytic Jena) in the mineralised matter. The colorimetric method was used to assess P content in the extract using the UV/VIS spectrophotometer (ATI Unicam 8625).

The Statistica 8.0 CZ programme was used for statistical evaluation of the electrical capacitance of the root system. The effect of the nutrient deficit on the formation of the root system was evaluated by the ANOVA analysis of variance. Differences among the treatments were evaluated by follow-up tests according to Tukey at 95% (p < 0.05) and 99% (p < 0.01) levels of significance.

## Results and discussion

### Analysis of plant matter

Plant samples were taken in the stage of the 4<sup>th</sup> and 8<sup>th</sup> true leaves and showed that growth and development of sunflower plants were most markedly affected by a deficit of P. While at the beginning of growth the amount of produced matter in this treatment did not considerably differ from the other combinations, in further development the amount of dry matter produced in the treatment without P was lower, by more than 50% rel. compared to the treatment with a complete nutrient solution (Tab. 2). The effect of the other nutrients deficit was not so significant ( $p < 0.05$ ). Especially in the case of nitrogen deficiency this conclusion contradicts the results of Hocking and Steer (1989), Loubser and Human (1993), Lopez-Bellido et al. (2003); in their experiments the deficit of nitrogen had a negative effect on biomass production.

**Table 2. Dry weight (DW) of sunflower**

Developmental stages	Complete solution	Nutrition solutions without				
		N	P	K	Ca	Mg
2 <sup>nd</sup> leaf	0.065	0.070	0.083	0.072	0.079	0.089
4 <sup>th</sup> leaf	0.47	0.62	0.29	0.61	0.54	0.68
8 <sup>th</sup> leaf	0.97	1.00	0.45	1.19	0.89	1.19

Table 3 shows that the deficit of macro biogenic nutrients in nutrient solutions considerably influenced the nutrient content in plant matter. In the stage of the 4<sup>th</sup> leaf as well as the 8<sup>th</sup> true leaves the nutrient deficit decreased their contents in all the combinations. Compared to the nutrient content in the plant treated with a complete solution this reduction, as an average of both stages of development, was as follows: for N 38.4 rel.%, for P 45.1 rel.%, for K 48.6 rel.%, for Mg 32.2 rel.% and for Ca 38.1 rel.%.

**Table 3. Nutrients concentration in plant of sunflower**

Variants of treatment	Content of nutrients (% DM)									
	Developmental stages 4 <sup>th</sup> leaf					Developmental stages 8 <sup>th</sup> leaf				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Complete sol.	2.99	0.28	0.63	1.57	0.36	2.82	0.13	6.41	1.74	0.30
Without N	2.04	0.49	0.94	1.70	0.31	1.55	0.25	6.79	1.48	0.17
Without P	3.04	0.14	0.76	1.63	0.31	3.72	0.08	5.65	1.48	0.28
Without K	2.49	0.22	0.48	1.57	0.32	3.09	0.18	1.68	2.56	0.98
Without Mg	3.26	0.19	0.78	1.70	0.22	2.91	0.13	7.00	1.63	0.22
Without Ca	4.05	0.40	0.89	1.37	0.42	3.98	0.43	8.52	0.63	0.49

### Size of the root system

The electrical capacitance of the root system of sunflower in the individual stages of development is given in Tab. 4 and 5.

The results show a significant difference ( $p < 0.05$ ) among the developmental stages of sunflower plants (Tab. 4).

**Table 4. The average root system surface area in the monitored developmental stages of sunflower. Values show mean of electrical capacitance (nF)  $\pm$  standard error (SE)**

Developmental stages	nF $\pm$ SE	P < 0.05
2 <sup>nd</sup> leaf	0.578 $\pm$ 0.017	a
4 <sup>th</sup> leaf	0.822 $\pm$ 0.032	b
8 <sup>th</sup> leaf	0.981 $\pm$ 0.070	c

Means followed by the different letters are significantly different ( $p < 0.05$ ).

Table 5 shows that the electric potential of the root system increased in time in all the treatments with macro biogenic elements deficient. The most marked increase in the size of the root between the stages of the 2<sup>nd</sup> and 8<sup>th</sup> true leaves was discovered in nitrogen and calcium deficient nutrient solutions (by 109.2% rel. and 95.5% rel., respectively). In these treatments its value also increased significantly between the stages of the 4<sup>th</sup>

and 8<sup>th</sup> true leaves (N by 34.8 and Ca by 37.1% rel.). The trends monitored in the combinations deficient in phosphorus, potassium and magnesium differed significantly from these treatments. During the experimental period we saw a minimal increase in the values characterising the size of the active root surface; in the nutrient solution without P only by 0.3% rel., without Mg by 1.1% rel. and without K by 6.1% rel.

The lowest measured value (nF) characterising the size of the root system was detected in the phosphorus-free solution, i.e. on all dates of sampling. On the contrary the highest values were monitored in the nitrogen-deficient treatment. These are the combinations that are always significantly different ( $p < 0.05$ ).

**Table 5. The average root system surface area (electrical capacitance nF). Values show mean of electrical capacitance (nF)  $\pm$  standard error (SE)**

Variants of treatment	Developmental stage 2 <sup>nd</sup> leaf	Developmental stage 4 <sup>th</sup> leaf	Developmental stage 8 <sup>th</sup> leaf
Complete sol.	0.550 <sup>ab</sup> $\pm$ 0.026	0.879 <sup>bc</sup> $\pm$ 0.015	1.073 <sup>ab</sup> $\pm$ 0.113
Without N	0.672 <sup>c</sup> $\pm$ 0.020	1.043 <sup>d</sup> $\pm$ 0.080	1.406 <sup>b</sup> $\pm$ 0.173
Without P	0.462 <sup>b</sup> $\pm$ 0.026	0.626 <sup>a</sup> $\pm$ 0.018	0.628 <sup>a</sup> $\pm$ 0.076
Without K	0.547 <sup>ab</sup> $\pm$ 0.024	0.750 <sup>ab</sup> $\pm$ 0.008	0.796 <sup>a</sup> $\pm$ 0.068
Without Mg	0.595 <sup>ac</sup> $\pm$ 0.027	0.719 <sup>a</sup> $\pm$ 0.009	0.727 <sup>a</sup> $\pm$ 0.090
Without Ca	0.643 <sup>ac</sup> $\pm$ 0.024	0.917 <sup>cd</sup> $\pm$ 0.019	1.257 <sup>b</sup> $\pm$ 0.040

Means followed by the different letters are significantly different ( $p < 0.05$ ).

Correlation coefficients given in Table 6 show the correlations between the content of nutrients in plant matter and the size of the root system. The size of the root system was most markedly dependent on phosphorus ( $r = 0.973$  and  $0.719$ ). In the stage of the 4<sup>th</sup> true leaf this dependence was statistically significant ( $p < 0.01$ ). Basing on the results of Cerkal et. al. (2008) it is evident that in wheat the correlation between nutrient uptake and size of the root system is negative. A negative correlation between nitrogen and calcium was also detected in our experiment in both stages of sunflower growth (Tab. 6).

**Table 6. Relationship (r) between root system surface area (electrical capacitance nF) and nutrients concentration in plant (% DM) in monitored growth phases of sunflower**

Developmental stages	Nutrients				
	N	P	K	Mg	Ca
4 <sup>th</sup> leaf	-0.212	0.973**	0.488	0.437	-0.167
8 <sup>th</sup> leaf	-0.458	0.719	0.479	-0.215	-0.465

\* significant different  $P < 0.05$ , \*\*  $P < 0.01$  and \*\*\*  $P < 0.001$

## Conclusion

The results of the pot experiment with sunflower showed that growth and development of the plants were affected most of all by phosphorus; in the later stage of development the production of plant biomass decreased by more than 50%. The effect of the deficiency of the other nutrients on the production of the aboveground parts of the plant was not so significant. The deficiency of macro biogenic elements markedly decreased their levels in the plant in the stages of the 4<sup>th</sup> and 8<sup>th</sup> true leaves. The size of the root system was significantly ( $p < 0.05$ ) dependent both on the growth stage of the plants and on the content of nutrients in the nutrient milieu of sunflower. In all nutrient-deficient treatments the electric capacity of the root system increased in time. Of all the macro nutrients the root was reduced most by an insufficient supply of phosphorus; on all dates of sampling. A statistically significant correlation ( $r = 0.973$ ) was also discovered between the size of the active surface of roots and the phosphorus content. By contrast the nitrogen-deficient treatment showed the highest values of the electric capacity of roots.

## Acknowledgements

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# Cadmium tolerance of maize and sunflower seedlings

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## Abstract

Cadmium is one of the most dangerous heavy metals, which may cause serious problems in certain physiological processes of living organisms even in small amounts. In our work the effects of cadmium on some physiological parameters of maize and sunflower seedlings were analysed. The contents of photosynthetic pigments and the morphological changes of the root were examined. Regarding the decrease of the absolute chlorophyll content corn reacted more sensitively, but higher amounts of cadmium (20 mg l<sup>-1</sup>) completely hindered the growth of sunflower shoots. As a result of the increasing cadmium concentration the absorbent surface of the root significantly decreased in case of both plants. We received different results in terms of the cadmium tolerance of these two plants.

Key words: cadmium, chlorophyll, carotenoid, root morphology

## Introduction

Heavy metals as stressors reduce plant production, and since they are incorporated and accumulated within plant tissues, it is inevitable for them to be transferred into animal and human food chain. Their toxic effect and the accumulation within plants depend on numerous factors: soil characteristics, concentration, contamination length, presence of complex creating materials in the rhizosphere, and also the plant species. Cadmium blocks photosynthesis and transpiration, hinders the uptake and transfer of essential microelements (Di Tioppi and Gabbrielli 1999), and it reduces the growth and weight of the root and the shoot (Gupta és Dixit 1992, Mench et al. 1994, Narwal et al. 1993, Kádár 1993, Reddy és Prasad 1993). As a result of Cd, radicals causing oxidative stress and reactive oxygen species are produced (Hendry et al. 1992). Ferretti et al. (1993) reported the reduction of photosynthesis and the amount of sugars and chlorophylls during cadmium treatment. The water balance of plants is also strongly affected by heavy metals, because through blocking rootling production, significantly reducing the absorbent surface. Moreover, they also reduce membrane permeability and the number and diameter of water transport vessels (Barceló and Poschenreider, 1990). Organic acids are important ingredients of soil, because they dissolve metals being in an otherwise insoluble mineral phase within the soil, increasing the mobility of these metals in the vicinity of roots, therefore improving their absorbability for the plants (López-Bucio et al. 2000).

## Materials and methods

Maize (*Zea mays*, L) and sunflower seeds (*Helianthus annuus* L.) were germinated between moistened filter papers at 25°C in dark. The paper was placed in a vertical position in order to provide for the linear growth of seedlings. The seedlings were transferred to a continuously aerated nutrient solution when the coleoptiles and hypocotyls were 4-5 cm. The composition of the nutrient solution was as follows: 2.0 mM Ca(NO<sub>3</sub>)<sub>2</sub>, 0.7 mM K<sub>2</sub>SO<sub>4</sub>, 0.5 mM MgSO<sub>4</sub>, 0.1 mM KH<sub>2</sub>PO<sub>4</sub>, 0.1 mM KCl, 1µM H<sub>3</sub>BO<sub>3</sub>, (10µM in the case of sunflower), 1µM MnSO<sub>4</sub>, 0.25 µM CuSO<sub>4</sub>, 0.01 µM (NH<sub>4</sub>)<sub>6</sub>Mo<sub>7</sub>O<sub>24</sub>. Iron was added to the nutrient solution as the form of Fe-EDTA in a concentration of 10<sup>-4</sup>M. When Cd treatment was applied, the concentration of CdSO<sub>4</sub> was 1, 5,

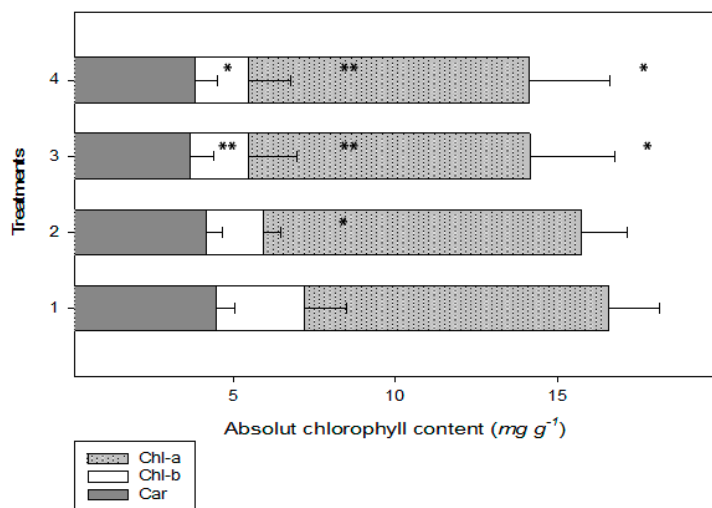
10, 20 mg l<sup>-1</sup>. The seedlings were grown under controlled environmental conditions (light/dark regime 10/14 h at 24/20°C, 65-70% relative humidity and a photosynthetic photon flux of 300 molm<sup>-2</sup>s<sup>-1</sup> at plant height). The contents of photosynthetic pigments were measured with Metertek SP-830 UV/VIS (Japan) according to the method of Moran and Porath (1980) in the 3<sup>rd</sup> leaves of the plants. The length of root (cm) was measured after of 3 weeks for different cadmium treatments.

**Results and discussion**

The effect of cadmium on the absolute chlorophyll content of maize and sunflower leaves was analysed. All of the applied cadmium treatments significantly (p< 0,001) reduced the amounts of chlorophyll -a, -b, and carotenoids in the case of maize (Table 1, Figure 1).

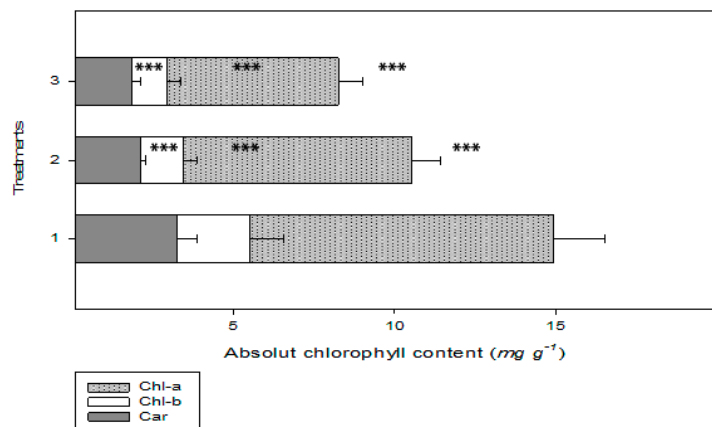
**Table 1. Decrease of the amount of photosynthetic pigments in comparison to the control (%).**

		Treatments			
		1 mg l <sup>-1</sup> Cd	5 mg l <sup>-1</sup> Cd	10 mg l <sup>-1</sup> Cd	20 mg l <sup>-1</sup> Cd
Sunflower	Chl-a	5%	15%	15%	-
	Chl-b	18%	24%	24%	-
	Car	7%	18%	15%	-
Maize	Chl-a	-	-	29%	45%
	Chl-b	-	-	38%	47%
	Car	-	-	35%	43%



**Figure 1. Changes of chlorophyll-a (Chl-a), chlorophyll-b (Chl-b) and carotenoid (Car) contents (mg g<sup>-1</sup>) influenced by different Cd treatments**

(1: control, 2: 10 mg l<sup>-1</sup> CdSO<sub>4</sub>, 3: 20 mg l<sup>-1</sup> CdSO<sub>4</sub>) in 21 days old maize plants. (n=12 ±s.e), p<0.05\*, p<0.01\*\*, p<0.001\*\*\*



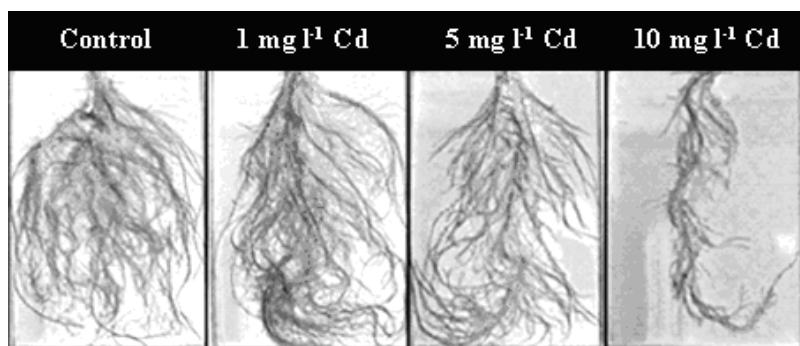
**Figure 2. Changes of chlorophyll-a (Chl-a), chlorophyll-b (Chl-b) and carotenoid (Car) contents (mg g<sup>-1</sup>) influenced by different Cd treatments**

(1: control, 2: 10 mg l<sup>-1</sup> CdSO<sub>4</sub>, 3: 20 mg l<sup>-1</sup> CdSO<sub>4</sub>) in 21 days old sunflower plants. (n=12 ±s.e), p<0.05\*, p<0.01\*\*, p<0.001\*\*\*

In the case of sunflower seedlings lower cadmium concentrations were used (1, 5, 10 mg l<sup>-1</sup>), because the 20 mg l<sup>-1</sup> cadmium concentration significantly damaged plants. According to our results, the 1 mg l<sup>-1</sup> Cd concentration did not cause a significant difference in the amount of chlorophyll-a compared to the control value, but as a result of the 5 and 10 mg l<sup>-1</sup> Cd treatments chlorophyll-a decreased significantly (≈ 20%). The amount of chlorophyll-b changed similarly to the changes of chlorophyll-a. However, the higher Cd doses caused more significant reduction (≈25%) in chlorophyll-b contents, and the reduction was also major in the case of 1mg l<sup>-1</sup> Cd concentration compared to the control value. In the case of carotenoids, the highest reduction occurred for the 5 mg l<sup>-1</sup> cadmium concentration.

These results are in conformity with the results of Ferretti et al. (1993), that the contents of chlorophylls are reduced as a result of heavy metals treatment.

The morphological changes of the roots as a result of cadmium treatments were also investigated. The effects of different cadmium treatments on the root of sunflower (*Helianthus annuus L. cv Nk Neoma*) are shown in the Picture 1. All of the applied cadmium contents caused significant reduction in the root size (Picture 1, Table 2) compared to the control values, which means that the nutritive absorbing surface was reduced both for maize and sunflower plants.



Picture 1. Effects of different cadmium treatments

(Control; 1 mg l<sup>-1</sup> CdSO<sub>4</sub>; 5 mg l<sup>-1</sup> CdSO<sub>4</sub>; 10 mg l<sup>-1</sup> CdSO<sub>4</sub>) on the root morphology of sunflower

Table 2. Maize and sunflower root length (cm) influenced by different Cd treatments

	Control	1 mg l <sup>-1</sup> Cd	5 mg l <sup>-1</sup> Cd	10 mg l <sup>-1</sup> Cd	20 mg l <sup>-1</sup> Cd
Sunflower	60,0± 15,70	49,8± 7,38	39,2± 12,64*	37,1± 18,07**	-
Maize	54,3± 14,80	-	-	41,7± 12,90*	40,5± 8,80**

(Control; 1 mg l<sup>-1</sup> CdSO<sub>4</sub>; 5 mg l<sup>-1</sup> CdSO<sub>4</sub>; 10 mg l<sup>-1</sup> CdSO<sub>4</sub>) (n=8± s.e.) significant differences compared to the control value: p<0.05\*, p<0.01\*\*, p<0.001\*\*\*

To contrast the sunflower root picture (Picture 1) and the root length parameters (Table 1), it can be seen that the effect of cadmium rather decreases the secondary-root amount, than the root length. This is relevant to Barceló and Poschenreider (1990) statement whereas the heavy metals major effects of the plant water balance, because inhibition of the secondary root production reduces the absorbent surface. It seems that the root of sunflower was more sensitive to the high Cd concentration, than the root of maize. The applied 10 mg l<sup>-1</sup> reduced the root length with 23% both in sunflower and maize.

### Conclusions

As it was observed, the decrease of chlorophyll contents and the root-growth were more intensive in the case of sunflower seedlings in comparison to corn. The detailed examination of chlorophyll-a, -b and carotenoids contents shows that there is a significant decrease in comparison to the control value. The differences of Cd-sensitivity are based on the different Cd-uptake system. The dicots release more organic acids (citric, and malic acids) that may form complexes with Cd, and make them absorbable for the plants.

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# Effect of applied herbicides (fluchloridone+s-metolachlor) on weeds in different stage of sunflower growth

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## Abstract

Weed control in sunflower is a necessary practice in cropping, because the weed infestation level directly affects the intensity of competitive relationships between crops and weeds. Suppression of some annual and invasive weeds is difficult due to deficiency of an effective herbicides and the lack of the effects of applied herbicides in years with dry springs, such was in 2009. The two-year study dealt with observed effects of applied herbicides on weeds in different stages of sunflower growth.

The intensity of weed infestation of sunflower, expressed through the number of weed species, number of plants per weed species and weeds fresh biomass, was always lower on the treated area and different at particular crop developmental stages. This affects the sunflower plant height, which was higher on the average in variants with the herbicide applications (70.4 cm) than in variants without the herbicides application (69.5 cm). Weed control in sunflower crops has to carry out with adequate herbicides, in proper time, prior to a critical period, when the value of morphological and yielding parameters of sunflower can be significantly reduced, due to the weeds.

Key words: sunflower, weeds, herbicide, fluchloridone, s-metolachlor

## Introduction

The impacts of meteorological factors, onset of plant diseases, as well as the intensity of weed infestation can be crucial for the successful sunflower production. The level of weed infestation of sunflower differs over locations and directly affects the intensity of competitive relationships between crops and weeds, which results in lower or greater losses of yield (Vratarić, 2004). The relationships between crops and weeds also depends on the distribution of weed communities, life cycle, and time of emergence and dynamics of weed growth, time of crop sowing, as well as soil and climatic conditions. It is considered that sunflower is a good competitor in relation to weeds, due to an intensive initial growth, large leaves and early canopy formation. However, the sunflower is a thermophile plant and it is sown in mid-spring, when a great number of weeds, especially troublesome ones: *A. artemisiifolia*, *X. strumarium*, *D. stramonium*, *A. retroflexus* etc. have already emerged. Chemical weed control in sunflower crops is difficult due to the lack of post-emergence broad-leaf herbicides (Malidža et al., 2005).

Having information on time of weed emergence in relation to crop emergence is an important factor in making decisions on weed control (Bosnić and Swanton, 1997). The observation of redroot pigweed (*A. retroflexus* L.) period to removal on dry matter of maize and soybean showed that each new leaf of the cultivated plants developed with the loss of 2%, if weeds were not removed in proper time (Knežević et al., 1997). Therefore, it is necessary to have knowledge on developmental stages of both, crops and weeds, in

order to determine the period in which weeds have to be suppressed in sunflower crops. A sufficiently selective herbicide applied in appropriate time is essential for successful chemical weed control in sunflower.

The spectrum of herbicides effects on weeds and selectivity to the crop are determined by studies on efficiency of certain herbicides. In recent times the products based on fluchloridone, acetochlor, trebutilazin and other active ingredients could be applied in soil treatments for suppression annual broad- and some grass weeds in sunflower (Konstantinović et al., 2010). Effects of the applied herbicides (fluchloridone+s-metolachlor) on weeds and plant height, as a result of weed-crop competition, at different developmental stages of sunflower were observed in the two-year period.

### Material and methods

The trial was carried out in the experimental field of the Maize Research Institute Zemun Polje, during 2008 and 2009. Winter wheat was a preceding crop in both years. Sowing of the imidazolinone-resistant sunflower hybrid NS RIMI was done mechanically by a pneumatic drill seeder Polt Nodet on April 9, 2008 and April 21, 2009. The inter-row distance was 70 cm, while the distance between plants in the row was 23.5 cm, hence the sowing density was 55-60,000 plants ha<sup>-1</sup>.

The application of herbicides included the following variants: A-without herbicides application and B-pre-emergence application of the combination of flurochloridone+s-metolachlor in the amount of 500 g l<sup>-1</sup> a.i. and 1350 g l<sup>-1</sup> a.i. (Racer 2 l ha<sup>-1</sup> + Dual Gold 1.5 l ha<sup>-1</sup>). Herbicides were applied using a knapsack sprayer on April 17, 2008 and April 21, 2009. After sunflower emergence in both variants, A and B, weeds were manually removed in five times, i.e. in five sunflower developmental stages: V3-4-leaf stage, V6-6-leaf stage, V9-9-leaf stage, R1-budding and R5-flowering. Each variant had three replications. The elementary plot was 10 m long and four sunflower rows i.e. 4.2 m wide.

The estimation of weed infestation was performed over the sunflower developmental stages, in a way that two 0.25 m<sup>2</sup> squares (70x35.7cm) were sampled from the two middle rows. A number of species, a number of plants and fresh biomass per weed species were determined. At the same time, the sunflower plant height was estimated by measuring 10 plants each in middle rows. Obtained data were statistically processed by ANOVA and differences between means were tested by the least significant difference (LSD) test.

### Meteorological conditions

Mean daily air temperatures during the growing season in both years of investigations were higher than a long-term average (19.0 °C), while the total precipitations from April to September were significantly lower than a long term average (320.8 mm), table 1.

**Table 1. Average monthly air temperatures and monthly precipitation sums from April to September in Zemun Polje**

Months	Temperature (°C)			Precipitation (mm)		
	2008	2009	1998-2007	2008	2009	1998-2007
April	14.1	15.8	13.3	27.3	7.3	52.6
May	19.3	19.8	18.2	39.7	27.4	44.3
June	23.0	21.0	21.7	36.3	71.9	89.6
July	23.5	24.1	22.5	46.2	31.2	56.6
August	24.2	23.9	20.5	19.7	36.6	56.8
September	17.5	20.6	17.9	54.4	4.0	50.9
Average/Sum	20.3	20.9	19.0	223.6	178.4	320.8

If compared, 2008 and 2009 did not much differ, each of other in relation to average monthly air temperatures (20.3 and 20.9 °C, respectively), but precipitation sums were lower in 2009 (178.4 mm) than in 2008 (223.6 mm). A dry period, during April 2009 with only 7.3 mm of precipitation was especially important, because it was a time of sunflower sowing and the application of herbicides.

## Results and discussion

According to obtained results, the number and dynamics of weed emergence in the sunflower crop significantly differed in dependence on the herbicide treatments (Table 2).

In each developmental stage, when weed infestation was estimated, the number of weed species and the number of plants per weed species, were, as expected, higher on the areas without herbicide treatment (A) than on herbicide treated areas (B). Out of 16 recorded weed species in the sunflower crop in 2008, *A. artemisiifolia* was the most numerous. Species *A. artemisiifolia* and *X. strumarium* were even present in a great number of plots in the variant with the herbicides application. The applied herbicides effectively reduced the number of annual, broad-leaf species such as *S. nigrum*, *D. stramonium*, *A. retroflexus*, *Ch. album* and *Ch. hybridum*. The number of plants per weed species increased with the growth and the development of sunflower and it was the highest at the beginning of flowering (R5) in both variants: treated and untreated (230.3 and 106.7 plants m<sup>-2</sup>).

During the second year of investigation, there were 12 weed species and *A. artemisiifolia* was again the most numerous (Table 3). In 2009, in the total weed infestation of sunflower, there were significantly included *D. stramonium*, *S. nigrum*, *X. strumarium* and *A. retroflexus* and their number was significant even on the herbicide treated areas.

The application of herbicides in 2009 did not result in significant differences in the number of weed species and the number of plants between treated and untreated areas, due to dry spring (Table 1), and delayed sunflower sowing. As a result, the number of weed species in all developmental stages of sunflower was almost the same in both variants, treated and untreated.

On the average for both years the number of plants per weed species and their fresh biomass were significantly lower on the treated area at all growth stages of sunflower (Table 4). The highest number of plants per weed species was recorded at the beginning of sunflower flowering (R5) on both areas treated (92.0 plants m<sup>-2</sup>) and untreated (148.8 plants m<sup>-2</sup>) and on the average (120.4 plants m<sup>-2</sup>). A similar regularity was determined for the weed fresh biomass (4495.7 g m<sup>-2</sup>, 5410.4 g m<sup>-2</sup> and 4953.0 g m<sup>-2</sup>, respectively). The weed infestation intensity was followed by the stages of growth and development of sunflower: the sunflower plant height was significantly higher in the herbicide treated (70.4 cm) than in the untreated variant (69.5 cm). Sunflower plants were especially higher on the treated area over the stages R1 and R5.

Table 2. Effects of applied herbicides on number of weeds in sunflower crop (No m<sup>-2</sup>) in 2008

Weed species	Time of estimation of weed infestation in sunflower crop									
	V3		V6		V9		R1		R5	
	A	B	A	B	A	B	A	B	A	B
<i>A. artemisiifolia</i>	68.7	26.0	78.0	39.3	67.3	44.7	84.0	38.7	110.0	76.6
<i>Ch. album</i>	30.0		14.0	0.7	32.7		34.0	0.7	45.7	4.0
<i>S. nigrum</i>	7.3	1.3	4.7		2.7		12.0		14.0	0.7
<i>X. strumarium</i>	4.0	19.3	20.7	7.3	20.7	5.3	10.0	8.0	33.3	18.7
<i>A. retroflexus</i>	4.0		2.0		2.7		2.0		2.7	
<i>D. stramonium</i>	1.3		8.7	3.3	3.3		7.3		13.3	2.0
<i>S. annua</i>	1.3		1.3		5.3		8.0			
<i>Ch. hybridum</i>	0.7		6.7		9.3		9.3		7.3	
<i>S. halepense</i>	12.7	10.0	28.7	6.0	18.0	20.7	10.7	1.3	4.0	4.7
<i>V. persica</i>	16.7		15.3		9.3					
<i>P. aviculare</i>		0.7								
<i>P. lapathifolium</i>			0.7							
<i>A. theophrasti</i>			0.7							
<i>G. aparine</i>						1.3				
<i>A. albus</i>						0.7	0.7			
<i>R. lutea</i>								1.3		
No of species	10	5	12	5	10	5	10	5	8	6
No of plants	146.7	57.3	181.5	56.6	171.3	72.7	178.0	48.7	230.3	106.7



Table 3. Effects of applied herbicides on number of weeds in sunflower crops (No m<sup>-2</sup>) in 2009.

Weed species	Time of estimation of weed infestation in sunflower crop									
	V3		V6		V9		R1		R5	
	A	B	A	B	A	B	A	B	A	B
<i>A. aretmsiifolia</i>	22.7	22.0	16.0	34.7	49.3	43.3	50.7	22.7	56.7	54.7
<i>D. stramonium</i>	19.3	2.7	32.7	9.3	24.0	14.0	22.2	7.3	6.7	14.7
<i>S. nigrum</i>	18.0	6.0	14.0	2.7	10.7	6.7	7.3	5.3	9.3	5.3
<i>X. strumarium</i>	2.0	2.0	2.0	2.7	1.3	2.0	2.7	2.7	3.3	1.3
<i>A. retroflexus</i>	2.0	1.3	9.3	0.7	2.0	2.7	4.0	4.0	2.0	
<i>Ch. hybridum</i>	5.3	1.3	7.3		5.3		6.0	2.7	5.3	0.7
<i>Ch. album</i>	2.0				0.7	0.7	0.7	0.7		
<i>S. annua</i>	0.7				0.7					
<i>S. halepense</i>		0.7	0.7	6.7	1.3	3.3	9.3	4.0	0.7	0.7
<i>B. convolvulus</i>					0.7					
<i>P. lapathifolium</i>				0.7	1.3					
<i>C. arvensis</i>						0.7				
No of species	8	7	7	7	11	8	8	8	7	6
No of plants	72.0	36.0	82.0	57.5	97.3	73.4	102.9	49.4	84.0	77.4

Table 4. Effects of herbicides application on dynamics of weed infestation and sunflower growth (2008-09 average)

Time of estimation	Number of plants per weed species m <sup>-2</sup>		Fresh biomass, g m <sup>-2</sup>		Sunflower plant height, cm	
	A	B	A	B	A	B
	V3	111,0	48,5	215,9	66,9	7,3
V6	133,0	57,0	313,6	178,2	11,3	11,0
V9	125,0	73,8	953,2	446,9	21,9	21,5
R1	143,7	49,7	4312,1	3230,7	107,9	111,1
R5	148,8	92,0	5410,4	4495,7	199,1	201,6
Average	132,3*	64,2	2241,0*	1683,6	69,5	70,4*
	LSD <sub>0,05</sub> =31,9		LSD <sub>0,05</sub> = 8,02		LSD <sub>0,05</sub> = 0,20	

According to Zollinger and Dexter (1994), weed plants create a different competition pressure on the sunflower crop in dependence on the developmental stage, habitus and abundance. Competition between row crops and weeds occur in the initial stages of emergence and first leaves formation (Simić, 2003; Vratarić 2004). Competition is especially expressed under conditions of water deficiency because weeds are more resistant to water deficit than crops. The application of soil herbicides, whose activity depends on precipitation and effect often lacks due to drought, additionally increases competition intensity (Malidža et al., 2005). It also affects the growth and development of crops and afterwards the yield. Although sunflower, as a robust plant, is a good competitor among row crops, the application of only soil herbicides after sowing and before emerging is not a sufficient measure to protect the crop. The preparates based on flurochloridone are efficient in suppression of annual broad-leaf species, such as *A. retroflexus*, *Ch. album*, *Ch. hybridum*, *S. Nigrum* and satisfactory *X. strumarium* and *P. persicaria* (Konstantinović et al., 2010). It is very important to remove species, as *X. strumarium* and *A. atremisiifolia*, which are invasive, troublesome and very often distributed in the sunflower crop, that can poison animals and cause various inflammations and allergies in humans (Vratarić, 2004).

Owing to this, weed suppression in sunflower crops needs a great attention. It is necessary to introduce new technology, such as hybrids tolerant to herbicides, which could provide herbicides application during the growing season, as well as to introduce cropping practices adapted to a given agroecological conditions (Malidža i sar., 2002).

## Conclusions

Obtained results indicate that the number of weeds in the sunflower crops under agroecological conditions of Zemun Polje noticeably depends on meteorological conditions of a year that affect efficiency of soil herbicides. The applied herbicides flurochloridone+s-metolachlor effectively reduced the number of annual broad-leaf species such as *S. nigrum*, *D. stramonium*, *A. retroflexus*, *Ch. album* and *Ch. hybridum* in 2008, while there was not significant differences in the number of weeds between treated and untreated areas in 2009.

The intensity of weed infestation of sunflower was different at crop developmental stages and it was reflected upon the sunflower plant height. Weed control in sunflower crops, beside by the application of the appropriate herbicides, has to be done in proper time when, due to the weed abundance, the morphological parameters of crops can be significantly reduced.

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# Zavisnost prinosa i kvalitete šećerne repe od roka vađenja i hibrida

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## Sažetak

Istraživanja prinosa i kvalitete korijena, ovisno o roku vađenja korištenjem 9 hibrida šećerne repe Z i N tipa, obavljena su u 2007. i 2008. godini. Vađenje repe izvršeno je u tri roka i to krajem kolovoza ili u prvim danima rujna kod prosječne dužine vegetacije od 166 dana te 30 odnosno 60 dana kasnije. U prosjeku za dvije godine produženje vegetacije za 30 dana u rujnu dovelo je do povećanja prinosa korijena za 11,15 t ha<sup>-1</sup>, te u listopadu za 8,77 t ha<sup>-1</sup>. Digestija se istovremeno u drugom roku vađenja nije značajnije povećala, tek za 0,29%, dok je u trećem u odnosu na prvo vađenje povećanje bilo visoko značajno i iznosilo je 0,68%. Prinos čistog šećera povećan je u drugom roku vađenja za 2,06 t ha<sup>-1</sup>, a u trećem roku u odnosu na drugi za 1,78 t ha<sup>-1</sup>. Između hibrida utvrđene su osjetne razlike u prinosu korijena, šećera i digestiji, kao i u jesenskom porastu. Rezultati istraživanja ukazuju na značajan utjecaj roka vađenja i hibrida na rezultate u proizvodnji šećerne repe.

Ključne riječi: šećerna repa, rok vađenja, hibrid, prinos, digestija

## Sugar beet yield and quality depending on digging period and hybrids

### Abstract

The research studies on root yield and quality depending on digging period and by applying 9 Z - and N - types of sugar beet hybrids were carried out during 2007 and 2008. Sugar beet digging was done three times: at the end of August, or in the first days of September with the average length of growing season of 166 days, and 30 or 60 days later. On average in 2 years growing season that was prolonged by 30 days in September induced root yield increase by 11.15 t ha<sup>-1</sup> and in October by 8.77 t ha<sup>-1</sup>. Simultaneously, in the second period of digging sugar content was not significantly increased, only by 0.29%, while in the third period when compared to the first one the increase was higher and reached 0.68%. Pure sugar yield was increased by 2.06 t ha<sup>-1</sup> in the second period, and in the third when compared to the second one by 1.78 t ha<sup>-1</sup>. Significant differences were determined between the hybrids in the values of root yield, sugar yield and sugar content, as well as in the autumn increase. The results of our research proved significant influence of digging period and hybrids on the results in sugar beet production.

Key words: sugar beet, digging period, hybrid, yield, sugar content

## Uvod

Dužina vegetacije šećerne repe jedan je od značajnih čimbenika koji utječe na masu i kvalitetu proizvedenog korijena (Kristek i sur., 1988.; Petkeviciene, 2008.). Broj dana rasta i razvoja biljke određen je rokom sjetve i rokom vađenja. Sjetvu ove kulture stoga valja otpočeti odmah čim to dopuštaju vremenske prilike i stanje tla. Na našem području sjetvu započinjemo u načelu sredinom ožujka, a završavamo u prvoj dekadi travnja. Ranim rokom sjetve (sredina ožujka) do prvih rokova vađenja (početak rujna) osiguravamo tek oko 160 dana vegetacije, a samo kasnijim rokovima vađenja (listopad), željenih više od 180 dana vegetacije. Zbog toga, svakako je interesantno vađenje šećerne repe izvršiti što kasnije. Međutim, uzimajući u obzir vremenske prilike, osobine i uređenost tla, izgrađenost puteva i kanalske mreže, opremljenost proizvođača, kulturu koja slijedi iza šećerne repe, kapacitete tvornica šećera, proizvedene količine repe, sa vađenjem smo prisiljeni započeti često već početkom rujna. Zbog ovih činjenica interesantno je izučiti reakciju hibrida obzirom na rok vađenja.

## Materijal i metode rada

Istraživanja su provedena u 2007. i 2008. godini na lokalitetu Topolje. U istraživanju je korišteno 9 hibrida od kojih je 6 pripadalo Z tipu (Marcus, Tibor, Severina, Gazeta, Protecta i Giraf), 1 N/Z tipu (Theodora), te 2 N tipu (Merak, Clementina). Sjetva je izvršena 14. i 16. ožujka, a vađenje u tri roka (Tablica 1.). Na ovaj način kod prvog roka vađenja ostvarena je prosječna dužina vegetacije od 166 dana, kod drugog roka 196 dana, a kod trećeg 226 dana. Pokusi su postavljeni po shemi slučajnoga bloknooga rasporeda u četiri ponavljanja. Veličina osnovne parcele iznosila je 72 m<sup>2</sup> (12 m dužine i 6 m širine, tj. 12 redova), a u vađenju 10<sup>2</sup> (10 m dužine, 2 reda).

Tablica 1. Datum sjetve i vađenja te dužina vegetacije šećerne repe u danima

Godina	Datum sjetve	Datum vađenja			Dužina vegetacije - dana		
		I	II	III	I	II	III
2007.	16. 03.	27. 08	28. 09	01. 11.	164	195	229
2008.	14. 03.	28. 08	01.10.	27. 10.	167	200	226

U svakom roku izvađena su dva reda, vodeći računa da se izbjegne utjecaj rubnog reda. Agrotehničke mjere proizvodnje repe u pokusima bile su standardne, tj. identične onima u redovnoj proizvodnji, osim vađenja repe, koje je izvršeno ručno u tri roka. Zaštita od pjegavosti lišća šećerne repe izvršena je u dva navrata primjenom 0,7 lha<sup>-1</sup> fungicida Sphere 267,5 EC (ciprokonazol - 8% + trifloksistrobin 18,75%). Vremenske prilike utjecale su na tijek porasta šećerne repe. Za njihovu analizu poslužili smo se podacima meteorološke postaje Osijek (Tablica 2.).

Tablica 2. Meteorološki podaci za Osijek u vegetaciji šećerne repe po mjesecima

God.	Oborine (mm)								Srednja temperatura zraka (oC)								$\bar{x}$
	IV	V	VI	VII	VIII	IX	X	Σ mm	IV	V	VI	VII	VIII	IX	X		
	2007.- 2009. godine								2007.- 2009. godine								
2007	3	56	33	27	46	65	94	324	13,3	18,3	22,2	23,9	22,2	14,5	10,3	17,8	
2008	50	67	76	79	46	86	30	434	12,5	18,1	21,5	21,8	21,8	15,7	13,0	17,7	
VGP*	54	58	88	65	59	45	41	410	11,3	16,5	19,5	21,0	20,3	16,6	11,2	16,6	

\* Višegodišnji prosjek (VGP) 1961-1990.

Prema količini oborina u vegetaciji (od IV. - X. mjeseca), 2007. godinu karakterizirala je manja, a 2008. veća količina oborina. U 2008. godini palo je 434 mm kiše, što je više od dugogodišnjeg prosjeka. Srednje temperature zraka u vegetaciji bile su slične, u ispitivanim godinama (17,8 °C, odnosno 17,7 °C), ali i znatno više od višegodišnjeg prosjeka.

## Rezultati i rasprava

Dobiveni rezultati pokazuju da je dužina vegetacije značajno utjecala na ostvareni prinos i kvalitetu korijena šećerne repe. Kasniji rokovi vađenja doveli su do povećanja proizvodnog rezultata, ali treba istaći da je to povećanje zavisilo od hibrida i njegovih osobina, pa i otpornosti prema patogenoj gljivi *Cercospora beticola* Sacc. To iz razloga što kod osjetljivih hibrida prema ovoj bolesti, kod duge vegetacije ni dva tretiranja fungicidima nisu bila dovoljna. Svakako da su i vremenske prilike, odnosno raspored i količine oborina, kao i kretanja temperatura (Tablica 2.) utjecalo na jesenski porast korijena i povećanje digestije. Produženje vegetacije za 30, odnosno 60 dana, u prosjeku svih hibrida u pokusu, dovelo je do vrlo značajnog porasta prinosa korijena i šećera.

Prinos korijena u prosjeku godina istraživanja i hibrida bio je visoko značajno veći u drugom u odnosu na prvi, te u trećem u odnosu na drugi rok vađenja. Produženje vegetacije odgađanjem vađenja, za prvih 30 dana dovelo je do osjetnog prosječnog povećanja prinosa korijena repe i to za 11,15  $\text{tha}^{-1}$  (17,17%) ili 372  $\text{kg ha}^{-1}$  dnevnog porasta (Tablica 3.).

Tablica 3. Prinos korijena šećerne repe ( $\text{tha}^{-1}$ ) zavisno o roku vađenja u 2007. i 2008. godini

Hibrid	Rok vađenja									Ukupni prosjek
	I			II			III			
	2007.	2008.	Prosjek	2007.	2008.	Prosjek	2007.	2008.	Prosjek	
Marcus	53,2	65,66	59,43	59,07	67,61	62,35	64,07	84,47	74,27	65,35
Tibor	58,5	70,11	62,81	69,27	87,73	78,5	78,07	99,93	89,00	76,77
Merak	60,6	79,61	70,11	79,13	84,53	81,83	81,53	96,33	88,93	80,2
Severina	68,85	73,8	71,33	74,87	81,53	78,11	84	106,8	95,4	81,61
Theodora	61,2	69,49	65,35	67,4	81,8	74,6	76,8	91,87	84,34	74,76
Clementina	58,15	76,19	67,17	68,33	83,47	75,9	70,8	94,8	82,8	75,29
Gazeta	56,25	50,65	53,45	67,47	85,93	76,7	87,4	90,13	88,77	72,97
Protecta	60,2	74,78	67,49	65,2	77,67	71,44	71,47	77,67	74,57	71,17
Giraf	70,9	60,34	65,62	83,53	84,8	84,17	83,6	87,4	85,5	78,43
Prosjek	60,87	68,96	64,92	70,47	81,67	76,07	77,53	92,15	84,84	75,28
Prosjek roka	64,92			76,07			84,84			
Prosjek god.	2007. = 69,62			2008. = 80,93						
LSD Rok	0,05 = 3,91			0,01 = 5,61						
LSD Hibrid	0,05 = 4,85			0,01 = 6,78						

Veći porast mase korijena od prvog do drugog roka utvrđen je u drugoj godini istraživanja. To iz razloga što je 2008. godine bila vlažnija, a samo u rujnu je palo čak 86 mm kiše. U 2007. godini nakon nedovoljne količina oborina u prethodna tri mjeseca, kiša je pala tek u rujnu (Tablica 2.). U slijedećih 30 dana vegetacije (listopad) prosječni porast korijena bio je manji - 8,77  $\text{tha}^{-1}$  (11,52%) ili 292  $\text{kg ha}^{-1}$  po danu. Produženjem vegetacije za 60 dana (rujan i listopad) dovelo je do porasta mase korijena po jednom hektaru za 19,92 t (30,68%) uz prosječni dnevni porast mase korijana od 332  $\text{kg ha}^{-1}$ . Analiza po hibridima ukazuje na različiti porast mase u jesenskom periodu, ali to ne možemo povezivati s tipom kojem hibrid pripada. Tako su npr., Gazeta i Severina (Z-tip) ostvarile nadprosječni porast mase korijena (35,32 i 24,07  $\text{tha}^{-1}$ ), s tim da je Severina već u prvom roku imala prinos korijena od 71, 33  $\text{tha}^{-1}$ . S druge strane, Merak i Clementina (N-tip) postigle su u jesen ispodprosječan porast repe, pa su i u prosjeku istraživanja ostvarile nešto niže prinose. Kristek i sur. (2007.) od sredine rujna do sredine listopada (34 dana) utvrdili su, na dva lokaliteta u 2006. godini, slični dnevni porast mase korijena od 287  $\text{kg ha}^{-1}$  uz dva tretiranja fungicidima, dok je na varijantama bez primjene fungicida porast korijena bio manji i iznosio 217  $\text{kg ha}^{-1}$ . Šapoval (1979.) navodi da je prosječni dnevni porast korijena u rujnu i listopadu iznosio po mjesecu oko 290  $\text{kg ha}^{-1}$ , ali da je pri nedostatku vlage u tlu bio manji, te je iznosio u rujnu 197  $\text{kg ha}^{-1}$ , a u listopadu 110  $\text{kg ha}^{-1}$ . Slične rezultate u svojim istraživanjima dobio je Petkeviciene (2008.).

Sadržaj šećera u prosjeku dvije godine istraživanja iznosio je, za naše uvijete, visokih 16,68%. Dva hibrida (Protecta i Tibor) ostvarila su prosječnu digestiju od preko 17%. Od prvog do drugog roka vađenja porast digestije bio je neznatan (Tablica 4.). To je posljedica nepovoljnog tijeka vremenskih prilika kao i tijeka rasta i razvoja repe. Od drugog do trećeg roka vađenja, u prosjeku istraživanja, utvrđen je značajan porast digestije od 0,39%. Slično povećanje sadržaja šećera od 0,46 i 0,79%, ovisno o lokalitetu, navode Kristek i sur. (2007.). Porast digestije zavisio je i od hibrida. Tako je npr. hibridom Severina ostvaren mali porast digestije, ali je

ona već u prvom roku imala 16,37% šećera, za razliku od nekih hibrida (Clementina, Gazeta) koji su imali velik porast digestije ali kod njih u prvom roku vađenja nalazimo znatno niže vrijednosti sadržaja šećera.

Tablica 4. Sadržaj šećera (%) zavisno o roku vađenja u 2007. i 2008. godini

Hibrid	Rok vađenja									Ukupni prosjek
	I			II			III			
	2007.	2008.	Prosjek	2007.	2008.	Prosjek	2007.	2008.	Prosjek	
Marcus	16,24	16,92	16,58	16,91	16,90	16,91	17,28	17,15	17,22	16,90
Tibor	16,78	17,17	16,98	16,86	17,26	17,06	16,69	17,46	17,08	17,04
Merak	16,20	16,83	16,52	16,43	16,67	16,55	17,31	17,38	17,35	16,81
Severina	16,39	16,34	16,37	16,27	16,80	16,54	16,23	16,99	16,61	16,51
Theodora	15,85	15,97	15,91	16,62	16,35	16,49	16,50	16,20	16,35	16,25
Clementina	15,33	14,91	15,12	15,37	15,60	15,49	16,76	16,17	16,47	15,69
Gazeta	15,71	17,46	16,59	15,92	17,15	16,54	17,65	17,53	17,59	16,91
Protecta	16,79	16,71	16,75	17,10	17,48	17,29	18,29	17,30	17,80	17,28
Giraf	15,67	17,15	16,41	16,39	17,60	16,70	16,49	17,38	16,94	16,68
Prosjek	16,11	16,61	16,36	16,43	16,87	16,65	17,02	17,06	17,04	16,68
Prosjek roka		16,36			16,65			17,04		
Prosjek god.			2007. = 16,52			2008. = 16,85				
LSD Rok			0,05 = 0,35			0,01 = 0,47				
LSD Hibrid			0,05 = 0,61			0,01 = 0,68				

Prinos šećera u prosjeku istraživanja iznosio je 11,07  $\text{tha}^{-1}$  (Tablica 5.). Veća razlika u ovom pokazatelju između hibrida primjetna je u prvom, a manja u trećem roku vađenja što govori o utjecaju hibrida na jesenski porast. Međutim, kod tog porasta tip kojem hibrid pripada nije bio

Tablica 5. Prinos čistog šećera ( $\text{tha}^{-1}$ ) zavisno o roku vađenja u 2007. i 2008. godini

Hibrid	Rok vađenja									Ukupni prosjek
	I			II			III			
	2007.	2008.	Prosjek	2007.	2008.	Prosjek	2007.	2008.	Prosjek	
Marcus	7,59	9,68	8,64	8,94	10,18	9,56	9,89	12,94	11,42	9,87
Tibor	8,63	10,41	9,52	10,36	13,41	11,89	11,28	15,57	13,43	11,61
Merak	8,64	11,48	10,06	11,50	12,02	11,76	12,45	14,90	13,68	11,83
Severina	9,67	10,11	9,89	10,68	11,92	11,30	11,89	15,93	13,91	11,70
Theodora	8,26	9,49	8,88	9,86	11,77	10,82	11,16	13,02	12,09	10,60
Clementina	7,57	9,02	8,30	9,23	11,07	10,15	10,43	13,19	11,81	10,09
Gazeta	7,68	7,65	7,67	9,43	12,85	11,14	13,62	14,10	13,86	10,89
Protecta	8,74	10,50	9,62	9,87	12,04	10,96	11,76	15,08	13,42	11,33
Giraf	9,54	9,07	9,31	12,09	13,30	12,70	12,14	13,63	12,89	11,63
Prosjek	8,48	9,71	9,10	10,22	12,10	11,16	11,62	14,26	12,94	11,07
Prosjek roka		9,10			11,16			12,94		
Prosjek god.			2007. = 10,11			2008. = 12,02				
LSD Rok			0,05 = 0,81			0,01 = 1,09				
LSD Hibrid			0,05 = 0,93			0,01 = 1,27				

presudan. Produženjem vegetacije za 30 dana (rujan), prosječno je povećan prinos šećera za 2,06  $\text{tha}^{-1}$  ili 22,6%, odnosno dnevno za 68,7  $\text{kg}^{-1}$ . U slijedećih 30 dana (listopad) došlo je do prosječnog porasta prinosa šećera za daljnjih 1,78  $\text{tha}^{-1}$ , odnosno 15,94% ili dnevno za 59,3  $\text{kg}^{-1}$ . Kristek i sur. (2007.) u rezultatima svojih istraživanja iznose da je, ovisno o očuvanosti lišća, pri produženju vegetacije za 34 dana (od sredine rujna do sredine listopada) dnevni porast prinosa šećera iznosio od 51 do 74  $\text{kg}^{-1}$ . Također, Kristek i sur. (1988.) u drugom slučaju navode da je dnevni porast iznosio oko 62  $\text{kg}^{-1}$ .

### Zaključak

Prolongiranjem roka vađenja repe, prinos korijena i šećera značajno su se povećavali. To povećanje je ovisilo i o hibridu, ali ne i o tipu (N ili Z) kojemu je hibrid pripadao. Porast sadržaja šećera bio je nejednak i zavisio je od vremenskih prilika. Prosječni porast korijena u rujnu iznosio je 11,15  $\text{tha}^{-1}$  ili 372  $\text{kgha}^{-1}$  dnevno, dok je u listopadu iznosio 8,77  $\text{tha}^{-1}$  ili 292  $\text{kgha}^{-1}$  dnevno. Sadržaj šećera iznosio je u prvom roku vađenja prosječno 16,36%, u drugom roku 16,65%, te u trećem roku u prosjeku 17,04%. Najveći prosječni prinos šećera od 12,94  $\text{tha}^{-1}$  postignut je u trećem roku vađenja.

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# Utjecaj načina dorade sjemena na poljsku klijavost šećerne repe

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## Sažetak

Istraživanja poljske klijavosti sjemena šećerne repe ovisno o načinu dorade sjemena provedena su u 2009. i 2010. godini na području Virovitice na tlu tipa pseudoglej na zaravni. U istraživanjima je korišteno sjeme dva hibrida šećerne repe tvrtke KWS (Colonia KWS i Jasmina KWS) doradeno na dva načina i to po standardnom postupku te po EPD (Early plant development) tehnologiji. Dobiveni rezultati su pokazali da je način dorade sjemena značajno utjecao na brzinu klijanja sjemena u polju ali nije imao utjecaja na ukupnu poljsku klijavost. Iz sjemena doradenog po EPD tehnologiji prosječno šest dana nakon sjetve, u poljskim je uvjetima izniklo 41% sjemena, što je bilo 3,4 puta više nego iz sjemena standardne dorade. Isto tako, početni porast biljaka razvijenih iz sjemena po EPD postupku bio je značajno veći, pa su biljke u fazi 6 - 8 listova imale za 2,0 puta veću masu od biljaka razvijenih iz sjemena standardne dorade. U fazi zatvaranja redova (12 - 14 listova) razlika u masi biljaka se smanjila, tako da su biljke iz sjemena EPD dorade bile teže 1,3 puta.

Ključne riječi: šećerna repa, način dorade, poljska klijavost

## Effect of the seed processing method on sugar beet field germination

### Abstract

The research studies into sugar beet field germination depending on the seed processing method were carried out in 2009 and 2010 on the Pseudogley soil plateau in Virovitica area. Seeds of two sugar beet hybrids by KWS (Colonia KWS and Jasmina KWS) were used by applying two processing methods, the standard method and EPD technology. The obtained results showed significant influence of processing method on germination speed of seeds in the field, but had no effect on total field germination. On average seven days after the sowing under field conditions from the seeds processed by EPD technology 41% or 3.4 times more seeds sprouted when compared to the seeds processed by the standard method. Similarly, initial growth of the plants from the seeds processed by EPD was significantly higher. Thus the plants in the 6 - 8 leaves phase had 2.0 times larger mass than the plants that grew from the seeds by applying standard processing method. In the phase of sugar beet leaf formation (12 - 14 leaves) difference in the mass decreased and the plants that grew from the seeds processed by EPD technology were heavier 1.3 times.

Key words: sugar beet, processing method, field germination



## Uvod

Šećerna repa je biljka vrlo sitnog sjemena, no i pored toga, cilj je sjetvu obaviti na konačan razmak u redu kako bi izbjegli upotrebu ljudskog rada za uređenje sklopa. Problem u praksi, zbog ranih rokova sjetve, često čine nepovoljni zemljišni i vremenski uvjeti u vrijeme klijanja i nicanja repe. Nameće se stoga zahtjev za što većom kvalitetom sjemena za sjetvu. Oplemenjivanjem ovaj problem nije riješen, već novom metodom dorade sjemena šećerne repe po EPD (Early plant development) tehnologiji koja je razvijena u KWS-u (KWS SAAT AG, 2006.). Prema EPD metodi dorade sjemena šećerne repe svaka partija sjemena se posebno dorađuje i oblaže posebnim hilomasama, koje se određuju za svaku pojedinu partiju sjemena (Jurišić, 2008.; KWS SAAT AG, 2006.). Uz ovaj postupak dorade sjeme brže klija, nicanje je ravnomjernije, čime se postiže ujednačenost biljaka u nicanju (Kockelmann i Meyer, 2006.). Isto tako, početni porast je brži pa biljke prije zatvaraju redove, manji su gubici prilikom vađenja i bolja je kvaliteta korijena (Draycott, 2006.). Cilj istraživanja bio je ispitati utjecaj dorade sjemena na brzinu nicanja u polju i ukupnu poljsku klijavost u našim uvjetima.

## Materijal i metode

Istraživanja su provedena u 2009. i 2010. godini postavljanjem poljskih pokusa na tlu nepovoljnih fizikalnih svojstava u Virovitici (pseudoglej na zaravni.). Ovaj tip tla je izabran kako bi što više do izražaja došla razlika u sposobnost sjemena da i u nepovoljnim uvjetima razvije klicu i biljku. U istraživanje su bila uključena dva hibrida šećerne repe i to Colonia KWS (1) i Jasmina KWS (2) dorađena po standardnom načinu dorade (varijanta A) i po EPD metodi dorade sjemena (varijanta B). Pokusi su postavljeni po split blok metodi u četiri ponavljanja. Predsjetvena priprema tla obavljena je na uobičajen način za ovo područje, vrlo kvalitetno. Sastojala se je od zatvaranja zimske brazde drljačom i dva prohoda sjetvospremača pri povoljnoj vlažnosti tla. Veličina osnovne parcele iznosila je 59,4 m<sup>2</sup> (22 x 2,7 m = 6 redova). Prije sjetve određena je laboratorijska klijavost sjemena standardnim metodama. Sjetva je obavljena 7. travnja 2009. godine te 23. ožujka 2010. godine na razmak između redova od 45 cm i razmak u redu od 19 cm. Tijekom nicanja šećerne repe osnovnu parcelu predstavljala su 4 reda dužine 19 m (4 x 100 posijanih sjemenki = 34,2 m<sup>2</sup>), gdje je od početka nicanja svaka dva dana u šest navrata utvrđen broj izniklih biljaka. Na kraju, u fazi 6 - 8, te u fazi 12 - 14 listova, odredili smo ukupnu masu razvijanih biljaka na dva reda dužine 22 m (9,90 m<sup>2</sup>). Prosječna temperatura zraka u vrijeme klijanja, nicanja i početnog porasta biljke (ožujak, travanj, svibanj) bila je u 2009. godini prosječno 2,6 °C iznad višegodišnjeg prosjeka (1961-1990.), a u 2010. godini za 1,0 °C, također iznad prosjeka. U prvoj godini istraživanja, u analiziranom razdoblju razvoja repe, palo je tek 59% oborina od višegodišnjeg prosjeka, a druge godine 123% više od višegodišnjeg prosjeka.

## Rezultati istraživanja

U istraživanju je korišteno sjeme visoke laboratorijske klijavosti i to od 98 do 100% (Tablica 1.). Između načina dorade i hibrida šećerne repe nisu utvrđene razlike u laboratorijskoj klijavosti sjemena.

**Tablica 1. Laboratorijska klijavost sjemena šećerne repe (%) po hibridima i načinu dorade.**

Način dorade - hibrid	Godina	
	2009.	2010.
A - 1	98	100
A - 2	99	100
B - 1	99	100
B - 2	99	99

A - standardni način dorade; 1-Colonia KWS, 2-Jasmina KWS

B - EPD metoda dorade

Poljska klijavost sjemena šećerne repe u 2009. godini određivana je šest puta i to prvi puta 12. travnja, pet dana nakon sjetve (Tablica 2.). Kod sjemena dorađenog po EPD tehnologiji poljska klijavost kod prvog brojanja iznosila je 41,00%, dok je uz standardnu doradu bila znatno niža i iznosila svega 11,63%. Pri slijedećem brojanju poljska klijavost EPD sjemena bila je već 71,62%, a uz standardnu doradu tek 38,63%. Razlika u poljskoj klijavosti u daljnjim brojanjima se smanjivala, da bi u zadnjem brojanju, 17 dana nakon sjetve, bila gotovo izjednačena. Kod sjemena dorađenog po EPD tehnologiji iznosila je 98,37%, a kod

standardno dorađenog sjemena 97,75%. Statistički vrlo značajna razlika između hibrida utvrđena je samo kod EPD načina dorade. Sjeme hibrida Jasmina KWS dorađeno po EPD tehnologiji formiralo je klice u većem broju ranije od sjemena Colonie KWS ali na kraju razlika između hibrida u ukupnom broju sjemenki, koje su razvile klicu i biljku, nije utvrđena.

U 2010. godini poljska je klijavost, sedam dana nakon sjetve, kod sjemena dorađenog po EPD tehnologiji, u prosjeku za dva hibrida, bila 35,12% (Tablica 3.). Istovremeno, kod sjemena standardne dorade poniklo je tek 9,88% posijanih sjemenki. Između sorata

**Tablica 2. Poljska klijavost sjemena šećerne repe (%) ovisno o načinu dorade sjemena i roku određivanja u 2009. godini.**

Način dorade - hibrid	Datum brojanja					
	12.04	14.04	16.04	18.04	20.04	22.04
A - 1	11,50	38,00	82,00	92,25	94,25	97,25
A - 2	11,75	39,25	82,00	94,00	97,25	98,25
B - 1	33,50	61,75	87,25	92,75	95,50	97,75
B - 2	48,50	81,50	96,50	98,75	99,00	99,00
Prosjek A (Standard)	11,63	38,63	82,00	91,13	95,75	97,75
Prosjek B (EPD)	41,00	71,62	91,87	95,75	97,25	98,37
Prosjek-1 (Colonia KWS)	22,50	49,88	84,63	92,50	94,88	98,13
Prosjek-2 (Jasmina KWS)	30,13	60,38	89,25	96,38	98,13	98,63
LSD Način dorade	0,05		4,96			
	0,01		6,74			
LSD Hibrid	0,05		6,05			
	0,01		8,22			

**Tablica 3. Poljska klijavost sjemena šećerne repe (%) ovisno o načinu dorade sjemena i roku određivanja u 2010. godini.**

Način dorade - hibrid	Datum brojanja					
	30.03	02.04	04.04	06.04	08.04	10.04
A - 1	10,25	25,25	53,50	82,50	96,25	98,25
A - 2	9,50	24,00	52,25	82,25	97,75	98,00
B - 1	34,50	59,75	91,75	98,00	98,75	98,75
B - 2	35,75	61,00	93,00	98,50	99,00	99,00
Prosjek A (Standard)	9,88	24,63	52,88	82,36	97,50	98,50
Prosjek B (EPD)	35,12	60,37	92,37	98,25	98,87	98,87
Prosjek-1 (Colonia KWS)	22,38	42,50	72,63	90,25	97,50	98,50
Prosjek-2 (Jasmina KWS)	22,63	42,50	72,63	90,38	98,38	98,44
LSD Način dorade	0,05		4,07			
	0,01		5,53			
LSD Hibrid	0,05		ns.			
	0,01		ns.			

dorađenih po istom načinu dorade (EPD) nije dobivena razlika u broju izniklih biljaka. U nastavku, razlike između načina dorade u poljskoj klijavosti su se smanjivale da bi 15 dana nakon sjetve sjeme iz standardne dorade postigao poljsku klijavost od 98,50%, a sjeme uz EPD metodu, 98,87%. Razlike između hibrida, u 2010. godini nisu dobivene niti u jednom roku. Sličan pozitivan utjecaja EPD načina dorade sjemena šećerne repe na brzinu klijanja u polju i početni porast biljke navode i drugi autori (KWS SAT AG, 2006.; Jurišić, 2008.).

Ukupna masa biljke šećerne repe određivana je u dva navrata i to u fazi 6 - 8 listova i u fazi 12 - 14 listova (Tablica 4.). U 2009. godini ukupnu masu biljke mjerili smo 18.05. prvi puta i 01.06. drugi puta.

Tablica 4. Masa biljaka šećerne repe (g) na 1m<sup>2</sup> mjerena u dva roka do faze zatvaranja redova.

Način dorade - hibrid	Godina					
	2009.		2010.		Prosjek	
	18.05.	01.06.	15.05.	02.06.	18.05.09. 15.05.10.	01.06.09. 02.06.10.
A - 1	26,3	1810,1	249,4	1631,1	137,9	1720,1
A - 2	30,1	2020,8	267,2	1752,0	148,7	1886,4
B - 1	260,0	2137,2	288,6	2137,2	274,3	2137,2
B - 2	301,8	2571,3	303,3	2216,7	302,6	2374,0
Prosjek A (Standard)	28,2	1915,5	258,3	1691,6	143,3	1803,6
Prosjek B (EPD)	280,9	2354,3	295,9	2177,0	288,4	2265,7
Prosjek-1 (Colonia KWS)	143,2	1973,7	269,0	1884,2	206,1	1929,0
Prosjek-2 (Jasmina KWS)	166,0	2296,1	285,3	1984,4	225,7	2140,3
LSD Način dorade	0,05	65,5		63,5		
	0,01	89,0		86,4		
LSD Hibrid	0,05	95,9		91,0		
	0,01	130,4		123,9		

U 2009. godini, pri nepovoljnim vremenskim prilikama, biljke iz sjemena standardne dorade (A) bile su male ukupnu mase svega 28,2 grama m<sup>2</sup>, dok su biljke dobivene iz sjemena EPD dorade (B) bile gotovo deset puta teže (Tablica 4.). U drugom roku mjerenja razlika je smanjena, ali su još uvijek biljke iz sjemena EPD dorade bile značajno teže od biljaka iz sjemena standardne dorade. Razlika u masi biljaka bila je vrlo značajna između hibrida samo kod drugog mjerenja, kako kod A, tako i kod B načina dorade. Veća masa biljaka, početkom lipnja, dobivena je hibridom Jasmina KWS.

Povoljni vremenski uvjeti u 2010. godini omogućili su znatno brži početni porast biljaka. Uz ovakve uvjete sredinom svibnja, biljke iz sjemena standardne dorade malo su zaostajale za biljkama iz sjemena EPD dorade (Tablica 4.). Međutim, razlika u drugom mjerenju između A i B varijante, bila je vrlo značajna kao i prethodne godine. Ponovo je hibridom Jasmina KWS ostvarena značajno veća masa biljaka.

### Zaključak

Rezultati istraživanja načina dorade sjemena šećerne repe pokazuju da sjeme dorađeno po EPD tehnologiji daje brži razvoj klica od sjemena dorađenog po standardnom načinu dorade sjemena. To se očitovalo u većem broju izniklih biljaka u kraćem vremenskom razdoblju, no razlika u ukupnom broju izniklih biljaka nije utvrđena. Također, mjerenja mase biljaka šećerne repe do zatvaranja redova pokazuje da su biljke iz sjemena dorađenog prema EPD tehnologiji imale veću ukupnu masu od biljaka razvijenih iz sjemena dorađenog standardnim načinom dorade. Poljska klijavost nije do zatvaranja redova zavisila od hibrida.

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# Učinak višekratne primjene smanjenih količina herbicida u šećernoj repi

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## Sažetak

Nedovoljna učinkovitost jednokratne primjene registrirane doze herbicida za suzbijanje korova u šećernoj repi razlogom su istraživanja novih pristupa suzbijanja korova u ovoj kulturi. Tijekom dvije vegetacijske sezone istraživana je učinkovitost višekratne primjene reduciranih doza herbicida u odnosu na registrirane (pune) doze. Rezultati istraživanja pokazuju da je višekratnom primjenom smanjenih količina herbicida moguće zadovoljavajuće suzbijati korove. Utvrđeno je da primjenom 50% i 60%ne doze od pune metamitrona, dezmedifama + fenmedifama + etofumesata i klopivalida moguće suzbijati korove kao i primjenom pune doze ovih herbicida. Smanjenjem pune doze za 60% ne daje zadovoljavajući učinak na *Chenopodium album* L., *Solanum nigrum* L. i *Polygonum persicaria*. Prosječni prinosi korijena i prinosi tehnološkog šećera nisu bili manji od prinosa s punim dozama herbicida što ukazuje na mogućnost primjene reduciranih doza herbicida u usjevu šećerne repe.

Ključne riječi: šećerna repa, korovi, reducirane doze herbicida

## Effect of repeated low-rate herbicide treatments in sugar beet crop

### Abstract

Increased awareness of the environmental damage along with a low efficacy of single treatment in sugar beet has encouraged scientists to develop new weed management approaches. Field trials were carried out during two growing seasons to determine the impact of reduced and full herbicide rates on weed control and yield of sugar beet. Applying methamitron, desmedipham + phenmedipham + etofumesate and clopyralid with 50% and 60% rates achieved an effect on weed control similar to 100% rate. A single 40% rate of desmed. + phenmed. + etofum and clopyralid had significantly lower effect on reducing the total number of *Chenopodium album*, *Solanum nigrum* and *Polygonum persicaria* when compared to higher rates. However, all herbicide treatments provided satisfactory weed control, and consequently, similar root and sugar yields.

Key words: sugar beet weeds, low herbicide rate

## Uvod

Sjetva šećerne repe rano u proljeće, vađenje u kasnu jesen, spor razvoj klijanaca i relativno dug period do zatvaranja sklopa, te nizak habitus glavni su razlozi slabe kompetitivne sposobnosti repe u odnosu na korove. Zbog navedenog, korovi mogu uzrokovati visok gubitak prinosa, čak i do izostanka prinosa (Marlander i sur., 2003). Zato je zaštita šećerne repe od korova jedan od neophodnih zahvata u tehnologiji uzgoja. Za suzbijanje korova u šećernoj repi u Republici Hrvatskoj registrirano je 18 djelatnih tvari odnosno herbicida (Barić i Ostojić, 2010). Nedovoljan učinak jednokratne primjene punih dozacija herbicida (Schweizer i May, 1993) u šećernoj repi kao i istraživanja kritičnog razdoblja zakorovljenosti potakli su razvoj novih pristupa u borbi protiv korova. Istraživanja Schweizera i Maya (1993), Mesbah i sur. (2004) i dr. ukazala su na mogućnost zadovoljavajuće zaštite od korova primjenom reduciranih doza herbicida u kritičnom razdoblju zakorovljenosti šećerne repe. Uspjeh borbe protiv korova primjenom reduciranih doza herbicida ovisi o odabranoj kombinaciji herbicida, broju aplikacija, zatečenoj korovnoj flori i stadiju rasta korova u vrijeme tretiranja. Dozu herbicida moguće je reducirati ukoliko se herbicidi primjene u ranim razvojnim fazama korova. S obzirom na dugu vegetaciju šećerne repe i njenu slabu kompetitivnost u odnosu na korove, tretiranja je potrebno ponavljati nekoliko puta u vegetaciji. Potrebno je izvršiti tri do pet tretiranja kombinacijama herbicida u vrijeme kritičnog razdoblja zakorovljenosti koje po većini autora traje od trećeg do devetog tjedna nakon nicanja šećerne repe.

Cilj ovog istraživanja je utvrditi učinak registriranih (punih) i reduciranih dozacija herbicida primijenjenih nakon nicanja šećerne repe i korova (post-emergence) s različitim brojem aplikacija. Utvrđen je i prinos i kakvoća korijena šećerne repe.

## Materijali i metode istraživanja

Poljska istraživanja provedena su 2001. i 2002. godine na lokacijama Budakovac i Gradina (Virovitica). Šećerna repa posijana je 1.04. 2001. i 15. 03. 2002. godine i uzgajana po standardnoj tehnologiji. Tretiranje herbicidima obavljeno je leđnom prskalicom "Solo" s utroškom škropiva od 200 litara ha<sup>-1</sup>. Svi herbicidni tretmani primijenjeni su nakon nicanja usjeva i korova u post-emergence roku primjene. Herbicidni tretmani u pokusu sadržavali su kombinaciju herbicida dezmedifama + fenmedifama + etofumesata + herbicidnog biljnog ulja (Betanal progress OF) kao kontaktna, metamitrona (Goltix 70 SC) kao rezidualna te klopivalida (Lontrel 300) kao translokacijska komponenta. Tretman 1 nije sadržavao rezidualni herbicid metamitron (tablica 1)

Tablica 1. Utrošak djelatnih tvari u istraživanju

Djelatne tvari	Tretmani (g ha <sup>-1</sup> )			
	1	2	3	4
dezmedifam	175	175	210	315
fenmedifam	225	225	270	405
etofumesat	275	275	330	495
metamitron	-	175	210	420
klopivalid	45	45	90	120
Ukupno d.t.	720	895	1110	1755
% redukcije herbicida	40	50	60	0

Tretmani 1 i 2 primijenjeni su u pet navrata u fazama V<sub>1.1</sub>, V<sub>1.9</sub>, V<sub>4</sub>, V<sub>6.1</sub> i V<sub>8.2</sub>. Tretman 3 primijenjen je u tri navrata (V<sub>1.9</sub>, V<sub>6.2</sub> i V<sub>8.1</sub>), kao i tretman 4 (V<sub>6.2</sub>, V<sub>6.5</sub> i V<sub>8.1</sub>). Za suzbijanje korovnih trava svakom tretmanu dodan je herbicidni pripravak Puma (quizalofop-tefuril). Utvrđivanje vrste i broja jedinki nadzemne mase korova obavljeno je na površini od 1,0 m<sup>2</sup> u vrijeme kada je većina korova dosegla maksimum svog razvoja. Redukcija broja jedinki i nadzemne mase korova u odnosu na netretiranu kontrolu izražena je koeficijentom učinkovitosti po Abbottu (1925). Utvrđivanje prinosa korijena šećerne repe obavljeno je na površini od 10 m<sup>2</sup>. Uzorak korijena sa svakog herbicidnog tretmana i kontrolne netretirane varijante dopremljen je u laboratorij tvornice šećera "Viro". Parametri za utvrđivanje kakvoće tehnološkog prinosa šećera bili su udio primjesa, digestija, sadržaj natrija (Na), kalija (K) i alfa amino dušika (N). Parametri kakvoće utvrđeni su po Braunschweigovoj formuli (Buchholz i sur. 1995)

## Rezultati i rasprava

U obje godine istraživanja na pokusnim parcelama uglavnom su bile prisutne jednogodišnje širokolisne vrste. Najzastupljenija širokolisna vrsta u istraživanju je bila *Ambrosia artemisiifolia* L. s prosječnim brojem jedinki od 11,3 m<sup>-2</sup>. Slijedeće po brojnosti bile su vrste *Polygonum persicaria* L. (9,5 m<sup>-2</sup>) i vrsta *Chenopodium album* L. s 7,1 jedinki m<sup>-2</sup>. Od uskolisnih vrsta bila je prisutna samo vrsta *Echinochloa crus-galli* L. s prosječno 15,1 jedinki m<sup>-2</sup>

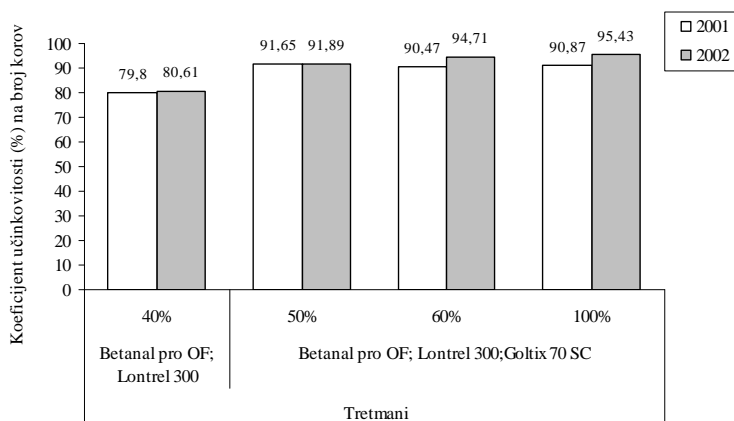
Prosječan učinak na redukciju broja jedinki korova u prvoj godini istraživanja bio je 89,4%, a u drugoj godini 88,6% u odnosu na netretiranu parcelu. Višekratna primjena herbicida s dozom 40% od pune najslabije je reducirao ukupan broj korova (80,2%) i znatno je slabije reducirao broj jedinki od ostalih tretmana u istraživanju (graf 1)

Rezultati ukazuju na potrebu dodavanja rezidualne komponente herbicidnoj kombinaciji dezmedifam + fenmedifam + etofumesat i klopivalid. Kada je dodana rezidualna komponenta metamitron učinak je poboljšao od 11,6% primjenom 50% doze do 12,9% kod primjene 100%tne doze. Rezultati Mitchella (1998) također upućuju da je potrebno u herbicidnu kombinaciju dezmedifam + fenmedifam + etofumesat dodati rezidualnu komponentu (metamitron ili lenacil) koja će spriječiti kasnije nicanje ljetnih korova u usjevu šećerne repe.

U istraživanju nije utvrđena statistički opravdana razlika u učinku na redukciju broja jedinki između dozacija reduciranih za 50% i 40% i punih dozacija herbicida

Višekratna primjena herbicida s 40% dozom od pune lošije je reducirala broj jedinki *Chenopodium album* L. (81,3%), a još lošije broj jedinki *Polygonum persicaria* L. (44,8%). Povećanjem dozacije herbicida na 50% i 60% od punih doza i primjenom punih doza herbicida učinak se značajno povisio i na svim tretmanima iznosio preko 90%. Istraživanja Wilson-a i sur. (2005) ukazuju na nedovoljan učinak 25%tnih doza herbicida od punih za redukciju vrste *Chenopodium album*. Autori također ističu mogućnost redukcije herbicida primjenom 50% tnih doza kombinacije herbicida. Za razliku od učinka na navedene korovne vrste učinak na vrstu *Ambrosia artemisiifolia* L. nije ovisio o dozaciji herbicida jer između herbicidnih tretmana nije utvrđena značajna razlika u učinku na ovu vrstu. Tako je i primjenom 40% doza od preporučenih broj jedinki *Ambrosia artemisiifolia* L. prosječno reducirano za relativno visokih 92,6%.

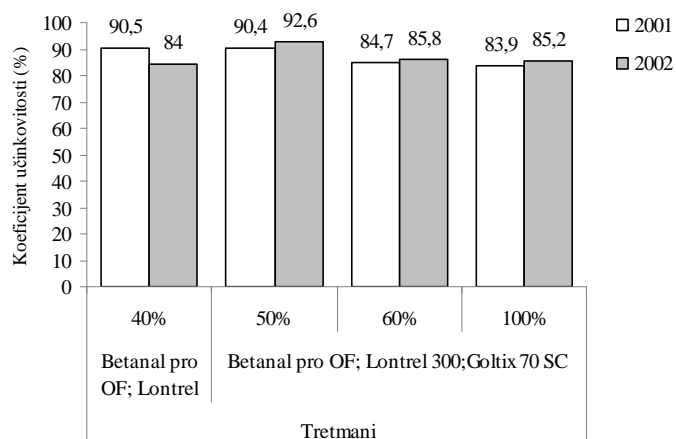
Učinak herbicidnih tretmana utvrđivan je i kroz parametar redukcije nadzemne zelene mase. Vjerodostojnijim pokazateljem za procjenu učinka herbicida smatra se upravo ovaj pokazatelj jer masa korova, a ne njihov broj nanosi štetu kulturi. Kao što je iz grafikona 2 vidljivo u istraživanju nije utvrđena statistički opravdana razlika između herbicidnih tretmana promatrano kroz redukciju nadzemne zelene mase korova. Tako je i višekratna primjena 40% doza od pune prosječno reducirala nadzemnu masu širokolisnih vrsta u prosjeku za 83% i statistički se nije razlikovala od primjene 50 i 60% doza od punih i punih doza herbicida. To potvrđuju i dobivene vrijednosti prinosa korijena šećerne repe (graf 3) gdje također nije utvrđena značajna razlika između herbicidnih tretmana. Iako je broj preostalih jedinki korova primjenom 40% doza od pune bio značajno veći od primjene 50% i 60% doza od pune kao i punih doza to nije utjecalo na konačni prinos korijena.



Graf 1. Učinak (%) istraživanih herbicidnih tretmana na redukciju broja jedinki korova

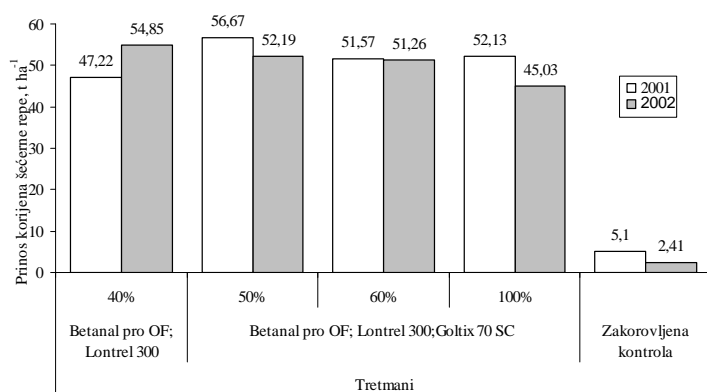
LSD=7,807

## Učinak višekratne primjene smanjenih količina herbicida u šećernoj repi



Graf 2. Učinak (%) za ukupnu nadzemnu masu korova

LSD = 24,7



Graf 3. Prinos korijena šećerne repe po istraživanim tretmanima u obje godine istraživanja

Podaci iz grafa 3 potvrđuju navedeno o štetnosti korova prema šećernoj repi. Naime, prinos na netretiranoj (zakorovljenoj) parceli bio je 10 puta u prvoj, odnosno 20 puta u drugoj godini istraživanja manji u odnosu na najniži prinos tretiranih parcela. Slične rezultate o utjecaju nesuzbijenih korova na prinos korijena šećerne repe donose i Abdollahi i Ghadiri (2004).

Konačni rezultat proizvodnje šećerne repe tehnološki je prinos šećera. Tehnološki prinos šećera varirao je slično kao i utvrđeni prinos korijena. Višekratnom primjenom 50% i 60% ostvareni su najviši prinosi šećera (6,6 i 6,2 t ha<sup>-1</sup>), primjenom 40% doza od punih ostvaren je prinos od 6,0 t ha<sup>-1</sup>, dok je primjenom punih doza ostvaren tehnološki prinos šećera od 5,9 t ha<sup>-1</sup>. Dobiveni podaci tehnološkog prinosa šećera jasno ukazuju na mogućnost redukcije herbicida uz istovremeno ostvarivanje zadovoljavajućih prinosa šećera.

### Zaključci

Rezultati svih pokazatelja (redukcija broja jedinki korova, redukcija nadzemne mase korova, prinos korijena i prinos šećera) kojima je utvrđivan učinak smanjenih dozacija herbicida na korove u šećernoj repi potvrđuju pretpostavku da je moguće pravovremenom (u ranom stadiju razvoja korova) višekratnom (3-5) primjenom postići zadovoljavajuće učinke. Tretiranje s 40% doze od pune doze postiže signifikantno manju redukciju broja jedinki korova, ali to ne utječe negativno na cilj uzgoja (prinos korijena i prinos šećera).

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# Utjecaj dužine vegetacije kultivara predivog lana na morfološka i tekstilno-tehnološka svojstva

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## Sažetak

U radu se iznose rezultati morfoloških (visina biljke, tehnička duljina stabljike i debljina stabljike) i tekstilno-tehnoloških svojstava (duljina, finoća i čvrstoća vlakana) pet inozemnih kultivara predivog lana različite dužine vegetacije. Pokusi s predivim lanom izvedeni su tijekom dvije godine (2007.-2008.) u Zagrebu na eutričnom smeđem antropogeniziranom tlu prema metodi slučajnog bloknoeg rasporeda u četiri ponavljanja. Na osnovi dobivenih dvogodišnjih istraživanja morfoloških i tekstilno-tehnoloških svojstava predivog lana utvrđeno je da postoje signifikantne razlike između istraživanih kultivara. Kultivari dulje vegetacije (Agatha i Viola) ostvarili su više vrijednosti istraživanih svojstava.

Ključne riječi: predivi lan, kultivari, morfološka svojstva, tekstilno-tehnološka svojstva

## The influence of vegetation ripening group of fiber flax cultivars on morphological and textile-technological traits

### Abstract

This paper presents the results of the morphological (plant height, technical stem length, stem thickness) and textile-technological traits (length, fineness and strength of fibre) of fiber flax of five foreign cultivars of different vegetation ripening group. Cultivar trials with fiber flax were set up in two years (2007-2008) and one location (Zagreb) on anthropogenized eutric cambisol. The trials were carried out according to the RCBD in four replication. According to the results of the two-years research into the morphological and textile-technological traits of fiber flax, significant differences were established between the cultivars under study. The cultivars belong to the full vegetation ripening group (Agatha and Viola) were recorded higher values of investigated traits.

Key words: fiber flax, cultivars, morphological traits, textile-technological traits

## Uvod

Današnji komercijalni europski kultivari predivog lana su jari kultivari prilagođeni maritimnoj klimi. Predivi lan ne podnosi negativne temperature u početku razvoja. Visoke pak temperature ubrzavaju sazrijevanje lana, pa samim time ne dolazi do izduživanja vlakna, a smanjuje se i kvaliteta (Butorac i sur., 2004a). Shekhar Sharma i Van Sumere (1992.) navode da vrijeme sjetve nema značajnijeg utjecaja na prinos stabljike, ali ima značajniji utjecaj na prinos i kvalitetu vlakna. Kvaliteta vlakna određena je prema svojstvima elementarne stanice vlakna i svojstvima strukture koje formiraju stanicu vlaknaca u vlakna (Shekhar Sharma i Van Sumere, 1992.). Lanena vlakna karakterizira visoki stupanj neujednačenosti morfologije na što se ne može bitno utjecati niti se može ukloniti tehnologijom proizvodnje i prerade, a značajno se odražava na svojstva vlakana. Dakle, veliki utjecaj na kvalitetu lanenih vlakana ima kultivar kroz ekspresiju agronomskih, morfoloških i fenoloških svojstava biljke koja su međusobno usko povezana. Stoga prilikom procjene aklimatizacijske sposobnosti kultivara potrebno je uvažavati ne samo svojstva biljke već i svojstva dobivenih vlakana, kao što su npr. duljina, finoća i čvrstoća, jer su ona usko povezana sa npr. visinom biljke, tehničkom duljinom stabljike i debljinom stabljike (Šurina i sur., 2009a i 2009b).

Budući da Hrvatska ne raspolaže vlastitim selekcijskim materijalom, upućena je na introdukciju stranih kultivara predivog lana, koji mogu u novonastalim uvjetima izgubiti vrijedna morfološka i tekstilno-tehnološka svojstva (Butorac i sur., 2003., Andrassy i sur., 2004., Butorac i sur., 2004a i 2004b, Pospišil i sur., 2004., Butorac i sur., 2006).

Cilj ovog rada bio je procijeniti aklimatizacijsku sposobnost pet kultivara predivog lana različite dužine vegetacije kroz valorizaciju njihovih morfoloških i tekstilno-tehnoloških svojstava.

## Materijal i metode

U 2007. i 2008. godini provedena su istraživanja s predivim lanom na pokušalištu Agronomskog fakulteta u Zagrebu na eutričnom smeđem antropogeniziranom tlu. U pokusu je bilo zastupljeno pet kultivara vlasništvo četiri selekcijske tvrtke i to: Viking (Cooperative Liniere de Fontaine Cany, Francuska), Viola (Van de Bilt Zaden, Nizozemska), Venica (Agritec, Češka), Agatha i Electra (Cebecco Seeds, Nizozemska). Kultivari su različite dužine vegetacije. Viking pripada srednje ranoj grupi sazrijevanja, Venica srednje ranoj do srednjoj, Agatha srednje kasnoj, a Viola i Electra srednje kasnoj do kasnoj.

Pokusi su provedeni prema metodi slučajnog bloknoeg rasporeda u četiri ponavljanja. Veličina osnovne parcele u pokusu iznosila je 10 m<sup>2</sup>. Provedena je uobičajena agrotehnika za sve istraživane kultivare.

U ovom radu iznose se samo neka istraživanja koja su provedena tijekom dvije godine. Tijekom vegetacije lana praćena je pojava početka cvatnje i rane žute zriobe. Početak cvatnje i rane žute zriobe određen je vizualno, pri čemu je kao kriterij uzeta pojava ulaska 50% biljaka sa cijele površine u te faze. Nakon što su biljke ubrane u ranoj žutoj zriobi na 100 biljaka određena je visina biljke, tehnička duljina stabljike i debljina stabljike. Visina biljke mjerena je od kotiledonskog nodija do vrha biljke, a tehnička duljina stabljike od kotiledonskog nodija do početka grananja biljke. Debljina stabljike određena je na sredini tehničke duljine stabljike. Stabljike lana podvrgnute su biološkoj maceraciji zagrijanom vodom u kontroliranim uvjetima (Pasković, 1957.). Pomoću valjkaste lomilice odvojen je drvenasti dio stabljike te je predivi lan prerađen u vlakno.

Za karakterizaciju lanenih vlakana definirana su tekstilno-tehnološka svojstva: duljina (HRN ISO 6989:2003), finoća (HRN EN ISO 1973:2008) i čvrstoća (HRN EN ISO 5079:2003). Korištene norme i propisi su prilagođeni ispitivanju tehničkih lanenih vlakana. Sva mjerenja ispitivanih svojstava provedena su na kondicioniranim uzorcima.

Svi prikupljeni podaci obrađeni su pomoću analize varijance, a razlike između srednjih vrijednosti testirane su Duncan-ovim testom (DMRT).

## Rezultati i rasprava

Prisutne su statistički opravdane razlike između istraživanih kultivara za sva istraživana svojstva predivog lana u obje godine istraživanja (Tablice 1-4)

Kao što je bilo i za očekivati signifikantno najranije je u fazu početka cvatnje i rane žute zriobe ušao kultivar Viking, koji kao što smo već naveli pripada srednje ranoj grupi sazrijevanja. Nakon toga u ove faze ušli su

kultivari Venica i Agatha, a signifikantno najkasnije Viola i Electra. Zbog previsokih temperatura u trećoj dekadi svibnja u obje godine istraživanja svi istraživani kultivari ušli su u ove faze deset do petnaest dana ranije od dosadašnjih istraživanja (Pavelek, 2001., i Daenekindt 2003.).

Kultivari kasnijih grupa sazrijevanja ostvarili su više vrijednosti visine biljaka i tehničkih duljina stabljike. Signifikantno najviše vrijednosti oba svojstva u 2007. godini ostvarili su kultivari Viola, Electra i Agatha koji pripadaju srednje kasnoj do kasnoj grupi sazrijevanja. Rezultati duljine vlakana su u skladu s rezultatima visine biljke i tehničke duljine stabljike. Najdulja vlakna dao je kultivar Venica, a odmah iza nje slijede kultivari Agatha, Viola i Electra između kojih nije bilo signifikantnih razlika u duljini vlakana. Tijekom 2008. godine signifikantno najviše biljke i najdulje tehničke duljine stabljike imali su kultivari Viola i Agatha što je također u skladu s duljinom vlakana (Tablice 2 i 4).

Za potrebe tekstilne prerade kada se procjenjuje kvaliteta vlaknate sirovine važno je zadovoljiti uvjete jednolikosti sirovine po svojstvima koja su bitna za izradu pređe kao npr. duljina i finoća. Duljina i finoća vlakana najvažnija su preradbeni svojstva koja određuju kvalitetu i prikladnost lanenih vlakana kao tekstilne sirovine za proizvodnju pređe i plošnih proizvoda. Preporuča se da tehnička duljina stabljike bude duža od 60 cm, jer su tada pojedinačna vlakna duža i kvalitetnija za preradu. U 2008. godini dobivene vrijednosti bile su niže. Tehnička duljina stabljike u većine kultivara bila je ispod 60 cm (Tablica 4). Kako su dobivene niže vrijednosti visine biljke i tehničke duljine vlakana tako su i niže vrijednosti duljine vlakana (osim kod kultivara Viking). Nešto niže vrijednosti od prosječnih posljedica su nepovoljnijih vremenskih prilika tijekom rasta i razvoja lana (kasnija sjetva - mraz; previsoke temperature u trećoj dekadi svibnja - isforsirana i prerana cvatnja; prevelike količine oborina u lipnju - neravnomjerno sazrijevanje). Isto tako, pokazalo se da uzgoj lana na pjeskovitom tlu, kakvo je tlo na kojem su provedena istraživanja, nije povoljno u godinama sa neravnomjernim rasporedom oborina (Butorac i sur., 2003., Butorac i sur., 2004a i 2004b).

Tablica 1. Prosječne vrijednosti fenoloških i morfoloških svojstava kultivara predivog lana u 2007. godini

Kultivar	Fenološka i morfološka svojstva				
	Početak cvatnje (dana)	Početak žute zriobe (dana)	Visina biljke (cm)	Tehnička duljina stabljike (cm)	Debljina stabljike (mm)
Viking	53 d	85 c	72,1 c	60,1 b	1,4 c
Viola	60 b	90 ab	81,2 a	67,0 a	1,7 a
Venica	56 c	86 c	76,0 bc	64,2 a	1,6 b
Agatha	59 b	89 b	77,1 ab	64,0 a	1,6 b
Electra	62 a	91 a	77,3 ab	65,1 a	1,6 b
DMRT	1,14	1,26	4,58	3,53	0,48

Tablica 2. Prosječne vrijednosti fenoloških i morfoloških svojstava kultivara predivog lana u 2008. godini

Kultivar	Fenološka i morfološka svojstva				
	Početak cvatnje (dana)	Početak žute zriobe (dana)	Visina biljke (cm)	Tehnička duljina stabljike (cm)	Debljina stabljike (mm)
Viking	56 d	82 c	61,0 b	53,7 c	1,4 b
Viola	61 b	86 a	68,0 a	59,6 a	1,4 b
Venica	58 c	83 bc	62,4 b	57,3 b	1,3 c
Agatha	60 b	84 b	68,8 a	60,5 a	1,5 a
Electra	63 a	87 a	62,6 b	56,5 b	1,5 a
DMRT	1,56	1,51	2,62	2,27	0,04

Debljina stabljike utječe na kvalitetu i količinu vlakna odnosno finoća vlakana ovisi o debljini stabljike. Vrlo tanka i vrlo debela stabljika manje je vrijedna za tekstilnu namjenu. Debljina stabljike u obje godine istraživanja kretala se od 1,3 do 1,7 mm što i najviše odgovara za dobivanje kvalitetnih vlakana dovoljne količine (Tablice 1 i 2). Ukoliko bi stabljika bila deblja, bi sadržavala veći udio pozdera, vlakno bi bilo grublje i manje čvrsto. U 2007. godini signifikantno najtanju stabljiku imao je kultivar Viking, a u 2008. godini kultivar Venica koji pripadaju srednje ranog do srednjoj grupi sazrijevanja. Sve dobivene vrijednosti u skladu su sa preporučljivim vrijednostima za debljinu stabljike. I finoća vlakana istraživanih kultivara u skladu je sa debljinom stabljike. Signifikantno najfinije vlakno u 2007. godini imao je kultivar Viking, a u 2008. kultivar Venica (Tablice 3 i 4). U većine istraživanih kultivara nije bilo razlika u finoći vlakana s obzirom na godinu istraživanja.

Tablica 3. Prosječne vrijednosti tekstilno-tehnoloških svojstava kultivara predivog lana u 2007. godini

Kultivar	Tekstilno-tehnološka svojstva		
	Duljina vlakana (cm)	Finoća vlakana (dtex)	Čvrstoća vlakana (cN tex <sup>-1</sup> )
Viking	33,8 b	36,5 b	85,6 ab
Viola	39,6 a	39,9 a	87,5 ab
Venica	41,6 a	37,5 a	90,0 ab
Agatha	40,0 a	38,6 a	94,0 a
Electra	38,9 a	37,8 a	83,3 b
DMRT	4,83	3,26	9,64

Tablica 4. Prosječne vrijednosti tekstilno-tehnoloških svojstava kultivara predivog lana u 2008. godini

Kultivar	Tekstilno-tehnološka svojstva		
	Duljina vlakana (cm)	Finoća vlakana (dtex)	Čvrstoća vlakana (cN tex <sup>-1</sup> )
Viking	37,1 a	39,1 a	75,9 ab
Viola	39,2 a	37,7 a	79,6 a
Venica	36,6 a	33,4 b	77,8 ab
Agatha	39,6 a	36,9 a	75,6 ab
Electra	33,4 b	39,1 a	71,0 b
DMRT	3,12	2,73	7,26

Najčvršće vlakno u 2007. godini imao je kultivar Agatha, u 2008. kultivar Viola, a najmanje u obje godine istraživanja kultivar Electra. Vlakna su bila čvršća za sve istraživane kultivare tijekom 2007. godine.

Danas, u jeku težnje za održivim razvojem i maksimalnim gospodarenjem svim resursima, važnost uzgoja i prerade lana očituje se kroz činjenicu da se svi dijelovi lanene biljke mogu u potpunosti iskoristiti. Fina tehnička lanena vlakna prerađuju se u svakodnevne (odjeća, stolno i posteljno rublje) i luksuzne proizvode. Sve više raste i zanimanje za korištenjem lanenih vlakna na području tehničkog tekstila gdje i gruba vlakna dobivaju sve veću važnost (bio-kompoziti). Danas se kućina smatra visokovrijednim sastojkom izolacijskih materijala koji se ugrađuju u automobile i razna druga transportna vozila (Šurina i sur., 2006. i 2009b). Svoju primjenu kućina nalazi i u industriji papira posebice onih vrsta za koje se očekuje dugotrajnost u uporabi (novčanice).

### Zaključci

Prema provedenoj analizi varijance prisutne su za sva istraživana svojstva opravdane razlike između istraživanih kultivara predivog lana. Glede dobivenih rezultata morfoloških svojstava lana tijekom dvogodišnjih istraživanja kultivari Agatha i Viola ostvarile su najviše vrijednosti. Vlakna dobivena od kultivara Agatha i Viola su kvalitetnija, tj. dulja, finija i čvršća što zadovoljava današnje suvremene trendove njihove upotrebe.

Prema tome, kultivari kasnijih grupa sazrijevanja bolje su se prilagodili nizinsko kontinentalnom dijelu sjeverozapadne Hrvatske i preporučujemo ih za daljnji uzgoj u ovom dijelu Hrvatske.

### Napomena

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# Prinos i sastavnice prinosa istraživanih sorata uljanog lana u sjeverozapadnoj Hrvatskoj

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## Sažetak

Tijekom 2009. i 2010. godine na pokusnom polju Agronomskog fakulteta u Zagrebu obavljena je evaluacija proizvodnih vrijednosti osam inozemnih sorata uljanog lana. Dobiveni rezultati istraživanja su pokazali da između istraživanih sorata uljanog lana postoje značajne razlike u prinosu sjemena i ulja te sastavnicama prinosa. Signifikantno najveći prinos sjemena ostvarile su sorte Altess u 2009. i Eole u 2010. godini. Najveći udio ulja u sjemenu imale su sorte Princess i Niagara. U obje godine istraživanja značajno najveći broj tobolaca po biljci imala je sorta Flanders. Najveću masu 1000 sjemenki imale su sorte Niagara i Biltstar.

Ključne riječi: uljani lan, sorta, prinos sjemena, udio ulja, sastavnice prinosa

## Yield and yield components of investigated linseed cultivar in Northwest Croatia

### Abstract

The objective of investigations carried out on the experimental field of the Faculty of Agriculture, Zagreb, in 2009 and 2010 was to evaluate the agronomic traits of eight foreign linseed cultivars. The obtained results show that there are significant differences among investigated cultivars in seed and oil yield and yield components. Cultivars Altess and Eole gave significantly the highest seed yield in 2009 and 2010, respectively. Cultivars Princess and Niagara achieved the highest oil content in seed. Cultivar Flanders obtained the significantly the highest capsules number in both investigated years. Cultivars Niagara and Biltstar achieved the highest 1000 seed weight.

Key words: linseed, cultivar, seed yield, oil content, yield components

### Uvod

Proizvodnja lana u Hrvatskoj je neopravdano zapostavljena. Prije nekoliko godina započeo je ponovni uzgoj predivog lana na području sjeverozapadne Hrvatske sa svrhom očuvanja kulturne baštine (Butorac i sur., 2006., 2009.). Uljani lan u nas nije imao do sada neku tradicionalnu i stabilnu proizvodnju (Šimetić, 2008.). Uzgajao se na manjim površinama za sjeme (ptičja hrana, pekarstvo, lijek) i kao sjemenski usjev, a od 2000. godine se uzgaja na Agronomskom fakultetu u Zagrebu u okviru istraživačkih projekata (Pospišil i sur., 2004.). Trenutno je uljani lan simbolično zastupljen u proizvodnji na površinama tvrtke Hana-Breznica na oko 15 ha.

U svijetu korištenje lana u ljudskoj prehrani brzo raste zbog visokog sadržaja dijetetskih vlakana, omega-3 masnih kiselina i antikancerogenih lignana. Budući da Hrvatska uvozi sjeme lana jer ga se može naći na

policama trgovina "zdrave" hrane i trgovačkih lanaca, očito je da interes na tržištu za njim postoji. Sjemenke lana imaju izuzetnu nutritivnu vrijednost i svestranu primjenu. Hladnim prešanjem sjemenka dobiva se visokokvalitetno laneno ulje. Laneno ulje se koristi prvenstveno za tehničke svrhe, ali se upotrebljava i u prehrani. Osim što su bogati izvor omega-3 masnih kiselina (linolenska kiselina) koje imaju višestruko djelovanje na zdravlje ljudi, poput snižavanja kolesterola u krvi, sjemenke lana su iznimno bogate i drugim ljekovitim tvarima. Tradicionalni visoko linolenski lan ima smeđe sjeme, dok lan s manje od 5% linolenske kiseline (solin) ima žuto sjeme (Cullis, 2007.) Ulje lana s manje od 5% linolenske kiseline koristi se za kuhanje. Cilj ovih istraživanja bio je utvrditi prinos sjemenka i sastavnice prinosa osam inozemnih sorata uljanog lana u agroekološkim uvjetima sjeverozapadne Hrvatske te na temelju dobivenih rezultata odabrati najpogodnije sorte za naše uvjete.

### Materijal i metode rada

Istraživanja su provedena kroz sortne mikropokuse postavljene na površinama Agronomskog fakulteta Sveučilišta u Zagrebu (45°49'26" N, 16°02'07" E), tijekom 2009. i 2010. godine. U istraživanja je bilo uključeno osam sorata uljanog lana i to: Atalante, Flanders, Biltstar, Altess, Mikael, Princess, Niagara i Eole. Pokusi su postavljeni po shemi slučajnog blokno rasporeda u pet ponavljanja. Veličina obračunske parcele iznosila je 6,6 m<sup>2</sup> (5,5 m x 6 redova a 20 cm). U pokusima je primijenjena uobičajena agrotehnika i zaštita usjeva. Sjetva je obavljena 6. 04. 2009. i 29. 03. 2010. godine. Sve sorte sijane su na bazi 1000 klijavih sjemenki na m<sup>2</sup>. Gnojidba lana obavljena je sa 58 kg/ha N, 80 kg/ha P<sub>2</sub>O<sub>5</sub> i 120 kg/ha K<sub>2</sub>O. Žetva lana je obavljena u drugoj polovici srpnja, malim kombajnom za pokuse "Wintersteiger". Prinos sjemenka preračunat je na 12% vlage. Udio ulja u sjemenu (na prosječnom uzorku iz pet repeticija) je određen po metodi ISO 659:1998. u Laboratoriju za tehnologiju ulja i masti Prehrambeno-biotehnološkog fakulteta u Zagrebu. Udio ulja u sjemenu i prinos ulja preračunati su na suhu tvar. Sastavnice prinosa (broj tobolaca po biljci, broj sjemenki po biljci, masa 1000 sjemenki, masa sjemenka po biljci) određeni su na uzorku od 50 biljaka po parceli neposredno prije žetve. Dobiveni podaci statistički su obrađeni analizom varijance (Mstat-C program, 1990.). Prosječne vrijednosti utvrđenih pokazatelja testirane su Duncans multiple range testom na razini 5%.

### Vremenske prilike i obilježja tla

Srednje mjesečne temperature zraka i mjesečne količine oborina tijekom istraživanja i višegodišnji prosjek za meteorološku postaju Zagreb - Maksimir prikazani su u tablici 1. Vremenske prilike u vegetacijskoj 2009. godini nisu pogodovale rastu i razvoju uljanog lana zbog visokih temperatura i blage suše tijekom travnja (u prve dvije dekade palo je 14,7 mm oborina) te viška vlage u vrijeme sazrijevanja lana. Zbog toga je u toj godini ostvareno slabo nicanje, odnosno manji broj biljaka po jedinici površine što je rezultiralo nižim prinosima. U 2010. godini tijekom svibnja i lipnja palo je nešto više oborina koje su produžile vegetaciju lana.

**Tablica 1. Srednje mjesečne temperature zraka i mjesečne količine oborina u godinama istraživanja i višegodišnji prosjek za meteorološku postaju Zagreb-Maksimir**

Mjesec	Srednja temperatura zraka, °C			Oborine, mm		
	2009.	2010.	Prosjek 1971.-2000.	2009.	2010.	Prosjek 1971.-2000.
Ožujak	7,6	6,8	6,4	42,7	45,7	52,6
Travanj	14,5	12,0	10,7	52,0	63,3	59,3
Svibanj	18,4	16,6	15,8	48,8	97,5	72,6
Lipanj	19,8	20,4	18,8	67,5	103,8	95,3
Srpanj	22,3	23,2	20,6	96,2	52,5	77,4
Prosjek/Ukupno	16,5	15,8	14,5	307,2	362,8	357,2

Izvor: Državni hidrometeorološki zavod, 2010.

Tlo pokusnog polja Agronomskog fakulteta u Zagrebu je eutrično emeđe, antropogenizirano, na slabo zamočvarenoj ilovači (Vidaček i sur. 1994.). Karakterizira ga nekarbonatni površinski horizont P dubine 0-20 cm i podpovršinski horizont (B) dubine 20-60 cm. Po mehaničkom sastavu tlo je homogena stratigrafske građe, a po teksturnoj oznaci praškasta ilovača. Karakterističan je visok sadržaj čestica praha u površinskom horizontu (68,2%) zbog čega je tlo sklono stvaranju pokorice. U oraničnom sloju tlo je kiselo (pH u 1M KCl = 4,91) i vrlo slabo humozno (0,9% humusa). Slabo je opskrbljeno biljci pristupačnim fosforom (P<sub>2</sub>O<sub>5</sub> = 9,0 mg/100 g tla) i srednje opskrbljeno biljci pristupačnim kalijem (K<sub>2</sub>O = 19,9 mg/100 g tla).

## Rezultati i rasprava

U 2009. godini ostvaren je sklop u žetvi od 320 do 380 biljaka/m<sup>2</sup>, a u 2010. godini od 841 do 912 biljaka/m<sup>2</sup>. Rezultati analize varijance ukazuju na značajne razlike između istraživanih sorata uljanog lana u prinosu sjemena i ulja (tablica 2.). U 2009. godini signifikantno najveći prinos sjemena ostvarila je sorta Altess. Najveći udio ulja (40,91% na suhu tvar) imala je sorta Princess, zatim Biltstar (39,60%), Niagara (38,67%), itd. Razlika u prinosu ulja između istraživanih sorata je vrlo značajna te su sorte razvrstane u četiri ranga (a-d). U prvom rangu (a) s najvećim prinosom sirovog ulja nalaze se sorte Altess i Biltstar.

Tablica 2. Prinos sjemena, udio ulja i prinos ulja istraživanih sorata uljanog lana 2009. godine

Sorta	Prinos sjemena (kg/ha)	Udio ulja (% na s.t.)	Prinos ulja (kg/ha)
Atalante	1437 b	37,06	468 bc
Flanders	1355 bc	36,01	429 cd
Biltstar	1469 b	39,60	512 ab
Altess	1644 a	38,24	553 a
Mikael	1406 bc	36,86	456 bcd
Princess	1346 bc	40,91	484 bc
Niagara	1381 bc	38,67	470 bc
Eole	1244 c	36,44	399 d

Srednje vrijednosti označene istim slovom signifikantno se ne razlikuju na razini 5% prema Duncan-testu

Istraživane sorte međusobno su se statistički razlikovale u broju tobolaca po biljci, broju sjemenki po tobolcu i masi 1000 sjemenki (tablica 3.). Signifikantno najveći broj tobolaca imala je sorta Flanders. Prema broju sjemenki po tobolcu u prvom rangu (a) se nalazi pet sorata, što znači da razlika u broju sjemenki po tobolcu koja među njima postoji nije statistički opravdana. Ipak, u prvom rangu s najvećim brojem sjemenki po tobolcu mogu se izdvojiti sorte Atalante i Biltstar. Prema masi 1000 sjemenki u prvom rangu (a) se nalaze sorte Altess i Niagara. Masa 1000 sjemenki varirala je od 5,79 g (Princess) do 7,05 g (Niagara).

Tablica 3. Sastavnice prinosa istraživanih sorata uljanog lana 2009. godine

Sorta	Broj tobolaca po biljci	Broj sjemenki po tobolcu	Masa 1000 sjemenki, g	Masa sjemena po biljci, g
Atalante	11,40 bc	7,37 a	6,01 bc	0,38
Flanders	14,35 a	6,98 ab	6,13 bc	0,47
Biltstar	9,37 d	7,34 a	6,33 bc	0,52
Altess	9,87 cd	6,51 b	6,53 ab	0,40
Mikael	12,51 b	6,79 ab	6,06 bc	0,52
Princess	9,92 cd	6,84 ab	5,79 c	0,49
Niagara	9,32 d	6,66 b	7,05 a	0,42
Eole	10,19 cd	5,92 c	6,13 bc	0,50

Srednje vrijednosti označene istim slovom signifikantno se ne razlikuju na razini 5% prema Duncan-testu

U 2010. godini značajno najveći prinos sjemena dala je sorta Eole (tablica 4.). Udio ulja varirao je od 38,98% (Atalante) do 46,06% (Niagara). Razlika u prinosu ulja između istraživanih sorata je statistički vrlo značajna, pa su sorte razvrstane čak u pet rangova (a-e). Najveći prinos ulja ostvarile su sorte Eole i Niagara. Statistički iste vrijednosti dobivene su i sa sortom Biltstar.

Tablica 4. Prinos sjemena, udio ulja i prinos ulja istraživanih sorata uljanog lana 2010. godine

Sorta	Prinos sjemena (kg/ha)	Udio ulja (% na s.t.)	Prinos ulja (kg/ha)
Atalante	2005 d	38,98	688 e
Flanders	2159 c	43,96	835 cd
Biltstar	2371 b	43,75	913 ab
Altess	2312 bc	42,63	867 bc
Mikael	2173 c	41,08	786 d
Princess	2194 c	44,19	853 c
Niagara	2366 b	46,06	959 a
Eole	2567 a	42,88	969 a

Srednje vrijednosti označene istim slovom signifikantno se ne razlikuju na razini 5% prema Duncan-testu



U 2010. godini utvrđene su značajne razlike u broju tobolaca po biljci i masi 1000 sjemenki, dok razlike u broju sjemenki po tobolcu i masi sjemena po biljci između istraživanih sorata uljanog lana nisu bile statistički opravdane (tablica 5.). Od pet sorata u prvom rangu (a), najveći broj tobolaca po biljci (8,20) imala je sorta Flanders. Razlika u masi 1000 sjemenki vrlo je značajna pa su sorte razvrstane u šest rangova (a-f). Značajno najveću masu 1000 sjemenki imala je sorta Biltstar.

Tablica 5. Sastavnice prinosa istraživanih sorata uljanog lana 2010. godine

Sorta	Broj tobolaca po biljci	Broj sjemenki po tobolcu	Masa 1000 sjemenki, g	Masa sjemena po biljci, g
Atalante	7,19 abc	7,02	5,95 e	0,35
Flanders	8,20 a	7,26	5,41 f	0,34
Biltstar	5,98 c	7,53	7,59 a	0,31
Altess	6,47 bc	7,38	7,15 b	0,34
Mikael	7,91 ab	7,23	6,37 d	0,38
Princess	6,98 abc	7,16	6,77 c	0,36
Niagara	6,14 c	7,58	7,29 b	0,34
Eole	6,91 abc	6,94	7,00 bc	0,33

Srednje vrijednosti označene istim slovom signifikantno se ne razlikuju na razini 5% prema Duncan-testu

### Zaključak

Na osnovi dvogodišnjih istraživanja prinosa i sastavnica prinosa osam inozemnih sorata uljanog lana u našim agroekološkim uvjetima mogu se donijeti sljedeći zaključci:

- Istraživane sorte uljanog lana značajno se međusobno razlikuju po prinosu sjemena,
- prinosu ulja, broju tobolaca po biljci i masi 1000 sjemenki.
- Po prinosu sjemena i ulja najrodnije sorte bile su Altess (2009.) i Eole (2010.). Visoki
- udio ulja u sjemenu imale su sorte: Princess, Niagara i Biltstar.
- Za naše uvjete mogli bi preporučiti sorte: Altess, Biltstar, Princes i Niagara.

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# Prinos zelene mase i korištenje sudanske trave kod naknadne sjetve

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## Sažetak

Cilj istraživanja bio je ispitati proizvodnost krme naknadnog usjeva sudanske trave i utjecaj hranidbe svježom zelenom masom sudanske trave na mliječnost muznih krava. Ispitivanje je provedeno na černozemnom tlu VUPIK-a d.d. Vukovar, PJ Ovčara i na mliječno-govedarskoj farmi Jakobovac, također VUPIK-a d.d. Unatoč kasnom roku sjetve (5.7.2010.) postignuti su visoki prinosi zelene mase prvog porasta (24,5 tha<sup>-1</sup>) i manji prinosi drugog porasta (10,4 tha<sup>-1</sup>). Uvođenje svježe zelene mase sudanske trave u obrok bilo je povezano s kontinuiranim povećanjem mliječnosti sa 17,9 na 19,3 litara mlijeka po kravi dnevno.

Ključne riječi: sudanska trava, prinos krme, mliječnost

## Herbage yield and usage of late sown sudangrass

### Abstract

Aim of the research was to investigate the herbage yield capability of late sown sudangrass and influence of its herbage inclusion into TMR (total mixed ratio) for dairy cattle. The research was conducted on chernozem soil of VUPIK d.d. PC Ovčara and on dairy farm Jakobovac, VUPIK d.d. Despite the late sowing term (5<sup>th</sup> July 2010) there were achieved high herbage yields of the 1<sup>st</sup> growth (24.5 t ha<sup>-1</sup>) and lower yield of the 2<sup>nd</sup> growth (10.4 t ha<sup>-1</sup>). Sudangrass herbage inclusion into TMR was associated with milk yield increase from 17.9 to 19.3 liters per cow per day.

Key words: sudangrass, herbage yield, milk yield

### Uvod

Sudanska trava (*Sorghum sudanense* Pers.) je jednogodišnja termofilna jara vrsta koja pripada porodici trava (*Poaceae*), podporodici *Panicoidae* i rodu *Sorghum*. U ishrani domaćih životinja može se koristiti kao svježa zelena krma ispašom ili košnjom, kao silaža te rjeđe kao sirovina za dehidraciju i proizvodnju biljnog brašna (Erić i sur. 2004.). Sudanska trava se može uzgajati kao glavni, naknadni i postrni usjev (Erić i sur., 2004.) zahvaljujući osobini vrlo brze tvorbe nadzemne biljne mase. Smith i Frederiksen (2000.) izvještavaju o uporabi sudanske trave za industrijsku preradu u papir. Državni zavod za statistiku Republike Hrvatske ne objavljuje podatke o površini pod sudanskom travom, međutim, zasijana površina se može procijeniti na temelju podataka o deklariranim ili uvezenim količinama sjemena. Prema izvješću Zavoda za sjemenarstvo i rasadničarstvo (\*\*Zavod za sjemenarstvo i rasadničarstvo, 2010.), u Hrvatsku je u sezoni 2009./2010. uvezeno 59.475 kg sjemena sudanske trave, dok domaće proizvodnje sjemena nije bilo. Ako se pretpostavi da

je prosječni utrošak sjemena sudanske trave 25 kg ha<sup>-1</sup> (\*\*Ministarstvo poljoprivrede, ribarstva i ruralnog razvoja, 2008.) tada je uvezena količina sjemena dostatna za sjetvu na 2.379 ha, što bi moglo biti blizu stvarno zasijanim površinama jer uvoznici nastoje uvesti količine za koje su procijenili da bi mogli prodati u tekućoj godini.

Gospodarska vrijednost sudanske trave se ogleda u visokim prinosima zelene krme koji se dobivaju u 2 do 4 otkosa tijekom vegetacije te u visokoj energetske vrijednosti suhe tvari zelene biljke, visokoj probavljivosti i visokoj *ad-libidum* konzumaciji kod preživača. Zbog svoje otpornosti na sušu odličan je komplement višegodišnjim krmnim travama čiji porast jenjava tijekom ljeta (Wheeler i McKinlay, 1998.). Hranidbena vrijednost zelene mase sudanske trave za preživače (DLG, 1997.) u fazi početka metličanja se zasniva na sadržaju hraniva u suhoj tvari: 14,8% sirovih bjelančevina s probavljivošću 75%; 3,6% sirovih masti s probavljivošću 60%; 24,2% sirovih vlakana s probavljivošću 76% i nedušičnih ekstraktivnih tvari 49,4% s probavljivošću 71%. Neto energetska vrijednost laktacije (NE<sub>L</sub>) kilograma suhe tvari u istoj fazi joj je 6,15 MJ što je slično neto energetske vrijednosti laktacije kilograma suhe tvari cijele biljke kukuruza u fazi kasne voštane zriobe zrna.

Pri korištenju sudanske trave za voluminoznu krmu potrebne su neke mjere opreza. U mlađim razvojnim stadijima sudanska trava sadrži cijanogene glukozide koji razgradnjom u probavilu oslobađaju otrovnu cijanovodičnu kiselinu. Zbog toga se sudansku travu preporučuje koristiti tek kad je viša od 45 cm (Wheeler i McKinlay, 1998.). Sinteza cijanogenih glukozida se događa i nakon izlaganja biljaka stresu, npr. suši, košnji ili manjem mrazu (Wheeler i McKinlay, 1998.) i to već nakon nekoliko sati od pojave stresa. Nakon prestanka stresa potrebno je 2 do 3 tjedna da bi se razgradili cijanogeni glukozidi i cijanovodična kiselina. Zbog toga su sijeno i silaža sudanske trave sigurne krme po pitanju cijanovodične kiseline. Ipak, nakon jačih mrazeva može doći do nagomilavanja nitrata u listovima, žilama i stabljikama jer korijen i žile ostaju aktivni u usvajanju i transportu nitrata, a listovi nemaju mogućnost njihove ugradnje u organske spojeve. Uslijed toga ne treba dugo čekati od pojave jačeg mraza pa do košnje za sijeno ili silažu (Wheeler i McKinlay, 1998.).

Cilj rada je ispitati proizvodnost zelene krme sudanske trave kod kasnog roka sjetve (početak srpnja) i utjecaj uvrštavanja svježih zelene mase sudanske trave na mlječnost krava.

### Materijal i metode

Ispitivanje je provedeno na černozemnom tlu na P.J. Ovčara i mliječno-govedarskoj farmi Jakobovac kombinata VUPIK d.d. Vukovar. Kružna proizvodna površina od 30 ha je nakon skidanja povrtnog graška obrađena podiranjem sa vibroaeratorom na 40 cm dubine i zatim je obavljena predstetvena priprema kombiniranim oruđima. Sudanska trava (sorta Susu) je posijana 5. srpnja 2010. godine kao naknadni usjev na 1,5 do 2 cm dubine s normom sjetve 21 kg ha<sup>-1</sup> sjemena. Ostvareni sklop je bio oko 90 biljaka po m<sup>2</sup>. Navodnjavanje je obavljeno u dva navrata sa po 25 litara vode po m<sup>2</sup>. Korištenje zelene mase sudanske trave za hranidbu mliječnih krava u zelenom stanju je započelo 3. kolovoza 2010. godine (30 dana nakon sjetve) kada je sudanska trava imala prosječnu visinu 67 cm. Od tada je korištena košnjom svakodnevno kako bi se namirio udio od 4 kg sudanske trave u dnevnom obroku, sve do 14. kolovoza. Prvi porast s dijela površine koji nije košen za hranidbu u zelenom stanju (27 ha) pokošen je 4. rujna (14 ha) i 5. rujna (13 ha) za silažu. Košnja drugog porasta je obavljena 14. listopada na 8 ha. Prinosi nadzemne mase prvog porasta na dane 3. i 6. kolovoza su procijenjeni aritmetičkom sredinom prinosa uzoraka površine od po 0,25 m<sup>2</sup> na 3 lokacije u usjevu, na visini iznad 10 cm od tla i preračunavanjem prinosa na 1 ha. Procjena visine biljke u prva dva roka provedena je na temelju prosječnih vrijednosti sa tri uzorkovane lokacije, a u ostalim rokovima na temelju jedne slučajno odabrane lokacije koja je vizualno odgovarala prosječnom stanju porasta. Interval pouzdanosti procjene aritmetičke sredine ( $\alpha = 0,05$ ) određen je funkcijom *confidence* MS Excella 2007. Podaci o prinosu na dane 4. i 5. rujna i 14. listopada dobiveni su kao kvocijent ukupne dnevne pokošene mase (t) i površine tla (ha). Koncentracija suhe tvari u zelenoj masi sudanske trave u fazi pred početak metličanja je procijenjena na osnovi mjerenja jednog slučajnog uzorka. Tijekom prikazanog razdoblja broj krava u mužnji se postepeno povećavao sa 444 na ukupno 557. U radu nije korišteno kontrolno stado bez dodane sudanske trave u dnevni obrok. Dnevna proizvodnja mlijeka po kravi (Holstein-frizijjska pasmina) se na farmi prati kontinuirano, a za procjenu utjecaja sudanske trave na mlječnost prikazana je prosječna dnevna mlječnost po kravi od 1. srpnja 2010. do 20. kolovoza 2010.

## Rezultati i rasprava

U provedenom ispitivanju se potvrdilo da sudanska trava ima vrlo brz porast. Naime, već 33 dana nakon sjetve postignut je prinos zelene mase  $16,29 \text{ tha}^{-1}$  (Tablica 1.). Ipak kod procjene dinamike proizvodnosti sudanske trave treba uzeti u obzir da su u prva dva navedena roka izmjereni prinosi dobiveni odvagama svake biljke pokošene točno na 10 cm visine što u praksi košnjom kombajnima i kosačicama nije ostvarivo. Također treba napomenuti da kod ovih ranih rokova nije bila izmjerena koncentracija suhe tvari što je svakako bitan kriterij za procjenu proizvodnosti usjeva.

Tablica 1. Prinosi zelene mase sudanske trave

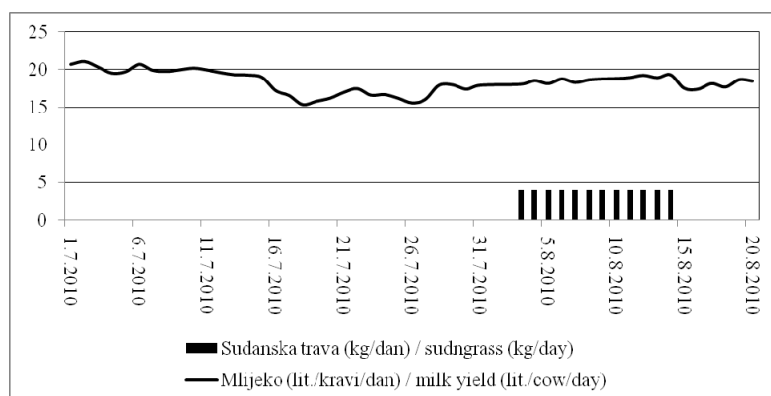
Datum košnje	Dana od sjetve	Porast	Visina (cm) +/- SE	Prinos zel. m. ( $\text{tha}^{-1}$ ) +/- SE
03.08.2010.	30	1./1 <sup>st</sup>	67,0 +/- 4,08	10,34 +/- 3,38
06.08.2010.	33	1./1 <sup>st</sup>	77,9 +/- 7,11	16,29 +/- 2,89
04.09.2010.	64	1./1 <sup>st</sup>	200,0	24,53
05.09.2010.	65	1./1 <sup>st</sup>	200,0	24,63
14.10.2010.		2./2 <sup>nd</sup>	190,0	10,35

U fazi pred početak metličanja do početka metličanja (što se poklapalo s druga dva roka košnje u rujnu), izmjerena je koncentracija suhe tvari u zelenoj masi sudanske trave 26%. Dobiveni prinosi zelene mase za silažu prvog porasta u toj fazi su bili  $24,53$  do  $24,63 \text{ tha}^{-1}$  (Tablica 1.) odnosno oko  $6,4 \text{ tha}^{-1}$  suhe tvari. Ostvareni prinos prvog porasta je bio niži nego kod Čupine i Erića (2001.) što se može pripisati kasnijem roku sjetve (5. srpnja) u ovom istraživanju u usporedbi s Čupinom i Erićem koji su kalendarski 30 dana ranijom sjetvom, 5. lipnja, dobili prinos prvog porasta  $39,3 \text{ tha}^{-1}$ , a sjetvom 30. svibnja  $42,2 \text{ tha}^{-1}$  i sjetvom 25. travnja  $52,1 \text{ tha}^{-1}$ .

Prinos drugog porasta je bio  $10,35 \text{ tha}^{-1}$  što je bilo niže od prvog (Tablica 1.), u skladu s očekivanjima za sudansku travu (Erić i sur., 2004.).

Kretanje mliječnosti u litrama mlijeka po kravi pokazalo je trend pada dolaskom ljeta (Grafikon 1.), međutim, može se primijetiti blagi ali kontinuirani porast mliječnosti od dana uvođenja svježe zelene sudanske trave u dnevni obrok, tj. od 3. kolovoza 2010. (Grafikon 1.). Pred uvođenje sudanske trave prosječna mliječnost je bila 17,9 litara mlijeka po kravi dnevno, dok je nakon 11 dana hranidbe sudanskom travom mliječnost porasla na 19,3 litara po kravi dnevno (Grafikon 1.).

Nakon izbacivanja svježe zelene mase sudanske trave iz dnevnog obroka zamijećen je nagli pad mliječnosti sa 19,3 litara po kravi dnevno na 17, 4 litara po kravi dnevno, drugi dan po izbacivanju sudanske trave.



Grafikon 1. Mliječnost i sadržaj sudanske trave u obroku

Na temelju provedenog istraživanja ne može se sa sigurnošću tvrditi da je uvrštavanje svježe zelene mase sudanske trave u obrok mliječnim kravama prouzročilo povećanje mliječnosti jer u ispitivanju nije bilo kontrolnog stada bez dodane svježe zelene sudanske trave. Ipak koincidencija kontinuiranog povećanja mliječnosti tijekom razdoblja hranidbe sa zelenom masom sudanske trave i nagli pad mliječnosti nakon izbacivanja iste iz obroka upućuje na uzročno-posljedičnu povezanost. U prilog prihvaćanju takve hipoteze ide i opće poznati stav da svježja zelena krma ima neke značajne prednosti u odnosu na konzerviranu krmu poput silaže. Jedna od najvećih prednosti vjerojatno je blizu neutralan pH svježe biljne mase dok je silaža

npr. kisela, s pH oko 4. Dobiveni rezultati upućuju na potrebu istraživanja organizacijskih mogućnosti i ekonomske opravdanosti uvođenja svježe zelene krme u većim udjelima u dnevne obroke preživačima. Naime efekat uvođenja 4 kg zelene mase u dnevni obrok bio je povezan s povećanjem mliječnosti od 1,4 litara po kravi dnevno, što je na farmi veličine 550 krava u mužnji imalo povećanje dnevne proizvodnje od 770 litara.

### Zaključci

Sjetvom sudanske trave u relativno kasnom roku (5. srpnja 2010.) postignuti su značajni prinosi zelene mase prvog porasta (24,5 tha-1) i manji prinosi drugog porasta (10,4 tha-1). Zelena masa je korištena za hranidbu mliječnih krava u svježem zelenom stanju i za pripremanje silaže. Nakon uvođenja svježe zelene mase sudanske trave u obrok mliječnih krava došlo je do kontinuiranog porasta mliječnosti sa 17,9 na 19,3 litara po kravi dnevno. Drugi dan nakon izbacivanja zelene mase sudanske trave iz obroka mliječnost je pala na 17,4 litara po kravi dnevno.

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sa2011\_0532

# Agronomska svojstva ozimog graška cv. Maksimirski rani u smjesi s pšenicom

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## Sažetak

Dvogodišnjim istraživanjima (2008-2009) utvrđivana su agronomska svojstva i prinos ozimog graška cv. Maksimirski rani u smjesi s pšenicom cv. Sana. Prije sjetve izvršena je predsjetvena bakterizacija sjemena graška sojem *Rhizobium leguminosarum* bv. *viciae* 1001 i KŽ 26 iz zbirke Zavoda za mikrobiologiju Agronomskog fakulteta Sveučilišta u Zagrebu. Najveći broj mahuna (19) i zrna po biljci graška (58) je utvrđen na bakteriziranoj varijanti sojem *R. leguminosarum* bv. *viciae* 1001. Najveća masa 1000 zrna (128 g) i masa zrna po biljci graška (7,4 g) također je utvrđena na bakteriziranoj varijanti *R. leguminosarum* bv. *viciae* 1001. Prosječni prinosi zrna graška cv. Maksimirski rani iznosili su od 2791 kg ha<sup>-1</sup> (kontrola) do 3164 kg ha<sup>-1</sup> (bakterizacija sojem *R. leguminosarum* bv. *viciae* 1001). Na osnovici ovih istraživanja možemo zaključiti da je najveći prinos zrna (3164 kg ha<sup>-1</sup>) ostvaren bakterizacijom zrna ozimog graška s sojem *R. leguminosarum* bv. *viciae* 1001.

Ključne riječi: ozimi grašak, bakterizacija, sojevi, prinos zrna, prinos bjelančevina

## Agronomic properties of winter pea cv. Maksimirski rani and wheat mixture

### Abstract

Two year field trials (2008-2009) were determined the agronomic properties and yield of winter pea cv. Maksimirski rani and wheat cv. Sana mixture. Just before sowing the inoculation of pea seeds was performed by the variety of *Rhizobium leguminosarum* bv. *viciae* 1001 and *R. leguminosarum* bv. *viciae* KŽ 26 which is part of the microbial collection of the Department of Microbiology at the Faculty of Agriculture University of Zagreb. The highest number of pods (19) and seeds per plant (58) was determined on the inoculated *R. leguminosarum* bv. *viciae* 1001. The highest weight of 1000 seeds (128 g) and weight of seeds per plant (7,4 g) was determined on the inoculated *R. leguminosarum* bv. *viciae* 1001. Average pea seed yield were ranging from 2791 kg ha<sup>-1</sup> (control) up to 3164 kg ha<sup>-1</sup> (inoculation *R. leguminosarum* bv. *viciae* 1001.). The conclusion of this research is that the highest yield of winter pea (3164 kg ha<sup>-1</sup>) was obtained with the inoculation winter pea strain *R. leguminosarum* bv. *viciae* 1001.

Key words: winter pea, inoculation, strains, grain yield, protein yield

## Uvod

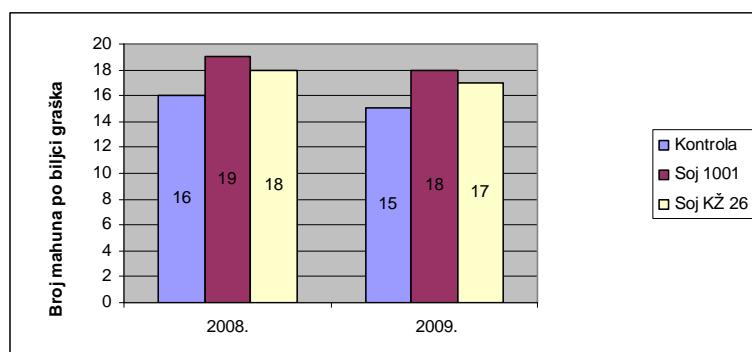
Skoro u svim agroekološkim uvjetima, ako se uspoređuje učinak djelovanja pojedinih elemenata, kako na biološki tako i na poljoprivredni prinos, dušik najviše utječe na povećanje toga prinosa. Mahunarke sadrže velike količine bjelančevina u nadzemnoj masi pa zato trebaju i veće količine dušika za formiranje prinosa. One mogu znatan dio potrebnog dušika osigurati biološkom fiksacijom iz atmosfere koja ga sadrži 78%, ili nad svakim hektarom 6 400 kg. Da bi mahunarke mogle koristiti dušik iz atmosfere moraju živjeti u simbiozi s učinkovitim sojevima kvržičnih bakterija iz rodova *Rhizobium* i *Bradyrhizobium*. Bez kvržičnih bakterija na svom korijenu ni mahunarke ne mogu koristiti dušik iz atmosfere, već su onda kao i sve ostale biljke upućene isključivo na korištenje dušika iz tla. Za vezanje dušika iz atmosfere mahunarke troše solarnu energiju akumuliranu u asimilatima biljke domaćina. Uzimajući u obzir, da na primjer, soja po jedinici prinosa zrna treba četiri puta više dušika nego žitarice (Hardy i Havelka, 1975) i da za vezanje tog dušika industrija treba utrošiti određene količine skupe fosilne energije, koja je ograničena, razumljiva su nastojanja da se mahunarkama omogući maksimalno korištenje dušika iz atmosfere, tim više što se za njegovu redukciju koristi solarna energija koja je svake godine obnovljivi izvor (Strunjak i Redžepović, 1986). Za poljoprivrednu proizvodnju vrlo je značajna simbioza kvržičnih bakterija iz rodova *Rhizobium* i *Bradyrhizobium* i mahunarki čime se biološki veže atmosferski dušik, koji se odmah koristi za sintezu bjelančevina i na taj se način sprječava opasnost od onečišćenja podzemnih voda nitratima, koja se inače javljaju kod intenzivne primjene mineralnih dušičnih gnojiva. Mahunarke uzgajane za zrno, sijeno, ispašu, zelenu gnojidbu ili druge svrhe, vežu putem svojih simpcionata na cijeloj zemlji oko  $80 \times 10^6$  tona atmosferskog dušika godišnje, što je više od polovice ukupne količine biološki vezanog dušika na zemlji (Evans i Barber, 1977), odnosno, u svijetu industrijskim Haber-Bosch postupkom osigurava se  $60 \times 10^6$  t dušika godišnje (FAO Technical Handbook, 1989). Mahunarke nakon žetve u tlu ostavljaju nekoliko tona lako razgradljive korijenove mase i strni po hektaru kojom obogaćuju tlo organskom tvari, bogatom dušikom (Russel, 1950). Na taj se način održava plodnost tla i omogućuje kulturama koje slijede u plodoredu da koriste vezani atmosferski dušik (Bonnier i Brakel, 1969). Time se proširuje plodored, sprečava se širenje pojedinih bolesti i štetnika, a posebice korova, sprečava se umornost tla, te ono najvažnije, omogućuje se kontinuirano korištenje ozimog graška u smjesi s žitaricama za hranidbu mliječnih krava u obliku zelene krme, silaže ili kao koncentrat (zrno). Cilj istraživanja je bio utvrditi najvažnija agronomska svojstva (broj mahuna, broj zrna i masa zrna po biljci, masu 1000 zrna, prinos zrna i prinos sirovih bjelančevina po ha) kultivara ozimog graška cv. Maksimirski rani bakteriziranog sojevima *Rhizobium leguminosarum* bv. *viciae* 1001 i *R. leguminosarum* bv. *viciae* KŽ 26.

## Materijal i metode

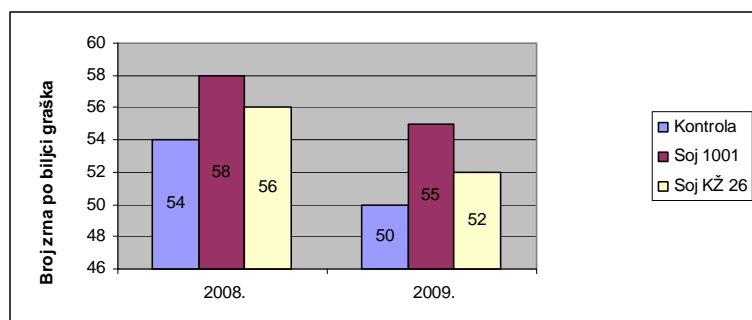
U Maksimiru su u razdoblju od 2007/2008. do 2008/2009. godine provedena istraživanja utjecaja bakterizacije na agronomska svojstva ozimog graška cv. Maksimirski rani u smjesi s pšenicom cv. Sana. Istraživanja su provedena s shemom pokusa slučajni blokni raspored u četiri repeticije sa bakterizacijom kao glavnim faktorom u tri stepenice (1. kontrola bez prihrane dušikom i bakterizacije sjemena graška, 2. bakterizacija sa sojem *Rhizobium leguminosarum* bv. *viciae* 1001, 3. bakterizacija sa sojem *Rhizobium leguminosarum* bv. *viciae* KŽ 26. Na pokušalištu Agronomskog fakulteta u Maksimiru je aluvijalno-koluvijalno smeđe tlo razvijeno na aluviju. Reakcija tla je neutralna, pH u nKCl iznosi 7,0. Tlo je slabo humozno i sadrži 1,8% humusa. Tlo je opskrbljeno (0,14%) dušikom. Prema sadržaju  $P_2O_5$  i  $K_2O$  u tlu, može se zaključiti da je tlo u Maksimiru osrednje do dobro opskrbljeno tim hranivima, odnosno u oraničnom sloju ima 35,7 mg  $P_2O_5$  i 18,6 mg  $K_2O/100$  g tla. Osnovna obrada tla obavljena je oranjem na 30 cm dubine. Predsjetvena priprema obavljena je sjetvospremačem. Osnovna gnojidba bila je s 500 kg/ha NPK 8:26:26 ili 40 kg/ha N, 130 kg/ha  $P_2O_5$  i 130 kg/ha  $K_2O$ . Sjetva je izvršena sijačicom Wintersteiger s raoničnim ulagačem na međuredni razmak 12 cm. Duljina jedne parcelice iznosila je 10 m, a širina 1,20 m, tako da je površina parcelice bila 12 m<sup>2</sup>, a razmak među parcelicama 0,70 m. Prvo su sijane varijante kontrole, a zatim bakterizirane varijante. Norma sjetve bila je 50 zrna graška cv. Maksimirski rani/m<sup>2</sup> i 200 zrna/m<sup>2</sup> pšenice cv. Sana. Žetva je bila 09.07.2008. i 12.07.2009. godine. Prinosi su utvrđivani na parcelici površine 12 m<sup>2</sup> u punoj zriobi graška i pšenice. Nakon žetve smjesa je bila odvojena posebno na grašak, posebno na pšenicu, a nakon toga je određen prinos. Na osnovici 10 biljaka uzetih prije žetve po varijantama utvrđene su komponente prinosa graška. Utvrđen je broj mahuna po biljci graška, broj zrna po biljci graška, masa 1000 zrna graška, masa zrna po biljci graška, prinos zrna graška te prinos sirovih bjelančevina graška (kg ha<sup>-1</sup>). Rezultati su bili obrađeni u statističkom programu SAS (SAS Institut, 1999).

## Rezultati i rasprava

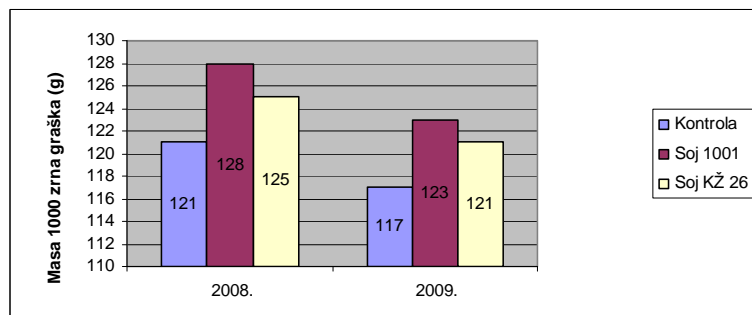
Porastom pučanstva svakim danom se povećavaju potrebe za hranom. Da bi se te povećane potrebe zadovoljile, traže se racionalnija rješenja koja obuhvaćaju štednju fosilne energije. Da bi se postigli visoki prinosi i visoka kakvoća, krmnim kulturama treba osigurati velike količine dušika. Budući da biljke iz porodice mahunarki žive u simbiozi s bakterijama iz roda *Rhizobium*, koje vežu atmosferski dušik, kojeg nad svakim hektarom površine ima oko 6 400 kg, one tom fiksacijom namiruju svoje potrebe za dušikom, koristeći pri tom sunčevu energiju. Toj simbioznoj fiksaciji dušika danas se posvećuje velika pažnja i u svijetu se izvode brojna istraživanja kako bi se odabrale najučinkovitije simbiotske zajednice kultivara mahunarki i sojeva bakterija. U tu su svrhu provedea istraživanja na Agronomskom fakultetu sa sojevima *Rhizobium leguminosarum* *bv. viciae* 1001 i KŽ 26 iz zbirke Zavoda za mikrobiologiju, kojim je bakterizirano sjeme novog kultivara ozimog graška cv. Maksimirski rani sa svrhom da se utvrdi učinkovitost fiksacije dušika kultivar graška x soj.



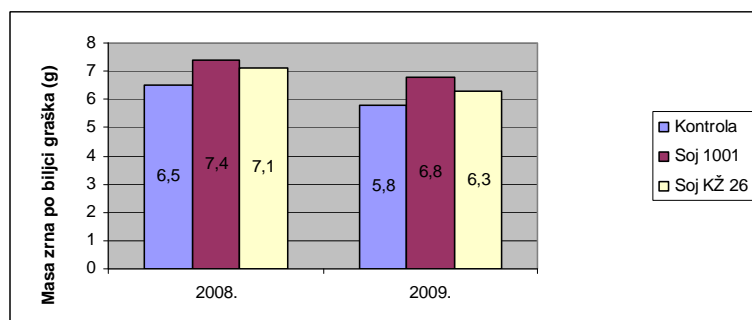
Grafikon 1. Broj mahuna po biljci graška



Grafikon 2. Broj zrna po biljci graška



Grafikon 3. Masa 1000 zrna graška (g)



Grafikon 4. Masa zrna po biljci graška (g)



Bakterizirana varijanta sojem *R. leguminosarum* bv. *viciae* 1001 imala je značajno ( $P < 0.05$ ) veći broj mahuna (19), broj zrna (58) te najveću masu 1000 zrna (128 g) kao i masu zrna po biljci graška (7,4 g) u odnosu na ostale varijante istraživanja (Grafikoni 1, 2, 3 i 4.) što je u suglasju s rezultatima Brkić i sur. (2004) i Uher i sur. (2006, 2009, 2010.). Bakterizirana varijanta sojem *R. leguminosarum* bv. *viciae* 1001 imala je značajno ( $P < 0.05$ ) veći prinos graška ( $3164 \text{ kg ha}^{-1}$ ) u odnosu na ostale varijante istraživanja (Tablica 1.) što je u suglasju s rezultatima Brkić i sur. (2004) i Uher i sur. (2006, 2009, 2010).

Obje bakterizirane varijante imale su u prosjeku 14,5% veći prinos sirovih bjelančevina u zrnu graška u odnosu na kontrolnu varijantu što je u suglasju s rezultatima Uher i sur. (2009, 2010) koji su utvrdili veće prinose sirovih bjelančevina graška na bakteriziranim varijantama graška u odnosu na kontrolu i varijante prihranjivane dušikom.

Tablica 1. Prinos zrna i sirovih bjelančevina graška ( $\text{kg ha}^{-1}$ )

Varijanta	Godina		Prosjek varijanata
	2008.	2009.	
Prinos zrna graška ( $\text{kg ha}^{-1}$ )			
Kontrola	2949	2633	2791
Soj 1001	3353	2974	3164
Soj KŽ 26	3209	2768	2988
Prosjek godina	3170	2792	
LSD 0,05			70 $\text{kg ha}^{-1}$
LSD 0,05 †			86 $\text{kg ha}^{-1}$
LSD 0,05 ‡			121 $\text{kg ha}^{-1}$
Prinos sirovih bjelančevina zrna graška ( $\text{kg ha}^{-1}$ )			
Kontrola	706	627	666
Soj 1001	833	742	788
Soj KŽ 26	789	685	737
Prosjek godina	776	685	
LSD 0,05			64 $\text{kg ha}^{-1}$
LSD 0,05 †			78 $\text{kg ha}^{-1}$
LSD 0,05 ‡			110 $\text{kg ha}^{-1}$

† LSD za usporedbu srednjih vrijednosti unutar godine

‡ LSD za usporedbu srednjih vrijednosti između godina

### Zaključak

Temeljem dvogodišnjih istraživanja učinkovitosti bakterizacije sjemena ozimog graška cv. Maksimirski rani sojevima *Rhizobium leguminosarum* bv. *viciae* 1001 i KŽ 26 u smjesi s pšenicom kao nosačem provedenih na Agronomskom fakultetu u Zagrebu može se zaključiti da bakterizacija sjemena istraživanog kultivara graška sojem *Rhizobium leguminosarum* bv. *viciae* 1001 je signifikantno utjecala na povećanje prinosa zrna cv. Maksimirski rani u odnosu na kontrolnu varijantu i varijantu bakteriziranu sojem *Rhizobium leguminosarum* bv. *viciae* KŽ 26 te na povećanje prinosa sirovih bjelančevina graška samo u odnosu na kontrolu.

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# Silage quality of maize-climbing bean intercropping

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## Abstract

Silage maize is a major forage source in the livestock production of many countries. It has relatively consistent nutritive value and high energy density, but relatively low crude protein content. The intercropping of maize with climbing bean (*Phaseolus vulgaris* L.) may serve as a way to increase crude protein and improve the overall nutritive value of silage. A field experiment was carried out in 2008 in order to determine the silage quality of maize (cv. Nexxos), monocropped or intercropped with climbing bean (cv. Jabelski visoki). Maize sown in two densities (6 and 9 plants m<sup>-2</sup>) was intercropped with climbing bean in maize-bean ratios: 1:1, 1:2 and 2:1. Silages were analysed for dry matter (DM), crude protein (CP), fat (CF), fibre (CFb) and ash (CA). All intercrop silages had higher crude protein values (71.0-79.3 g kg<sup>-1</sup>) and crude fat contents (45.2-50.1 g kg<sup>-1</sup>) than pure maize (65.6 and 19.6 g kg<sup>-1</sup>, respectively). The calculated energy densities (GE) of all intercrop silages were significantly higher (18.7-19.1 MJ kg<sup>-1</sup>) than that of pure maize (18.2 MJ kg<sup>-1</sup>).

Key words: intercropping, maize, climbing bean, silage quality

## Introduction

Energy and protein sources are of prime importance for ruminants as they stimulate microorganisms in the rumen and enhance the productive functions of the animals. Maize silage plays an important role as a winter feed in the livestock production of many countries and it comprises approximately 17.3% of arable land in Slovenia (SURS, 2005). The main advantages of silage maize are high yield obtained in a single harvest, simple ensilaging process and high energy value of maize as a feed. It has relatively consistent nutritive value and high energy density, but relatively low crude protein content, ranged between 53 and 105 g kg<sup>-1</sup> dry matter (Verbič, 2008).

Intercropping, the simultaneous cultivation of more than one species or cultivar on the same area of land, is being advocated as a new and improved approach to farming (INTERCROP, 2006). Proper spatial arrangements, planting rates and the maturity dates of components in maize-grain legume intercropping enhance biodiversity and have many advantages over pure maize cropping. The advantages are related to complementary use of environmental resources, increased and/or more stable yield which provides greater financial stability, better nutrient recycling and improved use of renewable nitrogen source by fixation, better weed, pest and diseases control, and may also serve as an alternative to increase the crude protein of silage (Rao and Morgado, 1984; Vandermeer, 1989; Anil and Phipps, 1998; Anil et al., 2000).

The present study was conducted to evaluate the silage quality of maize-climbing bean intercropping treatments, differing in planting and spatial arrangements, as an alternative to pure maize cropping.

## Materials and methods

Intercropping systems with different densities and spatial patterns of maize-climbing bean have been studied at the Faculty of Agriculture and Life Sciences at the University of Maribor over a four-year period (Bavec et al., 2005; Bavec et al., unpublished data). In addition to investigating the growth of intercropped crops and their productivity performance in previous years, in 2008, the silage quality was evaluated. The fresh material

used in this study was produced at the University Agriculture Centre Pohorski Dvor, Maribor, north-east Slovenia (46°39'N, 15°41'E, 282 m.a.s.l.), with 9.8 °C and 1047 mm as the long-term medium. The soil texture was sandy-loam (Dystric Cambisols on slate metamorphic rocks) with pH 6.0, 2.6% of organic carbon, 29.5 mg P<sub>2</sub>O<sub>5</sub>100 g<sup>-1</sup>, 12.7 g K<sub>2</sub>O 100 g<sup>-1</sup> (ammonium lactate) and 159 kg ha<sup>-1</sup> of mineral nitrogen up to depth 0.9 m. The measurements were taken before maize sowing. In late April dent maize (*Zea mays* var. *indentata*) cv. Nexxos was sown in two densities (6 and 9 plants m<sup>-2</sup>), as a pure crop and in intercropping with indeterminate-type climbing bean cv. Jabelski visoki. Climbing bean was sown close to maize in different maize to climbing bean planting ratios (1:1, 1:2 and 2:1) at maize growth stage 15 BBCH. The field experiment was set up in systematic - Mead's adaptation of Bleasdale's row design (Petersen, 1994) in one replication. Weeding was performed manually. The harvest was gathered on September 11, at the maize maturity stage of 1/2 to 3/4 milk line. Harvested intercrops were separated into maize and climbing bean, and components weight proportions were determined.

Maize and intercrops were chopped with a transportable chopper to a theoretical particle size of 0.5 cm. Obtained material was thoroughly mixed and filled in a 10-L plastic barrel.

Mini-silos were tightly sealed and kept in a storehouse (~20 °C) without light for 120 days. Ensilage was performed without additives in four replications. At the time of silo opening the content was homogenized and samples of 500 g were taken for further analyses.

The ensiled samples were analysed at the Institute of Agriculture and Forestry Murska Sobota (Slovenia). Dried samples (dried at 60 °C for 48 h in a forced-air oven) were ground by hammer mill, sieved through a 1 mm screen and stored in polyethylene bags until the analysis. According to the procedure dry matter (DM), crude protein (CP; Kjeldahl N x 6.25), crude fibre (CFb), crude fat (CF), ash (CA) and nitrogen free extract (NFE) were determined according to the standard procedures. All the parameters were expressed on a DM basis. The gross energy (GE) of the silages was calculated according to the proximate analysis using an official German equation (Gesellschaft für Ernährung, 1999):

$$GE \text{ (MJ kg}^{-1}\text{)} = 0.0239 \times g \text{ CP} + 0.0398 \times g \text{ CF} + 0.0201 \times g \text{ CFb} + 0.0175 \times g \text{ NFI}$$

Data were evaluated by analysis of variance using the Statgraphics Centurion XV statistical program (Statgraphic<sup>®</sup>, 2005) with the significance level set at  $P \leq 0.05$ . Comparison of means was done by Duncan test ( $\alpha=0.05$ ).

## Results and discussion

Since the present experiment was established in 2008 in addition to a trial run from the previous years, and exclusively for the purpose of silage quality evaluation, the results presented in Table 1 serve purely for illustrating the components contribution to total yield of silage mixtures.

**Table 1. Yield and final densities of components in different maize-climbing bean (M:B) intercropped silage mixtures**

Mixture (M:B; plants m <sup>-2</sup> )	Yield total (kg 10 m <sup>-2</sup> )	Component (kg, plants 10 m <sup>-2</sup> )			
		M (%)	M plants	B (kg)	B plants
M6B3	57.91	54.96 (94.9)	58	2.94 (5.1)	20
M6B6	36.21	34.91 (96.4)	48	1.30 (3.6)	10
M6B12	30.16	27.46 (96.9)	37	0.92 (3.1)	8
M9B4.5	64.26	63.01 (98.1)	90	1.24 (1.9)	15
M9B9	60.31	59.16 (98.1)	90	1.15 (1.9)	18
M9B18	76.59	74.60 (97.4)	87	1.99 (2.6)	27

Table 2 shows the proximate chemical composition and gross energy of silage obtained from pure cropping maize (pure maize) and maize-climbing bean mixtures (M:B). While average CFb content did not differ, other silage constituents were significantly different among treatments. Average DM concentrations of analysed silages were between 330 and 395 g kg<sup>-1</sup>, and therefore in the range of recommended values (300-400 g kg<sup>-1</sup>) (Verbič, 2008). However, the pure maize silage had a significantly lower average DM content than silages obtained from mixtures where maize was sown at the density of 6 plants m<sup>-2</sup>. It is known that protein, fat and mineral contents of legumes are higher than that of cereals (Souci et al., 1994). With exception of treatment M6B12, the recorded CP contents of all other maize-climbing bean silages were significantly

higher than the concentration obtained by pure maize (65.6 g kg<sup>-1</sup>). Similarly, the increase of silage CP content in maize-climbing bean intercropped silage mixtures is also reported in literature (Anil et al., 2000; Armstrong et al., 2005; Bildirici et al., 2009). The content of CF in pure maize was significantly lower than in silages made from mixtures (p<0.01). The average CA content of all intercropped mixtures established with higher maize density (9 plants m<sup>-2</sup>) was higher in comparison to the silage derived from pure maize. As expected, the NFE of pure maize silage was higher than those from mixtures.

The calculated GE of all intercrop silages was significantly higher (18.7-19.1 MJ kg<sup>-1</sup>), than that of pure maize (18.2 MJ kg<sup>-1</sup>).

**Table 2. Chemical composition of maize and different maize-climbing bean intercropped silage mixtures**

Mixture (M:B) (plants m <sup>-2</sup> )	DM** (g kg <sup>-1</sup> )	CP**	CF**	CFb <sup>ns</sup> (g kg <sup>-1</sup> DM)	CA**	NFE*	GE** (MJ kg <sup>-1</sup> )
Mpure	330d	65.6c	19.6b	176.1	36.7c	702.0a	18.2d
M6B3	395a	79.2a	46.9a	231.9	34.4c	607.6b	19.1a
M6B6	386ab	74.1ab	49.0a	194.2	37.5bc	645.2b	18.9ab
M6B12	374abc	71.0bc	48.7a	222.1	44.4a	613.7b	18.8bc
M9B4.5	363bcd	79.3a	50.1a	209.7	42.4a	618.5b	18.9ab
M9B9	352cd	72.2b	47.4a	208.3	41.7ab	630.4b	18.8bc
M9B18	362bcd	76.4ab	45.2a	201.2	44.7a	632.4b	18.7c

\*\*significant at the 0.01 probability levels; ns - non significant

<sup>a-d</sup> mean values followed by different letters within a column are significantly different (Duncan, α=0.05)

### Conclusions

The research work conducted in previous years demonstrates the feasibility of intercropping maize with climbing bean, and the present study confirms the advantage of such mixtures in the view of silage quality. Maize-climbing bean mixtures provided silage with improved crude protein, crude fat and subsequently gross energy value.

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# Influence of sod seeding on grassland quality in the first cut

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## Abstract

Sod seeding was carried out in the pasture sward in Bartošovice (Czech Republic). Four different ways of sowing in to the existing vegetation were used. The mixture of sod seeding contained *Festulolium pabulare*, *Dactylis glomerata*, *Arrhenatherum elatius* and *Lotus corniculatus*. The first cut was used for conservation. Grassland quality (botanical composition) and content of nutrients in the silages were evaluated. Different technologies of sod seeding improve dominance of new sown species in a grass stand. The most successful one was a radical disturbance of the original grass sward with technology Horsch Exaktor. Sod seeding improves grassland quality in terms of botanical composition (EGQ). Dominance of the sown species up to 20% was not sufficient for influencing the nutrients in ensilaging biomass. Content of CF and NDF influenced use of inoculants at ensilaging ( $P < 0.05$ ). Probiotic and probioenzymatic inoculants improve quality of silage process. Thanks to inoculants was lower content of butyric acid ( $P < 0.01$ ).

Key words: perennial grasses, forage, silages, content of nutrients

## Introduction

Grasslands can be used for forage production in a grass - arable land rotation. The first cut is harvested for conservation and the sward can be subsequently used for grazing until the end of the growing season. Winter feed ration is based on the conserved fodder from the first cut and serves also as additional feed in autumn (Achilles et al., 2002). Compared with haymaking, ensiling represents a much lower weather risk, less labour costs and less conservation losses (Achilles et al., 2002). Individual graminaceous species show great differences in their ensiling capacity (Holúbek et al., 2007). The goal of this paper is to evaluate grassland quality and quality of silages after sod seeding of a mixture of *Festulolium pabulare*, *Arrhenatherum elatius*, *Dactylis glomerata* and *Lotus corniculatus*.

## Material and methods

The field experiment was conducted in Bartošovice (north-east Bohemia) and established on 5<sup>th</sup> of May 2008 at the altitude of 650 m a.s.l. in three replicates. Soil mineral content was 133 mg kg<sup>-1</sup> P, 472 mg kg<sup>-1</sup> K, 1830 mg kg<sup>-1</sup> Ca and pH was 5.6 in the year of establishment. Size of experimental plot was 0.9 ha (20 x 450 m). There were 5 sowing treatments: (1) control (no seeding), (2) sod seeding without disruption grass stand (Lehner), (3) sod seeding with strip seed drill (SSD), (4) sod seeding with Horsch exaktor SE3 (Exaktor) and (5) sod seeding with Horsch disk pronto 3DC (Disk). Sod seeding was carried out with a mixture of *Festulolium pabulare* (cv. Felina, 14.5 kg ha<sup>-1</sup>), *Dactylis glomerata* (var. Vega, 5 kg ha<sup>-1</sup>), *Arrhenatherum elatius* (var. Median, 14.5 kg ha<sup>-1</sup>) and *Lotus corniculatus* (var. Taborsky, 1.5 kg ha<sup>-1</sup>). Biomass from the first cut was harvested on 2<sup>nd</sup> of June 2009 and used for making silage. The silages were made in the bale (diameter 1.5 m). Dry matter of silages biomass was from 20 to 24%. The silages additives were preservative probiotic (Mikrosil, 0.1 g kg<sup>-1</sup>) and probioenzymatic (Goldzym, 0.15 g kg<sup>-1</sup>) inoculants. Silages sampled 90 days after the beginning of conservation were assessed for organic acids and content of fibre. The content of

nutrients was established according to the norm of the Czech Standard Institute (Anonymous, 1997). Botanical composition was evaluated by the method of projective dominants on the area of 2 x 2 m. Grassland quality was evaluated according to a formula (Novak, 2004):

$$EGQ = \sum(FV \cdot \%D) / 8,$$

EGQ is evaluated grassland quality, FV is forage value and %D is dominance of species in grassland.

### Results and discussion

The dominance of sod seeding species was the highest when the Horsch Exactor was used. This technology disturbs a grass sward to a larger extent in comparison with the other technologies. Restriction of the competitive power of the old sward contributes to a favourable implementation of the new species. Sod seeding improves grassland quality (Table 1). The disturbance of the grass sward and subsequently access of sunlight increase dominance of white clover (not in the mixture). The proportion of the additional sowing species up to 20% was not enough to influence the nutrient concentration in the ensilaging biomass (Table 2). However higher dominance of the sod seeding grasses is expected in the following years and probably it can improve nutrient content then. According to Skládanka (2005), in June 2004, the share *Festulolium* in herbage was 23.1%. In 2001, the share of these species was up to 2%. This indicates that the proportion of oversown herb species can increase in four years by more than 20%. Content of water soluble carbohydrate (WSC) was in the observed grass stand higher than 90 g kg<sup>-1</sup>. According to Haigh (1995), a successful process of ensilaging requires an amount of 37 g kg<sup>-1</sup> WSC at least. Quality of ensilaging positively influences use of inoculants (Jones et al., 1999). The content of crude fibre (CF) and neutro-detergent fibre (NDF) was affected ( $P < 0.05$ ) by the use of probiotic and probioenzymatic preparations (Table 2). Thanks to enzymatic components (cellulase and hemicellulase) in preparation Goldzym was lower ( $P < 0.05$ ) content of NDF and CF. The preparations influenced considerably quality of silage infusions (Table 2). Especially the lower content of butyric acid ( $P < 0.01$ ) in the treated silages is a sign of better silage quality.

**Table 1. The projective dominance (%D) and grassland quality (EGQ) in dependence on technology of sod seeding on site Bartošovice**

Species	FV	Non seeding	Lehner	SSD	Exaktor	Disk
<i>Phleum pratense</i>	8	3	2	1	1	4
<i>Poa pratensis</i>	8	8	7	4	4	5
<i>Alopecurus pratensis</i>	7	12	10	8	10	9
<i>Agrostis capillaris</i>	5	3	4	3	3	4
<i>Erytrigia repens</i>	4	3	2	1		1
<i>Dactylis glomerata</i>	7	8	8	9	7	9
<i>Arrhenatherum elatius</i>	7		+	3	12	2
<i>Festulolium pabulare</i>	7		+	2	1	4
Grasses		40	35	33	40	40
<i>Trifolium repens</i>	8	20	35	38	19	30
<i>Lotus corniculatus</i>	7		+	+	3	+
Legumes		20	35	38	22	30
<i>Heracleum sphondylium</i>	5	4	3	2	4	3
<i>Alchemilla vulgaris</i>	5	1	3	2	2	4
<i>Taraxacum officinale</i>	5	14	12	14	14	10
<i>Ranunculus repens</i>	-2	4	2			1
Herbages		36	27	27	33	28
EGQ		69	78	81	72	78

+ dominance < 1%; FV = forage value, 8 = most valuable species, 0 = worthless species, -1 to -4 = toxic species  
In the table are only selected species with dominance >3% at least in one variant



**Table 2. Influence of sod seeding and preservative on the pH, content of lactic acid (LA), acetic acid (AA), butyric acid (BA), content of crude fibre (CF), acid detergent fibre (ADF) and neutro detergent fibre (NDF) in the bale silages**

Factor	DM g kg <sup>-1</sup>	pH	LA g kg <sup>-1</sup>	AA g kg <sup>-1</sup>	BA g kg <sup>-1</sup>	CF g kg <sup>-1</sup>	ADF g kg <sup>-1</sup>	NDF g kg <sup>-1</sup>
Sod seeding								
Control	207.2	4.59	64.0	17.0	15.0	250.0	356.2	447.9
Lehner	258.3	4.60	46.3	14.1	12.9	274.8	381.3	515.8
SSD	257.2	4.69	46.1	13.5	15.3	285.1	395.3	534.1
Exaktor	239.4	4.41	61.5	11.5	13.7	248.2	388.6	475.2
Disk	229.7	4.58	60.9	21.5	14.9	271.1	401.4	498.8
p	0.436	0.974	0.946	0.804	0.999	0.683	0.453	0.672
Preservative								
Control	242.3	5.09 <sup>a</sup>	22.8 <sup>a</sup>	20.2	27.6 <sup>a</sup>	297.4 <sup>a</sup>	402.8	550.7 <sup>a</sup>
Mikrosil	251.0	4.38 <sup>b</sup>	65.0 <sup>b</sup>	11.9	9.9 <sup>b</sup>	253.8 <sup>ab</sup>	365.1	487.9 <sup>ab</sup>
Goldzym	221.8	4.25 <sup>b</sup>	79.5 <sup>b</sup>	14.4	5.6 <sup>b</sup>	246.2 <sup>b</sup>	385.7	444.5 <sup>b</sup>
p	0.459	0.000	0.003	0.412	0.000	0.024	0.145	0.047

The mean with different superscripts (<sup>a,b,c</sup>) are significant at level  $P < 0.05$

### Conclusions

Different technologies of sod seeding improve rate of new seed species to a grass stand. The more successful was a radical disturbance of the 'old' grass sward with technology Horsch Exaktor. Sod seeding improves grassland quality. Dominance of the additional sowing species was up to 20%. The disturbance of the grass sward increases dominance of white clover (not in the mixture). Nutrient content in the ensilaging biomass was not influenced by the sod seeding. Fibre content (CF and NDF) and digestibility were improved by the use of inoculants.

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# Utjecaj napasivanja i gnojidbe dušikom na udio odumrle tvari u travno-djetelinskoj smjesi

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## Sažetak

Cilj istraživanja bio je utvrditi trogodišnji utjecaj napasivanja govedima i ovcama te gnojidbe sa 150 i 0 kg dušika ha<sup>-1</sup> na masu odumrle tvari (OT) i njen udio u prinosu suhe tvari (ST) travno djetelinske smjese (TDS) sastavljene od klupčaste oštrice, vlasnjače livadne i bijele djeteline.

Napasivanje ovcama rezultiralo je manjom masom OT za 31% i manjim udjelom OT u prinosu ST TDS za 30,5% u odnosu na napasivanje govedima.

Udio OT bio je najveći u prvoj (10,1%), izuzetno sušnoj godini, a najmanji u trećoj godini (2,7%).

Odumiranje biljnih dijelova je bilo u direktnoj vezi s vrstom životinje kojom se napasuje travnjak, dok opskrba tla dušikom nije utjecala na odumiranje biljnih dijelova. Suša je utjecala na smanjenje prinosa i povećala udio odumrlog dijela.

Ključne riječi: dušik, napasivanje, odumrla tvar, TDS

## Influence of grazing and N fertilization on share of dead plant material in grass-clover mixture

### Abstract

The aim of research was to determine in a three-year period the effect of grazing by cattle (C) and sheep (S) and N application (0 and 150 kg ha<sup>-1</sup> N) on the share of plant dead material (PDM) in grass-clover mixture (GCM) containing cocksfoot, smooth-stalked meadow grass and white clover.

Sheep grazing in comparison to cattle grazing resulted in lower mass of PDM for 31%, and smaller PDM share in the total mixture for 30.5%.

The highest share of PDM (10.1%) was in year 2000 which was exceptionally dry with the smallest GCM dry matter yield recorded, while the lowest share was in year 2002 (2.7%).

Furthermore, the results show that PDM appearance was directly connected with different types of grazing animals, and amount of soil nitrogen had no impact on PDM appearance. Drought had significant influence on lower yield and higher share of PDM.

Key words: nitrogen, grazing, plant dead material, grass-clover mixture

## Uvod

Odumiranje biljnih dijelova redovita je pojava tijekom korištenja pašnjaka. Ukoliko postoje odumrli dijelovi biljaka, bez obzira na razlog odumiranja, to je često ograničavajući čimbenik za bolje iskorištenje krme od strane preživača. Životinje pasu radije listove nego stabljike, mlađe listove radije nego starije (Watkin i Clements, 1978), a odumrlu biljnu tvar odbacuju (Thomson, 1978). Odumiranje može nastati uslijed prebujnosti tratine (prevelika količina dušika i dr.) i ukoliko se takva tratina ne napasuje pravovremeno, prizemno lišće počinje venuti i hrani se asimilatima gornjeg lišća, a tamo gdje je mnogo vlage i topline mogu se jako razmnožiti gljivice i plijesni. U takvoj krmi je više odumrlih biljnih dijelova te ju stoka izbjegava (Šoštarić-Pisačić, 1968). Odumiranje i gubici biljne mase pašnjaka nastaju i od gaženja tratine stokom, od zagađivanja balegom i urinom (Hirata i Higashiyama, 1996), od ostavljanja pojedinih "bujnih" mjesta onih biljnih vrsta koje stoka izbjegava, posebno se to događa na mjestima gdje goveda preživaju jer tu pojačano izlučuju ekskreme (Murphy i sur., 1995). Različite životinje različito pasu i tako mogu imati različiti utjecaj na razvoj biljne vrste. Barthram (1981) navodi da ovce radije smanjuju količinu konzumirane krme nego da pasu dio tratine sa odumrlim dijelovima. Slično čine i goveda (Ganskopp, 1993).

## Materijal i metode

Na 610-880 m nadmorske visine (Medvednica) zasnovana je travno djetelinska smjesa (TDS) sastavljena od bijele djeteline (*Trifolium repens* cv. Rivendel) - 6,4 kg ha<sup>-1</sup>, klupčaste oštrice (*Dactylis glomerata* cv. Amba) - 12 kg ha<sup>-1</sup> i vlasnjače livadne (*Poa pratensis* cv. Balin) - 6,4 kg ha<sup>-1</sup>. Tijekom tri godine (2000.- 2002.) praćen je utjecaj napasivanja (govedima i ovcama, pasmina Charolais) te gnojidbe sa 150 kg dušika ha<sup>-1</sup> (N<sub>150</sub>) u odnosu na kontrolu (N<sub>0</sub>) na prinos travnjaka, masu te udio odumrlih biljnih dijelova.

Prije sjetve u tlo je unešeno 40 kg N, 130 kg P<sub>2</sub>O<sub>5</sub> i 130 kg K<sub>2</sub>O po hektaru. Fosfor i kalij su u istim količinama aplicirani u jesen i u narednim godinama.

Istraživanja su postavljena kao dvofaktorijelni pokus po shemi slučajnog bloknoeg rasporeda u tri ponavljanja.

Ukupna površina (0,6 ha) podijeljena je na 12 pregona (0,05 ha) sa opterećenjem pašnjaka od 10-12 junica po pregonu, te 40 ovaca sa pripadajućim janjcima po pregonu.

Godišnja aplikacija dušika kod tretmana N<sub>150</sub> izvođena je u šest obroka po 25 kg ha<sup>-1</sup> N, prvi puta neposredno pred kretanje vegetacije u proljeće (ožujak), te poslije svakog turnusa napasivanja.

Za određivanje početka napasivanja koristio se mjerni štap za mjerenje visine tratine. Napasivanje govedima započinjalo je pri visini tratine od 17 do 20 cm, a napasivanje ovcama kod visine 13-15 cm. Napasivanje se odvijalo do visine tratine od 5 cm, a trajalo je maksimalno 24 sata po pregonu.

Prva godina je bila izrazito sušna (goveda su pasla u 5, a ovce u 7 turnusa), a druge dvije godine su bile humidnije (goveda su pasla u 6, a ovce u 7 turnusa).

Prinos zelene mase pašnjaka utvrđivan je košnjom (ručnim škarama za travu) i vaganjem pokošene biljne mase s 12 slučajno odabranih mjesta po pregonu površine 0,25 m<sup>2</sup>, neposredno prije svakog turnusa napasivanja. Uzimanjem 12 poduzoraka od 0,1 kg pokošene biljne mase po pregonu, razdvajanjem uzorka na žive i odumrle biljne dijelove i sušenjem do konstantne mase na 105 °C utvrđen je prinos odumrlih i živih dijelova TDS te ukupni prinos suhe tvari pašnjaka. Dobiveni podaci su obrađeni u statističkom programu SAS (SAS Institut, 1997), koristeći GLM proceduru.

## Rezultati i rasprava

U trogodišnjem prosjeku, napasivanjem ovcama utvrđen je značajno veći prinos ST TDS (Tablica 1.) u odnosu na varijantu napasivanu govedima (P<0,05). Suprotno tome, značajno više odumrle ST TDS izmjereno je na varijantama napasivanim govedima (za 0,26 t ha<sup>-1</sup>) (P<0,01). Promatrano po pojedinim godinama istraživanja, iako je redovito više biljnih dijelova odumiralo na varijantama napasivanim govedima, značajno veće odumiranje ustanovljeno je jedino u 2001. godini (P<0,01). Rezultati se slažu sa rezultatima Murphy i sur. (1995.) koji su kod rotacijskog napasivanja govedima utvrdili 35% nepopašenost pašnjaka, a kod ovaca je cjelokupna površina bila popašena.

Razlog većeg udjela odumrle tvari na pregonima napasivanim govedima zasigurno u jednom dijelu leži i u kasnijem početku napasivanja na pregonima napasivanim govedima (Maćešić, 2002).

Varijantom N<sub>150</sub> postignut je u trogodišnjem prosjeku značajno veći prinos ST TDS nego na varijanti bez primjene dušika (P<0,01).

Varijanta dušika i interakcija napasivanje x gnojidba nisu imale opravdan utjecaj na masu suhe tvari odumrlih biljnih dijelova TDS i njen udio u smjesi, ni po godinama istraživanja niti u trogodišnjem prosjeku.

U razdoblju od 2000.-2002. godine, neovisno o tretmanu, utvrđene su značajne razlike u masi i udjelu odumrlih biljnih dijelova u ukupnoj suhoj tvari tratine (P<0,01). Iako je podjednako biljnih dijelova (t ha<sup>-1</sup>) odumrlo u prve dvije godine, a manje u trećoj godini, značajno najveći udio odumrle tvari u tratini bio je u prvoj godini kada je zbog izrazite suše prinos ST TDS bio najmanji.

**Tablica 1. Utjecaj napasivanja i gnojidbe dušikom na prinos suhe tvari travno-djetelinske smjese (t ha<sup>-1</sup>), masa suhe tvari odumrlih biljnih dijelova (t ha<sup>-1</sup>) i udio odumrlih biljnih dijelova (%) u ukupnom prinosu suhe tvari travno-djetelinske smjese, 2000-2002.**

Tretman	2000			2001		
	ST TDS t ha <sup>-1</sup>	Odumrla tvar		ST TDS t ha <sup>-1</sup>	Odumrla tvar	
		ST t ha <sup>-1</sup>	%		ST t ha <sup>-1</sup>	%
Goveda (C)	8,67	0,97	11,41	13,31	1,23	8,10
Ovce (S)	9,56	0,86	8,75	13,55	0,63	4,69
Significance	NS	NS	NS	NS	**	NS
N0	7,97	0,80	10,11	12,65	0,91	6,62
N150	10,25	1,04	10,05	14,20	0,96	6,18
Significance	NS	NS	NS	NS	NS	NS
CN0	6,89	0,79	11,43	12,60	1,22	8,48
CN150	10,44	1,15	11,40	14,01	1,24	7,73
SN0	9,05	0,81	8,78	12,70	0,60	4,75
SN150	10,06	0,92	8,71	14,40	0,67	4,64
Significance	NS	NS	NS	NS	NS	NS
Prosjeck	9,11 <sup>c</sup>	0,92 <sup>a</sup>	10,08 <sup>a</sup>	13,43 <sup>a</sup>	0,93 <sup>a</sup>	6,40 <sup>b</sup>
Significance						

Tretman	2002			2000/2002		
	ST TDS t ha <sup>-1</sup>	Odumrla tvar		ST TDS t ha <sup>-1</sup>	Odumrla tvar	
		ST t ha <sup>-1</sup>	%		ST t ha <sup>-1</sup>	%
Goveda (C)	10,89	0,33	3,08	10,96 <sup>b</sup>	0,84 <sup>a</sup>	7,53 <sup>a</sup>
Ovce (S)	11,50	0,23	2,25	11,54 <sup>a</sup>	0,58 <sup>b</sup>	5,23 <sup>b</sup>
Significance	NS	NS	NS	*	**	**
N0	10,16	0,24	2,50	10,26 <sup>b</sup>	0,65	6,41
N150	12,24	0,32	2,82	12,23 <sup>a</sup>	0,77	6,35
Significance	NS	NS	NS	**	NS	NS
CN0	9,71	0,26	2,71	9,73	0,76	7,54
CN150	12,08	0,39	3,45	12,18	0,93	7,52
SN0	10,61	0,22	2,30	10,79	0,54	5,28
SN150	12,40	0,25	2,20	12,28	0,61	5,18
Significance	NS	NS	NS	NS	NS	NS
Prosjeck	11,20 <sup>b</sup>	0,28 <sup>b</sup>	2,66 <sup>c</sup>	11,25	0,71	6,38
Significance				**	**	**

Signifikantno na razini: \*0,05; \*\*0,01; NS Nije signifikantno;

Prosječne vrijednosti u redovima označene različitim slovima su signifikantno različite

TDS - travno-djetelinska smjesa; ST - suha tvar; Goveda (C); ovce (S)

N<sub>0</sub> - 0 kg ha<sup>-1</sup> god<sup>-1</sup> dušika / kg ha<sup>-1</sup>; N<sub>150</sub> - 150 kg ha<sup>-1</sup> god<sup>-1</sup> dušika / kg ha<sup>-1</sup>

## Zaključak

Napasivanje ovaca u odnosu na napasivanje govedima djelovalo je na povećanje prinosa ST TDS za 5,3%, smanjenje mase ST odumrlih biljnih dijelova za 30,95% i smanjenje udjela ST odumrlih biljnih dijelova u ukupnom prinosu ST TDS za 30,5%.

Aplikacijom 150 kg N ha<sup>-1</sup> u odnosu na kontrolnu varijantu (N<sub>0</sub>) postignut je za 18,5% veći prinos ST TDS, ali nije bilo utjecaja na masu suhe tvari odumrlih biljnih dijelova kao ni na udio odumrle tvari u ukupnom prinosu suhe tvari tratine.

Od ukupno utvrđenih 33,74 t ha<sup>-1</sup> ST TDS u tri godine istraživanja, u 2000. godini je utvrđeno 27%, u 2001. 39,8% i u 2002. godini 33,2%. Od prve do treće godine istraživanja, ustanovljeno je značajno povećanje udjela odumrlih biljnih dijelova u ukupnom prinosu ST TDS.

Klimatski uvjeti bili su značajan čimbenik prinosa i odumiranja biljnih dijelova.

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# Allelopathic inhibitory effect of *Pteridium aquilinum* (L.) Kuhn on germination of *Festuca arundinacea* Schreb. and *Trifolium pratense* L.

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## Abstract

Significant areas of land formerly used in Lika, due to cessation of agricultural production are covered with bracken (*Pteridium aquilinum* (L.) Kuhn.), opening the way for vegetation succession to the forest stage. The aim of this study was to determine the competitiveness of two forage crops in these areas with the aim of suppressing and crowding out bracken. The experiment was performed *in vitro* in which the seeds of tall fescue (*Festuca arundinacea* Schreb.) and red clover (*Trifolium pratense* L.) were treated with extract of bracken, *Pteridium aquilinum*. We measured the number of germinated seeds and the length of plumule and radicle. The results show a decrease in germination of red clover for 2%, respectively tall fescue by 31%. Radicle length in red clover was reduced by 33.1%, while the reduction in length at tall fescue was 66.7% for radicle and 51.1% for plumule. This study confirmed allelopathic inhibitory effect of bracken extract on red clover and tall fescue germination and primary development. The data suggest a potentially large losses in efforts of introduction of these crops through sowing on bracken fields, which especially applies to tall fescue.

Key words: allelopathy, agriculture restoration, bracken, *Pteridium aquilinum*, *Festuca arundinacea*, *Trifolium pratense*

## Alelopatski inhibicijski utjecaj bujadi (*Pteridium aquilinum* (L.) Kuhn) na klijavost trskolike vlasulje (*Festuca arundinacea* Schreb.) i crvene djeteline (*Trifolium pratense* L.)

### Sažetak

Uslijed smanjenja i obustave poljoprivredne proizvodnje u Lici značajan dio nekad korištenih površina, zauzela je bujad (*Pteridium aquilinum* (L.) Kuhn.) tvoreći bujadnice, čime je na tom prostoru otvoren put vegetacijskoj sukcesiji prema šumi. Cilj ovog istraživanja bio je utvrditi potencijalnu kompetitivnost dviju krmnih kultura na takvim prostorima, a u cilju potiskivanja i iskorjenjivanja bujadi. Pokus je proveden *in vitro*, gdje je sjeme trskolike vlasulje (*Festuca arundinacea* Schreb.) i crvene djeteline (*Trifolium pratense* L.) tretirano ekstraktom bujadi. Mjeren je broj iskljalih sjemenki te dužine klica i korijenaka. Rezultati pokazuju kako se u tretmanu ekstraktom bujadi smanjuje klijavost crvene djeteline za 2%, a kod trskolike vlasulje za 31%. Dužina korijenka kod crvene djeteline bila je smanjena za 33,1% dok je redukcija kod trskolike vlasulje iznosila 66,7% za korijenak, odnosno 51,1% za klicu. Ovo istraživanje je potvrdilo alelopatski inhibicijski utjecaj ekstrakta paprati na klijavost i primarni razvoj crvene djeteline i trskolike vlasulje. Dobiveni podaci sugeriraju na potencijalne velike gubitke uslijed

usijavanja navedenih krmnih kultura na bujadištima, što se posebno odnosi na trstikastu vlasulju.

Ključne riječi: alelopatija, obnova poljoprivredne proizvodnje, bujad, *Pteridium aquilinum*, *Festuca arundinacea*, *Trifolium pratense*

## Introduction

Large areas in Lika (Croatia) of nearly 200 km<sup>2</sup> are occupied by bracken habitats or stands dominated with common bracken (*Pteridium aquilinum* (L.) Kuhn). From the past century, especially within the last 20 years, livestock production practice in these areas has been significantly decreased and somewhere fully suspended. In the past, bracken was collected and used for a livestock litter. Gradual field work abandonment in these areas induced vegetation succession through the emergence of pioneer tree species such as aspen (*Populus tremula*), birch (*Betula verrucosa*), which opened the path of development towards the forest (Topic & Vukelic, 2009). Bracken fields rehabilitation and their return to agricultural production is not a simple process for a number of factors. Brackens build dense canopy which overshadow the ground and has a strong and deep rhizome which is difficult to eradicate. In addition to the fern-toxic in animal nutrition (Cooper-Driver, 1976; Pamukcu et al., 1978), it also contains a number of allelochemicals which have strong allelopathic effect on other plants (Gliessman, 1976). Recent research focused on rooting out brackens showed that it is possible to eradicate brackens, if mowing is performed at least twice a year with application of herbicides and by resowing with competing species (Petrov & Marrs 1999, Marrs & Watt, 2006). We conducted this survey on this track with an aim to determine the potential of two forage crops: red clover (*Trifolium pratense* L.) and tall fescue (*Festuca arundinacea* Schreb.), have for sowing in the areas dominated by bracken.

## Materials and methods

Plant materials used in this study were the above-ground parts of bracken (*Pteridium aquilinum*), grass seeds of tall fescue (*Festuca arundinacea* cv. BARADISO) and red clover (*Trifolium pratense* cv. VESNA). Respective varieties of grass and clover were selected due to its current availability, but also because of the previously conducted research in Grassland Research Centre of Faculty of Agriculture. Fern extract was prepared for the treated seed of grass and clover. The concentration of applied bracken extract was adjusted with the previously determined yield of dry matter of brackenfields which was 10917 kg DM ha<sup>-1</sup>, and is converted to the Petri dish surface of 7 cm in radius in which the experiment was implemented. The experiment was set in quadruplicate, where in every dish with a three layer cellulose paper sheet 25 seeds were topped with 10 ml of distilled water, in the control/blank group, while in the treatment group they were topped with 10 ml of aqueous bracken extract. They were all placed on germination in darkness at room temperature between 20 ° and 25 ° C. After 6 (*T. pratense*) and 7 days (*F. arundinacea*), dishes with the germinated seeds were scanned and the length of radicle and plumule was measured on rectified images using the software package ArcGIS 9 (ESRI).

## Results and discussion

It was determined that the germination level of red clover in the treated group declined by 2% (from 100 to 98). Germination of tall fescue in control group was significantly lower at start with 61%, while in the treatment it was 42%, which marked a decline of 31% (Figure 1).

After 6 days, the radicle length of red clover in the control group varied between 6.1 and 85.5 mm, with the average of 55.3 mm; while in the treatment with the bracken extract, the radicle length range was between 9.3 and 68.9 mm with an average value of 37 mm which reduced the normal radicle length by 33.1%. The average length of tall fescue radicle in the control group after 7 days was 25.6 mm, while the average length of plumule was 21.9 mm. In the treated group of red clover, the average radicle length decreased to 8.5 mm, while the plumule was on average 10.7 mm long, so radicle was reduced by 66.7% and plumule by 51.1% (Table 1). In addition to reducing the length of radicle and plumule, changes were also recorded in their mutual length ratio, k:r (control) = 1:0.85, k:r (treatment) = 1:1.26, suggesting amplified depressing effect especially on the development of the root system.

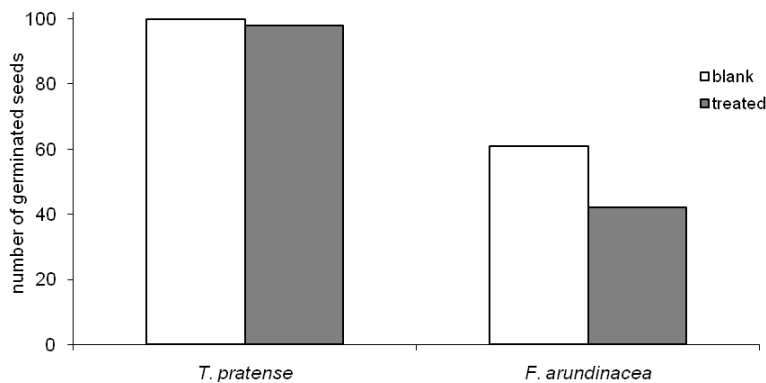


Figure 1. Decline in seed germination of red clover and tall fescue treated with bracken extract

Table 1. Differences in the length of plumule (p) and radicle (r) between the control group and treated groups, r (T), p (T), n - number of germinated seeds, SD - standard deviation

	Trifolium pratense		Festuca arundinacea			
	r	r(T)	r	r(T)	k	k(T)
n	100	98	61	42	61	42
average(mm)	55.3	37.0	25.6	8.5	21.9	10.7
SD	13.7	11.5	13.5	6.4	13.9	6.4

### Conclusions

This study confirmed allelopathic inhibitory effect of bracken extract on germination and development of red clover and tall fescue. The data suggests potentially large losses in efforts of introduction of these crops through sowing on bracken fields, which especially applies to tall fescue.

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# The effect of Fe/Zn ratio on the evolution of latent zinc deficiency in crop plants

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## Abstract

Zn is one of the most important micronutrient in human body and in plants as well. The absence of zinc damages several physiological processes. As a result for the expected yield is not negligible. Almost half of the world's cereal crops are deficient in Zn, leading to poor crop yield. In fact, one-third of the world's population is at risk of Zn deficiency in rates, ranging from 4% to 73% depending on the given country. Zn deficiency in agricultural soils is also a major global problem affecting both crop yield and quality.

In this study, the effect of different Fe/Zn ratio on some physiological parameters of maize and cucumber seedlings were investigated such as volume of shoots and roots, number and distance of internodes and in one case the element contents.

Key words: Fe/Zn ratio, latent Zn deficiency, volume of shoots and roots, number and distance of internodes

## Introduction

High pH and calcium carbonate contents are the main reasons for the low availability of Zn for plants (Karimian and Moafpouryan, 1999). It has been reported that the high-concentration application of phosphate fertilisers reduces Zn availability (Khosgoftarmanesh et al., 2006). Usually, Zn is absorbed strongly in the upper part the soil, and it has been observed that the uptakeable Zn contents of soil are lower than 1.4 mg kg<sup>-1</sup>. The critical deficiency level of Zn in soil has been reported to be 0.6 to 2.0 mg kg<sup>-1</sup> depending on extraction method (Bhupinder et al., 2005). According to Takkar et al. (1989) the critical deficiency level of Zn in maize is between 0.38 - 1.14 mg kg<sup>-1</sup> in different soil of India. Nambiar and Motiramani (1981) established that the Fe/Zn ratio in corn tissue appears to be a promising diagnostic tool for prediction of latent Zn deficiency in crop plants. Gangwar and Mann (1972) suggested that the excess Fe can cause Zn deficiency in rice. Zare et al. (2009) has examined DTPA and EDTA extractable Zn critical level and tissue Fe/Zn ratio with 12 soil series and two Zn fertiliser (0 and 15 mg Zn kg<sup>-1</sup> as zinc sulphate) in greenhouse experiment. It has published, that the critical iron-zinc ratio in corn shoot was 3.9 this value indicates latent Zn deficiency. According to Warnock (1970) the Fe concentration seven-times and the Mn concentration two-times higher than the control in Zn-deficient plants. It is observed, that the antagonism between Fe, Zn, Mn lead to latent Zn deficiency in the case of high Fe concentration. Marschner (1995) established, that the antagonistic effect of added Zn on Fe uptake appear when the available Fe concentration is low in the soil.

## Materials and methods

The experimental plants were maize (*Zea mays L. cvs. Reseda SC.*) and cucumber (*Cucumis sativum L. cv. Delicatess*). Monocot and dicot plants were chosen to investigate the effects of differing Fe/Zn causing latent Zn deficiency, because they have different nutrient uptake mechanism.

The seeds were germinated on moistened filter paper at 25°C. The seedlings were transferred to a continuously aerated nutrient solution of the following composition: 2.0 mM Ca(NO<sub>3</sub>)<sub>2</sub>, 0.7 mM K<sub>2</sub>SO<sub>4</sub>, 0.5

mM MgSO<sub>4</sub>, 0.1 mM KH<sub>2</sub>PO<sub>4</sub>, 0.1 mM KCl, 1μM H<sub>3</sub>BO<sub>3</sub>, 1μM MnSO<sub>4</sub>, 0.25 μM CuSO<sub>4</sub>, 0.01 μM (NH<sub>4</sub>)<sub>6</sub>Mo<sub>7</sub>O<sub>24</sub>. The nutrient solution of cucumber contains 10μM H<sub>3</sub>BO<sub>3</sub>. The iron as Fe-EDTA was added to the nutrient solution in a concentration of 10<sup>-4</sup>M. The seedlings were grown under controlled environmental conditions (light/dark regime 16/8 h at 20-25 °C, 65-75% relative humidity and a photosynthetic photon flux density 300 μmol m<sup>-2</sup>s<sup>-1</sup>. The element contents were measured with ICP spectrophotometer. The volume of shoots and roots, number and distance of internodes and in one case the element contents were also measured. 15 different treatments were applied (Table 1.)

**Table 1. The different proportioned Fe/Zn treatments**

Number	Treatments	Number	Treatments	Number	Treatments
1	Control	6	1xZn+5xFe	11	5xZn+10xFe
2	-Zn+1xFe	7	1xZn+10xFe	12	10xZn+ -Fe
3	-Zn+5xFe	8	5xZn+ -Fe	13	10xZn+1xFe
4	- Zn+10xFe	9	5xZn+1xFe	14	10xZn+5xFe
5	1xZn+ -Fe	10	5xZn+5xFe	15	10xZn+10xFe

### Results and discussion

The effect of different Fe/Zn ratio was examined on some physiological parameters of maize and cucumber seedlings. The high amount of iron induced latent Zn deficiency in accordance with the literature. The contents of Fe and Zn were measured and the ratio of Fe/Zn was also calculated in the case of cucumber leaves (Table 2). In this case the plants have grown on totally Zn-deficient nutrient solution.

**Table 2. The element contents (mg plant<sup>-1</sup>) and Fe/Zn ratio of 23-day old cucumber leaves grown on normal (control) and totally Zn-deficient nutrient solution (-Zn) (n=3±s.e.). Significant difference to the control: \*p <0.05, \*\*\*p<0.001.**

Elements	Control	- Zn
Fe	99,40±1,04	141,25±35,70*
Zn	41,60±4,55	15,58±2,90***
Fe/Zn ratio	2,41±0,29	9,22±2,55

**Table 3. The effect of different zinc (Zn) and iron (Fe) treatments on the volume of shoots and roots in the case of maize seedlings (cm<sup>3</sup> plant<sup>-1</sup>) (n=8±s.e.). Significant difference to the control: \*p <0.05, \*\*p<0.01, \*\*\*p<0.001.**

Treatments		shoots	roots
1	Control	9,0000±0,80	4,3125±1,16
2	- Zn+1xFe	7,5625±0,50	4,7500±1,10
3	- Zn+5xFe	4,8375±0,92	2,8500±0,34
4	- Zn+10xFe	2,9125±0,49**	1,3750±0,36***
5	1xZn+ -Fe	6,7500±1,56	2,6750±0,80
6	1xZn+5xFe	4,8500±0,95	2,7500±0,71
7	1xZn+10xFe	6,0428±1,70	2,1714±0,66*
8	5xZn+ -Fe	8,2000±1,13	2,9125±0,65
9	5xZn+1xFe	10,3125±1,71	5,2250±0,36
10	5xZn+5xFe	9,0429±1,50	5,4375±1,30
11	5xZn+10xFe	8,4167±1,90	1,9500±0,43**
12	10xZn+-Fe	4,8250±1,24	1,6125±0,45***
13	10xZn+1xFe	10,9000±1,80	8,4500±1,20
14	10xZn+5xFe	10,5500±0,53	5,1250±0,58
15	10xZn+10xFe	9,0000±1,40	4,0625±1,06

As our results show (Table 2) the iron contents of Zn-deficient cucumber leaves were extremely higher with 42% than the control. On the other hand a zinc concentration in Zn-deficient plants is one third to the control.

## The effect of Fe/Zn ratio on the evolution of latent zinc deficiency in crop plants

The ratio of Fe and Zn was also calculated. The Fe/Zn ratio of control plant was under 3.9 ( $2,41 \pm 0,29$ ), which is not the critical Zn deficiency level, but in the case of -Zn treatment the ratio was  $9,22 \pm 2,55$ , which shows the induced latent Zn deficiency via higher Fe contents (Zare et al., 2009).

The Zn deficiency can cause damage in the development and growth of plant (Kalocsai, 2006). The volume of shoots and roots of plants were measured to determine the effect of different Fe/Zn ratio (Table 3, Figure 1).

The added different amount of Fe decreased the volume both of shoots and roots in Zn-deficient treatments directly proportional to the concentration of iron comparison to the control. The application of 1xZn treatments also reduced the volume, but that not depend on the concentration of iron. The highest concentration of Zn increased the volume of shoots and roots of maize directly proportional to the concentration of iron, because the level of Fe is lower or equal with the Zn.

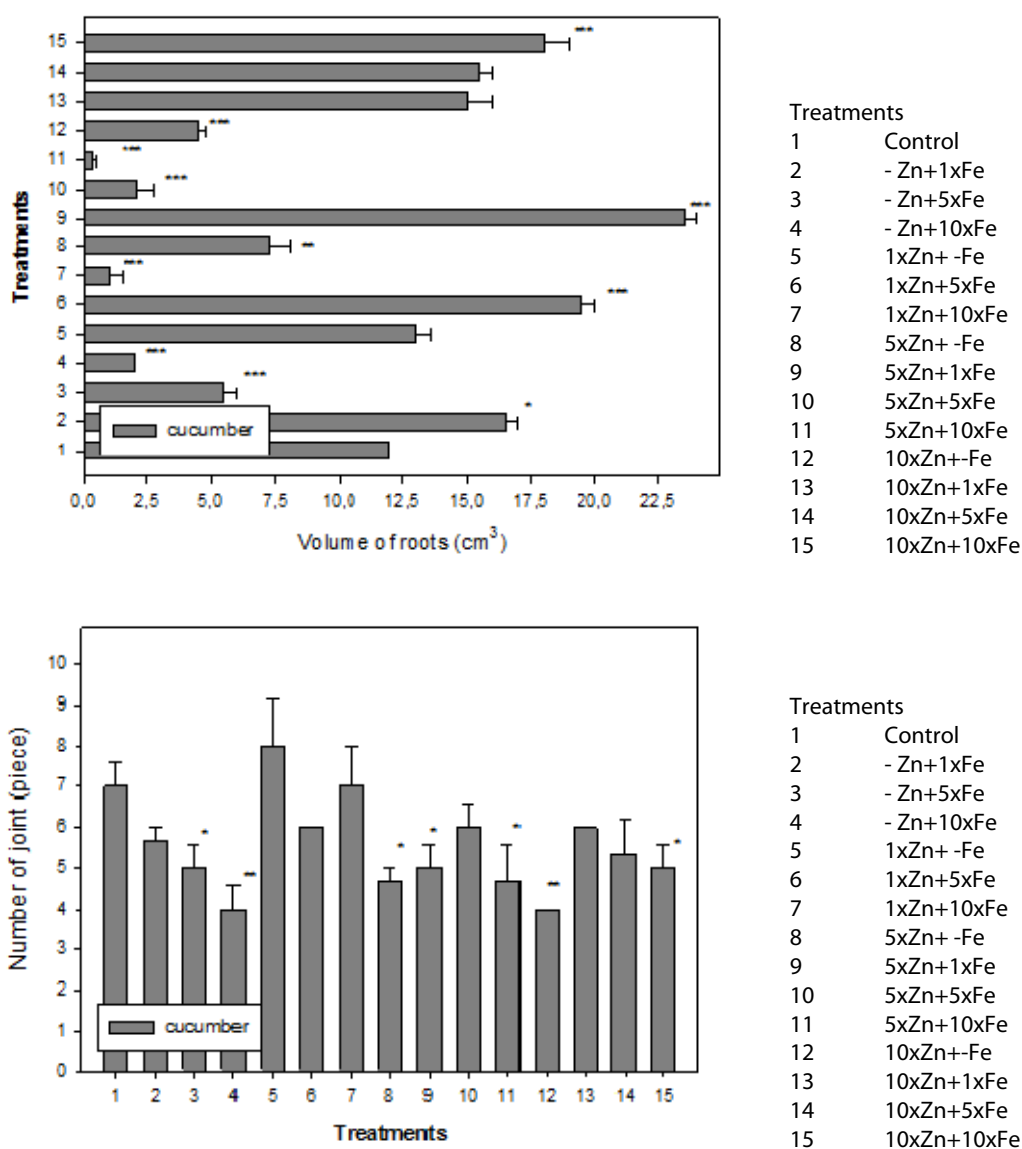


Figure 1. The effect of different zinc (Zn) and iron (Fe) treatments on the volume of shoots and roots in the case of cucumber seedlings (cm<sup>3</sup> plant<sup>-1</sup>) (n=4±s.e.). Significant difference to the control: \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001.

The volume of roots represented same tendency under increasing iron treatment in case of Zn-deficient cucumber, comparison to the volume of roots of maize. Low values were measured in the case of treatment 3, 4, 7, 8, 10, 11, 12 comparisons to the control, the treatment 2, 6, 9, 15 exceed the control value.

According to several scientists the non-optimal concentration of Zn and Fe can produce Zn deficiency in plant tissues, as a consequence of this, the internodes of shoots get shorter and the plant dwarf, which evidence the retarded auxin synthesis (Kalocsai, 2006). Therefore the number and average distance of internodes of cucumber were also investigated (Figure 2 and Table 4).

Figure 2. The effect of different zinc (Zn) and iron (Fe) treatments on the number of internodes of cucumber shoots (piece plant<sup>-1</sup>) (n=6±s.e.). Significant difference to the control: \*p <0.05, \*\*p<0.01.

**Table 4. The effect of different zinc (Zn) and iron (Fe) treatments on number and average distance of internodes of cucumber seedlings (cm<sup>3</sup> plant<sup>-1</sup>) (n=6±s.e.). Significant difference to the control: \*p <0.05, \*\*p<0.01, \*\*\*p<0.001.**

Treatments		number of internodes	average distance of internodes
1	control	7,0±1,0	2,38±0,78
2	- Zn+1xFe	5,7±0,5	0,68±0,32***
3	- Zn+5xFe	5,0±1,0*	0,35±0,13***
4	- Zn+10xFe	4,0±1,0**	0,24±0,04***
5	1xZn+ -Fe	8,0±2,0	1,84±1,03
6	1xZn+5xFe	6,0±0,0	0,72±0,32***
7	1xZn+10xFe	7,0±1,7	1,38±0,70**
8	5xZn+ -Fe	4,7±0,5*	0,59±0,04***
9	5xZn+1xFe	5,0±1,0*	0,81±0,54***
10	5xZn+5xFe	6,0±1,0	1,04±0,05***
11	5xZn+10xFe	4,7±1,5*	0,44±0,36***
12	10xZn+ -Fe	4,0±0,0**	0,30±0,18***
13	10xZn+1xFe	6,0±0,0	0,90±0,19***
14	10xZn+5xFe	5,3±1,5	0,59±0,30***
15	10xZn+10xFe	5,0±1,0*	0,50±0,20***

As our results show in Table 4 and Figure 2, the different iron concentration modified the number of internodes. The increasing Fe doses decreased the number of internodes in the case of Zn deficiency and 10 times higher Zn doses, and increased the number of internodes in case of treatments 5xZn.

The average distance of internodes of cucumber was reduced by -Zn treatment. The level of reduction depended on the added iron concentration in case of -Zn treatments. Significant reduction was measured besides Zn application in all cases comparison to the control.

## Conclusions

Correspondingly to Zare et al. (2009) and Warnock (1970) it was observed, that the Fe/Zn ratio of control plant is under 3.9 is the critical Zn deficiency level, but in the case of -Zn treatment the ratio is exceeded the 3.9 value, which showed induced latent Zn deficiency via higher Fe contents. The added different amount of Fe decreased the volume of shoots and roots in Zn-deficient treatments directly proportional to the concentration of iron comparison to the control. The increasing Fe doses decreased the number of internodes in Zn deficiency and in case of 10 times higher Zn treatment as well. The average distance of internodes of cucumber was reduced in all cases comparison to the control.

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# Smanjenje prinosa poljoprivrednih kultura u uvjetima bez navodnjavanja na području sjeveroistočne Bosne

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## Sažetak

U radu su predstavljena istraživanja koja su na području sjeveroistočne Bosne provedena s ciljem utvrđivanja utjecaja agroklimatskih uvjeta na smanjenje prinosa kukuruza, soje i krumpira. Analizirani su klimatski podaci s dvije meteorološke stanice: Tuzla i Bijeljina (razdoblje 1961-2008. god.). U obradi podataka korišten je kompjuterski program CROPWAT. Utvrđeno smanjenje prinosa na području Tuzle je iznosilo od 5% na srednje teškom do 9,3% na teškom tlu, a na području Bijeljine od 9,3% na srednje teškom do 16,1% na teškom tlu, njegov trend i učestalost jasno ukazuju na potrebu promjene dosadašnjeg pristupa u načinu korištenja tla i značaj izgradnje natapnih sistema na ovom području.

Ključne riječi: smanjenje prinosa, referentna evapotranspiracija, efektivne padavine CROPWAT 8.0, ratarske kulture

## Crops yield reduction in conditions without irrigation in northeastern Bosnia

### Abstract

This paper presents the research carried out in order to assess the influence of agroclimatic conditions to yield reduction of maize, soybean and potato. Climate data from two meteorological stations were used: Tuzla and Bijeljina for the period 1961-2008. Data were processed with the aid of the CROPWAT computer program. It was found that the yield reduction in the Tuzla area ranged from 5% on medium to 9.3% on heavy soil, and in the Bijeljina area from 9.3% on medium to 16.1% on heavy soil, its trend and frequency clearly indicate the need to change the current approach of soil use and the importance of building irrigation system in this area.

Key words: yield reduction, reference evapotranspiration, effective rainfall, CROPWAT 8.0, field crops

### Uvod

Područje sjeveroistočne Bosne predstavlja jedan od najznačajnijih prostora za organiziranje poljoprivredne proizvodnje na području BiH. Trenutna nekonkurentnost poljoprivredne proizvodnje na ovom prostoru prvenstveno je posljedica niskog tehnološkog nivoa proizvodnje, usitnjenosti posjeda i niskih prinosa. S druge strane, slab institucionalni kapacitet, posebno poljoprivredne stručne službe, niska stopa ulaganja i nepostojanje ili nefunkcioniranje poljoprivredne i ruralne infrastrukture, ozbiljna su ograničenja za

povećanje produktivnosti ovog sektora. Manjak padalina koji se na ovom području kreće oko 100 mm (Vlahinić, 2000) nepovoljno se odražava na poljoprivrednu proizvodnju, koja se uglavnom odvija u uvjetima bez navodnjavanja. U ovom radu predstavljena su istraživanja koja su na području sjeveroistočne Bosne provedena s ciljem utvrđivanja utjecaja deficita vode na smanjenje prinosa poljoprivrednih kultura, te značaja i potrebe poduzimanja odgovarajućih mjera prilagodbe klimatskim promjenama.

### Materijal i metode

Za sagledavanje klimatskih karakteristika područja sjeveroistočne Bosne korišteni su podaci meteoroloških stanica Tuzla (305 m.n.m) i Bijeljina (90 m.n.m), period 1961-2008. god., koje prema položaju i nadmorskoj visini na kojoj se nalaze dosta objektivno predstavljaju prostor na kome se odvija glavina poljoprivredne proizvodnje na ovom području. U obuhvaćenom vremenskom periodu za područje Bijeljine nedostaju podaci o klimi za razdoblje 1997-2008. god., jer tijekom rata nisu vršena mjerenja. Razmatrane su slijedeće ratarske kulture: kukuruz, soja i krumpir. Vrijednosti referentne evapotranspiracije ( $ET_o$ ) utvrđene su metodom Penman-Monteitha (Allen i sur., 1998), efektivne padavine USBR metodom (Dastone, 1975), a evapotranspiracije kultura ( $ET_c$ ) iz odnosa  $ET_c = ET_o \times k_c$ , uz korištenje kompjuterskog programa CROPWAT (Smith, 1992.). Vrijednosti koeficijenta kulture ( $k_c$ ) tijekom vegetacije određene su u zavisnosti od rokova sjetve, razvojne faze kulture i dužine njenog trajanja.

Manjak vode u tlu utvrđen je uz uvažavanje podataka o karakteristikama tla preuzetih iz Pedološke karte BiH (Zavod za agropedologiju Sarajevo, 1990.), prema kojoj je utvrđeno da su na poljoprivrednim površinama razmatranog područja uglavnom zastupljena tla srednje teškog i teškog teksturnog sastava. Postotno smanjenje prinosa u odnosu na optimalne uvjete proizvodnje, nastalo kao rezultat vodnog stresa, određeno je prema FAO metodologiji (Doorenbos i sur., 1986.).

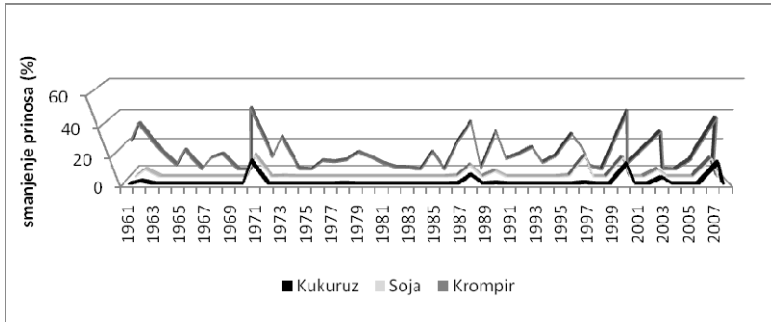
### Rezultati i rasprava

U tablici 1. date su srednje vrijednosti referentne evapotranspiracije i efektivnih padalina izračunate na osnovu raspoloživih klimatskih podataka za područje Tuzle i Bijeljine za period 1961-2008. god.

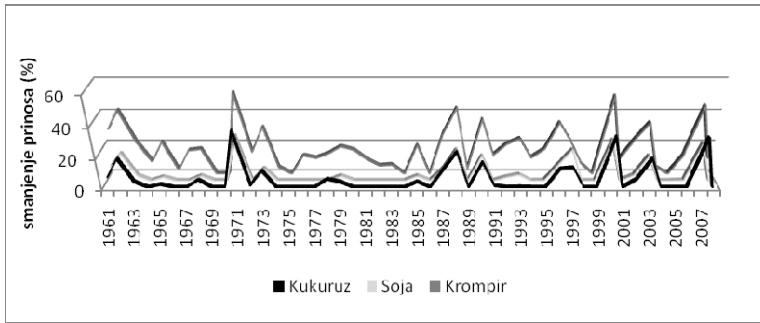
Tablica 1. Referentna evapotranspiracija i efektivne padaline na području Tuzle i Bijeljine za razdoblje 1961 - 2008. god.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Veg	God
TUZLA														
Referentna evapotranspiracija (mm)	12	22	46	71	98	111	122	109	69	40	19	11	580	731
Efektivne padaline (mm)	50	43	49	60	65	87	82	58	68	67	68	63	420	759
BIJELJINA														
Referentna evapotranspiracija (mm)	12	22	44	70	102	116	128	112	70	40	18	11	598	745
Efektivne padaline (mm)	50	40	43	55	60	68	64	54	59	58	57	56	359	664

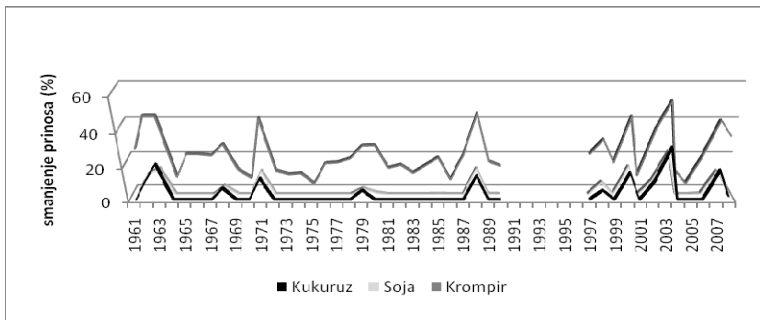
Usporedbom navedenih podataka uočava se razlika koja tijekom vegetacije iznosi 160 mm na području Tuzle, odnosno 239 mm na području Bijeljine, što upućuje na zaključak da padavine na područjima Tuzle i Bijeljine, a moglo bi se reći i čitave sjeveroistočne Bosne, ne zadovoljavaju u potpunosti potrebe razmatranih kultura za vodom. Smanjenje prinosa kukuruza, soje i krumpira koje se može očekivati u postojećim uvjetima na tlima srednje teškog i teškog teksturnog sastava, po godinama istraživanja, prikazano je u grafovima 1, 2, 3 i 4. U istraživanom razdoblju najveće smanjenje prinosa utvrđeno je kod krumpira: 43,6% na srednje teškom i 53,2% na teškom tlu (1971. god. na području Tuzle), odnosno 51,0% na srednje teškom i 59,6% na teškom tlu (2003. god. na području Bijeljine). U istim godinama, koje se mogu okarakterizirati kao najsušnije, veće vrijednosti smanjenja prinosa utvrđene na tlu težeg teksturnog sastava. Posebno se ističe 2003. god. kada je utvrđeno smanjenje prinosa kukuruza na području Bijeljine iznosilo 31,3%, a soje 25,7%. Za razliku od kukuruza i soje, smanjenje prinosa kod krumpira je evidentno i u hidrološki povoljnijim godinama



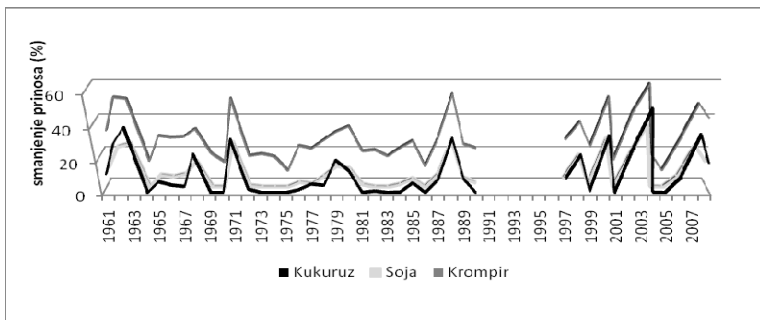
Grafikon 1. Smanjenje prinosa po godinama istraživanja na srednje teškom tlu - Tuzla



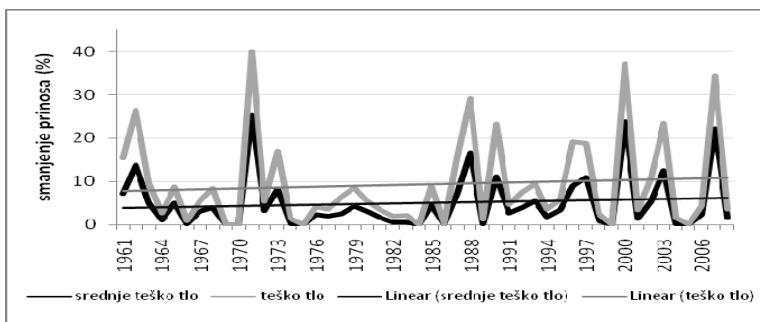
Grafikon 2. Smanjenje prinosa po godinama istraživanja na teškom tlu - Tuzla



Grafikon 3. Smanjenje prinosa po godinama istraživanja na srednje teškom tlu - Bijeljina



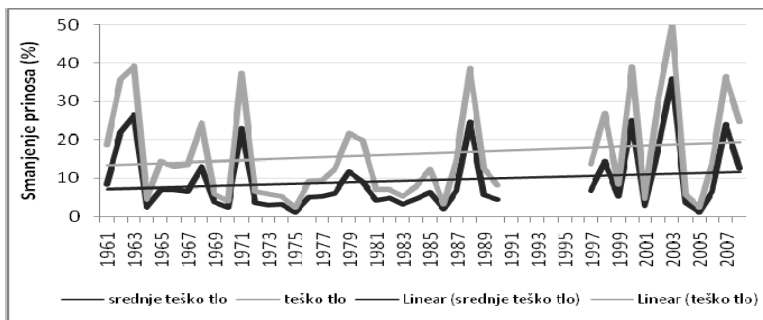
Grafikon 4. Smanjenje prinosa po godinama istraživanja na teškom tlu - Bijeljina



Grafikon 5. Prosječno smanjenje prinosa istraživanih kultura na području Tuzle



## Smanjenje prinosa poljoprivrednih kultura u uvjetima bez navodnjavanja na području sjeveroistočne Bosne



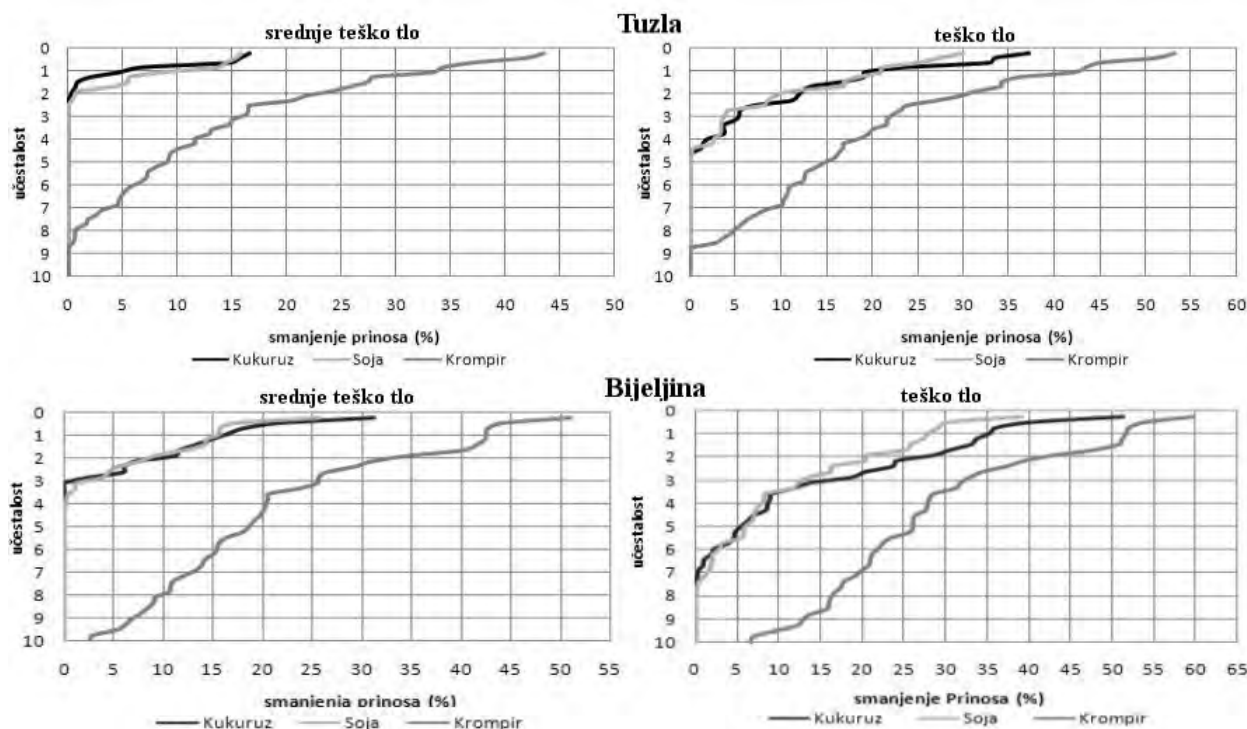
**Grafikon 6. Prosječno smanjenje prinosa istraživanih kultura na području Bijeljine**

Prosječno smanjenje prinosa razmatranih kultura u razdoblju 1961-2008. god. (Graf. 5.) na području Tuzle je iznosilo od 5% na srednje teškom do 9,3% na teškom tlu, a na području Bijeljine (Graf. 6.) od 9,3% na srednje teškom do 16,1% na teškom tlu.

Na prikazanim grafikonima također se može uočiti da prosječno smanjenje prinosa u istraživanom razdoblju ima trend blagog porasta u odnosu na početni period, koji je nešto izraženiji na tlu težeg teksturnog sastava.

Analizom učestalosti (Graf. 7.) utvrđeno je da se na području Tuzle jednom u 10 godina na srednje teškom, odnosno teškom tlu može očekivati smanjenje prinosa kukuruza od 5 - 20%, soje od 10 - 22% i krumpira od 34 - 43%, a na području Bijeljine kod kukuruza od 17 - 36%, soje od 16 - 28% i kruompira od 43 - 52%.

Iz dobivenih rezultata jasno se vidi da postojeći klimatski uslovi i režim vode u tlu značajno utiču na uspješnost proizvodnje kukuruza, soje i krumpira na području sjeveroistočne Bosne. U pogledu osjetljivosti na deficit vode u tlu posebno se ističe krumpir kod koga se smanjenje prinosa u postojećim agroklimatskim uvjetima od 9-15% (na području Tuzle), odnosno 18-27% (na području Bijeljine) može očekivati svake druge godine, dakle i u onim godinama koje su za kukuruz i soju okarakterizirane kao hidrološki povoljne. Utvrđeno smanjenje prinosa, njegov trend i učestalost jasno ukazuju na potrebu promjene dosadašnjeg pristupa u načinu korištenja tla. Obzirom da se veći prinosi poljoprivrednih kultura mogu očekivati samo uvjetima dovoljne opskrbljenosti tla vodom u svim fazama njihovog razvoja, uvođenje navodnjavanja u cilju ublažavanje posljedica suše predstavljalo bi najbolje dugoročno rješenje za stabilnost poljoprivredne proizvodnje na ovom prostoru.



**Grafikon 7. Učestalost smanjenja prinosa jednom u 10 godina na srednje teškom i teškom tlu na području sjeveroistočne Bosne**

### Zaključak

Manjak padalina i sve učestalija pojava sušnih razdoblja na području sjeveroistočne Bosne nepovoljno se odražava na prinose poljoprivrednih kultura koje se uzgajaju u uvjetima bez navodnjavanja. Prosječno smanjenje prinosa razmatranih kultura u periodu 1961-2008. god. na području Tuzle je iznosilo od 5% na srednje teškom do 9,3% na teškom tlu, a na području Bijeljine od 9,3% na srednje teškom do 16,1% na teškom tlu. Najveće smanjenje prinosa utvrđeno je kod krumpira gdje iznosi 43,6% na srednje teškom i 53,2% na teškom tlu (1971. god. na području Tuzle), odnosno 51,0% na srednje teškom i 59,6% na teškom tlu (2003. god. na području Bijeljine). U istim godinama, koje se mogu okarakterizirati kao najsušnije, veće vrijednosti smanjenja prinosa utvrđene su na tlu težeg teksturnog sastava. Posebno se ističe 2003. god. kada je utvrđeno smanjenje prinosa kukuruza na području Bijeljine iznosilo 31,3%, a soje 25,7%. Utvrđeno smanjenje prinosa, njegov trend i učestalost jasno ukazuju na potrebu promjene dosadašnjeg pristupa u načinu korištenja tla i značaj izgradnje natapnih sistema na ovom području.

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# Development of modular-built strip-tillage implement for minimum tillage experiments in Hungary

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## Abstract

In the region, including Hungary, the extreme weather is also becoming more frequently seen. As a consequence certain periods of heavy rains or drought can be observed at times. This extreme weather is caused by the climate change. This weather requires new tillage systems which have not been used previously in the region. The strip-tillage is an environment friendly tillage system, basically known and used in North-America. By using this method, we can minimize the resources we use for the tillage as well as, being able to realize the biological and physical harmony of the soil itself. In this project, we had been designed a strip-tillage implement, which allows us to introduce this tillage technology in Hungary with the help of the tools of systematic machine design. As a result of our work, we designed a tillage unit with modular structure, which will help to conduct successfully - according to our hopes - this technology in the Hungarian agriculture.

Key words: strip-tillage, minimum-tillage, environment friendly tillage

## Introduction

The result and experience of the domestic and foreign studies shows, strip-tillage is a possible technology which reduce the harmful effects of the climate change. Strip tillage, which is a type of minimum tillage, combines no tillage and full tillage to produce row crops. The cropped strips are 150-200 mm wide but sometimes occur wider (250-300 mm). The depth of the strips varies between 100 and 250 mm. The area between the tilled rows left undisturbed. Often both types of fertilizer (liquid or dry granulate fertilizer) are injected into the rows during the tilling operation. Strip-tillage operations can be performed in the spring.

The strip-tillage consists of a number of consecutive operations. An ordinary strip-tillage implement involves the following components. These components are the front coulter blade, the row cleaners, the tillage shanks, the berm discs and optional rubber packing wheels or berm reels (the last two components are not equipped in all of the machines) (Birkás, 2000).

Coulter blade cuts through the soil and residue ahead of the tillage shank. Ordinary these blades diameter varies between 508-610 mm. The coulters require special mounting that allows flexible movement over stones to avoid the crash of the implement. The diameter of the blades influences the cut efficiency. Row cleaners' function to clear the cut residue away from the front of the tillage shank. The cleaners are usually fitted behind the cultural blades but there are some manufacturer who mounted it directly in front of the front blades. The residue which was removed from the tilled strips covers the untilled areas. This residue cover protects the soil against losing their moisture content. One of the most important part of a strip-tillage implement is the tillage shank which penetrates and loosens soil. Normally it is designed with a fertilizer injection tube to make it possible to use liquid or dry granular fertilizers during the strip tillage operation. Tillage depth is dependent on the soil type and conditions and the specific crop to be planted. Berm discs are mounted on each side behind the tillage shank. The discs are mounted that way that the stripes made by the

shank should be covered preventing the moisture level of the soil from drying in the spring or, alternatively, mounted to create a slight depression in the soil to catch snow and rain to increase soil moisture for the next crop. The last part of the strip-tillage operation is the soil surface conditioning. Berm reels are mounted behind the shank and the berm discs to break soil clods and smooth the soil surface. There are several types of baskets available in the strip-tillage equipments (solid, straight tooth, arrow tooth, etc.). Some manufacturers use rubber packing wheels instead of conditioning baskets (sometimes without berm discs) (Nowatzki et. al., 2008).

In Table 1. we collected the most important advantages and disadvantages of strip-tillage. The strip-tillage used effectively for corn and soya bean production.

The domestic application of this tillage technology requires a strip-tillage unit which meets the inland demands. Therefore we set an objective to design an implement which satisfies this requirement.

**Table 1. Advantages and disadvantages of strip-tillage. (Birkás, 2000)**

Advantages	Disadvantages
Reduce soil erosion	Possible dependence on herbicides
Cost-effective automation	Cold seed bed when seeding
Effective soil moisture conservation	Necessary precise work schedule
The tilled areas warm earlier in spring. This helps the germination and plant emergence.	

### Materials and methods

As a first step in our work we collected the most relevant information e.g. the customers' demands, previous experience, market and technical information. In this work, we paid great attention to the examination of the following areas: patents, analysis of the North-American market and a former domestic investigational report (Kurucz, 1966). We examined the performance and structure of the equipments available in the USA. Some of the overseas solutions are displayed in Picture 1.



**Picture 1. Strip-tillage equipment used in the United States (Remingler PST, Twin Diamond StripCat, Agco Sunflower 7600)**

Using this information, we set up a detailed list of requirements and we found that the machine to be developed has to achieve the following operations:

- preliminary row cleaning (optional)
- soil opening
- row cleaning
- soil loosening
- soil surface conditioning
- soil surface compression (optional)

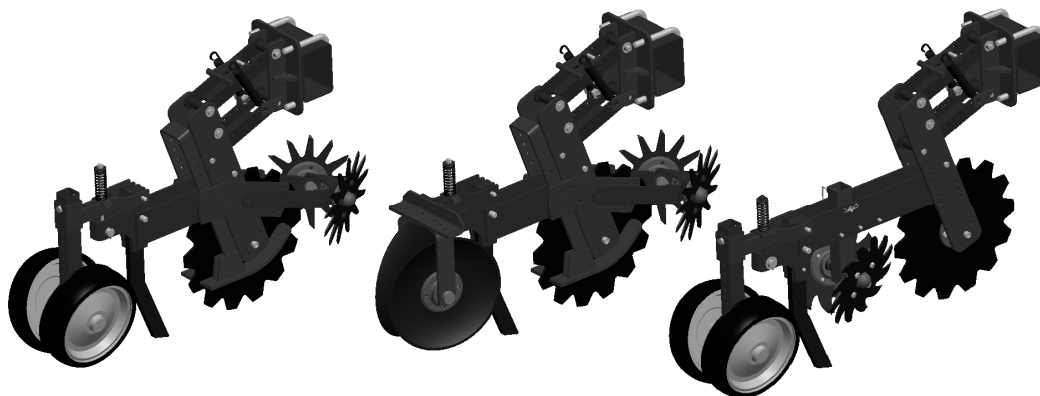
In the next step - following the systematic machine design - we have started to elaborate our concepts according to the list of requirements. We have chosen to generate concepts for each sub-function and then we used the Morphological Chart (MC) method to generate logically suitable concepts aiming to fulfill the most requirements. Our morphological chart can be seen on Picture 2.

Development of modular-built strip-tillage implement for minimum tillage experiments in Hungary

Suspension	Implement down pressing	Preliminary row cleaning	Depth control	Soil opening	Row cleaning	Soil loosening	Soil surface conditioning	Soil compression	Soil c. down pressing
mounting pin	hydraulic	twin inclined double disc couler.	depth limiter rubber wheel	disc couler	twin inclined double disc couler	tillage shank	different type of discs	tire type roller	hydraulic
parallelogram arm	gravitational	rotary hoe wheel	depth-limiter edge	sliding couler	rotary hoe wheel	loosening knife	rubber packing wheel	solid roller	gravitational
rod steel arm	spring	finger basket		loosening knife	finger basket	rotary cultivator	land plane	toothed roller	spring
	screw spindle	without preliminary row cleaner		without soil opener	without row cleaner				screw spindle
	pneumatic spring								pneumatic spring

Picture 2. Morphological chart for strip-tillage unit with some possible solutions (the final solution is highlighted and marked with dashed line)

After we examined that the concepts operate as anticipated, with reasonable further development, which is a primary goal in concept development, we refined enough them to evaluate the technologies needed to realize them, to evaluate their basic architecture, and - with limited degree - to evaluate their manufacturability. Our process was special, since we used CAD representations from the very beginning, trying to incorporate each and every bit of information about the design knowledge at the time. Picture 3. shows our concepts.



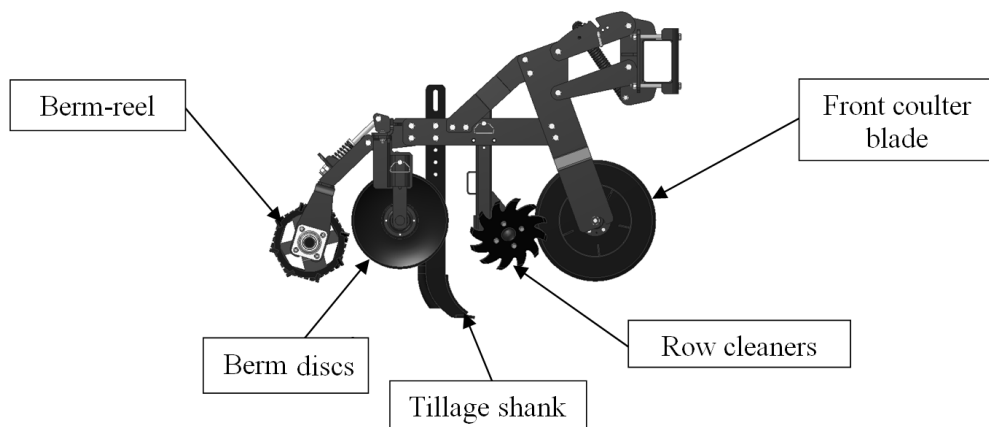
Picture 3. Our different solutions for strip-tillage unit according to the morphological chart

The difficulty in concept evaluation and decision-making is that we must choose which concepts to spend time developing, when we still have limited knowledge and data on which to base this selection. Ideally, we should have enough information about each concept before committing to one of them. This requires resources; spread among many concepts and possibly, inadequate development of any one of them. Many companies generate only one concept and then spend time developing it. Others develop many concepts in parallel, eliminating the weaker one along the way.

We followed the second way. We have developed more than one concept parallelly, but instead of using the former methods, we tried to combine the solutions of a certain concept, by building a modular system product. This approach was fostered by both the MC method, and the fact that the preliminary CAD models contained the function-solution fit information (Ullman, 2010)

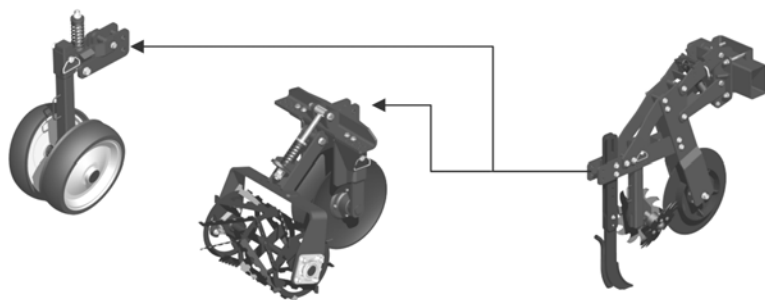
## Results

By thinking on the elaborated conceptions, we laid down the final plans of the strip-tillage implement. When elaborating the details, we greatly emphasized the modular structure, which makes it possible, to design later versions of the unit. Other key considerations were the most possible use of commercial items - e.g.: the front coulter blade, the discs' hubs etc. - which helps reducing the manufacturing cost, and time. The final equipment, and the subassemblies are displayed in Picture 4.



Picture 4. The final strip-tillage design

The equipment is made in two different forms. The first one, the more complex, seed-bed-preparing unit presents all the elements of the above displayed strip-tillage procedure. In this version, after cutting the residue, clearing the row and getting the chemical fertilizer in the ground with the tillage shank, there is a ridge. And finally, after the set of operations, the berm reel will spread the overturned big clods. The second, simpler version misses the berm reel and discs in the back, instead a few simple rubber packing wheels are integrated behind the shank. To decrease the downtime task and the number of unique parts, both strip-tillage implements have a common frame, to which the different hind adapters can be directly connected by two bolts. This setup makes it possible to easily change the adapters, according to the changing demands of the users, and there is no need to buy a new unit. In Picture 5. the different adapters and the common frame are displayed.



Picture 5. The modular system

During the development of the final equipment, we gave high notice to make the cultivator unit adoptable to all kinds of soil. To achieve this, we developed a parallelogram lever structure, on which the hold-down force can be adjusted by discreet values in a range of 0-2500 N, to guarantee the optimal holding-down matching in the circumstances given. During the design process, we aimed to give scope to adjust the sub-assemblies in the biggest possible range. Due to this, the built in, 330 mm diameter uniquely developed row cleaner discs are adjustable in 100 mm range and the tillage shank in 250 mm range. This adjustment possibility makes it achievable the adequate row cleaning and the nutrient supply of soil in the desired depth by grained fertilizers. 100 mm deep, even hack-depth is ensured by a depth-limiter edge on the 500 mm diameter front coulter blade.

We aimed the biggest possible adjustment range in the case of the 400 mm diameter berm discs too. Besides adjusting vertically and horizontally it is possible to adjust the angular offset by discreet values in a 0-15° range.

We used a special tension-spring device, which is evenly holding down the berm-reel, this way ensuring an even 500N hold-down force while working. A similarly developed tension-structure gives similar hold-down force to the rubber packing wheels. The berm-reel had been given an arrow-shape-rib to ensure balanced running.

### Conclusions

Setting up the requirements and the help of the Morphological Chart method we determined the most important components of our strip-tillage unit. We found that the modular design is the only way which satisfies economically the wide range of domestic demands.

The modular development makes it possible to get liquid fertilizers into the soil later, by connecting a simple adapter to the frame. For carrying strip-tillage implements, and the nutrition supply, we are developing a complete carry-frame, which makes it possible to assemble a whole compound with 4,5 m work-width. We plan to conduct field measurements in next spring, the results of which will confirm our expectations concerning the cultivating technology.

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# The biodiversity and dissemination of mycotoxin-producing fungi in cereals and cereal products

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## Abstract

Cereal products are of great importance in human nutrition due to the daily intake of natural fibers. In the last decade, the nutritionists' effort to introduce whole grain products brought about the concern to ensure mycotoxin-free cereal products. Our study has two objectives. The first is to evaluate the frequency of fungi on seeds of wheat, barley and maize. In wheat, we determined mycobiota belonging to genera *Fusarium*, *Alternaria* and *Penicillium*. The barley seeds mycobiota contain *Chaetomium*, *Trichoderma* and *Fusarium* species. The highest fungal biodiversity was determined on the maize seeds: *Aspergillus*, *Fusarium*, *Penicillium*, *Chaetomium* and *Cladosporium* species were identified. The second objective of our research was to study the persistence and dissemination of fungi in bakery products. The study was conducted on wheat bread flour, which was stored in different packaging: polyethylene (PE), polypropylene (PP) and punched polypropylene (pPP). In the seventh day of storage, we established the coverage degree of bread moulds; we made isolations to study morphological aspects that led to the identification of *Penicillium freuetans* and *Aspergillus fumigatus*.

Key words: mycotoxin-producing fungi, cereal seed mycobiota, fungus bread

## Introduction

The interest shown by Romanian consumers towards using whole grain products has increased in the last decade. The concerns of researchers to ensure safety and nutritional quality of products led to increased monitoring of grain concerning the contamination with mycotoxins.

Mycotoxins are secondary metabolites produced by the fungi that cause adverse effects on the body where they are consumed, therefore food and feed contamination by mycotoxins is a major problem, acknowledged by the international community only after 1970 (Bhat, and Vasanthi, 1999; Shephard, 2006; Doolotkeldieva, 2010). Aflatoxin, ochratoxin, trichothecenes, zearalenone, fumonisins, tremorgenic toxins and ergot alkaloids are the most important mycotoxins that present significant problems (Zain, 2010). Mycotoxicosis is a disease caused by eating food contaminated with mycotoxins and includes distinct syndromes as well as non-specific conditions. The appearance, growth, propagation and synthesis of fungal mycotoxins in grain are influenced by many factors starting with the cereal crop plant health, conditions of storage and processing as well as the genetic characteristics of fungi (Savu and Georgescu, 2004; Popescu and Cotuna, 2009).

Our study has two objectives. The first consists in assessing the contamination level of wheat, barley and maize seeds with mycotoxin-producing fungi. The second objective is the study of persistence and dissemination of fungi in bakery products. The study was conducted on bread made from wheat flour, packed in different materials.



## Material and methods

We studied the cereals most cultivated in Banat: wheat (*Triticum aestivum L*) seeds variety Alex, barley seeds (*Hordeum vulgare L.*) variety Madalin and maize seeds hybrid Partizan. Determining the degree of colonization of seeds was achieved by the technique of direct isolation of fungi on specific culture media. The medium used was Czapek growth medium with 3% glucose and 0.005% chloramphenicol. First, the seeds were disinfected with ethyl alcohol 70% for 2 minutes and then washed thoroughly in sterile water for 2 minutes; after that, we plated on surfaces media in Petri plates. We used an average sample of which 10 seeds were filed on the medium. We worked in three replicates. After five days, we determined the degree of seed colonisation with fungi and the frequency of occurrence (Doolotkeldieva, 2010). In order to identify the fungi, they were put in pure culture on MEA medium (Fluka) with 2% malt extract and the *Aspergillus* species were cultivated on pepton yeast extract ironcitrate agar (PYIC) for *Aspergillus flavus* and *parasiticus* confirmation (Cotty, 1989). The study of persistence and dissemination of fungi in bakery products was conducted on bread made of wheat flour and obtained in the Bakery department of the Faculty of Agri-food Processing Technologies. The bread was stored in three types of packaging: polypropylene (PP), polyethylene (PE) and polypropylene perforated (pPP), maintained at a temperature of 7-10 degrees Celsius. We made daily observations about the occurrence of fungal infection, the degree of mould coverage in the fifth and seventh day. In order to identify the fungus, we made isolations and replications on the 2% malt extract agar (MEA), we studied the cultural characteristics: texture, topography and the pigmentation, reverse pigmentation, the type of fructifications, hyphae, septation shape, size and colour, the arrangement of conidia, the type of conidiogenous cell, the presence of sporodochia for the taxonomic classification.

## Results and discussion

### The level of fungal contamination on wheat seeds

After 5 days of incubating the seeds at 24 - 27 degrees Celsius, readings were made to determine the level of fungal colonization and to calculate the frequency of occurrence for each genus and species. Figure 1 presents the results on wheat seeds. The average level of seed colonization (LC) was 56%. Frequency of occurrence (%) was calculated by a ratio between the number of samples with fungus infections and the total number of samples. 20% of the wheat seeds were colonized by *Alternaria alternata*. On the MEA medium, the colonies are fast growing, black to olivaceous-black or greyish in colour and present a suede-like texture. The *A. alternata* is known as AAL mycotoxins producers (Li et al., 2001). These mycotoxins included alternariol and its monomethyl ester, altenuene, altertoxin I, and tenuazonic acid.

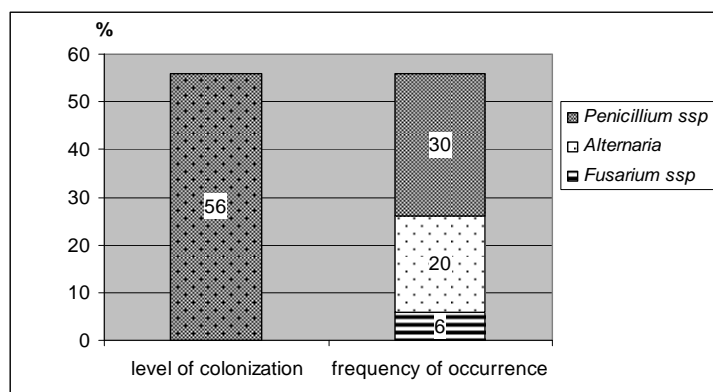


Figure 1. The level of fungus colonization and frequency of occurrence on wheat seeds

*Fusarium graminearum* has 6% frequency of occurrence on the wheat seeds and it can produce many mycotoxins, like DON, also known as vomitoxin (Sudakin, 2003). Morphological characteristics of this fungus in culture include extensive cotton-like mycelium, often with pink or purple colour. From the reverse, it is red. The mycelia produce macro- and microconidia from slender phialides.

High frequency was determined for genus *Penicillium* with 30% frequency of occurrence.

### The level of fungal contamination on the barley seeds

In barley, the highest frequency of contamination was recorded for *Trichoderma* (Fig. 2.). In our case, *Trichoderma viride* was identified, with dark green mycelium, dusty aspect, in clumps conidiophores and green colour. The *Trichoderma viride* can produce trichodermin (Wannemacher et al., 2001). Low frequency was identified for fungi *Chaetomium globosum*, 7% and *Fusarium graminearum*, 6%.

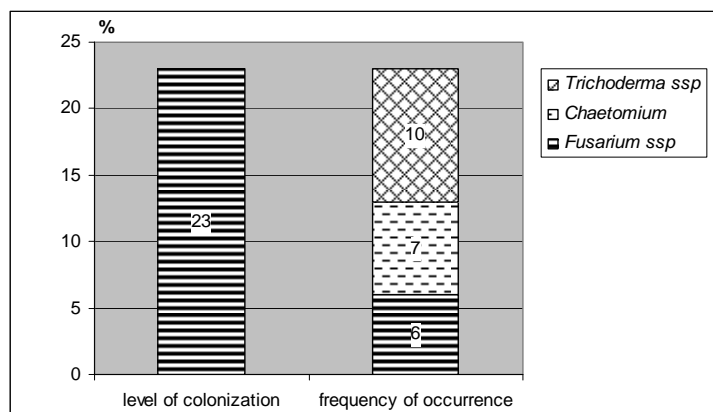


Figure 2. The level of fungus colonization and frequency of occurrence on barley seeds

### The level of fungal contamination on the corn seeds

The highest biodiversity of fungi was found on maize seeds. Seed contamination level was 53% (Figure 3). The species isolated and identified were *Aspergillus (flavus and terreus)* (13%), *Fusarium roseum* (10%), *Penicillium sp.* (10%) *Chaetomium sp.* (10%) and *Cladosporium spp.* (10%). Of these, *Aspergillus* is the most important fungus in the production of mycotoxins. *A. flavus* colonies are yellowish-green-olive, with a cream reverse, consisting of a dense felt of conidiophores or mature vesicles bearing phialides over their entire surface. They present rapid growth and their texture is woolly to cottony. Hyphae are septate conidial heads; they are radiate uni- and biseriolate, producing only phialides covering the vesicle

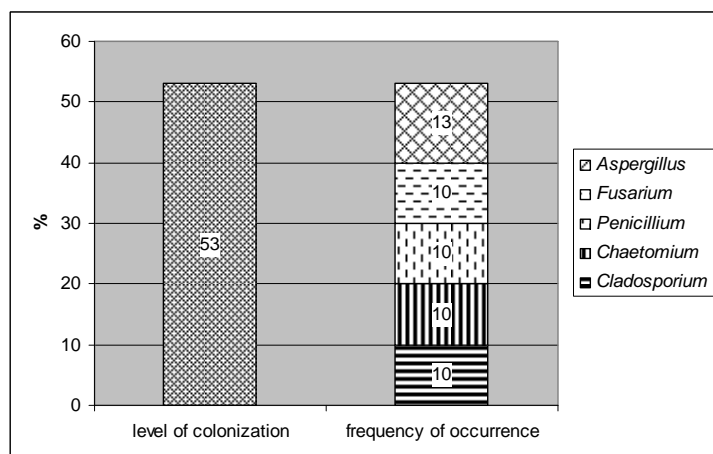


Figure 3. The level of fungus colonization and frequency of occurrence on corn seeds

### The study of persistence and dissemination of fungi in bread

The three types of packages provide different conditions for bread storage. The moisture of the product maintained at 30% is the decisive factor that favoured the growth and development of the fungi. Thus, for the variant of bread stored in pPP bags, humidity drops quickly, after three days the bread presented a hard crust and fungal contamination was visible only in the 7th day. Fungus contamination was located just inside the bread with coverage of only 5-7%. By isolating and running a macro- and microscopic study, we could highlight the presence of a velvety mycelium, with no perithecium or sclerotia, conidiophores starting directly from the substrate, no exudates, with grey-green colour, conidiophores with ramifications and globular conidia. These characteristics are specific for *Penicillium frequentans*.

In the second sample, the bread was stored in PP bag, where humidity was better maintained. Thus, the fungal contamination occurred after 5 days and on the seventh day, the fungal coverage reached 85%. The study of fungi led to the identification of two species: *Penicillium frequentans* and *Penicillium nigricans* (dark grey to olive mycelium colour and branched conidiophores similar to mono-verticillata series).

The bread packed in PP bags preserved its freshness for 3 days; the mould appeared on the 5th day. On the seventh day, coverage with fungi was 20%. Two morphological types were identified, belonging to genus *Aspergillus sp. versicolor* (colony with dusty look, high growing rates, velvety, having no sclerotia or perithecium) and *Penicilium frequentans*.

### Conclusions

The biodiversity of opportunistic fungi on cereal seeds is large. Their quantitative but also the qualitative variations are influenced by many internal and external factors. Among these, we find the correct application of a technology that is not lacking in treatments and protection against insect pests that favour plant damage and contamination with fungi producing mycotoxins, collecting seeds at an adequate humidity and providing proper postharvest ripening conditions.

This high number of mycotoxin producing fungi does not necessarily imply the existence of mycotoxins, but increases the potential of synthesis of these substances if they do not meet the optimal parameters of grain storage postharvest conditions.

Through the process of baking bread, because the temperature inside it does not exceed 100 degrees Celsius, mould spores remain dormant being able to affect product shelf life and consumer safety.

To reduce severity of the mycotoxin problem, we need investment in research and applications for increasing their economic impact.

### Acknowledgements

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# Fish electrical repeller ELZA2 as a prevention of European otter (*Lutra lutra*) access to fish farming facilities

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## Abstract

The European otter is a common fish predator spread over the majority of the Czech Republic territory. As a protected predatory species, its feeding habits conduce to conflicts between aquaculture and nature protection. Thus, an efficient non-lethal prevention of otter access to aquaculture facilities is highly desired and actually does not exist. The aim of this study was to check the efficiency of fish electrical repeller ELZA2 as a feasible protection against European otter access to trout farms. Negative reaction of otters to the electric field elicited by the repeller was confirmed in this study and thus, the efficiency of the electrical repeller ELZA2 proved to be satisfactory.

Key words: European otter, predation on fish, trout culture, protection

## Introduction

Recently, the number of otters in the Czech Republic increased considerably (Poledník and Poledníková 2006). Individual populations and their expansion were described by e.g. Grendziok and Lojkásek (1995), Benda (1996) and Poledník et al. (2005). Aquaculture facilities (pond and trout farms) are supposed to play a key role in otter spreading (Dulfer et al. 1996).

The otter is a carnivore species (Kučerová and Roche 1999) and a food opportunist. The occurrence and proportion of individual fish species in otter diet varies in accordance with their abundance and especially with their availability and capture vulnerability (Chanin 1985, Carss 1995). On average, 80 - 95% of otter diet consists of fish (Kruuk et al. 1993) with daily consumption rate corresponding to 0.4 - 0.9 kg (Ruiz-Olmo 1995). The amount of food ingested rises in winter period (1.5 kg per day) and also during lactation when nursing females require a higher volume of food (Veselovský 1998).

As presented in many otter food studies from various habitats, fish that occur in otter diet are usually between 10 and 15 cm (Mason and Macdonald 1986, Kožená et al. 1992, Hájková 2001, Roche 2001, Kortan et al. 2010). However in carp ponds and breeding units, otters are able to catch even bigger fish, weighing up to several kg (Adamek et al. 2003).

The conflicts between nature protection requirements and economic interests of fish farmers are increasing with rising numbers of otters (Kranz et al. 1998, Kranz 2000, Poledník et al. 2005, Kloskowski 2005). Otter attendance of fish farming facilities is intensified in winter, when otters focus their hunting efforts upon available prey. In that time period majority of waterbodies is frozen and otter visit sites of high fish density (such as trout farms and storage ponds) with considerably increased frequency. In practice, the protection of these facilities from otter attendance is impossible or extremely difficult. The only available protection of trout farms and small ponds is by implementing an electric wire fence. Its mode of functioning is quite satisfactory, however some critical points remain particularly in winter time - when thick snow layers and open inlet and outlet canals remain always as "vulnerable" sites of a fish farming facility efficiently protected by electric wire fence.

Since fish density is a stimulative factor for the selection of feeding sites by otter (Kruuk et al. 1993, Kruuk

1995, Carss 1995), trout farms constitute a very “seductive” food resource particularly during the winter period with seriously restricted prey availability on another waterbodies. Thus the inlet and outlet canals are posing a certain continuous risk of free otter access beyond control. The only ways how to secure these sites are dense mechanical screens but their installation is always associated with frequent clogging requiring regular control and cleaning.

This study deals with the applicability of fish electrical repeller for protection of fish farm inlets and outlets against otter access. ELZA2 is an electrical device originally assigned for prevention of undesirable fish entry into small hydropower plants inflows however it may be successfully installed also for control of fish entry into fish farming facilities via inflow and outflow canals (Adámek 1997).

## Materials and methods

### Study area

The pilot experiments with electrical repeller installation aimed at the prevention of otter access were performed on four sites on the territory of the Czech Republic - trout farm Milence (1) (49°16'26.707"N, 13°9'7.421"E, Nov 2007 - Feb 2009) and Domašov nad Bystřicí (2) (49°43'18.394"N, 17°27'3.184"E, Nov 2008 - Aug 2010), trout hatcheries Pstruží (3) (49°33'57.42"N, 18°21'0.887"E, Jan 2009 - Aug 2010) and the Station of Fauna Protection Pavlov (4) (49°42'5.009"N, 15°20'14.334"E, 29 Apr - 11 June 2009).

### The electrical repeller ELZA2

The electrical fish repeller ELZA2 (Radomír Bednář Co., Olomouc, Czech Republic) is powered by low voltage source (12V DC) which is increased by the transformer unit and subsequently shaped into short acicular pulses with rapid forehead lead lines and exponential shape of run-down curve. The output pulses are divided into several outputs through only one active electrode. The others are phase-delayed (pulse delayed), therefore there is no necessity to set-up any parallel configuration of electrodes. The repeller consists of following elements: 1) device “ELZA2” - plastic box size 200x150x85 mm, 2) adapter 12V/1A, 3) electrodes (Fig.1) - copper tubes 22/1 with specificity length, max 0.4 m distant, 4) service cables to electrodes. The most important factors influencing the ELZA2 efficiency are water conductivity, stream bed composition, water temperature and oxygen content.

Parameters: supply voltage 10 - 15 V; supply current 600 mA max; output voltage 6 - 12 V; frequency 10 Hz; energy discharge 0.053 J; supply 7 W.

### Experimental methods

Immediately after the installation, the device was left turned off for 7 - 14 days to enable otter to get acquainted and accustomed with new “disturbing” element. Once clearly evident indication of otter throughpass was recorded, the device was switched on into operation and the site was checked daily for signs of otter presence (snow footprints, fish prey remains).

Studies with captive otters were arranged with the aim to lure them on live fish in a pond separated from otter’s housing pond by a channel provided with ELZA2 electrodes.

Note: Faculty of Fisheries and Protection of Waters, University of South Bohemia, is accredited as user facility Ref. No. 22760/2009-17210 according to Law 246/1992 about “Animal welfare” with testimony for user facilities Ref. No. 22761/2009-17210. Research staff of RIFCH USB involved in the project possess a testimony according to §17 of Law 246/1992 about “Animal welfare”.



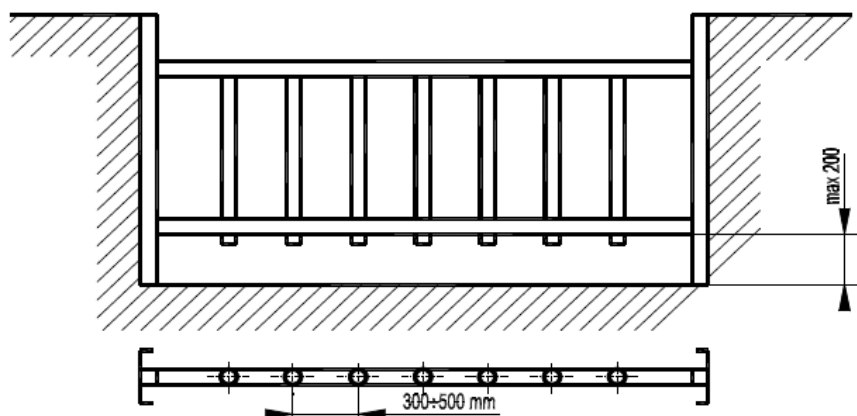


Fig.1. Positioning of the electrical repeller ELZA2 copper electrodes.

### Results and discussion

The electrical equipment ELZA2 is designed as a protection device against fish entry into sites where their presence is undesirable. The application of this device was first time tested as prevention against otter access.

#### Trout farm sites (wild otters)

##### Milence

The electric repeller was in function since November 2007. For the period of subsequent two-year lasting operation, only one otter visit (24<sup>th</sup> February 2009) was recorded. This event happened during the period of extremely low temperatures (around -20°C). Under such unfavourable weather conditions with drastically reduced ability to catch food fish in the wild, otter may be roused to extreme solutions - in this case to pass through the electrodes in operation. Actually, under these circumstances, otter suffer from hunger for long and on the other hand, they need more food for compensation of energy losses due to severe frost (Veselovský 1998). This contradiction often implies a reduced perception of endangering.

##### Pstruží

The equipment was put into action since January 2009. The otter invaded the facility area first time fourteen days after installing with switched off electricity. This corresponds to the fact that otter is very perceptive to any change in its environment and any new barrier leads to the avoidance of it for several days or weeks (Veselovský 1998). Altogether, otter penetration into the protected site was recorded five times during the period of repeller operation (Table 1). Otter passed twice through the electrodes which were frozen in ice and three times otter burrowed the hole underneath the farm fence. Electrodes frozen in the ice layer disallowed the inherence of electric fields around the electrodes. The device was in function but the otter did not perceive the electric field in certain distance from electrodes.

For the time remaining, otter footprints were recorded in snow on inlet banks several times in the distance of 1 m from the electrodes. They demonstrated otter stopped swimming, left the water and examined the possibility of penetration via underneath the fence.

##### Domašov nad Bystřicí

The equipment was installed in November 2008 and no signs of otter visits were recorded since thereafter despite losses caused by otter predation were quite serious during previous periods.

**Table 1. Wild otters' attendance (number of visits per week) at protected trout hatcheries and farms prior to and during ELZA2 operation. Note: \* estimation by respective farm managers**

Site	Previous years*	7-14 days prior to operation	During ELZA2 operation (reason for failure)		
			Electrodes in ice	Extreme frost	Fence undermining
Milence	2-3	1	0	1	0
Pstruží	2-3	2	2	0	3
Domašov n. B.	3	1	0	0	0

### Captive conditions

Three males (4 - 13 years old) and one female (17 years old) were used separately for the experimental purposes. Their response upon the operation of the electrical repeller was absolutely unclear since two of the animals avoided crossing the repeller electrodes despite the device was switched off. On the other hand two otters crossed the electrodes regularly even during the period of switched on device. It was obvious that behavioural alterations in captive otters are accentuated in the extent which unable them to be used as model animals for this kind of experiments.

### Conclusion

Otter negative response (avoidance) to the operation of electrical repeller was proved in field studies on Czech trout farms. Previous regular otter penetration into farms (usually 2 - 3 times per week) was put down significantly during the 1- to 2-year periods of ELZA2 operation. Otter visits into "protected" trout farms were restricted just on occasional penetrations caused by extreme conditions - deep frost, ice frozen electrodes and fence undermining. Experimental evaluation of ELZA2 efficiency against otter penetration cannot be done with captive animals due to their altered behavioural patterns.

### Acknowledgements

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# Utjecaj temperature, slanosti i individualne mase na metabolizam ušate *Oblada melanura*

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## Sažetak

U ovom radu istraživana je metabolička aktivnost ušate *Oblada melanura* u odnosu na temperaturu i slanost kao abiotičke pokazatelje te masu ušate kao biotički pokazatelj. Metabolizam ušate je praćen potrošnjom kisika na 20 jedinki. Multiplom regresijskom analizom utjecaja nezavisnih parametara temperature, slanosti medija i mase ušate na potrošnju kisika utvrđeni su statistički značajni trendovi iskazani standardiziranim regresijskim koeficijentima  $\beta$  (beta) 0,799792 za temperaturu, 0,326579 za slanost i -0,478292 za masu ušate.

Ključne riječi: ušata, respirometrija, metabolizam

## Influence of temperature, salinity and body mass on the metabolism of the saddled bream *Oblada melanura*

### Abstract

Metabolic rates of 20 individuals of Saddled bream *Oblada melanura* were measured at combination of the following factors: temperature, salinity and body mass. Our research of oxygen consumption of saddled bream analyzed with multiple regression shows that sea temperature, salinity and body mass of saddled bream had significant trend shown by standardized regression coefficient  $\beta$  (beta) for sea temperature 0.799792, salinity 0.326579 and body mass -0.478292.

Key words: saddled bream, respirometry, metabolic rate

### Uvod

Ušata (*Oblada melanura*, Linnaeus, 1758) je jedna od najbrojnije zastupljenih vrsta porodice Sparida u Jadranskom moru (Jardas, 1996). Rasprostranjena je u čitavom Mediteranu, dok je u Crnom moru prilično rijetka. Također, boravi duž istočnoatlanske obale, od Biskajskog zaljeva na sjeveru (Olivier, 1975) pa sve do obala Angole na jugu, oko Kanarskih otoka, Madeire i Zelenortskog otočja. Prema zoogeografskim osobitostima pripada atlansko-tropskom biogeografskom elementu (Bauchot i Hureau, 1986). Njezina zastupljenost u lovinama svih vrsta porodice Sparida duž istočne obale Jadranskog mora, tijekom šesnaestogodišnjeg praćenog razdoblja (1977-1992) bila je od 12,4 do 22,7% (prosječno 18%), a u lovinama cijelog istočnojadranskog priobalnog ribolova od 7,5 do 10,6% (prosječno 8,4%). Utvrđene vrijednosti ukazuju na vrlo značajan udio ušate u lovinama gospodarskih ribara (Pallaoro, 1996). Slijedom rastućeg ribolovnog pritiska i ušata je postala predmetom pojačanog izlova što ukazuju na potrebu istraživanja biologije ove vrste i eventualni razvitak odgovarajuće tehnike i uvjeta (temperatura, slanost) njezinog uzgoja u zatočeništvu.

Temperatura vode i utjecaj koji ima na većinu biokemijskih i fizioloških procesa čine je najvažnijim fizičkim parametrom u okolišu akvatičnih organizama (Reynolds i Casterlin, 1979). Međutim, ostali ekološki parametri (kao što su kisik i slanost) također utječu na metabolizam ribe (Priede, 1985). Da bi se riješila kompleksnost okolišnih utjecaja na metabolizam ribe, Fry (1971) predlaže konceptualni model koji su implementirali i dopunjavali Neill i Bryan, 1991. godine te Neill i sur., 1994. godine. Na temelju tog modela u ovom se istraživanju nastojalo utvrditi kako temperatura, slanost i masa (dob) utječu na metabolizam ušate.

### Materijali i metode

Potrošnja kisika ušate je mjerena u odnosu na temperaturu mora (19-26°C), slanost (33 i 37 psu) i prosječnu tjelesnu masu (0,32; 3; 30,3 g) tj. različite dobne skupine ušata. U pokusu je korišteno 20 jedinki sa po pet jedinki u skupini (Claireaux i Lagardere, 1999). Potrošnja kisika mjerila se pomoću Oxyscan graphic (UMS GmbH) i pripadajućeg mikro senzora kisika Clarkova polarografskog principa djelovanja. Rabljeni senzor kisika mjeri količinu otopljenog kisika u morskoj vodi i potpuno je temperaturno, obzirom na atmosferski tlak zraka kompenziran. Vrijednost otopljenog kisika mjerena je svakih 5 minuta kroz razdoblje od 30 minuta. Količina potrošenog kisika izračunavana je iz razlike količine otopljenog kisika na početku i kraju mjernog razdoblja ravnomjernog pada količine otopljenog kisika od 10 min. Iz te vrijednosti apsolutne potrošnje kisika i mase ribe u pokusu određena je potrošnja kisika u  $\text{gO}_2 \text{ g}_{\text{ribe}}^{-1} \text{ h}^{-1}$  (Glavić, 2007).

Sustav za mjerenje kisika se sastojao od sonde za mjerenje količine otopljenog kisika i respirometrijske komore. Korištene su tri komore cilindričnog oblika, zapremnine 862,29 mL, 74,849 mL i 37,150 mL potpuno zračno brtvljene, tako da jedinka tijekom mjerenja koristi jednokratnu količinu kisika otopljen u poznatom volumenu vode. Svaka komora je gumenom cjevčicom bila povezana s 10 L posudom s morskom vodom koja je bila aerirana kako bi se postigla što veća koncentracija otopljenog kisika u njoj. Prije svakog mjerenja potrošnje kisika, mjerni je uređaj kalibriran s praznom komorom (bez ribe). Po stavljanju ribe u komoru, uspostavljan je protok mora u komori. Nakon 20 minutnog razdoblja prilagodbe i umirivanja ribe započeto je mjerenje. Rezultati mjerenja evidentirani su krivuljom pomoću koje je procijenjena stalnost potrošnje kisika u pojedinom mjerenju.

### Rezultati i rasprava

Kod prosječne temperature morske vode od 22,6°C prosječna potrošnja kisika kod ušata prosječne mase 0,32 g je bila  $0,8264 \pm 0,1013 \text{ O}_2 \text{ mg/g/h}$ , kod ušata prosječne mase 3,0 g  $0,1781 \pm 0,1086 \text{ O}_2 \text{ mg/g/h}$  i kod ušata prosječne mase 30,3 g  $0,27586 \pm 0,548 \text{ O}_2 \text{ mg/g/h}$ . Multipla regresijska analiza utjecaja nezavisnih čimbenika temperature morske vode, mase ušate i slanosti medija na potrošnju kisika istraživanih dobnih kategorija ušata pokazuje statistički značajne trendove iskazane standardiziranim regresijskim koeficijentima  $\beta$  (beta) i dani su u tablici 1 ( $R^2=0,88322190$ ;  $F(3,16)=40,337$ ;  $p<0,05$ ).

Tablica 1. Utjecaji temperature mora, slanosti i mase ušate na potrošnju kisika

Utjecaj	$\beta$ (beta)	t	p-razina
T C <sup>-1a</sup>	0,799792	8,84808	0,000000
S psu <sup>b</sup>	0,326579	3,53696	0,002741
BW g <sup>-1c</sup>	-0,478292	-5,31346	0,000070

<sup>a</sup> temperatura morske vode

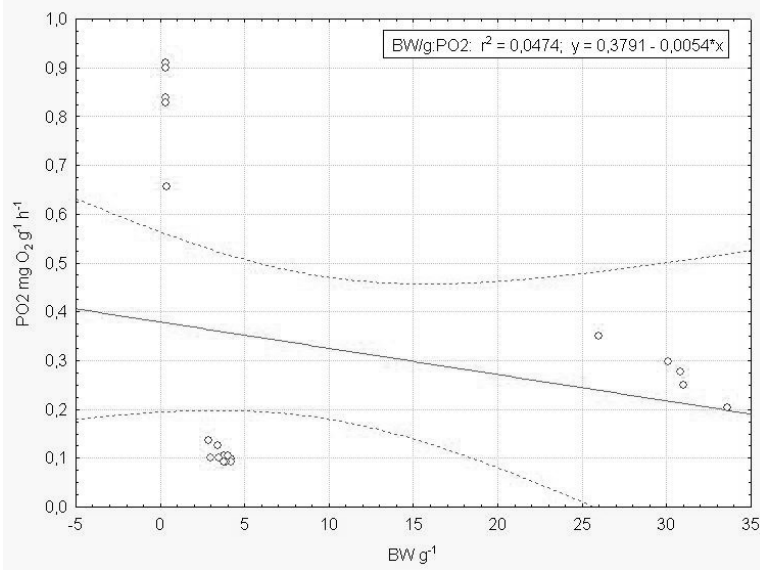
<sup>b</sup> slanost morske vode

<sup>c</sup> masa ušate

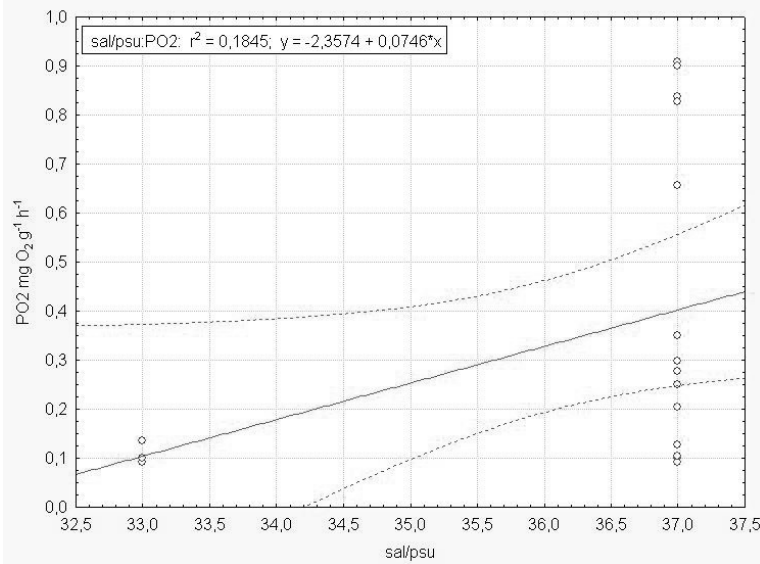
Vrijednosti potrošnje kisika ušate s obzirom na masu ribe pokazuju stalan pad s povećanjem mase ribe pri prosječnoj temperaturi mora od 22,6°C (Slika 1).

Potrošnja kisika ušate u zavisnosti o slanosti morske vode pokazuje pozitivnu korelaciju (Slika 2). Pri prosječnoj temperaturi morske vode od 22,7°C vrijednosti potrošnje kisika rastu s povećanjem slanosti.

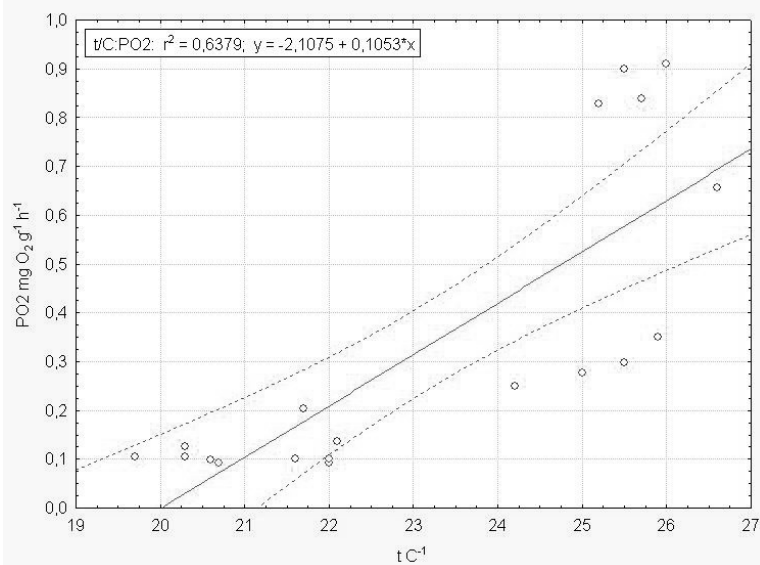
Utjecaj temperature morske vode na potrošnju kisika mlađi ušate pokazuje također pozitivnu vezu. Kod prosječne slanosti morske vode od 37 psu s povišenjem temperature povećava se i potrošnja kisika (Slika 3).



Slika 1. Scatterplot zavisnosti potrošnje kisika ušata o tjelesnoj masi. Regresijska jednačba utjecaja dana je u grafu.



Slika 2. Scatterplot zavisnosti potrošnje kisika ušata o slanosti medija. Regresijska jednačba utjecaja dana je u grafu.



Slika 3. Scatterplot zavisnosti potrošnje kisika ušata o temperaturi medija. Regresijska jednačba utjecaja dana je u grafu.

Mjerenje potrošnje kisika kod ušate dalo je uvid u metaboličku aktivnost ušate u zatočeništvu, u odnosu na temperaturu i slanost medija kao abiotičke, okolišne, te dob i masu ušate kao biotičke čimbenike. Pošto su ribe hladnokrvni organizmi, temperatura medija u kojem se nalaze određuje ukupnu metaboličku aktivnost organizma. Kao izravna posljedica povećane ili smanjene metaboličke aktivnosti, povećavaju se, odnosno smanjuju i potrebe organizma za kisikom. Više je istraživanja provedenih na ribama dokazalo alometrijsku vezu između potrošnje kisika i tjelesne mase (Dolnik, 1978; Peters, 1993; Zotin i sur., 2000). Utvrđeno je da postoji jasan trend smanjenja apsolutne potrošnje kisika s porastom mase. Naši rezultati su pokazali postojanje pozitivne korelacije između potrošnje kisika i slanosti medija. Smanjenjem slanosti i potrošnja kisika pada. Niža slanost u korelaciji je s nižim metabolizmom (Boeuf i Payan, 2001).

Uspoređujući potrošnju kisika lubina u zavisnosti o temperaturi medija Claireaux i Lagardere (1999) su utvrdili pozitivnu korelaciju, a što je potvrđeno i u našem istraživanju kod ušate. Melzner i sur., (2004) potvrđuju pretpostavke o potrošnji kisika vezanoj za temperaturu medija tvrdeći da povišene temperature ograničavaju iskorištenje apsorbiranog kisika zbog gubitka koordinacije između komponenti u lancu prijenosa i isporuke kisika u ciljne stanice.

### Zaključak

Slijedom utvrđenih korelacija temperature morske vode, mase ušate i slanosti medija na potrošnju kisika može se zaključiti da se manipulacijom abiotičkih parametara (temperaturom i slanosti morske vode) može utjecati na metabolizam ušate.

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# Raspodjela ličinki kamenice *Ostrea edulis* u Malostonskom zaljevu tijekom sezone mrješćenja 2008/09. godine

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## Sažetak

Prostorno vremenska raspodjela ličinki kamenice tijekom sezone intezivnog mrješćenja kontinuirano se u najvećem hrvatskom uzgajalištu školjkaša u Malostonskom zaljevu prati od 1998. godine. Rezultati monitoringa u zadnje dvije sezone 2008/09. godine pokazuju znatnu međusobnu razliku u reproduktivnom potencijalu zaljeva. Dok je u 2008. god. opaženo maksimalno 5848 ličinki u prostornom metru morske vode, ta je vrijednost godinu kasnije iznosila samo 950 kom./m<sup>3</sup>. Znatan pad broja ličinki u 2009. god. očituje se i u srednjoj vrijednosti za sve postaje zajedno (235 kom./m<sup>3</sup>), dok je predhodne godine bilo 709 kom./m<sup>3</sup>.

Ključne riječi: europska plosnata kamenica, ličinke, mrješćenje, Malostonski zaljev

## Spatial and temporal distribution of the European flat oyster *Ostrea edulis* larvae in the bay of Mali Ston during two year period 2008/09.

### Abstract

There has been continuous monitoring of spatial and temporal distribution of oyster larvae during peak spawning season in the largest croatian shellfish farm in the Mali Ston bay since 1998. Last two year monitoring results (2008-2009) show significant difference in the reproductive performance of the bay. While in 2008 there has been maximum of 5848 larvae m<sup>-3</sup>, there has been only 950 larvae m<sup>-3</sup> in 2009. Mean larval count for all sampling stations shows also significant decrease (709 larvae m<sup>-3</sup> in 2008, and 235 larvae m<sup>-3</sup> in 2009).

Key words: European flat oyster, larvae, spawning period, Mali Ston bay

### Uvod

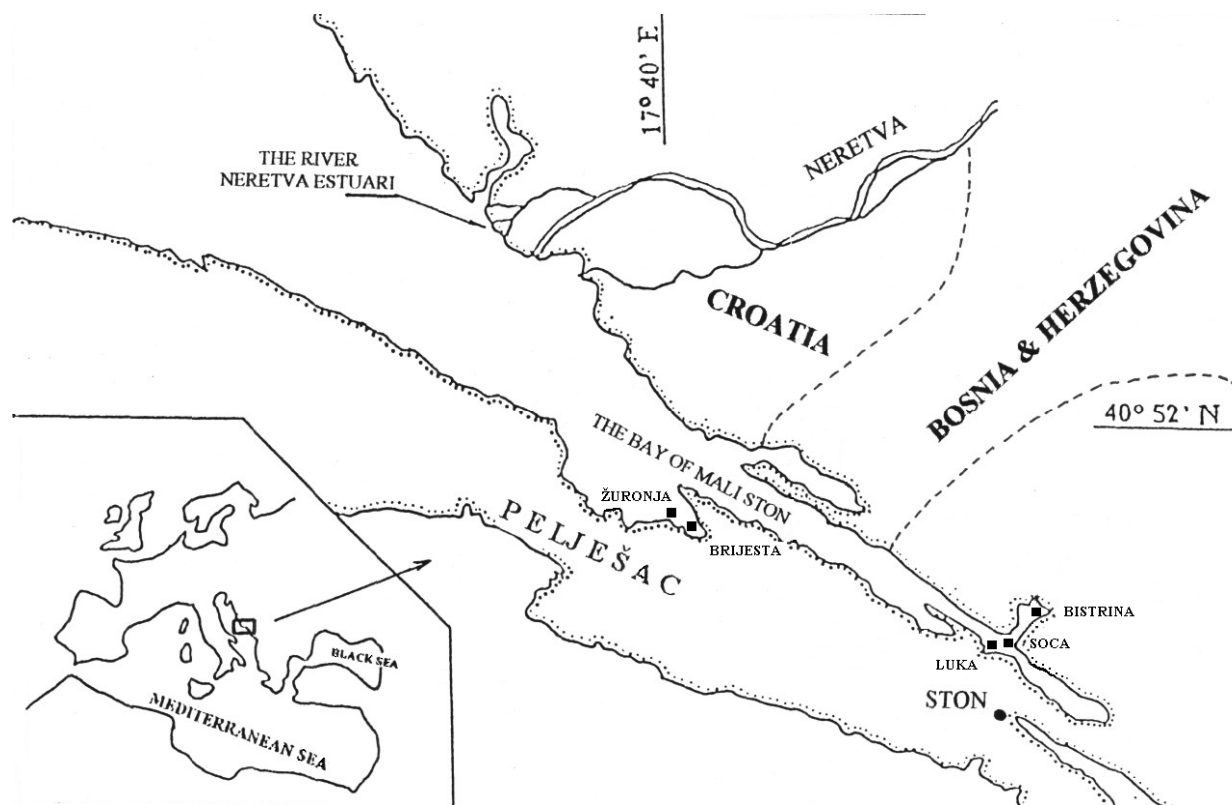
Područje Malostonskog zaljeva najveće je uzgajalište školjkaša na istočnoj obali Jadranskog mora s višestoljetnom tradicijom u ovoj grani gospodarstva, koja po nekim izvorima datira još od rimskih vremena (Basioli, 1968). Suvremena proizvodnja europske plosnate kamenice *Ostrea edulis* (Linnaeus, 1758) isključivo se zasniva na sakupljanju mlađi iz prirodne sredine. Takav sustav proizvodnje zahtijeva stalno praćenje prostorno vremenske raspodjele ličinki tijekom sezone intezivnog mrješćenja u cilju što učinkovitijeg polaganja kolektora za prikupljanje mlađi, s čime se povremeno započelo u 70-tim godinama prošlog stoljeća

(Morović i Šimunović, 1980; Onofri, 2003), a od 1998. god. monitoring se na području zaljeva kontinuirano provodi (Bratoš i sur., 2002). Rezultati istraživanja raspodjele ličinki tijekom sezone mrješčenja 2008/09. god. prezentirani su ovom radu.

### Materijal i metode

Monitoring se tijekom sezone intezivnog mrješčenja odvijao na tri postaje (Bistrina, Soca, Luka) u središnjem dijelu Malostonskog zaljeva te na dvije postaje (Brijesta, Žuronja) u vanjskom dijelu zaljeva (Slika 1). Lokacije uzorkovanja određene su kriterijima veće gustoće uzgojnih instalacija s kamenicom te većim reproduktivnim potencijalom ovog školjkaša uočenim u ranijim istraživanjima. Uzorkovanje je započelo početkom svibnja i trajalo do početka studenog (2008. god.), odnosno prosinca (2009. god.) te se ovisno o intezitetu mrješčenja, odnosno broju ličinki u stupcu morske vode, odvijalo jednom tjedno ili rjeđe.

U 2008. godini uzorkovanje je obavljeno tijekom 17 terenskih izlazaka, a 2009. god. tijekom 20 izlazaka. Svi uzorci su sakupljeni standardnom planktonskom mrežom promjera ustiju 31 cm, veličine oka 125  $\mu\text{m}$  te obrađeni u laboratoriju pod binokularnim mikroskopom. Mreža se na svakoj postaji povlačila vertikalnim potezom od dna do površine. Na postajama središnjeg dijela zaljeva dubinaorskog dna kretala se između 5,5 i 10 metara. U vanjskom dijelu dubina je iznosila 6-9 metara. Broj ličinki je preračunan po metru prostornom ( $\text{m}^3$ ) morske vode, a uzgajivači su redovito odmah nakon uzorkovanja i obrade uzoraka isti dan posebnim letcima obavješćivani o stanju broja ličinki kamenice na svim promatranim postajama, s preporukom gdje, a gdje ne polagati kolektore za prihvata mladi. Ovakav način komuniciranja s uzgajivačima pokazao se u potpunosti zadovoljavajući i kontinuirano se koristi od uspostave 2003. godine.



Slika 1. Karta postaja u Malostonskom zaljevu na kojima je praćena prostorno vremenska raspodjela ličinki europske plosnate kamenice

## Rezultati i rasprava

Europska plosnata kamenica u Malostonskom zaljevu mrijesti se tijekom cijele godine. Broj ličinki u akvatoriju zaljeva počinje rasti s porastom temperature morske vode i maksimalne vrijednosti doseže u toplijem dijelu godine od sredine proljeća do kraja ljeta (Bratoš i sur., 2002). Slična situacija opažena je u 2008. god. kada je sredinom svibnja zabilježen maksimalni broj ličinki od 2494 kom./m<sup>3</sup> u središnjem te 5848 kom./m<sup>3</sup> u vanjskom dijelu zaljeva, na svim istraživanim postajama koncentracija ličinki bila veća od 1000 komada u prostornom metru morske vode.

Srednja vrijednost broja ličinki na svim istraživanim postajama zajedno tijekom razdoblja monitoringa u središnjem dijelu zaljeva iznosila je 692 kom./m<sup>3</sup>. U vanjskom dijelu Malostonskog zaljeva ta je vrijednost bila neznatno viša (735 kom./m<sup>3</sup>). Hlađenjem vodenog stupca početkom studenog i opadanjem broja ličinki ispod 100 kom./m<sup>3</sup>, završeno je praćenje njihove prostorno vremenske raspodjele na navedenim postajama u akvatoriju zaljeva. Podatke o maksimalnom broju ličinki kamenice u akvatoriju Malostonskog zaljeva tijekom toplijeg dijela godine s najvišom vrijednošću početkom rujna te također visokim vrijednostima u lipnju i srpnju, potvrđuju i Morović i Šimunović (1980).

Isti autori nalaze maksimalni broj ličinki od preko 75 tisuća komada u prostornom metru morske vode na postaji Krstac u svibnju 1974. godine, što višestruko nadmašuje maksimum u 2008. god. Uzgajivačima preporučuju polaganje kolektora kod koncentracije ličinki od 15000 kom./m<sup>3</sup>. Nakon toga 1986. god. maksimalno je zabilježeno 55600 kom./m<sup>3</sup> (Onofri, 2003). Vrijednosti broja ličinki koje iznose Morović i Šimunović (1980) višestruko su veće i od onih opaženih kod Bratoš i sur., (2002) kad je nađeno svega 5029 kom./m<sup>3</sup>. Uzrok ovakvim razlikama u koncentraciji ličinki može biti smanjena proizvodnja kamenice kao izravna posljedica oružanog sukoba tijekom Domovinskog rata, ali i promjena temperature i kvalitete morske vode te smanjenu količinu planktonske hrane u akvatoriju Malostonskog zaljeva (Bratoš i sur., 2002). Na nekoliko lokacija na području sjevernog Jadrana Hrs-Brenko (1971) nalazi također dosta niže vrijednosti broja ličinki, ne viših od 1000 kom./m<sup>3</sup>. Nadalje Cano et al. (1997) na španjolskoj obali također bilježe značajno manju koncentraciju ličinki europske plosnate kamenice u stupcu morske vode od 6000 kom./m<sup>3</sup>.

Iako je tijekom sezone mrješćenja u 2009. godini obavljen nešto veći broj uzorkovanja, rezultati pokazuju značajno smanjenje broja ličinki kamenice u stupcu morske vode u odnosu na prethodnu 2008. god. Porast broja ličinki u prostornom metru morske vode zabilježen je početkom lipnja. Tada je u središnjem dijelu Malostonskog zaljeva na postaji Soca zabilježen najveći broj ličinki od 950 kom./m<sup>3</sup>. U vanjskom dijelu zaljeva na postaji Žuronja nešto niža vrijednost od 846 kom./m<sup>3</sup> zabilježena je mjesec dana kasnije početkom srpnja 2009. god. (Tablica 1).

Tablica 1. Maksimalna vrijednost broja ličinki kamenice (kom./m<sup>3</sup>) po postajama tijekom razdoblja monitoringa 2008/09. godine.

Godina/postaja	Luka	Soca	Bistrina	Žuronja	Brijesta
2008.	2494	1870	787	5848	2078
2009.	831	950	579	846	675

Od kraja srpnja količina ličinki počinje postupno opadati uz sporadična povećanja na nekim postajama u kolovozu i rujnu. Tijekom listopada i prosinca broj ličinki kamenice opet se značajnije smanjuje, da bi početkom prosinca na svim postajama pao ispod 30 kom./m<sup>3</sup>. Zbog male količine ličinki tijekom cijele sezone uzgajivačima je preporučeno polaganje kolektora pri koncentraciji od 500 kom./m<sup>3</sup>.

Rezultati monitoringa u 2009. god. pokazuju značajno manje vrijednosti broja ličinki u odnosu na prethodnu godinu, što predstavlja prekid višegodišnjeg trenda njihova rasta u Malostonskom zaljevu. Količina ličinki nije niti jedan put prešla granicu rentabilnosti polaganja kolektora od 1000 kom./m<sup>3</sup>, što se nije dogodilo od 2004. god. kad su zabilježene najniže vrijednosti broja ličinki otkad se odvija kontinuirani monitoring tijekom sezone intezivnog mrješćenja. Interesantno je da je u 2008. god. broj ličinki čak 21 put prelazio 1000 kom./m<sup>3</sup>. Pad je vidljiv i iz srednjih vrijednosti količine ličinki u istraživanom razdoblju. U 2008. god. najveći reproduktivni potencijal (1008 kom./m<sup>3</sup>) zabilježen je na lokalitetu Luka u središnjem, a godinu dana kasnije najveća srednja vrijednost od svega 350 kom./m<sup>3</sup> zabilježena je ovaj put na postaji Žuronja u vanjskom dijelu zaljeva. Sličan odnos tijekom monitoringa je i za ukupne srednje vrijednosti na svim postajama zajedno, naime ta je vrijednost u 2008. god. iznosila 709 kom./m<sup>3</sup>, a u 2009. god. znatno manje (235 kom./m<sup>3</sup>) (Tablica 2).

Tablica 2. Srednja vrijednost broja ličinki kamenice (kom./m<sup>3</sup>) za svaku postaju pojedinačno i ukupno za sve postaje zajedno tijekom razdoblja monitoringa 2008/09. god.

Godina/postaja	Luka	Soca	Bistrina	Žuronja	Brijesta	Ukupno
2008.	1008	710	359	950	519	709
2009.	198	219	235	350	171	235

Smanjenje broja ličinaka tijekom 2009. god. negativno se odrazilo na prihvata mlađi kamenice na kolektorima, što će rezultirati smanjenjem proizvodnje na uzgajalištima unutar Malostonskog zaljeva. Da bi se ocijenilo radi li se o dugotrajnijim promjenama reproduktivnog potencijala u akvatoriju Malostonskog zaljeva ili razdoblje intezivnog mrješćenja 2009. god. predstavlja samo kratkotrajno cikličko smanjenje broja ličinki, potrebno je nastaviti s daljnjim praćenjem prostorno vremenske raspodjele ličinki na postajama duž zaljeva. To će omogućiti kvalitetno planiranje komercijalnog uzgoja europske plosnate kamenice u jugoistočnom dijelu Jadrana.

### Zaključak

Vrlo niske vrijednosti broja ličinki kamenice u razdoblju intezivnog mrješćenja 2009. godine označavaju prekid višegodišnjeg trenda rasta reproduktivnog potencijala akvatorija Malostonskog zaljeva, te predstavljaju značajan pad u odnosu na predhodnu sezonu. Predstavljaju također značajan pad u odnosu na predhodnu sezonu, kako u zabilježenim maksimumima i srednjim vrijednostima na pojedinim postajama, tako i u ukupnoj srednoj vrijednosti za sve postaje zajedno.

U proizvodnim sustavima koji isključivo ovise o prikupljanju mlađi iz prirodne sredine kao što je područje Malostonskog zaljeva, izuzetno je važan kontinuirani sustav praćenja prostorno vremenske raspodjele ličinki u razdoblju intezivnog mrješćenja kamenice, jer je to jedini način upozorenja uzgajivačima da se pravovremeno pripreme na eventualno nedovoljnu količinu mlađi na kolektorima.

Radi li se u ovom slučaju samo o jednoj lošijoj sezoni 2009. god., ili je to možda najava eventualnog dugotrajnijeg smanjenja reproduktivnog potencijala populacije europske plosnate kamenice u najstarijem i najvećem uzgajalištu u Hrvatskoj, pokazat će praćenje raspodjele ličinki ovog školjkaša u narednim sezonama.

### Napomena

Monitoring ličinki kamenice obavljan je u suradnji s Tehnološkim centrom za marikulturu (MARIBIC) Sveučilišta u Dubrovniku u okviru dvogodišnjeg projekta "Značajke uzgojnih lokaliteta na osnovi praćenja rasta, indeksa kondicije, zdravstvenog statusa i spolnog sazrijevanja uzgojnih populacija kamenice i mušule u području Malostonskog zaljeva" financiranog od strane Dubrovačko-neretvanske županije.

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# Preliminary results on the growth and mortality of warty venus *Venus verrucosa* (Linnaeus, 1758) in the suspension

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## Abstract

At the end of 2007, experiment in the field on growth rate and mortality of warty venus *Venus verrucosa* was started on the Luka location in the middle part of Mali Ston bay (south Adriatic) aiming to investigate the possibility of commercially culturing this shellfish species. Experimental wire mesh cylindrical cage with 73 collected specimens was placed on the depth of 3 m. Low growth rate and high mortality within the experimental population was recorded during summer period, and the experiment was stopped in the beginning of 2009 because of loss of the cage with remaining specimens.

Key words: Warty venus, *Venus verrucosa*, growth rate, mortality rate, suspension

## Preliminarni rezultati praćenja stope rasta i smrtnosti brbavice *Venus verrucosa* (Linnaeus, 1758) u kavezu iznad morskog dna

### Sažetak

Na lokaciji Luka u središnjem dijelu Malostonskog zaljeva krajem 2007. godine postavljen je pokus praćenja stope rasta i smrtnosti brbavice *Venus verrucosa*, u cilju ispitivanja mogućnosti pronalazanja adekvatne tehnologije komercijalnog uzgoja ovog za marikulturu vrlo interesantnog školjkaša. U ljetnom razdoblju je zabilježena niska stopa rasta te vrlo visoka smrtnost pokusnih jedinki. Pokus je prekinut početkom 2009. godine zbog nestanka kaveza s preostalim manjim brojem školjkaša.

Ključne riječi: brbavica, *Venus verrucosa*, rast, smrtnost

### Introduction

Warty venus *Venus verrucosa* (Linnaeus, 1758) is shellfish species common to the Mediterranean Sea, and can be found on the sandy bottoms and in the *Possidonia oceanica* meadows down to depth of about 30 m (Poppe and Goto, 1993). On the eastern coast of the Adriatic Sea it is usually collected by diving (Benović, 1997), in amounts of 500 tonnes yearly (Hervat et al., 2006). Along the Italian southern Adriatic coast catches are also around 500 tonnes per year (Arneri et al., 1998).

The biology of *V. verrucosa* has been previously investigated by several authors. Reproduction cycle in the wild has been investigated by Marano et al. (1982), Valli et al. (1988) and Tirado et al. (2003) while growth rate has been investigated by Arneri et al. (1998) and by Hervat et al. (2006). Potential for artificial reproduction has been investigated by Rossi et al. (1994) and there has been successful spawning of this species on the eastern Adriatic coast during 2008 (Jug-Dujaković et al., 2009; Gavrilović et al., 2009).

Considering its commercial importance, warty venus seems to be very interesting shellfish for the introduction into the mariculture. In that respect this paper presents preliminary results of the growth and mortality rates in experimental suspended cage.

### Materials and methods

By the end of December of 2007, 73 collected shellfish were placed in the experimental cage, and growth recording was commenced. Shellfish specimens were placed in the plastic insulated wire mesh cylindrical cage 150 mm high and 250 mm diameter, wrapped in the net with opening of 10 mm. Since all commercial breeding of shellfish in the Mali Ston bay has been occurred at the depth of 4 to 4.5 m, cage with specimens was placed on the depth of 3 m, approximately at the middle of farming column.

The individuals were measured once a month throughout experiment. Each *V. verrucosa* specimen was measured with a vernier caliper along two axes: length (anterior to posterior margin), and height (dorso-ventral axis from the umbo to the ventral margin) (Seed, 1980). All measurements were taken to the 0.1 mm. Dead specimens were recorded during the measurements. Last measurement was taken in the December of 2008, and the experiment was terminated in the February of 2009 due to the loss of cage line. Sea temperature was monitored daily and salinity was monitored monthly.

### Results and discussion

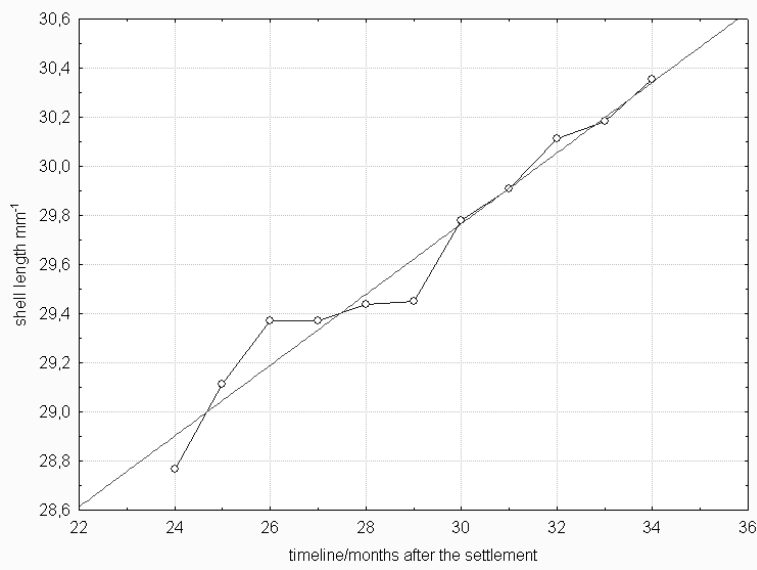
Warty venus, being cultured during one-year period showed slow growth rate along with above 50% mortality (fig.1a). Initial average shell length of specimens placed in cages was  $28.77 \pm 2.82$  mm; average shell height was  $25.75 \pm 2.61$  mm. After a year in the experiment average shell length was  $30.35 \pm 1.90$  mm, and average shell height was  $27.47 \pm 2.10$  mm. Mean monthly growth increment in length in the course of investigated period was  $0.16 \text{ mm month}^{-1}$ , with maximum of  $0.35 \text{ mm month}^{-1}$  in January. In April there was no recorded growth in relation to the March. For shell height mean was  $0.17 \text{ mm month}^{-1}$ , monthly maximum was recorded in January,  $0.42 \text{ mm month}^{-1}$  and minimum in July,  $0.01 \text{ mm month}^{-1}$ . The average temperature for experimental period was  $16.01^\circ\text{C}$  and the average salinity was 36.3 ppt. Regression analysis was performed on the linearized (LOG-transformed) data of shell length, which showed significant, although small standardized linear regression coefficient:  $\beta = 0.157712 \pm 0.039852$  ( $R^2 = 0.024873$ ,  $t = 3.9575$ ,  $p = 0.000085$ ). Regression plot is shown on figure 1b.

Low shell growth rate of *V. verrucosa* was recorded also in previous studies. Thus Hervat et al. (2006) conclude that this species reaches its minimal commercial shell length of 25 mm in second year of life, while the majority of the growth takes place until six years old. Estimated age of specimens in fore mentioned experiment 37.1-52.0 mm long was 4.5-11.5 years, which was in concurrence with some previous measurements taken from the Italian and Greek populations (Arneri et al., 1998).

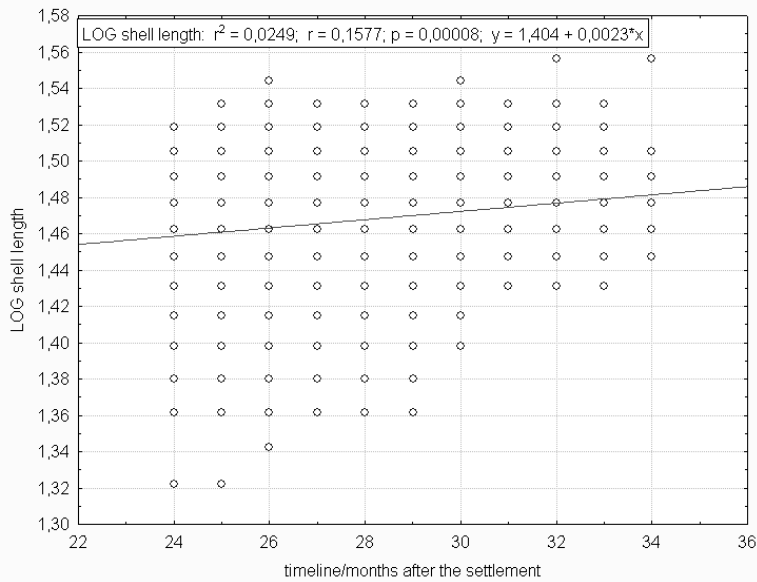
Greatest absolute mortality of warty venus was recorded during august 2008 (25 individuals, 36.76%). Greatest relative monthly mortality was recorded during October the same year, and was 37.14%. Afterwards the mortality rate was steadily decreasing toward the end of experiment. Since mortality was low until the august of 2008, large mortality could be explained by high summer sea temperature. In the wild *V. verrucosa* lives buried in the soft substrate a few centimetres where the variations of temperature are limited. Furthermore, *V. verrucosa* cannot be found on the surface of bottom during summer months, but only in the colder part of year (Franušić, personal communication). Total survival rate of warty venus after one-year experiment was only 26.03% (fig. 2).

Considering that previously growth of warty venus was monitored only in wild populations, further study will reveal its real potential as a culture species.

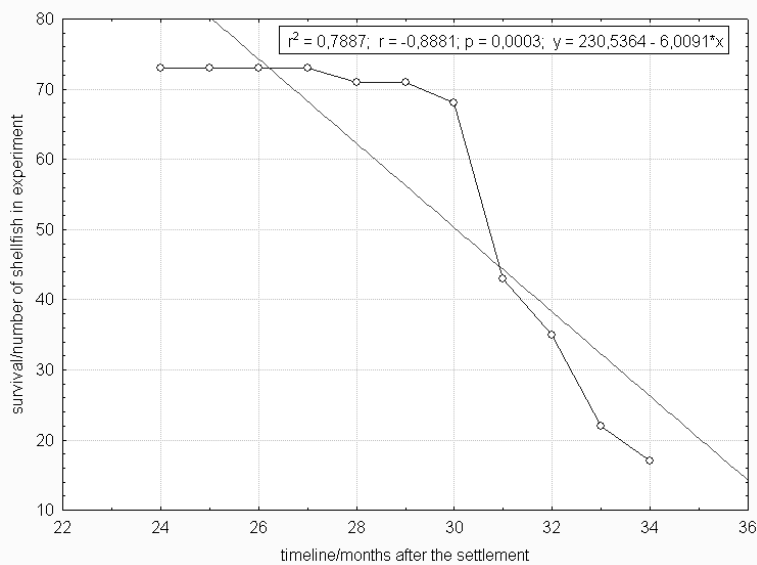
**Preliminary results on the growth and mortality of warty venus *Venus verrucosa* (Linnaeus, 1758) in the suspension**



**Figure 1a.** Shell length of warty venus *Venus verrucosa*, in suspension cage during one-year cycle.



**Figure 1b.** Regression plot on LOG-transformed shell length data.



**Figure 2.** Survival of warty venus during culturing period.

## Conclusion

Low growth rate and increasing mortality of warty venus during one-year trials was probably caused by high culture density and shallow water placement of cage. Relatively high temperature values of surface water during summer-autumn period contributed significantly to low rate of survival (little over 20%). Taking into account the fact that warty venus lives solitary, in contrast to more gregarious shellfish species, and digs into the substrate during warmer periods, we can conclude that, in order to evaluate its culture potential, all these behaviour characteristics must be addressed in future experimental design.

## Acknowledgement

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# Usporedba dvije metode procjene dobi srne obične (*Capreolus capreolus*)

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## Sažetak

U radu su uspoređene dvije metode procjene dobi srne obične (*Capreolus capreolus*). Prva se temeljila na razvitku zubala i istrošenosti stalnih zubi, a druga na brojanju godišnjih naslaga zubnog cementa u prvom donjem kutnjaku ( $M_1$ ). Analizom je obuhvaćena 141 vilica srneće divljači iz tri različite županije u Republici Hrvatskoj. Istovremeno su mjerene tri kranimetrijske značajke vilice; dužina diasteme, dužina zubnog reda i ukupna dužina vilice. Prateći obrazac rasta i izmjene mliječnih zubi dob se može procijeniti za jedinke do četrnaest mjeseci. Metoda istrošenosti stalnog zubala pokazala se kao dobra terenska metoda, ali samo za okvirnu procjenu određivanja dobi. Primjenom ovih metoda dob se pogrešno procjeni u preko 50% slučajeva i to uglavnom precijeni za jednu do tri godine, dok se analiza godišnjih naslaga zubnog cementa pokazala kao najpouzdanija metoda. Kranimetrijska analiza vilica pokazala je pozitivnu korelaciju s godinama starosti, no ipak se ne može uzeti kao relevantna za samostalno procjenjivanje dobi.

Ključne riječi: srna obična, procjena dobi, istrošenost zubala, naslage zubnog cementa

## Comparison of two methods of age determination on roe deer

### Abstract

The study compares method of age estimation based on the development and wear of permanent teeth with the method of estimating age based on counting annual layers of dental cement in the lower first molar ( $M_1$ ). The analysis included 141 roe deer mandibles from three different regions in the Republic of Croatia. With these two methods were measured three craniometric characteristics of the mandible; length of diastema, length of tooth row and the total length of the mandible, for which research has proven that although some of them are positively correlated with age are not sufficient to independently assess age. Following the pattern of growth and change of milk teeth age can be accurately determined for the individual to fourteen months, a permanent tooth wear proved to be a good field method, but only to roughly determine the age, while the analysis of annual layers of dental cement proved to be accurate and reliable method of assessing age deer. The results show that the method of assessing age by developing and permanent tooth wear age wrongly assessed in more than 50% of cases, mostly overestimate for one to three years.

Key words: roe deer, age estimation, tooth wear, dental cement layers

## Uvod

Srna obična (*Capreolus capreolus*) je najbrojnija vrsta krupne divljači u Republici Hrvatskoj s najslabije iskorištenim prirodnim potencijalom. Ujedno je i najperspektivnija gospodarska vrsta. Lovna površina u Hrvatskoj danas iznosi 4.428.915 ha (Florijančić i sur., 2009.), a procjenjuje se da na 2,2 milijuna hektara postoje uvjeti za gospodarenje srnom uz prosječno 7 grla na 100 ha što navodi na zaključak da bi potencijal mogao biti oko 150 000 grla u matičnom fondu, a to bi omogućilo odstrel od 50 000 grla (Raguž i sur., 2004.). Matični fond srneće divljači na dan 1. travnja 2008. godine je prema podacima Središnje lovne evidencije iznosio 56.702 grla uz odstrel od 13.845 grla (Ivasić i sur. 2009.), što je daleko ispod kapaciteta staništa (Dumić, 2006.). Jedan od ključnih zadataka lovne struke je održavanje ravnomjerne spolne, ali i pravilne dobe strukture kao osnovnog uvjeta stvaranja i održavanja vitalnih i reproduktivno sposobnih populacija divljači (Gačić, 1999.). Radi lakšeg planiranja i provođenja uzgoja divljači sve se jedinke u populaciji uvrštava u određene dobne razrede. Prema našem, trenutno važećem Pravilniku o sadržaju, načinu izrade i postupku donošenja, odnosno odobravanja lovnogospodarske osnove, programa uzgoja divljači i programa zaštite divljači (Anon., 2006., 2008.) dobni razredi su sljedeći: mladunčad - divljač do konca prve lovne godine i pomladak - divljač tijekom druge lovne godine. Iako daljnji dobni razredi nisu strogo definirani istim Pravilnikom, nepisano je pravilo izrađivača lovnogospodarskih osnova da dobni razred mladih obuhvaća srneću divljač tijekom treće i četvrte lovne godine, srednjih tijekom pete i šeste lovne godine i zrelih tijekom 7 i više lovnih godina. Zbog relativno kratke gospodarske starosti (6-7 godina) koja u velikoj mjeri određuje i stvarnu dužinu života (Danklin, 1996.), greška u procjeni dobi od dvije ili čak više godina, bilo da se radi o precjenjivanju ili podcjenjivanju stvarne starosti ima izuzetno veliki značaj. Ovakve greške izazivaju poremećaje u dobroj strukturi i neminovno smanjuju njenu vitalnost i reproduktivni potencijal (Gačić, 1999.). Iz gore navedenog lako je zaključiti kako je procjena dobi problematika koja zauzima krucijalno mjesto u suvremenom lovnom gospodarenju (Krapinec i sur., 2009.).

## Materijal i metode

U četverogodišnjem razdoblju (2007. - 2010. godina) prikupljena je 141 vilica (*os mandibularis s. mandibula*) srneće divljači s područja triju županija; Bjelovarsko - bilogorske (60 srnjaka i 11 srna), Karlovačke (31 srnjak) i Zagrebačke (33 srnjaka i 6 srna). Vilice su stečene putem odstrjela (125 uzoraka), pronalaskom kostura i lešina divljači (6 uzoraka) i stradavanjem u prometu (10 uzoraka). Dob svake jedinke procijenjena je prvo prema razvitku zubala i stupnju istrošenosti stalnih zubi vizualnim pregledom i usporedbom sa slikama iz literature (Car, 1961.), (Gostiša, 1952.), (Čeović, 1953.), (Darabuš i sur., 2009.), (Krže, 2000.), (Whitehead, 2008.), (Hespler i Krewer 2006.). Paralelno je uz pregled istrošenosti stalnih zubi obavljena i kranimetrijska izmjera tri značajke vilice koje se najčešće mjere te ih je moguće uspoređivati s istim u literaturi (Danklin, 1996.), (Pételis, 2003.). To su: dužina bezubog ruba ili diasteme, dužina zubnog reda i ukupna dužina vilice. Sve tri izmjere iskazane su u centimetrima na dvije decimale. Mjerenje je vršeno metalnom pomičnom mjerilom marke Meba.

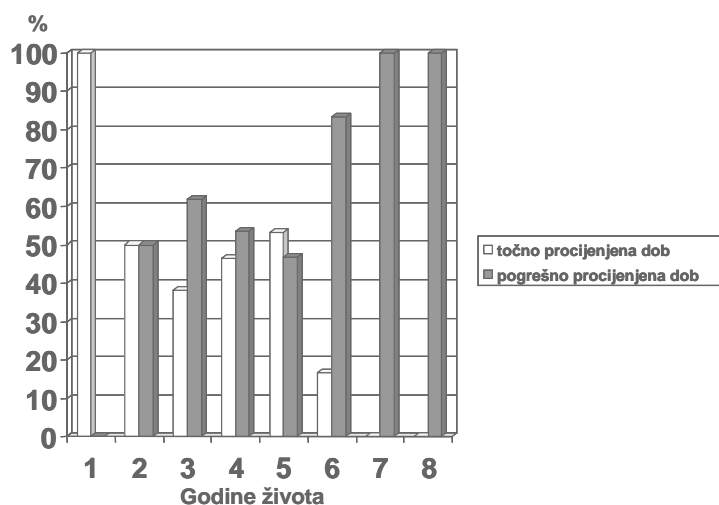
Dob je procijenjena i prema broju godišnjih naslaga zubnog cementa (Mitchell, 1963) na uzdužnim presjecima prvog donjeg kutnjaka ( $M_1$ ). Vilica se pričvrsti u ručnoj stezi. Preciznom pilom za metal reže se prvi kutnjak ( $M_1$ ) pod pravim kutom u odnosu na uzdužnu os vilice. Površina reza se polira finim brusnim kamenom u okomitom smjeru reza zuba. Godišnji prsteni u zubnom cementu su brojani pod binokularom marke Carl Zeiss Jena, model Q 1 pod povećanjima od 10, 16 i 26 puta uz povremeno zakretanje zuba da bi se s obzirom na smjer padanja svjetlosnog snopa postigla najbolja vidljivost. Kontrolna provjera je rađena binokularom s mogućnošću istovremenog fotografiranja uzorka marke Leica Wild model M28 uz povećanja od 6, 16, 32 i 40 puta, dok je fotoaparata bio marke Olympus, model SP 500 UZ. Provjera je rađena na Šumarskom fakultetu u Zagrebu, na Zavodu za zaštitu šuma i lovno gospodarenje. Statistička obrada rezultata obavljena je u računalnom programu SPSS 16.0.1. Statistics (2007.).

## Rezultati i rasprava

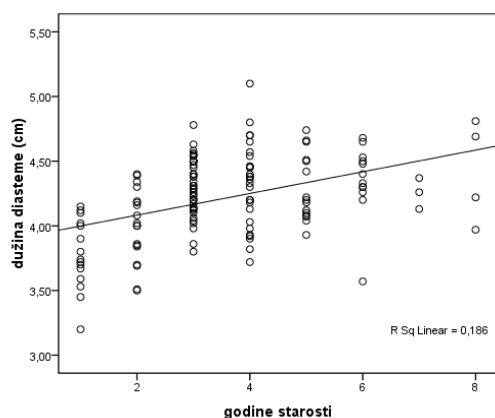
Grlima do godine dana starosti dob je točno procijenjena koristeći metodu koja prati razvitak zubala. Na presjeku zubi tih jedinki (ako su bile odstrijeljene tijekom zime) u zubnom cementu postoji vidljiv samo jedan tanak sloj tamne boje. Kod jedinki odstrijeljenih tijekom svibnja, lipnja i srpnja vidljiv je uz tamni sloj i sloj svjetlije boje dok je unutrašnjost zubne pulpe redovito neispunjena. Kod jedinki starijih od godine dana unutar zubne pulpe se razvija sekundarni dentin, a u zubnom cementu su vidljive naslage tamne i svijetle

## Usporedba dvije metode procjene dobi srne obične (*Capreolus capreolus*)

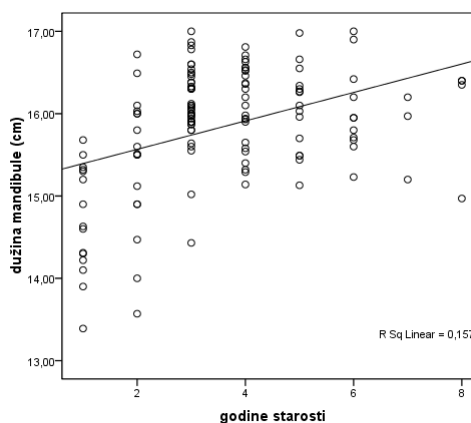
boje. Razlike u vidljivosti i prepoznatljivosti naslaga između muških i ženskih grla nisu uočene kao niti razlike između jedinki odstrijeljenih u različitim županijama. U dobi od dvije godine na 50% jedinki je pogrešno procijenjena dob koristeći se metodom istrošenosti stalnih zubi. U dobi od tri godine na 61,9% jedinki je pogrešno procijenjena dob, a od toga je 52,38% procijenjeno za 1 godinu, 7,14% procijenjeno za 2 godine i 2,38% procijenjeno za 3 godine. U dobi od četiri godine na 53,57% jedinki je pogrešno procijenjena dob, a od toga je 50% procijenjeno za 1 godinu i 3,57% procijenjeno za 2 godine. U dobi od pet godina na 46,65% jedinki je pogrešno procijenjena dob, a od toga je 33,33% procijenjeno za 1 godinu, 6,66% procijenjeno za 2 godine i 6,66% podcijenjeno za 1 godinu. U dobi od šest godina na 83,32% jedinki je pogrešno procijenjena dob, a od toga je 58,33% procijenjeno za 1 godinu, 8,33% procijenjeno za 2 godine i 16,67% podcijenjeno za 1 godinu. U dobi od sedam godina na 100% jedinki je pogrešno procijenjena dob, a od toga je 33,33% procijenjeno za 1 godinu, 33,33% procijenjeno za 2 godine i 33,33% podcijenjeno za 1 godinu. U dobi od osam godina na 100% jedinki je pogrešno procijenjena dob, a od toga je 75% procijenjeno za 1 godinu i 25% procijenjeno za 2 godine.



Grafikon 1: Postotni odnos točno i pogrešno procijenjenih dobi primjenom metode temeljene na razvoju zubala i istrošenosti stalnih zubi prema stvarnim godinama života



Grafikon 2: Korelacijski odnos dužina diasteme i godina starosti



Grafikon 3: Korelacijski odnos dužina vilice i godina starosti

Za utvrđivanje povezanosti između mjerenih svojstava i godina starosti napravljena je Pearsonova korelacija. Utvrđena je pozitivna korelacija između godina starosti i diasteme ( $r = 0,431$ ,  $n = 135$ ,  $p < 0,01$ ) te između godina starosti i vilice ( $r = 0,397$ ,  $n = 131$ ,  $p < 0,01$ ), dok između godina starosti i zubnog reda korelacija nije utvrđena.

Metoda procjene dobi po istrošenosti stalnih zubi je vrlo jednostavna i terenski prihvatljiva te nam može poslužiti za okvirno procjenjivanje dobi srneće divljači. Problem nastaje prilikom njene primjene i ispunjavanja LGO - 3 obrasca u kojem su dobni razredi strogo podijeljeni. U dobi od 2, 3 i 4 godine, dob divljači se za više od 50 posto precjenjuje za jednu godinu. Takvi rezultati se podudaraju s rezultatima istraživanja Szabik (1973.) i Hewisona (1999.) U dobi od 5, 6 i više godina dolazi uz precjenjivanje dobi i podcjenjivanje dobi jedinke na određenom broju uzoraka. Zbirno gledajući, primjenom ove metode na 53,19% uzoraka dob je pogrešno procijenjena. Ako izuzmemo jedinke do godine dana života (kojima je moguće točno procijeniti dob) i gledamo samo jedinke od 2 - 8 godina života vidimo da je dob u 60,48% uzoraka pogrešno utvrđena.

Metoda procjenjivanja dobi prema broju godišnjih naslaga zubnog cementa je terenski vrlo ograničavajuća odnosno neprihvatljiva. Zahtijeva određenu opremu, mnogo više vremena za pripremu i očitavanje uzoraka kao i određeno znanje i vještinu. Godišnje naslage su relativno dobro vidljive ali u nekoliko slučajeva primijećeno je da se one na pojedinim mjestima sužavaju, spajaju i potom razdvajaju što neuvježbanom oku uvelike otežava brojanje i očitavanje, što se podudara s istraživanjima Gačića (1999.) i Høyea (2001.).

Mana svih navedenih metoda leži u činjenici da su one primjenjive tek nakon izvršenog odstrjela tj. na mrtvoj divljači kad se eventualna pogreška odstrjela ne može više ispraviti. Međutim, te metode omogućuju kontrolu ispravnosti odstrjela i točnosti procjene dobi živih jedinki što je od velikog značaja za planiranje i provođenje lovnog gospodarenja. Iz tog razloga se dob svih odstrijeljenih jedinki koja je procijenjena prije odstrjela mora obavezno usporediti sa dobi koja se određuje nakon odstrjela.

### Zaključak

Dob srne obične prema razvoju i izmjeni mliječnog zubala moguće je točno odrediti kod jedinki mlađih od četrnaest mjeseci. Metoda prema stupnju istrošenosti stalnih zubi prikladna je samo za okvirnu procjenu jer se njenom primjenom dob u većini slučajeva precjenjuje za 1 ili više godina. Ovu metodu ne bi samostalno (bez provjere rezultata nekom drugom metodom) trebali koristiti prilikom ispunjavanja Pravilnikom propisanih obrazaca. Metoda određivanja starosti brojanjem godišnjih naslaga zubnog cementa na uzdužnom presjeku prvog donjeg kutnjaka ( $M_1$ ) je točna i pouzdana. Dužina diasteme i ukupna dužina vilice mogu se uzeti samo kao smjernice, ali ne i kao pouzdan pokazatelj u procjenjivanju dobi, dok dužina zubnog reda nije vezana uz dob jedinke i prema njoj se ista ne može odrediti. Prilikom ocjenjivanja trofeja, a u nemogućnosti korištenja metode procjenjivanja dobi prema broju godišnjih naslaga zubnog cementa potrebno je koristiti nekoliko metoda (prema preporukama stručne literature) kako bi se dob što točnije utvrdila.

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# Oxygen consumption and resting metabolism of post-hatching cuttlefish *Sepia officinalis* (Linnaeus, 1758)

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## Abstract

Oxygen consumption of post-hatching cuttlefish, *Sepia officinalis* (Linnaeus, 1758), up to the age of 48 days was investigated in the laboratory trial. Total of 139 animals were subjected to respirometry measurements. The oxygen consumption ranged from 129.316 to 479.7371  $\mu\text{g O}_2 \text{ g}^{-1}\text{h}^{-1}$  (mean oxygen consumption  $280.5348 \pm 77.7149 \mu\text{g O}_2 \text{ g}^{-1}\text{h}^{-1}$ ). Statistical relation between oxygen demand and body weight and age show decrease with both independent variables respectively.

Key words: oxygen consumption, resting metabolism, cuttlefish.

## Potrošnja kisika i metabolizam pri mirovanju juvenilne sipe, *Sepia officinalis* (Linnaeus, 1758)

### Sažetak

Potrošnja kisika juvenilne sipe, *Sepia officinalis* (Linnaeus, 1758), je mjerena u laboratorijskom pokusu do dobi od 48 dana. Ukupno je u pokusu korišteno 139 jedinki. Potrošnja kisika se kretala u rasponu od 129.316 do 479.7371  $\mu\text{g O}_2 \text{ g}^{-1}\text{h}^{-1}$ , sa srednjom vrijednosti od  $280.5348 \pm 77.7149 \mu\text{g O}_2 \text{ g}^{-1}\text{h}^{-1}$ . Na osnovu rezultata dobiven je trend pada potrošnje kisika sa povećanjem mase i starosti sipe.

Ključne riječi: potrošnja kisika, metabolizam pri mirovanju, sipa

### Introduction

Cuttlefish, *Sepia officinalis* (Linnaeus, 1758) is temperate and tropical water cephalopod species that lives solitary in circalittoral space, down to 200 m. The cuttlefish migrates seasonally inshore (Bakhaykho i Drammeh, 1982), and spawns in shallow waters. The eggs are laid at depths rarely greater than 40 m, and in waters of southern Adriatic sea usually at 7-15 m (Glavic, 2007). The animal is semelparous, and the spawning is characterized as intermittent terminal (Rocha et al., 2001). The water temperature is already documented as a major factor affecting overall metabolic activity of aquatic organisms (Magnuson et al., 1979), and oxygen consumption expressed as P50 (Brix et al., 1994.). Available oxygen in turn influences the distribution of cuttlefish (Johansen et al., 1982). Therefore, we can characterize the temperature as a limiting factor for cuttlefish (Fry, 1971). These measurements were conducted to get insight into respiration rate, resting metabolic needs and costs of young cuttlefish in relation to size and time after hatching, during first 48 days of life.

## Materials and methods

Oxygen consumption was measured on cuttlefish that hatched from eggs layed in the laboratory. Parental stock of adult cuttlefish ( $m=378\pm 84g$ ), six females, were collected at the river Neretva mouth ( $40^{\circ}01'37.11''N$  and  $17^{\circ}25'02.62''E$ ) from a depth of 7-9m ( $S=36psu$ ,  $t=13^{\circ}C$ ), on march 23rd 2005. In all, 616 eggs were layed on the plastic mesh placed vertically in the holding tank by at least three females. After 67 days, first young cuttlefish started to hatch. After the hatching, young cuttlefish were fed daily live misids, species *Hemimysis lamornae mediterranea*, Bacescu, 1936. The measurements of resting metabolic rate (RMR) started with the very hatching process, that took place in the respirometric chamber. The method used was constant volume respirometry, because of small weight of subject (0.09-0.56g). The cylindrical respirometric chamber, 38.9cm<sup>3</sup> volume, was fitted with Clarke's polarographic measuring element (Radiometer type E 5046) and signal analyzer (Radiometer type PHM 72). Salinity was kept at 35-39psu, and temperature 16.8-23.5°C. The measurement intervals were set at 30 min, and the oxygen levels, as partial pressure of O<sub>2</sub> was recorded every 5min. The temperature difference did not exceed 2.0°C. For each of 8 weekly measurements, 18 animals were chosen, making total of 145 measured cuttlefish. All groups of data were subjected to Kolmogorov-Smirnov normality test ( $p<0.20$ ), and histogram of group data were produced to assess the within-group distribution pattern. Repeated measures ANOVA ( $p<0.05$ ) was used on age groups of data to reveal the influence on cuttlefish respiratory activity. Simple linear regression of log-transformed data was used to show the trend of the respiratory activity dependence to the age and wet weight of juvenile cuttlefish. All statistical analyses and graphs were produced using Statsoft Statistica v 7.0 for Windows.

## Results and discussion

In total 139 animals (BW 0.09-2.19g, mean BW 0.432g, SD  $\pm$  0.300385g) were measured. All respirometric data were obtained under normoxic water conditions (PO<sub>2</sub>, Pw<sub>0</sub>=134 mm Hg, Pwt=102 mm Hg, eg.%sat. at 80-120). The temperature in the acclimation tanks, as well as inside of the respirometer chamber was kept at the average values of  $21.64\pm 0.914^{\circ}C$ . The salinity of the sea water was ambiental, and has changed significantly through the experiment (31.00-40.00psu, avg 37.02psu), and has to be addressed to as a independent variable. The mean oxygen consumption throughout the experiment was  $280.5348 \pm 77.7149 \mu g$  O<sub>2</sub>g.<sup>-1</sup>h.<sup>-1</sup>, min. 129.316  $\mu g$  O<sub>2</sub>g.<sup>-1</sup>h.<sup>-1</sup>, max. 479.737  $\mu g$  O<sub>2</sub>g.<sup>-1</sup>h.<sup>-1</sup>. The highest average oxygen consumption was measured in two weeks post hatching cuttlefish. The results of ANOVA statistical analysis shows that age is a significant determinant of young cuttlefish specific respiratory activity (univariate repeated measures ANOVA,  $F=3.470505$ ,  $p=0.005459$ ). Regression of the log weight-specific oxygen consumption to the log wet body weight of post-hatching cuttlefish showed decrease in oxygen demand with the increase in weight, and could be expressed by the equation:  $\log VO_2 = 2.3546 - 0.1673 \cdot \log BW$ . The correlation coefficient  $r=-0.3976$ , and the determination coefficient  $R^2= 0.1581$ ,  $N=140$  ( $p<0,05$ ). Graphical depiction of trend is given on figure 1. Also, oxygen consumption was regressed to the age of young cuttlefish, up to the 49-th day of life. Regression showed that there is a trend of decreasing oxygen demand in cuttlefish with age (fig 2). Comparing cuttlefish oxygen consumption to the commercially cultured fish such as seabass, *Dicentrarchus labrax* yields significantly lower oxygen demand for seabass (65, 160, 360 and 340 mg O<sub>2</sub> g.<sup>-1</sup>h.<sup>-1</sup> at 10, 15, 20 and 25 °C respectively, (Claireaux and Lagardère ,1999). However, Johansen et al. (1982) state that cuttlefish oxygen demand is lower that the one in commercially cultured prawns.

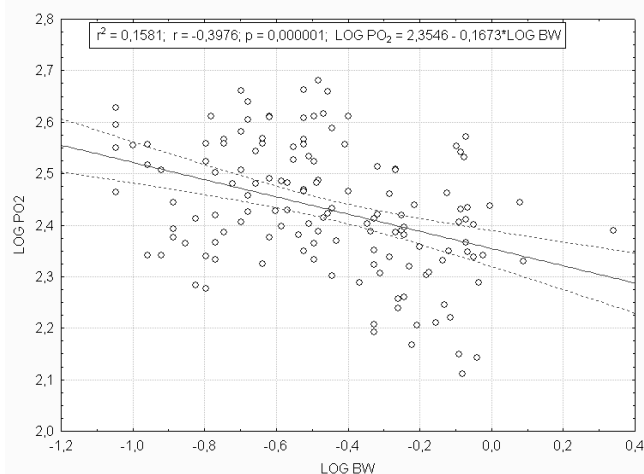


Figure 1. Scatterplot of relation between LOG oxygen consumption and LOG wet body weight of juvenile cuttlefish, *Sepia officinalis*.

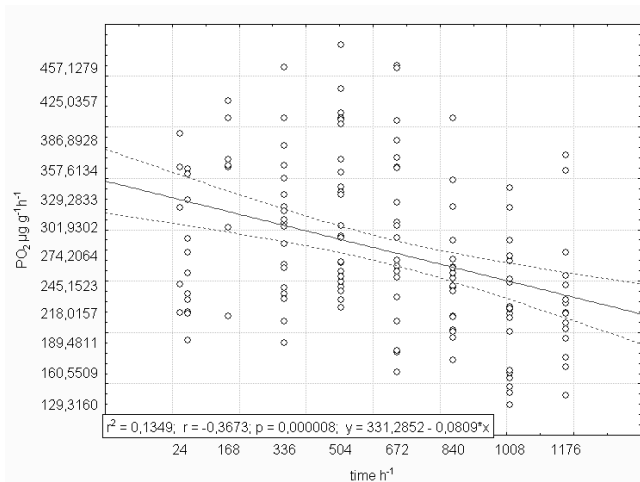


Figure 2. Scatterplot of relation of oxygen consumption and age of young cuttlefish.

### Conclusion

Results show strong statistical relationship between oxygen consumption and wet body weight and age of cuttlefish, indicating decrease of oxygen demand with age and with the increase of body weight. Also, as indicated in the literature on the subject, the oxygen demand of cuttlefish falls between that of commercially cultured fish and prawns.

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# The experimental rearing of fan mussel *Pinna nobilis* (Linnaeus, 1758)

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## Abstract

The growth of fan mussel *Pinna nobilis* was investigated in commercial shellfish farm in Mali Ston Bay (South-Eastern Adriatic, Croatia). During October to December 2006 juvenile stages of fan mussel were collected at commercial shellfish spat collectors. For the experimental cultivation specimens (n-354) were placed in specially modeled cages (30cm high and 15cm diameter). After one-year of research fast growth was noted; from a minimum of 16.0mm to a maximum of 157.0mm of shell length.

Key words: fan mussel, *Pinna nobilis*, rearing, growth

## Pokusni uzgoj plemenite periske *Pinna nobilis* (Linnaeus, 1758)

### Sažetak

Istraživan je rast plemenite periske *Pinna nobilis* u uvjetima komercijalnog uzgajališta u Malostonskom zaljevu. U razdoblju od listopada do prosinca 2006 juvenilni primjerci plemenite periske skupljani su na komercijalnim kolektorima (n-354). Pokusni uzgoj sakupljenih primjeraka postavljen je u specijalno izrađene kaveze (30cm visoke i 15cm široke). Jednogodišnja istraživanja pokazuju brzi rast s minimalnih 16.0mm do maksimalne visine od 157.0mm visine školjke.

Ključne riječi: plemenita periska, *Pinna nobilis*, uzgoj, rast

### Introduction

The fan mussel, *Pinna nobilis* is endemic to the Mediterranean Sea. It is one of the largest bivalves in the world, reaching sizes of up to 86cm (Moreteau and Vicente, 1982). According to the latest data, maximum lengths are up to 120cm (Zavodnik et al. 1991). It has very variable recruitment (Butler et al. 1993), and occurs at depths between 0.5 and 60m. It lives mostly on soft-bottom areas overgrown by meadows of the seagrasses *Posidonia oceanica*, *Cymodocea nodosa*, *Zostera marina* or *Zostera noltii* (Zavodnik et al. 1991), but also on bare sandy bottoms (Katsanevakis, 2006, 2007). The population of fan mussel has been greatly reduced during the past few decades as a result of recreational and commercial fishing for food, use of its shell for decorative purposes, and incidental killing by trawling and anchoring. A variety of previous investigations focused on the age and growth rate of the fan mussel under natural conditions (Richardson et al, 1999, 2004; Katsanevakis 2007; Rabaoui et al. 2007; Garcia-March and Márquez-Aliaga, 2007). Solving the problem of controlled breeding could protect natural populations and reduce the harm from illegal extraction from the seabed. This research opens the possibility for commercial production in the future, when the technology for culture in all stages is developed. In this paper, we present the preliminary results of the first controlled cage rearing of fan mussel.

## Material and methods

Juvenile stages of fan mussel (354 specimens) were collected in the Mali Ston Bay during October to December 2006. All specimens were collected at commercial collectors for flat oyster, *Ostrea edulis* and Mediterranean mussel, *Mytilus galloprovincialis*. Collected specimens were measured immediately after removal from the collector. For the experimental cultivation specimens were placed in specially modeled cages (30cm high and 15cm diameter). Cages were made of wire mesh covered with fishing net (mesh size 4mm). Wire framed cages had plastic insulation. The cages were cylindrical and within it, there were two round pieces of Styrofoam (3cm thickness) with holes (1cm deep) in the middle and on the bottom, in which specimens were placed. Holes in the Styrofoam were made so that the lower third section of shells was placed in the hole in the Styrofoam. The individuals were measured once a month throughout experiment. These measurements included maximum dorsal height; ventral and anterior-posterior shell length. Dead or damaged specimens were recorded during the measurements. Each specimen in the cage was marked by a number. Three months after the start of the experiments, the cage sizes were changed. The new cages were squared (40x40x40cm) with a perforation size of 1cm<sup>2</sup>, and with a grid at the bottom for enabling the setting of individuals in a natural vertical position. Sea temperature was monitored daily and salinity was monitored monthly.

## Results and discussion

The average length of specimens harvested from the collectors was 29.0±12.1mm, while the average height was 12.9±14.1mm; the minimum length was 16mm, while the maximum was 35mm.

As with other research on this species (Richardson *et al.*, 1999, 2004; Katsanevakis 2007; Rabaoui *et al.* 2007; Garcia-March & Márquez-Aliaga, 2007), our case also confirmed that fan mussel shows rapid growth. The results of the one-year research indicate fast growth from a minimum of 16.0mm to a maximum of 157.0mm (Fig. 1). Specimens in the experiment increased their growth already after 80 days by cca 50%. Two months later and 140 days since the beginning of the experiment, an almost 100% increase in growth rate was recorded (Fig. 1). We recorded a low mortality rate, which amounted to 6,6%. Vicente *et al.* (1980) and Moreteau and Vicente (1982) reported fast shell growth over the first 2 to 3 years, and a much slower growth thereafter.

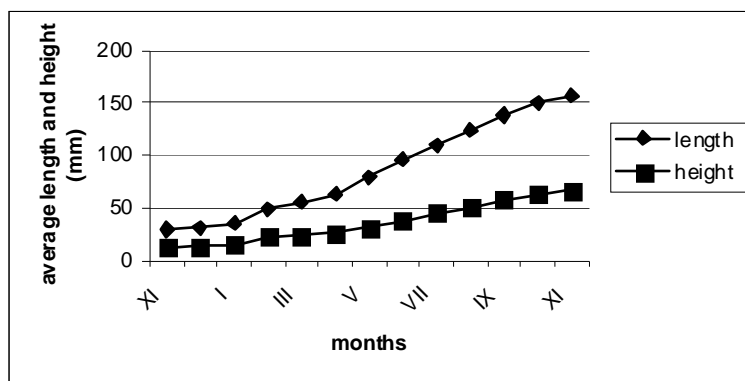


Fig. 1. The average length and height growth during experimental period

Katsanevakis (2006) reported fan mussel growth in Greek waters (Lake Vouliagmeni). He noted that *P. nobilis* is growing fast, mostly during the first 3 years of life, and that it may live beyond 15 years. Difference exists in the growth rates of fan mussels at certain locations or in different parts of the Mediterranean, which can be associated with temperature, depth and available food quantities (Zavodnik, 1967; Moreteau & Vicente, 1982; Vicente, 1990; Vicente & Moreteau, 1991; Katsanevakis, 2006, 2007; García-March *et al.* 2007). The average monthly growth of shell length for the experimental period was 8.4±4.5mm month<sup>-1</sup> (Fig. 2). The highest average growth of shell length was recorded in June with a value of 17.1mm month<sup>-1</sup>, while the highest average growth in height occurred in February at 7.8mm month<sup>-1</sup>. The lowest values of shell growth at this depth were recorded in December, when length was 2.2mm month<sup>-1</sup>, and height was 0.8mm month<sup>-1</sup>.

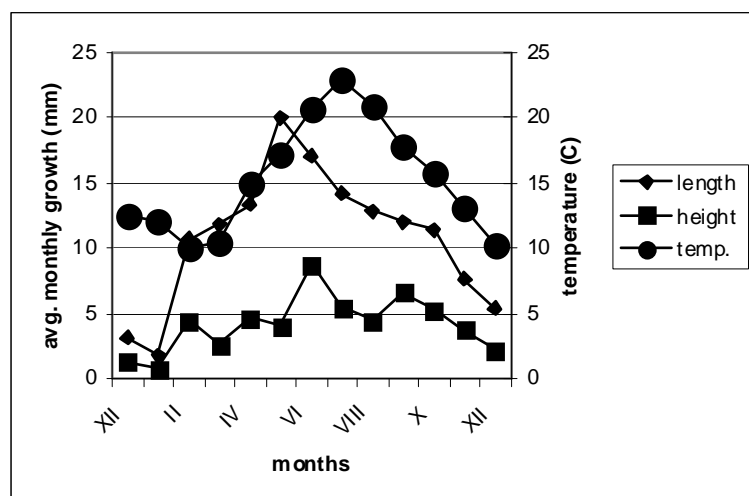


Fig 2. The average monthly length and height growth during experimental period

The average temperature for experimental period was, 16.3°C and the average salinity was 36.0psu. The temperature profile during the experiment are presented in Fig.2.

The growth of *P. nobilis* natural population is described by Katsanevakis (2007) and results are similar to our findings and show peak of growth rates during late spring - early summer and slow growth during the cold season showed.

Controlled rearing along with protection mechanisms, such as the introduction of over fishing adults as reared specimens, can open the doors to mariculture and the gastronomic supply in the region for this species.

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# The experimental rearing of Noah's Ark, *Arca noae* (Linnaeus, 1758) and Bearded Horse Mussel, *Modiolus barbatus* (Linnaeus, 1758) in Mali Ston Bay

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## Abstract

The growth rate of shellfish bivalve, noah's ark, *Arca noae* (Linnaeus, 1758) and bearded horse mussel, *Modiolus barbatus* (Linnaeus, 1758) was investigated under commercial conditions at a shellfish farm in Mali Ston Bay. In February 2007. juvenile stages of *A. noae* (average shell length of  $21.70 \pm 7.13$  mm) and *M. barbatus* (average shell length of  $20.85 \pm 6.80$  mm) were collected in the Mali Ston Bay at a depth of 0.5 to 3m. After two years the length of *A. noae* ranged from a minimum of 6.0 mm to a maximum of 52.0mm, with an average length of  $32.73 \pm 8.09$  mm. For *M. barbatus* the length ranged from a minimum of 8.3mm to a final maximum of 50.3mm., with an average length of  $33.19 \pm 6.14$  mm.

Key words: noah's ark, *Arca noae*, bearded horse mussel, *Modiolus barbatus*, growth rate

## Pokusni uzgoj kunjke, *Arca noae* (Linnaeus, 1758) i bijele mušule, *Modiolus barbatus* (Linnaeus, 1758) u Malostonskom zaljevu

### Sažetak

Istraživan je rast školjkaša, kunjke *Arca noae* (Linnaeus, 1758) i bijele mušule, *Modiolus barbatus* (Linnaeus, 1758) u uvjetima komercijalnog uzgajališta kamenice u Malostonskom zaljevu. Tijekom veljače 2007 sakupljeni su juvenilni primjerci ovih školjkaša (*A. noae* srednje dužine ljuštore  $21,70 \pm 7,13$  mm i *M. barbatus* srednje dužine ljuštore  $20,85 \pm 6,80$  mm), sa dubine od 0.5 do 3 m u Malostonskom zaljevu. Nakon dvogodišnjeg uzgoja dužina ljuštore *A. noae* bila je u rasponu od 6.0 mm do 52.0 mm, sa srednjom vrijednosti od  $32,73 \pm 8,09$  mm, na kraju pokusnog razdoblja. Srednjak dužine ljuštore *M. barbatus* bio je na kraju pokusa  $33.19 \pm 6.14$  mm s početnim minimumu od 8.3 mm i završnim maksimumom od 50.3 mm.

Ključne riječi: kunjka, *Arca noae*, bijela mušula, *Modiolus barbatus*, rast

## Introduction

The bivalve noah's ark, *Arca noae* (Linnaeus, 1758) and bearded horse mussel, *Modiolus barbatus* (Linnaeus, 1758) are commercially important edible shellfish species. *A. noae* is distributed in the eastern Atlantic Ocean, the Mediterranean Sea, the Black Sea, and the West Indies (Nordsieck, 1969). *M. barbatus* is widespread from the British Isles south to Mauritania, West Africa and are found in the Mediterranean (Poppe and Goto 2000). In the Adriatic Sea, both species are widely distributed and locally common (Hrs Brenko and Legac, 1996; Benović, 1997; Zavodnik, 1997). *A. noae* lives attached with solid byssus on all types of hard substrate, including rocks or shells, from low tide to depths of over 100 m and can grow up to 90 mm in length (Poppe and Goto, 2000). The horse mussel occurs in the lower eulittoral-sublittoral fringe and extend down to depths of 110 m, where they attach by strong byssus threads to rocky substrata. This paper describes preliminary consideration towards the controlled culture of *A. noae* and *M. barbatus* on commercial farms.

## Materials and methods

Juvenile stages of *A. noae* and *M. barbatus* were collected in the Mali Ston Bay during February 2007. All specimens were collected at a depth of 0.5 to 3 m, over an area of 500 m<sup>2</sup>. For this investigation, 100 juveniles of *A. noae* and 100 juveniles of *M. barbatus* were collected together, along with the substrate on which they grew. Collected specimens were measured immediately after removal from the seabed. The specimens were not removed from the rocks. For the experimental cultivation specimens on rocks were placed in commercial oyster baskets at a depth of 8 m. The individuals were measured every two months throughout the experiment. These measurements included ventral and anterior-posterior shell length. Dead or damaged specimens were recorded during the measurements. Sea temperature was monitored daily and salinity was monitored monthly.

## Results and discussion

The average length of *A. noae* specimens harvested from the seabed was 21.70±7.13mm (min. 6.0mm, max. 36.6mm), while the average length of *M. barbatus* was 20.85±6.80mm (min. 8.2, max. 33.1mm) (Fig. 1).

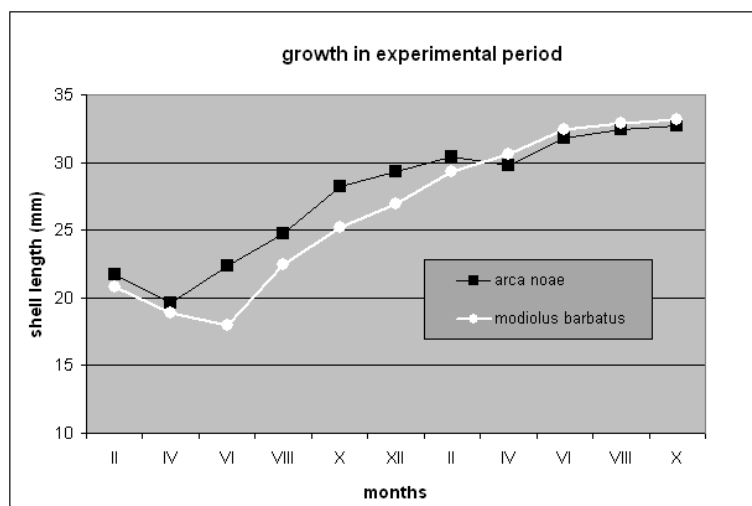


Fig. 1. The average length measured during the experimental period

The results of the two years research demonstrate a range from a minimum measured length of 6.0 mm for *A. noae*, to a maximum length of 52.0 mm. Average length at the end of the experimental period was 32.73±8.09 mm. Similar results were noted for *M. barbatus*, with an initial minimum of 8.3 mm, to a final maximum of 50.3 mm, with an average length at the end of experimental period of 33.19±6.14 mm (Fig. 1). Our study demonstrates a low 9.0% mortality rate for *A. noae*. The mortality rate for *M. barbatus* was higher at 34%.

The average monthly growth of *A. noae* shell length was  $1.29 \pm 1.34$  mm month<sup>-1</sup>. The monthly growth for *M. barbatus* was higher at  $1.89 \pm 1.1$  mm month<sup>-1</sup>. The highest average growth was recorded between June and September of 2006 for both species, with a value of 3.48 mm month<sup>-1</sup> for *A. noae*, and 4.47 mm month<sup>-1</sup> for *M. barbatus*. The lowest values were recorded between November and February, when average increase in length was 0.27 mm month<sup>-1</sup> for *M. barbatus* and 0.33 mm month<sup>-1</sup> for *A. noae*. The average temperature over the experimental period was, 16.3°C and the average salinity was 36.0psu.

As noted in other research on this species, it was confirmed that these two shellfish species are a slow-growing, demonstrating growth of less than 20 mm over the experimental period of two years. The same results were also confirmed by Peharda et al. (2002), while studying the natural populations of *A. noae* in a few locations in the Adriatic sea. They noted a maximum size of 70 mm and an age of up to 16 years. Peharda et al. (2007) also noted slow growth of *M. barbatus* which attains a length of 40 and 50 mm within 5 and 8 years respectively.

Due to the slow growth of these shellfish species and easy collecting, formation of broodstock at strategic locations will be important towards increasing the abundance of natural populations.

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# Značaj kvalitetne ishrane pčela u pravcu povećanja količine peludi

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## Sažetak

Cilj istraživanja je bio da se odredi optimalna zamjena prirodnoj pčelinjoj hrani u poljskim uslovima u bespašnom i pašnom periodu. Pčelinja društva su hranjena s medom, šećernim sirupom, glukozno-fruktoznim sirupom i invert sirupima. Na početku prihrane prosječan površina peludi se kretala od 7,90 dm<sup>2</sup> (med) do 14,40 dm<sup>2</sup> (enzimski invert sirup). Na kraju prihrane prosječna površina peludi se kretala od 39,10 dm<sup>2</sup> (šećerni sirup) do 89,50 dm<sup>2</sup> (kiselinski invert sirup). Utvrđeno je da nepostoji statistički značajna razlika u pogledu količine skupljene peludi samo između pčelinjih društava hranjenih sa medom i šećernim sirupom. Kod ostalih poređenja utvrđena je statistički značajna razlika samo uz prag značajnosti 0,05.

Ključne riječi: umjetno prihranjivanje, med, pelud, medonosna paša

## The importance of quality nutrition in order to increase bee pollen yield

### Abstract

The aim of study was to determine the optimal replacement of natural bee food in field conditions in honeyflow and non-honeyflow period. Colonies were fed with honey, sugar syrup, glucose-fructose syrup and invert syrup. At the start of supplemental feeding an average surface of pollen ranged from 7.90 dm<sup>2</sup> (honey) to 14.40 dm<sup>2</sup> (enzymatic invert syrup). At the end of the supplemental feeding, average surface of pollen ranged from 39.10 dm<sup>2</sup> (sugar syrup) to 89.50 dm<sup>2</sup> (acidic invert syrup). As a conclusion, no statistically significant difference in the amount of pollen collected between bee colonies fed with honey and sugar syrup was found. In other comparisons, significant differences were found only with the significance threshold of 0.05.

Key words: artificial feeding, honey, pollen, honey bee

### Uvod

Medonosna pčela pronalazi hranu za sebe u vidu nektara, peludi i vode. Aktivni dio pčelarske sezone omogućava medonosnoj pčeli da ove izvore hrane pronađe u prirodi i vlastitom preradom ih prilagodi za svoje potrebe. U godinama kada pčela nije u mogućnosti da obezbjedi dovoljne količine hrane za sebe, neophodna je intervencija čovjeka, u smislu kvalitetne prihrane pčelinjih društava. U nektaru pčela pronalazi mnoštvo korisnih šećera, od kojih su najviše zastupljeni monosaharidi - glukoza i fruktoza, te disaharid - saharoza. Količina svih šećera u nektaru se kreće u rasponu od 4-60% i više, što zavisi od biljnog porijekla i faktora spoljašnje sredine (Shuel,1975). Medonosno bilje je interesantno za pčelu sve dok sadržaj šećera u nektaru ne bude niži od 30-50% (Waller, 1972). Pelud ili cvjetni prah su muške spolne stanice biljaka, koje



skupljaju pčele i pohranjuju u saće kao izvor proteina, važnih vitamina (A, B-kompleksa, C, D, E, K) i 28 minerala, te brojnih minerala u tragovima, veoma bitnih u ishrani pčelinjeg legla i ishrani ljudi. Po svojoj strukturi pčelinja se peludsastoji od mnoštva peludnih zrnaca, različite boje, oblika i porijekla. Tome ide u prilog i činjenica da postoji značajna pozitivna korelacija između razvoja mliječne (poždrijelne) žlijezde pčela i količine esencijalnih aminokiselina u peludi (McCaughy i sur., 1980). Potrošnja peludi u pčelinjem društvu zavisi prvenstveno od jačine pčelinjeg društva, pa tako po Eischen i sur., (1983) radilice u slabijim društvima konzumiraju više peludi i odgoje više legla po jednoj pčeli, nego radilice u jačim društvima. Pelud ima i svoje adekvatne zamjene, s ciljem podsticanja intenzivnog razvoja pčelinjeg legla, u periodu kada peludi nema dovoljno. Najčešća zamjena peludi sastoji se od sojinog brašna, sušenog pivskog kvasca, obranog mlijeka i vitamini B-kompleksa (Konstantinović i sar., 1987). Stoga je cilj istraživanja bio utvrditi optimalnu zamjena prirodnoj pčelinjoj hrani u poljskim, prirodnim uslovima, te da se odredi najpovoljnije dodavanje iste, u smislu stimulisanja razvoja legla i pčelinjeg društva.

### Materijal i metode

Istraživanja su sprovedena u poljskim uslovima, na proizvodnim pčelinjim društvima u periodu od 20. 3 - 10. 4 2003. godine. Na početku eksperimenta sprovedena je detaljna analiza trenutnog stanja pčelinjih društava u pogledu površine peludi, koja se nalazila u okvirima, u neposrednoj blizini pčelinjeg legla. Pčelinja društva su naseljena u standardne LR košnice, pčelinjak je bio stacionarnog tipa, kapaciteta 21 pčelinje društvo, od kojih su po tri hranjena sa istom vrstom hrane. Sva društva su stimulatивно prihranjivana medom (kontrolna grupa), šećernim sirupom, kukuruzno-glukozno-fruktoznim sirupom i invert sirupima (kiselinski i enzimski) - eksperimentalne grupe, sa po 0,5 l svako drugo veče. Šećerni sirup je spravljan u odnosu šećer: voda 1:1, dok je kukuruzno - glukozno - fruktozni sirup, proizveden kiselinskom preradom kukuruza, korišten u izvornom obliku i 50%-tnom rastvoru. Kiselinski invert sirupi su spravljeni kiselinskom hidrolizom složenih šećera, uz upotrebu mliječne (kiselinski invert sirup 1) i oksalne kiseline (kiselinski invert sirup 2). Enzimski invert sirup je spravljan enzimskom hidrolizom složenih šećera, uz pomoć prečišćenog, sintetski proizvedenog enzima invertaze. Prihranjivanje pčelinjih društava je izvršeno u proljećnom periodu, u vrijeme voćne paše, u trajanju od 21 dana. Nakon sprovedene prihrane, pristupilo se ponovnom mjerenju istih parametara. Dobijeni rezultati eksperimenta su statistički obrađeni i testirani analizom varijanse Lsd testom.

### Rezultati i rasprava

Istraživanjem je utvrđeno (tablica 1) da je apsolutno najveće povećanje površine peludi bilo kod pčelinjih društava hranjenih s kiselinski invert sirupom (+79,1), dok je najmanje povećanje bilo u košnicama hranjenim sa šećernim sirupom (+9,1). Površina peludi je utvrđena mjerenjem obe površine rama i ukupna vrijednost u dm<sup>2</sup> obračunata kao 100%.

Tablica 1. Površina peludi (dm<sup>2</sup>) na početku i na kraju prihrane (n=21)

	Med	Šećerni Sirup	Frudeksmal	50% Frudeksmal	Kiselinski invert sirup 1	Kiselinski invert sirup 2	Enzimski invert sirup
Početak prihrane	7,90	9,00	10,60	5,90	10,40	8,40	14,40
Kraj prihrane	75,30	39,10	60,20	83,30	89,50	56,30	68,50
Razlika	+67,40	+9,10	+49,60	+77,40	+79,10	+47,90	+54,10

U pogledu kvaliteta hrane za pčele, ista mora biti podvrgnuta procesu invertovanja složenih šećera, kako bi se prilagodila probavnom sistemu medonosne pčele. Enzimsko invertovanje složenih šećera je proces, s kojim, dobrim dijelom, ukupni šećeri, po sastavu, su veoma slični medu i nemaju štetnih uticaja na zdravlje pčela. Kiselinski invert sirupi se moraju, nakon processa invertovanja, podvrgnuti procesu neutralizacije i samo kao takvi se mogu koristiti u ishrani pčela. Frudesmal (fdm) se može koristiti u ishrani pčela, pod uslovom da su količine sirupa koje se daju pčelama uvijek svježije (Mirjanić, 2005).

Statističkom obradom podataka (S<sub>x</sub>d=6,68; t=8,78), utvrđena je statistička značajna razlika između pojedinih načina ishrane pčela (t<sub>0,05</sub>=2.45 (\*\*); t<sub>0,01</sub>=3.71 (\*)). Međusobna zavisnost pojedinih načina ishrane pčela u poređenju s ishranom medom, kao kontrolnom grupom, prikazana je u tablici 2.

Tablica 2. Vrijednosti t-testa na osnovu testa razlike parova površine peludi

	Šećerni Sirup	FDM Frudeksmal	50%FDM Frudeksmal	KIS1 Kiselinski invert sirup 1	KIS2 Kiselinski invert sirup 2	EIS Enzimski invert sirup
Med	2,51	3,05*	3,79**	3,11*	3,49*	3,08*

( $t_{0,05}=2.45$  (\*);  $t_{0,01}=3.71$  (\*\*))

Iz prikazanih rezultata se može uočiti da postoji statistički značajna razlika između svih eksperimentalnih grupa poređenih s kontrolnom grupom (med), osim u slučaju prihrane pčelinjih društava sa šećernim sirupom. Kod poređenja 50% FDM-a i meda, ta razlika je visoko značajna i iznosi 3,79\*\*. Na količinu peludi u proizvodnim pčelinjim društvima utiče više faktora, od kojih su najvažniji vrsta i kvalitet pčelinje hrane, klimatske prilike, produkcija peludi od strane biljaka i aminokiselinski sastav peludi. S druge strane na prinos peludi, utiče i količina pčelinjeg legla u košnici, koja je u obrnutoj korelaciji s količinom peludi u košnici (Mirjanić, 2007).

### Zaključci

Ishrana pčela s medom je ekonomski i zdravstveno ne opravdana, te shodno tome je neophodno pristupiti prihranjivanju pčela i sa alternativnim izvorima hrane. Rezultati istraživanja ukazuju da kvalitet vještačke hrane za pčele mora biti veoma sličan prirodnoj hrani, kako bi smo mogli očekivati, u toku pčelarske sezone, visoke proizvodne rezultate, u pogledu meda i drugih pčelinjih proizvoda. Samo stalnim nadzorom kvaliteta hrane za pčele postavljeni ciljevi u pčelarskoj praksi se mogu dostići.

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# Management of problem brown bears (*Ursus arctos*) in Croatia

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## Abstract

Croatia holds a stable brown bear (*Ursus arctos* L.) population of around 1000 individuals, managed by the national Brown Bear Management Plan. Implementation of the Plan is regulated by National Bear Management Committee and Bear Emergency Team. The latter handles all situations with bear related problems. Due to opportunistic life style bears occasionally search for food from anthropogenic sources. Such feeding habits are often combined with loss of fear against humans, which is unacceptable and characterized as problematic behavior. If adverse conditioning (noise repellents and rubber bullets) used to scare problem animals don't work a permit for the removal of specific individual is issued. Appearance of orphan bears is another source of problem animals which requires special attention. The most important part of problem bear management is prevention, which includes public education campaigns about cohabitation with bears.

Key words: brown bear, *Ursus arctos*, management, problem animals, Croatia

## Gospodarenje problematičnim smeđim medvjedima (*Ursus arctos*) u Hrvatskoj

### Sažetak

Hrvatska ima stabilnu populaciju smeđeg medvjeda (*Ursus arctos* L.) od oko 1000 jedinki, kojima se gospodari temeljem Plana upravljanja smeđim medvjedom u Republici Hrvatskoj. U provođenju Plana upravljanja sudjeluju Nacionalno povjerenstva za izradu i provedbu Plana gospodarenja te Interventni tim za smeđeg medvjeda. Interventni tim je nadležan za sve problematične situacije povezane s medvjedima. Zbog oportunističkog načina prehrane medvjedi ponekad traže hranu iz ljudskih izvora. Takve prehrabene navike često su povezane s gubitkom straha od ljudi, što je neprihvatljivo i karakterizira se kao problematično ponašanje. Ukoliko se medvjeda ne uspije prestrašiti i odučiti od neprihvatljivog ponašanja pomoću zvučnih repelenata ili gumenih metaka i problematično ponašanje se nastavi, Povjerenstvo izdaje dozvolu za odstrjel te problematične jedinke. Mladunčad medvjeda koja ostane bez majke također je izvor problematičnog ponašanja medvjeda te zahtjeva posebnu pažnju. Najvažniji dio gospodarenja problematičnim medvjedima je prevencija, što uključuje javne edukativne kampanje o suživotu s medvjedima.

Ključne riječi: smeđi medvjed, *Ursus arctos*, gospodarenje, problematične životinje, Hrvatska

## Introduction

Croatia holds a stable brown bear (*Ursus arctos L.*) population of around 1 000 individuals that inhabit an area of 12 372 km<sup>2</sup> (almost 22% of the land surface) (Huber et al., 2008a). Population has been steadily increasing since 1950`s, nowadays reaching its biological and social carrying capacity (Huber et al., 2008b).

Since 2005, bears in Croatia are managed according to Brown Bear Management Plan for the Republic of Croatia (Decak et al., 2005), which has been revised in 2008 (Huber et al., 2008a). Implementation of the Plan is supervised by the National Committee, consisting of 10 representatives of different interest groups (hunters, foresters, scientists, state institutions). Hunting quota and hunting season are regulated by yearly Action plans. For the period 2005 - 2008, yearly hunting quotas of 70 animals have not been reached. As population growth has been confirmed by genetic research (Huber et al., 2008a), in order to stabilize population size, hunting quota has been increased to 100 bears in 2009 and 2010. In the period 2005 - 2009 a total of 280 bears have been harvested as a part of regular hunting, and additional 136 animals died due to other causes (mainly traffic accidents, unknown cause and occasionally poaching).

An operational Bear emergency team exists in Croatia since 2005. The emergency team operates according to a protocol. In general, it tries to prevent the appearance of all bear related problems, react in any unusual situation corresponding to bears, and help monitor all bear related issues (Huber et al., 2008c). The team has 10 members, mostly wildlife professionals such as scientists, hunters or national park rangers. Their activity has proven to be essential for successful management, mostly in situations with problem bears.

Due to opportunistic life style, bears occasionally search for food from anthropogenic sources. That may be the crops in the fields, domestic animals, food storages or organic waste in various stages of disposal. Such feeding habits are often combined with loss of fear towards humans. Though it very rarely leads to aggression towards people, such behavior is unacceptable and is characterized as problematic (Huber et al., 2008b).

In parts of Croatia where bears are hunted, damage compensation is paid by hunting unit leaseholders, whereas in national parks and in areas with only accidental presence of bears, compensation is paid from the state budget. Data about human-bear conflicts in Croatia, gathered during the 5 - year period (2004 - 2008) show that human-bear conflicts were infrequent in Croatia and the property damage was not significant for a population of 1 000 bears (Sindicic et al., 2009). A total of 220 cases of bear damage have been reported in this period (average 44 per year), with total cost of approximately 42 000 \$ in terms of compensation. Consecutive series of attacks, which were concentrated in a shorter period, indicate that those attacks were caused by the same problem individuals, probably attracted by garbage. Bear attacks on humans have not been recorded in this period.

## Material and methods

This paper presents the results of implementation of the Brown bear management Plan for the Republic of Croatia for the 5 - year period (from 2005 till the end of 2010). Data about problem bears has been gathered by the Committee in charge for the implementation of the Plan.

## Results and discussion

Problem bears are defined in Brown Bear Management Plan for the Republic of Croatia as bears that repeatedly cause damage, search for food from human sources, approach human settlements, and have lost fear of humans. If such an animal appears, the Protocol of the Bear emergency team requires neutralization of primary factors that attract such behavior, for example garbage as a source of food. Members of the Emergency team (or local hunting organization instructed by the Emergency team) are obliged to try to stop the problem behavior by using methods of adverse conditioning. Noise repellents and rubber bullets are used to attempt to scare the animal away. If the bear continues to exhibit problem behavior, Committee issues a permit for the removal of such individual. The animal is shot by a hunter from the local hunting organization. In case that animal has to be shot outside the hunting area, police attendance is required. Problem animal can not be sold for trophy hunting in order to avoid killing of non-problem animal with eventually larger trophy value. In the period 2005 to 2009 a total of 7 brown bears have been shot as problem animals.

Appearance of orphan bear cubs is another category of problem behavior which requires special attention. Bear cubs sometimes get separated from their mothers because they wander away, due to natural hazards like floods, or the mothers get killed. Orphan cubs have difficulties in surviving on their own; the younger they are, the chance for survival is lower. While searching for food orphan cubs sometimes meet people, which may start feeding cubs or even take them home. Bear cubs easily get imprinted (even one meal from human hand can be enough), so once they get used to getting food from humans their survival in the nature is impossible. Usually, when Committee finds out for orphan cubs kept by people, it is too late to return them to the nature. Croatia has limited capacities for life-time keeping of this kind of animals, and only recently a sanctuary for orphan bear cubs in Kuterevo has been legalized. During the last five years, in total 13 orphan cubs that were unable to survive in the nature were placed in Kuterevo, but not all of them have survived until today (Huber, pers. com). Due to ethical reasons and possible negative public reactions, euthanasia has not been considered yet as a tool for solving an orphan cub problem.

As a typical example, in 2010, a case of an orphan bear cub in Gorski kotar has attracted much of a public and media attention, representing an example how media pressure can facilitate administration to do their job in issuing necessary permits. A game warden found an orphan cub and saved its life by artificial (bottle) feeding, but inevitably changed its behavior to total dependence of humans. When the location of the cub was revealed by the media, and masses of people started to approach and feed the cub, it was finally placed in a sanctuary.

The most important part of problem bear management is prevention. This includes education of public and wildlife professionals about techniques for safe cohabitation with bears. Public educational campaigns focus both on inhabitants of bear habitat, and occasional visitors such as hikers. Education on damage prevention methods is very important to keep damage at minimal levels. Also, implementation of the Management plan includes donations of electric fences for protection of bee hives, sheep flocks or orchards. Additional activities have been focused on illegal garbage dumps and garbage which is accessible to bears, producing problematic behavior. Special bear proof garbage cans have been designed and donated to institutions at critical locations. Also, local authorities have been urged to include the issue of the bear presence in their garbage management practice.

### Conclusions

Management of an increasing brown bear population in a human dominated landscape is a challenge, and Croatia sets an example of a well managed bear population. Population size is controlled with hunting quotas, and over 1000 animals cause minimal damage to human property. The appearance of problem bears is controlled by a series of activities, and in the case of total failure, this bears are shot applying the special permit system.

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# Honey quality on the Slovene market

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## Abstract

Monitoring of honey quality on the Slovene market was carried out at Agricultural Institute of Slovenia in cooperation with Ministry of Agriculture, Forestry and Food of the Republic of Slovenia. In this paper the results of monitoring over the period from 2008 to 2009 are presented. During this time 86 samples of honey were evaluated for physico-chemical parameters that can be used for the classification and quality control of honey. Appropriateness of physico-chemical parameters was examined according to valid Slovenian and EU legislation. Sampling was performed at various supermarkets, grocer's shops and market halls in Slovenia. The results of analyses showed that 12 out of 86 samples (14%) were non-conformable with the legislation. The hydroxymethylfurfural (HMF) content was exceeded in 4 honey samples, which means that samples were heated over a permissible temperature or stored for a longer period of time. The value of electrical conductivity in 8 samples was not accordant with legislation regarding the declared botanical origin, which means that designation of samples was not appropriate.

Key words: honey, quality parameters, monitoring, Slovene market

## Introduction

Honey is a natural sweet substance produced by *Apis mellifera* bees from the nectar of plants (blossom or nectar honey) or from secretion of living parts of plants or plant sucking insects (honeydew honey). Bees have been producing honey for 150 million years, but some of the earliest written references about honey were found in ancient Egypt (40th century BC). Honey consists of different carbohydrates, i.e. fructose (about 38.5%), glucose (about 31.0%), sucrose (about 5.0%), and maltose (1.0%). Additionally, honey contains other useful substances, i.e. enzymes (invertase, amylase, glucose oxidase, catalase, lipase), organic acids (gluconic acid, apple acid, tartaric acid, citric acid), vitamins (B1 B2, B6, PP, C), micro and macro elements (K, Ca, Na, Mg, Fe). That is the reason for high nutritional value as well as remedial properties of honey (Bogdanov et al., 2008). Scientists have found that honey has a powerful inhibitory effect on about sixty species of bacteria. Besides treating wounds and skin infections, honey has proved useful for treating burns as well as a wide variety of internal diseases such as respiratory infections and intestinal disorders (Molan, 1992). Nowadays, important producers of honey are China, Argentina, Turkey, Ukraine, Mexico, etc (Belitz et al., 1992).

Honey products have to satisfy numerous quality and certification criteria before commercialization, especially in industrial countries, where there is a need of having high quality food products with well-defined characteristics. In Europe, the composition of honey as well as its manufacture is regulated by the Council Directive 2001/110/EC of 20 December 2001. In March 2004, the Republic of Slovenia entirely summarized this directive in the Official Gazette of RS, No. 31/ 31 March 2004; Honey regulations. When placed on the market as honey or used in any product intended for human consumption, honey must meet the following composition criteria (Table 1):

Table 1. Slovene and European legislations relating honey

	Physical-chemical parameter	Slovene and EU legislation
Fructose + glucose	For blossom honey	min. 60 g/100 g
	For honeydew honey, blends of honeydew with blossom honey	min. 45 g/100 g
Sucrose (in general)	For some types of honey (acacia, citrus, lavender...)	max. 5g/100 g
		max. 10g/100 g or 15g/100 g
Moisture	In general	max. 20%
	For some types of honey (heather, baker's honey)	max. 23% or 25%
Water insoluble matter	In general	max. 0,1 g/100g
	Pressed honey	max. 0,5 g/100g
Electrical Conductivity	For blossom honey	max. 800 µS/cm
	For honeydew honey, chestnut honey	min. 800 µS/cm
Free acids	In general	max. 50 mmol/kg
	For baker's honey	max. 80 mmol/kg
Diastase activity	In general, except for baker's honey	min. 8
	For honey with low natural enzyme content	min. 3
HMF	In general, except for baker's honey	max. 40 mg/kg
	For honey of declared origin from regions with tropical climate	max. 80 mg/kg

In the period 2008 to 2009 monitoring of honey quality was carried out at the Agricultural Institute of Slovenia with the cooperation of Ministry of Agriculture, Forestry and Food of the Republic of Slovenia. In the frame of this work samples were bought at various markets in Slovenia and physical-chemical parameters, which characterize honey quality were determined. Appropriateness of physical-chemical parameters was examined according to valid Slovene and EU legislation.

Materials and methods

Sampling

Different types of Slovene and foreign honey samples were included in monitoring program. 86 samples were bought at various supermarkets, grocer's shops and market halls in Slovenia. The physical-chemical parameters were determined in all samples. The sampling was performed by the staff of Agricultural Institute of Slovenia and the selection of samples was achieved randomly.

69 samples were bought in six supermarkets in Slovenia (10 of these have been marked as "Higher Quality Honey"), 13 samples were bought in two grocer's shops (9 of these were labelled with "Protected Characterization of Geographical Origin") and 4 samples were sampled in market halls.

Botanical origin "Blossom honey" was declared for the majority of samples (34%). Statements "Honeydew honey", "Honey from acacia tree" and simply "Honey" were presented on 12% to 14% samples and "Honey from lime tree" on 7%. "Honey from pine tree", "Rosemary honey", "Fir honey" and "Mixed honey" were presented as singular sample (Fig. 1).

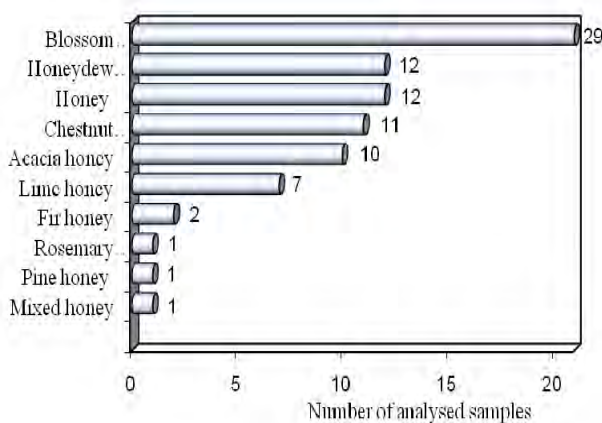
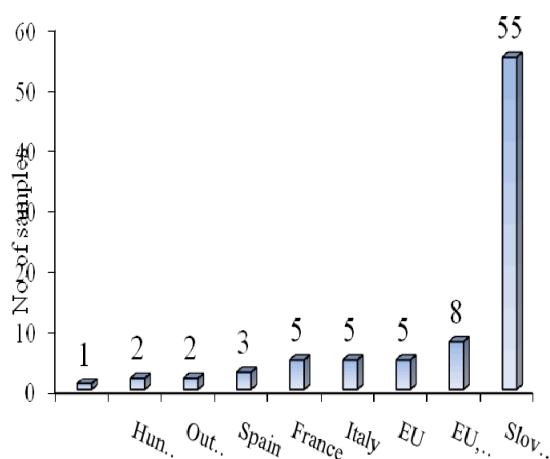


Figure 1. The number of analysed samples according to declared botanical origin

64% of samples were of Slovene geographical origin, remaining 36% samples had a declared geographical origin such as "EU and out of EU", "EU", "Out of EU", "Italy", "France", "Spain", "Hungary" and "Argentina" (Fig. 2).



**Figure 2. The number of analysed samples according to declared geographical origin**

The samples of honey were bottled in glass jars of 450 g to 1000 g and labelled with data such as the type of sample, name of producer, origin, identification number, etc.

### Chemical analyses

Agricultural Institute of Slovenia has been accredited for honey analyses according to SIST EN ISO/IEC 17025 by the French accreditation committee (COFRAC) since 2003. Ministry of Agriculture, Forestry and Food of the Republic of Slovenia authorized the Agricultural Institute of Slovenia as “National Laboratory for Honey Analyses” in 1999.

Physico-chemical parameters defining the quality of honey and its classification were carried out in accordance with the French official methods (Meth.Off.A, 1977):

Sugars (fructose, glucose, sucrose). Sample of honey was dissolved in a mixture of water and acetonitrile. Quantification of sugars was conducted using high performance liquid chromatography with refractive index detection (Meth.Off.A, 1977).

Moisture. Refractive index of honey was determined by Abbe refractometer and equivalent content of water is found in the table (Meth.Off.A, 1977).

Water insoluble matter was determined according to the method based upon filtration of impurities in honey (Meth.Off.A, 1977).

Electrical conductivity of honey solution containing 20% of honey dry matter and dissolved in 100 ml distilled water was determined. The measurement was carried out by conduct meter (Meth.Off.A, 1977).

Free acidity was determined by titrimetry. The sample was dissolved in water and titrated to pH 8.3 with 0.1 M sodium hydroxide solution (DIN 10756).

Diastase activity was measured photometrically. Results were calculated as Schade Unit as ml of 1% starch hydrolyzed by an enzyme in 1 g honey in 1 h (Meth.Off.A, 1977).

Hydroxymethylfurfural (HMF) was determined photometrically; p-toluidine and barbituric acid solution were added to honey solution and the resultant color was measured against a blank in 1-cm cuvettes at 550 nm (Meth.Off.A, 1977).

### Results and discussion

The results of analyses show that 12 out of 86 samples were non-conformable with the legislation valid in Slovenia and European Union. The HMF content was exceeding in 4 honey samples and electrical conductivity of 8 samples was not within the acceptable range.

Elevated contents of HMF provide an indication of overheating, storage inadequate conditions or ageing of the honey. According to the Slovene and European legislation the maximum permissible level for HMF content in honey is 40 mg/kg, except for baker’s honey, and 80 mg/kg for honey from the regions with tropical climate and the mixtures thereof. Three out of four non-conformable samples were declared as “EU and out of EU”. None was declared as “Honey from the Regions with Tropical Climate” so the HMF content must not exceed the permissible level of 40 mg/kg. The samples were bought in supermarkets (Table 2).



Table 2. Non-conformable samples regarding HMF

Sample	Botanical origin	Place of sampling	HMF (mg/kg)	Legislation HMF (mg/kg)
1	Blossom honey	Supermarket	51,6	< 40
2	Rosemary honey	Supermarket	65,1	< 40
3	Blossom honey	Supermarket	45,1	< 40
4	Blossom honey	Supermarket	68,8	< 40

Electrical conductivity is one of the criterion for the botanical origin determination. The value of electrical conductivity depends on the ash content of honey sample. Honeydew and chestnut honey contain more ash and the resulting electrical conductivity is higher (more than 800  $\mu\text{S}/\text{cm}$ ). Blossom honeys and the mixtures of blossom and honeydew honey contain less ash and the resulting conductivity is lower (less than 800  $\mu\text{S}/\text{cm}$ ). The electrical conductivity data for different unifloral, blossom and honeydew honeys are prescribed by Slovene and European legislation (Table 1). In this investigation 8 out of 86 analysed samples were non-conformable with the legislation. Four out of eight non-conformable samples were declared as "Honeydew honey", two samples were of "Chestnut" origin, one sample of nectar origin "Blossom honey" and one sample had the declared origin "Pine honey". All samples were bought on the Slovene market and were of EU origin.

Table 3. Non-conformable samples regarding electrical conductivity

Sample	Botanical origin	Place of sampling	El. cond. ( $\mu\text{S}/\text{cm}$ )	Legislation El. cond. ( $\mu\text{S}/\text{cm}$ )
1	Chetsnut honey	Supermarket	784	> 800
2	Honeydew honey	Supermarket	743	> 800
3	Pine honey	Supermarket	694	> 800
4	Honeydew honey	Supermarket	793	> 800
5	Blossom honey	Grocer's shop	1047	< 800
6	Honeydew honey	Market hall	724	> 800
7	Chestnut honey	Supermarket	765	> 800
8	Honeydew honey	Grocer's shop	752	> 800

One out of eight samples non-conformable with legislation regarding the electrical conductivity was labelled with "Protected Characterization of Geographical Origin". It was declared as "Honeydew honey" and the electrical conductivity value was too low (752  $\mu\text{S}/\text{cm}$ ). The electrical conductivity values for seven non-conformable samples ("Chestnut", "Honeydew" and "Pine honey") were in the range from 694 to 793  $\mu\text{S}/\text{cm}$ . The conductivity value of one "Blossom honey" was 1047  $\mu\text{S}/\text{cm}$ , which exceeded the permissible level of 800  $\mu\text{S}/\text{cm}$ . Most likely the non-conformable samples were the mixtures of blossom and honeydew honey with peculiar flavour of declared honey type. The results of electrical conductivity indicate on incorrect declaration of eight samples (Table 3).

## Conclusions

The results of monitoring over the period 2008 to 2009 have shown non-conformity with the valid legislation for 14% of honey samples bought on the Slovene market. According to the exceeded value of HMF, 4 samples were non-conformable, i.e. aged, stored in poor conditions or overheated above the permissible temperature (40°C). Regarding the invalid value of electrical conductivity, 8 samples were incorrectly declared as to the botanical origin and the type of honey, respectively. The consequence may cause a misleading reaction of the consumer.

In the research described in this paper we determined only two quality parameters which deviated from Slovene and EU norms (HMF content and electrical conductivity). In our previous comparable investigations we have also found other non-conformable parameters (mainly diastase activity and sugars) which indicated overheating of honey, unsuitable declaration and in some cases adulteration of honey (high sucrose content).

According to the results obtained in our laboratory in the last years it would be reasonable to intensify the control of honey available on the Slovene market. The other European countries probably share the same experiences?

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# Fenotipske odlike cigaje u ekološkom uzgoju

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## Sažetak

Cilj je rada utvrditi fenotipske odlike odraslih ovaca i šilježica cigaja pasmine u ekološkom uzgoju. Utvrđene su slične fenotipske odlike cigaje (eksterijerne odlike, indeksi tjelesne razvijenosti i tjelesna masa) s rezultatima dosadašnjih istraživanja provedenih s cigajom u našoj zemlji te određene razlike u usporedbi s onima u zemljama našega okruženja. Fenotipske odlike šilježica bile su različite, što je vjerojatno utjecaj različite dobi. Fenotipske odlike pokazuju da je cigaja naša najkrupnija pasmina ovaca (tjelesna masa 74,65 kg, visina grebena 81,20 cm). Navedeni rezultati ukazuju na zadovoljavajuće uvjete držanja i hranidbe u ekološkom uzgoju te mogućnost širenja uzgoja cigaje prema ekološkim načelima.

Ključne riječi: cigaja, fenotipske odlike, ekološki uzgoj

## Phenotypic characteristics of Tsigai ewes in organic breeding

### Abstract

The aim of the study was to determine the phenotypic characteristics of adult ewes and ewe hoggets Tsigai breeds in organic breeding. Determined are similar phenotypic characteristics Tsigai ewes (exterior characteristics, the indices of body development and body weight) with the results of previous research conducted with Tsigai ewes in our country, and some differences compared with those in the countries of our environment. Phenotypic characteristics of ewe hoggets were different, which is probably the influence of different age. Phenotypic characteristics show that Tsigai is our largest ewe breeds (body weight 74.65 kg, height at withers 81.20 cm). These results indicate a satisfactory housing condition and nutrition in organic breeding and the possibility of expanding cultivation Tsigai ewes according to organic principles.

Key words: Tsigai, phenotypic characteristics, organic breeding

### Uvod

Očuvanje genetske raznolikosti u svijetu u sve je većem zamahu. Sukladno se s tim i u Republici Hrvatskoj poduzimaju mjere s ciljem zaštite animalnih genetskih resursa. U ovčarstvu su to naše izvorne pasmine ovaca u koje se ubraja i cigaja. Značenje je cigaje kao pasmine bilo daleko veće u prošlosti, nego li je to danas. Međutim, ipak se poradilo na njenom širenju i povećanju brojnosti, osobito u Slavoniji. Prema podacima HPA (2010.) u Republici Hrvatskoj je pod selekcijskim obuhvatom 1937 ovaca, 56 ovnova i 856 grla mlađih kategorija ovaca pasmine cigaja. Procjena je, da se danas u Republici Hrvatskoj ukupno uzgaja oko 3500 grla cigaje. Uz očuvanje animalnih genetskih resursa značajan se interes iskazuje i za širenje ekološke stočarske proizvodnje te samim tim i ekološke ovčarske proizvodnje. Jedan od načina očuvanja i širenja uzgoja cigaje je i kroz ekološku proizvodnju, s obzirom na tradiciju uzgoja, okolišne prednosti, dobru prilagodbu i kvalitetan završni proizvod-janjetinu. U Republici Hrvatskoj se već duži niz godina provode istraživanja na cigaji (Rastija i sur., 1995.; Vrdoljak i sur., 2007.; Antunović i sur., 2008.a; Antunović i sur., 2009.a; Balić, 2010.).

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Međutim, malo je radova koji istražuju ekološki uzgoj cigaje (Godanj, 2009.). Slična je situacija i s uzgojima cigaje u zemljama našega okruženja (Gaspardy i sur., 2001.; Ćinkulov i sur., 2003., Kusza i sur., 2010.)

Cilj je ovoga rada ukazati na fenotipske odlike odraslih ovaca i šilježica cigaja pasmine u ekološkom uzgoju te ih usporediti s dosadašnjim rezultatima u istraživanjima provednim u Republici Hrvatskoj i zemljama našega okruženja.

### Materijal i metode

Istraživanje je provedeno sa 50 odraslih ovaca i 20 šilježica cigaja pasmine na jednoj ovčarskoj farmi u Baranji. Odrasle ovce su bile prosječne dobi 4 godine, a šilježice 12 mjeseci. Ovce su držane prema ekološkim načelima (Pravilnik o ekološkoj proizvodnji životinjskih proizvoda, N.N. 13/02.). Tijekom zimske sezone hranidbe, kada je i istraživanje provedeno, osnovica obroka bila je smjesa kukuruza i ječma (300g/dan) i sijeno lucerne koje su ovce dobivale po volji.

Ovce su vagane istoga dana kada su im uzete i sve tjelesne mjere. Tjelesne su mjere ovaca (visina grebena, dužina trupa, širina prsa, dubina prsa, opseg prsa, opseg cjevanice, dužina i širina zdjelice) uzete lidtynovim štapom ili stočnom vrpcom. Indeks tjelesne kondicije ovaca određen je prema Russel-u (1991.) s ocjenama od 1-5, a indeksi anamorfoznosti i tjelesnih proporcija prema Chiofalo i sur. (2004.).

Rezultati istraživanja obrađeni su deskriptivnom statistikom u kompjutorskom programu Statistica Stat Soft Windows (2008.).

### Rezultati i rasprava

U Tablici 1. prikazane su fenotipske odlike odraslih ovaca cigaja pasmine u ekološkom uzgoju.

Tablica 1. Fenotipske odlike odraslih cigaja u ekološkom uzgoju (n = 50)

Tjelesne mjere	Mean	s	Min	Max	SE
Tjelesna masa, kg	74,64	8,60	55,00	99,00	1,22
Visina grebena, cm	81,20	5,76	69,00	98,00	0,81
Dužina trupa, cm	91,21	5,80	80,00	101,00	0,82
Opseg prsa, cm	111,67	6,79	101,00	128,00	0,96
Dubina prsa, cm	32,11	2,82	24,00	36,50	0,42
Širina prsa, cm	22,75	2,14	18,00	28,00	0,31
Dužina zdjelice, cm	28,23	2,95	19,50	34,00	0,49
Širina zdjelice, cm	23,15	2,06	19,50	28,00	0,34
Opseg cjevanice, cm	9,12	0,44	8,00	10,00	0,06

s- standardna devijacija, SE- standardna greška

Tablica 2. Fenotipske odlike šilježica pasmine cigaja u ekološkom uzgoju (n = 20)

Tjelesne mjere	Mean	s	Min	Max	SE
Tjelesna masa, kg	45,88	5,40	39,00	61,00	1,21
Visina grebena, cm	70,45	9,28	55,00	88,00	2,52
Dužina trupa, cm	78,05	7,96	70,00	98,50	1,78
Opseg prsa, cm	98,10	8,92	87,00	122,00	1,99
Dubina prsa, cm	27,48	1,80	24,00	31,00	0,40
Širina prsa, cm	20,13	2,37	15,00	25,00	0,53
Dužina zdjelice, cm	23,58	2,07	19,00	27,00	0,46
Širina zdjelice, cm	20,83	2,34	19,00	27,50	0,52
Opseg cjevanice, cm	8,60	0,45	8,00	9,50	0,10

s- standardna devijacija, SE- standardna greška

S obzirom da u dostupnoj literaturi gotovo nema istraživanja provedenih s cigajom u ekološkom uzgoju, osim istraživanja Godanj (2009.), rezultate ovoga rada ćemo usporediti s onima iz konvencionalnoga uzgoja. Usporedbom fenotipskih odlika odraslih ovaca i šilježica cigaja pasmine (Tablica 2.) s rezultatima drugih istraživanja provedenih u našoj zemlji (Tablica 3.) u konvencionalnim uvjetima držanja, kao i istraživanja Godanj (2009.) provedenog u ekološkom uzgoju, vidljivo je da su one bile slične. Fenotipske odlike šilježica cigaja pasmine bile su različite (Tablica 2. i 3.). Razlog ovome je različita dob šilježica koje su ispitivane u

## Fenotipske odlike cigaje u ekološkom uzgoju

navedenim istraživanjima. Analizirajući fenotipske odlike šilježica i odraslih ovaca cigaja pasmine vidljivo je da su šilježice u dobi od 12 mjeseci postigle 61% tjelesne mase i 87% visine grebena odraslih ovaca. Ovi rezultati ukazuju da je cigaja srednje ranozrela pasmina. Usporedbom fenotipskih odlika cigaje s nekim hrvatskim izvornim pasminama ovaca (istarska ovca, dalmatinska pramenka, krčka ovca, paška ovca, creska ovca te dubrovačka ruda) prikazanim u istraživanjima Mioč-a i sur. (2007.) te Antunović-a i sur. (2008.b) vidljivo je da je cigaja fenotipski gledano naša najkrupnija pasmina ovaca.

**Tablica 3. Fenotipske odlike odraslih cigaja i šilježica zabilježene u dosadašnjim istraživanjima**

Tjelesne mjere	Vrdoljak i sur. (2007.)		Godanj (2009.)		Balić (2010.)	
	Odrasle ovce	Šilježice	Odrasle ovce	Šilježice	Odrasle ovce	Šilježice
1, kg	67,85	52,97	76,60	46,15	70,25	45,60
2, cm	75,95	67,72	82,40	81,00	71,60	59,90
3, cm	85,80	75,00	93,40	84,15	81,42	71,90
4, cm	98,42	90,61	116,50	103,60	102,05	92,50
5, cm	32,94	30,17	31,93	27,80	32,77	27,20
6, cm	22,52	20,08	22,50	21,50	21,52	19,11
7, cm	9,51	9,08	8,85	8,65	9,65	8,60
8, cm	-	-	26,21	25,05	25,93	22,00
9, cm	-	-	23,21	22,15	22,38	19,50

1- tjelesna masa, 2- visina grebena, 3- dužina trupa, 4- opseg prsa, 5- dubina prsa, 6- širina prsa, 7- opseg cjevanice, 8- dužina zdjelice, 9- širina zdjelice

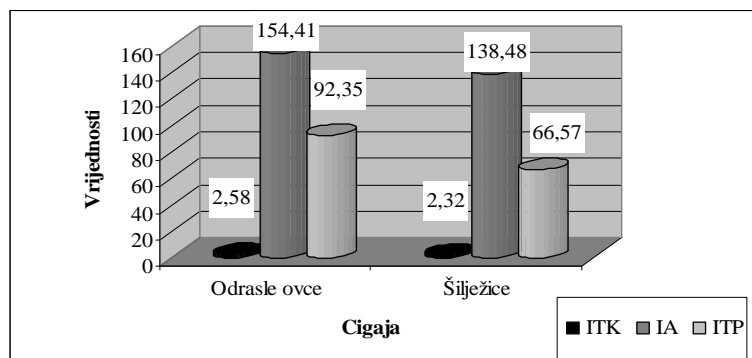
Fenotipske odlike ovaca cigaja pasmine, različitih tipova, u zemljama našega okruženja prikazane su u Tablici 4.

**Tablica 4. Fenotipske odlike cigaje u zemljama našega okruženja**

Tjelesne mjere	Gaspardy i sur. (2001.)		Činkulov i sur. (2003.)		Joitoiu (2004.)	Popovici (1954.)	Nikolić (1937.)
	Cigaja (Gene-reserve variant)	Cigaja (Milking variant)	Somborska cigaja	Čokanska cigaja	Carabash-Teleorman cigaja	Banatska crnoglava cigaja	Cigaja
1, kg	53,4	76,0	86,55	62,86	78,77	51,62	65,29
2, cm	67,5	73,8	79,48	75,32	76,58	70,78	78,78
3, cm	75,0	79,6	88,42	77,19	86,11	73,95	85,03
4, cm	35,1	34,8	36,20	31,76	38,07	33,59	31,72
5, cm	24,3	25,0	26,06	22,26	21,41	21,18	21,38
6, cm	8,5	10,1	10,07	9,22	9,73	9,07	-

1- tjelesna masa, 2- visina grebena, 3- dužina trupa, 4- dubina prsa, 5- širina prsa, 6- opseg cjevanice

Analizirajući fenotipske odlike cigaje u ovom istraživanju te ih uspoređujući s istraživanjima provednim na cigaji u zemljama našega okruženja vidljiva je određena razlika. Naime, u Mađarskoj (Gaspardy i sur., 2001.) i Srbiji (Činkulov i sur., 2003.) postoje dva tipa cigaje i to jedan vrlo sličan našoj cigaji i jedan tip s nešto lošijim fenotipskim odlikama. U Rumunjskoj (Joitoiu, 2004. i Popovici, 1954.) također iznose različite rezultate fenotipskih odlika ovaca cigaja pasmine.



**Grafikon 1. Indeksi tjelesne razvijenosti ovaca cigaja pasmine (ITK- indeks tjelesne kondicije; IA-indeks anamorfoznosti, ITP- indeks tjelesnih proporcija)**

Rezultati mjerenja indeksa tjelesne razvijenosti odraslih ovaca i šilježica cigaja pasmine potvrđuju tezu, da je cigaja fenotipski gledano naša najkrupnija pasmina ovaca (Grafikon 1.). Fenotipske odlike ovaca cigaja

pasmine (eksterijerne odlike, tjelesne mase i indeksi tjelesne razvijenosti) ukazuju na zadovoljavajuće uvjete držanja i hranidbe u ekološkom uzgoju na navedenom gospodarstvu. Mogući smjerovi uzgoja današnjih izvornih pasmina ovaca u svijetu temelje se na njihovoj zaštiti kao ugroženim genetskim resursima te ekološkom uzgoju. Zbog toga bi zanimanje za cigaju trebalo rasti. Sve uvo ukazuje na mogućnost širenja uzgoja cigaje, uz povećanje profitabilnosti proizvodnje, kroz ekološki način uzgoja te ide u prilog njenoga očuvanja.

### Zaključci

Navedeni rezultati fenotipskih odlika ovaca cigaja pasmine (eksterijerne odlike, tjelesne mase i indeksi tjelesne razvijenosti) ukazuju na zadovoljavajuće uvjete držanja i hranidbe u ekološkom uzgoju na navedenom gospodarstvu. Sve uvo ukazuje na mogućnost širenja uzgoja cigaje te povećanja profitabilnosti proizvodnje kroz ekološki način uzgoja.

### Zahvala

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# Bolesti stada i ekološki problemi u intenzivnoj proizvodnji svinja

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## Sažetak

U ovom radu prikazan je pregled istraživanja koja su se odnosila na rješavanje zdravstveno-reproduktivnih problema na svinjogojkim farmama. Današnja industrijska proizvodnja svinja bazira se na provođenju biosigurnosnih mjera, kao i na rješavanju ekoloških problema, koji znatno opterećuju proizvodnju. Dobro zdravlje svinja je uvjet dobre reprodukcije, odnosno rentabilne proizvodnje. Zdravstveno stanje zavisi od mnogih čimbenika, kao što su uvjeti držanja, njega, ishrana i provođenje mjera preventive. Bolesti kao što su neonatalni proljev, neonatalna dizenterija, edemska bolest, ezofagogastrični ulkus, osteodistrofije, kompleks respiratornih oboljenja, dizenterija, a u novije doba proliferativne enteropatije, koje mogu ugroziti proizvodnju svinja u intenzivnom uzgoju, moguće je primjenom profilaktičkih i terapijskih mjera, kao i pojačanom kontrolom stručnih službi držati pod kontrolom. Posebno osjetljivi i kritični periodi su: prasenje, prvih 24-48 sati nakon prasenja, 7-10 dana nakon prasenja i period 10-14 dana po odbijanju prasadi. Fleksibilnom suradnjom vlasnika farmi sa stručnim službama, uz poštovanje i sprovođenje stručnih saznanja, te primjenom niza biotehničkih mjera i stavljanjem naglaska na preventivu bolesti svinja, a u cilju promocije dobrog zdravlja svinja, moguće je poboljšati proizvodnju. Biosigurnost, dobrobit, dobra proizvođačka praksa i analiza rizika na kritičnim kontrolnim tačkama su veoma značajani elementi u intenzivnoj proizvodnji svinja. Planska primjena biosigurnosnih mjera presudna je u zaštiti zdravlja svinja a time i u uspjehu proizvodnje.

Ključne riječi: svinje, bolesti stada, biosigurnost, ekologija

## Herd diseases and ecological problems in intensive pig production

### Abstract

Good health of pigs is qualification for good reproduction and profitable production. Pig health can be improved in aim to achieve higher production. Disease like neonatal diarrhea, neonatal scour, edema disease, esophagogastric ulcer, osteodystrophia, Actinobacillosis, atrophic rhinitis, dysentery and recent times proliferate enteropathies could be competent services. Especially critical periods are sowing, 24-48 hours after farrowing, and period 10-14 days after weaning. By flexible cooperation of farm owner and veterinarians by appreciation of now days knowledge production is possible to improve and serve concept "from stable to table". In this concept veterinarians have significant role from economic and ecologic point of view. Biosecurity, welfare, good producers, clinicians, or hazard analysis, on critical points are very important issues in intensive pig production. Consistent application of biosecurity measures is crucial in swine health protection and production efficiency, and for good promotion of health herd.

Key words: swine, herd diseases, biosecurity, ecology

### Uvod

Zdravlje svinja se može poboljšati u cilju postizanja što veće proizvodnje. Bolesti kao što su neonatalna dizenterija, edemska bolest, ezofagogastrični ulkus, dizenterija, osteodistrofije, kompleks respiratornih oboljenja, a u novije vrijeme proliferativne enteropatije multikauzalne etiologije i pojedine parazitoze (izosporoz, kriptosporidioza) koje mogu ugroziti proizvodnju svinja u intenzivnom uzgoju, moguće je primjenom profilaktičkih, terapijskih mjera i pojačanim radom stručnih službi držati pod kontrolom (Pavlović i sur., 2004, 2007; Bojkovski i sur., 2005; Savić i sur., 2010a,b).

Fleksibilnom suradnjom vlasnika farmi sa stručnim službama, a uz poštovanje i sprovođenje stručnih znanja, te primjenom niza biotehničkih mjera i stavljanjem naglaska na preventivu bolesti u cilju promocije dobrog zdravlja svinja, moguće je poboljšati dobrobit svinja i proizvodnju. O značajnim problemima dobiti i biosigurnosti na farmama svinja može se naći u radu Hristova i sur. (2006, 2008).

### Najčešći problemi na farmama svinja

U intenzivnoj svinjogojskoj proizvodnji kontrola reprodukcije stada predstavlja osnovu dobre i rentabilne proizvodnje. Na reprodukciju svinja utječu brojni faktori od kojih se kao značajni izdvajaju: način držanja, ishrana, godišnja doba, položaj farme, mikroklimatski uvjeti, provođenje biosigurnosnih mjera, veličina stada, zdravstveno stanje stada (prisustvo uzgojnih, parazitskih i zaraznih bolesti), tjelesna kondicija, način primjene umjetnog osjemenjivanja (Lončarević i sur., 1997).

Upotreba duboko zamrznutog sjemena danas se više koristi u svijetu na farmama svinja industrijskog tipa. Duboko zamrznuto sjeme čuva genetički materijal duži vremenski period nego kratkotrajno zamrznuto sjeme i značajno smanjuje rizik od unošenja bolesti u stado. O problemima vezanim za spolne bolesti svinja može se naći u radu Stankovića i sur. (2007).

Problem neplodnosti je jedan od glavnih problema na farmama svinja, čiji su uzroci različiti. Jedan od aktualnih problema je pojava sezonske neplodnosti koja je prisutna na farmama u toku ljetnih mjeseci i stvara problem proizvođačima koji žele maksimizirati reproduktivnu efikasnost (Petrukić i sur., 2009; 2010). Na reprodukciju svinja značajno utiče i stres, i danas se sve više obraća pažnja kako ga svesti na najmanju moguću mjeru. Farme koje tek razvijaju svoj menadžment imaju veći problem sa stresom nego farme koje imaju organiziranu kompletnu proizvodnju. Pri tome, jedan od ključnih čimbenika dobre i rentabilne reprodukcije jeste obezbeđenje optimalne temperature i vlažnosti zraka u objektima za smeštaj svinja na farmi.

Svinje su osjetljive na djelovanje visokih temperatura, te pri dužem boravku u sredini gdje je temperatura iznad gornje granice optimalne (odnosno između 24 i 30°C) kod dojnih krmača može doći i do povećanja rektalne temperature (Williams i sur., 2009), što obično ne prelazi vrijednosti koje ugrožavaju život jedinke. Međutim, posledice toplotnog stresa mogu se odraziti na fiziološke funkcije organizma svinja. Tako u svom radu Bragan i sur. (1998) navode da jedan od razloga zbog čega opada količina mlijeka kod krmača pri visokoj temperaturi u objektu jeste smanjenje konzumacije hrane i mobilizacije tjelesnih rezervi, a u cilju smanjene proizvodnje tjelesne toplote. Black i sur. (1993) u svom su istraživanju utvrdili da je pad od 20% u proizvodnji toplote u vezi s padom količine mlijeka krmača od 25% i 40% smanjenim unosom hrane.

Debele krmače, koje nose veliki broj plodova i uz to konzumiraju veliku količinu hrane u objektima gde su povećani vlaga i temperatura, podložnije su stresu i pokazuju znakove respiratornog distresa. Visoka razina kortikosteroida u krvi životinja koje su izložene djelovanju stresora djeluju na smanjenje otpornosti kod životinja a time i omogućavaju da one postanu visoko prijemljive na različite infekcije. To je jedan od razloga za uvođenje preporuka vezanih za način ishrane prema tjelesnoj kondiciji životinja, a detalje o značaju pravilne ishrane krmača u zavisnosti od njihovih energetske potrebe prikazala je u svom radu Edwards (2003).

Upotreba lijekovitih dodataka u hrani u toku laktacije, a u cilju sprječavanja nastanka infekcija se generalno ne preporučuje već se isti koriste samo ako je zaista neophodno, odnosno njihova je upotreba ograničena na period od sedam dana poslije završetka laktacije. Obavezna upotreba lijekova u preventivne svrhe povezana je sa mjerama kontrole određenih zaraznih bolesti, što je regulirano odgovarajućim zakonima i propisima, a u Republici Srbiji Zakonom o veterinarstvu (Anon., 2005; 2010).

Uzgojne strategije u suvremenom stočarstvu sve više podstiču prirodnu otpornost jedinki. U proizvodnji svinja genetika ima za cilj poboljšati proizvodne sposobnosti postojećih pasmina koje se koriste na farmama industrijskog tipa, stvaranjem novih oblika kvalitetnijih pasmina sa većim genetskim potencijalom, i sa

uzgojem u čistoj krvi ili križanjem u komercijalne svrhe. Jedan dio naših istraživanja je bio usmjeren na istraživanja promijene kariotipa svinja u intenzivnom uzgoju. Ustanovili smo da promjene na kariotipu mogu nastati pod utjecajem kemijskih spojeva, koje se mogu naći u hrani, vodi ili uopće u sredini gdje žive ispitivane životinje (Bojkovski, 2010a). Otkrivanje nosilaca kromosomskih promijena dovodi do isključenja iz programa reprodukcije.

#### Aktualna istraživanja u području intenzivne proizvodnje svinja

U dužem vremenskom periodu, na velikim farmama svinja praćeno je prisustvo kemijskih zonečišćivača životne sredine (teški metali) i njihov utjecaj na zdravstveno stanje životinja. Posebnu opasnost za žive organizme predstavljaju teški metali koji reagirajući sa organskim molekulima mijenjaju njihovu strukturu i funkciju. U organizam teški metali prodiru preko organa za disanje, organa za probavu i kože. Rezultati našeg višegodišnjeg istraživanja ukazuju da postoji opasnost od kontaminacije stočne hrane teškim metalima i njihovog nakupljanja u organizam životinja, kao i negativnog djelovanja na reproduktivnu sposobnost domaćih životinja. Toksičnost teških metala generalno vodi prema formiranju slobodnih radikala, inhibirajući aktivnost enzima antioksidativne obrane kao i oksidaciju glutationa, i stvaranju malonil-dialdehida (MDA) kao markera oksidativnog stresa. Njihova toksičnost potiče od tendencije da stvaraju kovalentne veze sa sulfhidrilnim grupama biomakromolekula ili istiskuju određene kofaktore, čime inhibiraju aktivnost pojedinih enzima (Bojkovski i sar., 2010b). Naša preporuka za farme industrijskog tipa je da treba djelovati u cilju smanjenja rizika izloženosti teškim metalima, raditi na uvođenju višestupanjskog nadzora kvalitete sirovina i gotovih proizvoda, kao i na primjeni adekvatnih protektora od toksičnih učinaka ovih agenasa (Bojkovski i sar., 2010a). Spomenuta istraživanja predstavljaju dopunu istraživanja u području primjene biosigurnosnih mjera na farmama svinja (Bojkovski i sur., 2010b). Planska primjena mjera iz planova biosigurnosti presudna je u zaštiti zdravlja svinja i za uspjeh proizvodnje. Biosigurnosni planovi su ključni u prevenciji bolesti i sprečavanju neželjenih situacija i unapređenju poslovanja (Uhlehoop, 2007).

Ocjena biosigurnosti na osnovu indikatora (izolacija, kao mjera biosigurnosti na farmi, karantena, ocjena zdravstvenog statusa stada, odnos osoblja prema opremi i životinjama, kontrola kretanja i prometa, režim posjeta, kontrola hrane i opreme za hranjenje, izđubavanje, uklanjanje lešava uginulih životinja, odnos prema drugim životinjama na farmi, kontrola ptica, glodavaca), trebalo bi postati rutinski mehanizam u procjeni biosigurnosti na farmi, koji ukazuju na smjer daljeg djelovanja i eventualno njihovog unapređenja (Lončarević i sur., 1997; Stanković i sur., 2008). Primjera radi, na osnovu analize najčešćih propusta u osiguravanju biosigurnosti Stanković i Hristov (2009) iznose da je nivo biosigurnosti na ispitivanoj farmi svinja ocijenjen sa 3,96 (vrlo dobar). Navedeni rezultat ukazuje na trenutno stanje biosigurnosti jedne farme, ali se uvijek mora imati u vidu međusobna interakcija i sveukupnost djelovanja parametara biosigurnosti (Stanković i Hristov, 2009). Držaoći imaju najveću odgovornost u zaštiti vlastitih stada po pitanju unošenja bolesti kontrolom kretanja, pravilnim postupkom i smještajem grupa životinja i sanitacijom. Zaposleni na farmi i posjetioci moraju biti svjesni svoje uloge u očuvanju sigurnog zdravstvenog statusa farme (Stanković i Hristov, 2009).

#### Zaključak

Veterinarska struka ima vrlo važnu ulogu u stočarstvu, zaštiti zdravlja životinja, ljudi i životne sredine. Svakodnevno se nameće pitanje kako proizvesti što više proizvoda ali zdravstveno sigurne hrane. Zato se na zdravstvenu zaštitu farmskih životinja primjenom više preventivnih, a manje terapijskih mjera može ispuniti koncept u kome će biti istovremeno zastupljene rentabilna proizvodnja, ali i višestruka kontrola od toksičnih agenasa u kojoj veterinarska struka odgovorno učestvuje.

#### Zahvala

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# Boja mesa različito držane simentalске junadi

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## Sažetak

Boja mesa je jedan od najvažnijih čimbenika koji utječe na odluku potrošača pri kupovini junećeg mesa. Cilj ovog istraživanja bio je utvrditi utjecaj načina držanja na boju junećeg mesa pri ujednačenoj hranidbi. Predmetnim istraživanjem su obuhvaćeni trupovi muške i ženske junadi držane na rešetkastom podu, dubokoj stelji i kosoj ploči. Junad držana na rešetkastom podu imala su prosječnu vrijednost L\* pokazatelja boje (41,38) neznatno manju od junadi držane na dubokoj stelji (41,41) i junadi držane na kosoj ploči (41,70). Ostala dva istraživana pokazatelja boje (a\* i b\*) također nisu značajnije varirali ovisno o načinu držanja toвне junadi.

Ključne riječi: toвна junad, način držanja, boja mesa

## Beef meat colour of different housed Simmental steers and heifers

### Abstract

Meat colour is one of the most important factors affecting consumer purchasing decision. The aim of this research was to determine effect of different beef housing systems on meat colour with same feeding management. In research were included trunks of steers and heifers housed on slotted floor, deep litter and slash-plate system. Animals kept on slotted floor had slightly lower L\* (41.38) value than animals kept on deep litter (41.41) and slash-plate system (41.70). Other two researched meat colour parameters (a\* and b\*) showed no significant difference between housing systems.

Key words: steers and heifers, type of housing, meat colour

### Uvod

Potrošači nerado kupuju juneće meso tamnije boje jer smatraju da je ono dobiveno od stare ili bolesne junadi. Smith i sur. (2000) navode da se u svijetu na osnovu poremećaja boje govedskog mesa godišnje gubi preko bilijun dolara. Zbog toga je nepoželjna boja jedan od značajnijih problema pri prodaji govedskog mesa. Boja mesa, prema Mancini i Hunt (2005) ovisi o mnogobrojnim čimbenicima koji se mogu svesti na genetske (pasmına ili genotip životinje) i paragenetske (hranidba, način držanja, postupci s životinjama prije i nakon klanja, prerada mesa, pakiranje, distribucija, skladištenje i slično). Također, poznato je da u dobro iskrvarenom trupu boja mesa najviše ovisi o sadržaju mišićnih pigmenata: mioglobina (oko 90%) te hemoglobina i citokroma. Količina mioglobina u mesu ovisi o pasmini, dobi, hranidbi te tipu mišića (Hui i sur., 2001). U junećem mesu se javljaju tri tipa mioglobina: deoksimioglobin (DMb), oksimioglobin (OMb) i metmioglobin (MMb). Kada meso ima purpurno crvenu ili purpurno rozu boju govorimo o DMb, on nastaje odmah nakon rezanja mesa. Oksimioglobin ima svjetlu višnja crvenu boju nastaje nakon izloženosti mesa kisiku, dok se pod MMb podrazumijeva tamna nepoželjna boja mesa na površini ispod koje se nalazi OMb.

Oksidacija, odnosno stvaranje MMb ovisi o redukcijskoj aktivnosti enzima u mesu, parcijalnom pritisku kisika, pH vrijednosti mesa i mikrobiološkoj aktivnosti (Mancini i Hunt, 2005).

Mjerenje boje mesa najbolje je provoditi 24 sata nakon klanja. Danas su u svijetu za mjerenje boje mesa prihvaćeni CIE (Commission Internationale de l'Eclairage) standardi za određivanje boje mesa. Honikel (1998) za mjerenje boje mesa preporuča CIE 1976 (L\*, a\*, b\*) spektar boja uz standardnu iluminaciju za meso (D 65). Pri tome vrijednost L\* predstavlja svjetloću mesa koja može biti od tamnog do svijetlog (0 = crno; 100 = bijelo). Spektar od zelene do crvene boje predstavlja a\* vrijednost, mjernog opsega od -60 do 60 pri čemu niža vrijednost označava više zelene, a manje crvene boje i obrnuto. Vrijednost b\* predstavlja spektar nijansi između plave i žute boje, mjernog opsega od -60 do 60 pri čemu niže vrijednosti označavaju više plave, a manje žute boje. Općenito, prihvatljivije je meso s više žute, a manje plave boje (Yiu i sur., 2001). Stabilizacija boje podrazumijeva vrijeme u kojem je površina mišića izložena utjecaju kisika kako bi miooglobin prešao u oksimiooglobin. U sustavu ocjene govedskih trupova na liniji klanja, USDA preporučuje 10-minutnu stabilizaciju. Također, Kelava i sur. (2008) naglašavaju da je za mjerenje boje junećeg mesa potrebna stabilizacija od najmanje 10 minuta, jer su tada najveće vrijednosti koeficijenta determinacije.

Najčešći problem koji je vezan uz boju junećeg mesa je pojava tamnog, suhog i tvrdog mesa (engl. dry, firm, dark; DFD). Pojava tamnog mesa najčešće je vezana uz djelovanje različitih stresora na životinje prije klanja. Naime, dugotrajnim utjecajem stresa na životinje prije klanja dolazi do prekomjernog trošenja glikogena te ga ne ostaje dovoljno u mišićima za *post mortalne* glikolitičke procese. U životinja koje imaju male rezerve mišićnog glikogena ne dolazi do stvaranja dovoljne količine mliječne kiseline tako da konačna pH vrijednost ne padne na onu zadovoljavajuću od 5,4 do 5,7 nego ostane viša od 5,8. Navedeno za posljedicu ima stvaranje zatvorene i zbijene mišićne strukture koja ima smanjenu refleksiju svjetlosti što za posljedicu ima tamno i suho meso (Littler i House, 2001). Negativno djelovanje stresa neposredno prije klanja (transport, miješanje junadi, narušavanje hijerarhijskog odnosa) na boju junećeg mesa bilo je predmetom brojnih istraživanja (Broom i sur., 2003; Ferreira i sur., 2006; Marenčić i sur., 2009), dok je utjecaj načina držanja junadi u tovu na pokazatelje boje mesa slabije istražen. Stoga je cilj ovog istraživanja utvrditi da li tri najčešća načina držanja toвне junadi u Hrvatskoj (tov na dubokoj stelji, kosoj ploči i rešetkastom podu) pri istom managementu hranidbe mogu imati utjecaj na boju junećeg mesa.

### Materijal i metode

Predmetnim istraživanjem bilo je obuhvaćeno 2 447 grla utovljene junadi (♂=1215; ♀=1232) s tri farme, odnosno iz tri različita načina držanja junadi: duboka stelja, kosa ploča i rešetkasti pod. Po jednom tovnom junetu držanom na dubokoj stelji dnevna potrošnja slame iznosila je od 6 do 7 kg, dok je na kosoj ploči ta količina iznosila svega 1,9-2 kg/grlu/dan. Hranidba toвне junadi bila je gotovo identična, obzirom da su sve tri farme dio jednog velikog proizvodnog koncerna. Prosječna dob muške utovljene junadi pri klanju iznosila je 16,5 mjeseci dok su ženska junad klana s prosječno 13,6 mjeseci. Prijevoz junadi do klaonice, kao i postupak klanja provedeni su u ovlaštenoj klaonici sukladno važećoj zakonskoj regulativi (NN 20/04, NN 116/05). Masa toplih polovica vagana je prije skidanja bubrega i bubrežnog masnog tkiva. Klasiranje govedih trupova proveli su ovlašteni klasifikatori (Agroinspekt d.o.o.) prema EUROPE sustavu. Klasiranjem su goveđi trupovi svrstani u kategorije (Z=mlada junetina od 8-12 mjeseci, A=mladi bikovi od 12 do 24 mjeseca, E=junice), klase (E=izvršna, U=vrlo dobra, R=dobra, O=osrednja, P=slaba) te im je ujedno određen stupanj prekrivenosti masnim tkivom (1=vrlo slaba, 2=slaba, 3=srednja, 4=jaka, 5=vrlo jaka). Boja mesa mjerena je prilikom presjeka desne polovice na dva dijela (rasijecanje govedih trupova na četvrtine) nakon 24-satnog hlađenja polovica na + 4 °C. Za određivanje boje mesa odabrana je mišićna regija *m. longissimus dorsi* (MLD) u razini između 6. i 7. rebra. Boja je mjerena pomoću uređaja Minolta Chroma Meter CR-410 s 50 milimetarskim dijametarskim područjem mjerenja i standardnom iluminacijom za meso (D65) utvrđenim za spektar boja L\*, a\*, b\* (CIE, 1976). Mjerenju boje pristupilo se nakon stabilizacije mesa u trajanju od 10-15 minuta (Kelava i sur., 2008). Prikupljeni podaci boje junećih trupova i podataka s linije klanja obrađeni su korištenjem MEANS i GLM procedura statističkog programa SAS (2001).

### Rezultati i rasprava

Na tablici 1 prikazani su podaci s linije klanja za juneće trupove na kojima je napravljena izmjera boje. Ženska junad imala je prosječnu masu trupa od 267,17±0,70 kg, muški trupovi imali su značajno (P<0,001) veću masu i manju prekrivenost masnim tkivom što je sukladno ranijem istraživanju Karolyia i sur. (2006).



## Boja mesa različito držane simentalске junadi

Istraživanjem nije utvrđen značajan utjecaj sustava držanja na masu trupa, klasu i stupanj prekrivenosti muških jedinki obuhvaćenih ovim istraživanjem.

Tablica 1. Opisni statistički pokazatelji istraživanih junećih trupova na liniji klanja

	Rešetkasti pod		Kosa ploča		Duboka stelja	
	♂ n=317	♀ n=207	♂ n=345	♀ n=765	♂ n=553	♀ n=260
Masa toplih polovica, kg						
$\bar{x}$	344,50	268,84	335,67	267,85	342,425	263,85
sd	55,31	25,01	49,71	23,42	53,18	27,64
Min.-Max.	199-534	149-356	167-482	130-411	156-487	139-353
Klasa (EUROP)*						
$\bar{x}$	4	4,13	4,17	4,20	4,16	4,12
sd	0,74	0,73	0,72	0,68	0,75	0,72
Min.-Max	2-5	2-5	2-5	2-5	2-5	2-5
Stupanj prekrivenosti masnim tkivom, (ocjene 1-5)						
$\bar{x}$	3,09	3,35	3,19	3,35	3,13	3,49
sd	0,43	0,55	0,55	0,53	0,50	0,55
Min.-Max	2-4	2-5	2-5	2-5	2-4	2-5
Dob pri klanju, dana						
$\bar{x}$	522,52	440,37	506,64	426,67	488,11	421,87
sd	59,19	65,64	61,84	38,63	56,44	44,67
Min.-Max	357-658	311-684	360-773	307-664	353-617	330-521

\* EUROP klasifikacija, ocijene od 5=E (izvršna) do 1=P (slaba)

Ženska junad držana na dubokoj stelji imala su značajno ( $P < 0,05$ ) veću prekrivenost trupa masnim tkivom u odnosu na žensku junad držanu na kosoj ploči i rešetkastom podu. Navedena razlika u prekrivenosti dijelomično se može objasniti smanjenim kretanjem, odnosno većim mirovanjem ženske junadi na dubokoj stelji pa je stoga intenzivnije nakupljanje masnog tkiva.

Tablica 2. Boja mesa različito držane tovne junadi (LSM $\pm$ S.E.)

Pokazatelji boje	Spol	Rešetkasti pod	Kosa ploča	Duboka stelja	Razina značajnosti
L*	♂	39,49 $\pm$ 0,18	40,04 $\pm$ 0,17	39,82 $\pm$ 0,13	ns
	♀	43,34 $\pm$ 0,22	43,30 $\pm$ 0,11	42,85 $\pm$ 0,20	ns
a*	♂	23,97 $\pm$ 0,14	23,86 $\pm$ 0,14	23,82 $\pm$ 0,11	ns
	♀	23,62 $\pm$ 0,18	23,96 $\pm$ 0,09	23,96 $\pm$ 0,16	ns
b*	♂	8,66 $\pm$ 0,11	8,46 $\pm$ 0,11	8,43 $\pm$ 0,09	ns
	♀	8,95 $\pm$ 0,14	9,22 $\pm$ 0,07	9,14 $\pm$ 0,13	ns

Istraživanjem nisu utvrđene značajne razlike u boji mesa između različito držane tovne junadi istog spola (Tablica 2.). Do sličnih rezultata su došli Iacurto i sur. (2005) koji pritom nisu utvrdili znatne razlike u boji mesa između junadi držane u zatvorenom dok je junad držana na paši imala tamniju boju mesa. Predmetnim istraživanjem utvrđene su značajne ( $P < 0,001$ ) razlike u L\* pokazatelju boje između muške i ženske junadi držane na rešetkastom podu, kosoj ploči i dubokoj stelji. Navedeno je potvrđeno rezultatima drugih istraživanja (Monin i Ouali, 1991; Zhang i sur., 2010) pri čemu je zaključeno da je za tamniju boju mesa muških životinja odgovoran njihov nemirniji temperament zbog čega izgube veću količinu glikogena u vremenu prije klanja. Gubitak glikogena negativno djeluje na konačnu pH vrijednost mesa koja je usko povezana s pokazateljima boje junećeg mesa.

### Zaključci

Različit način držanja tovne jundi istog spola nije značajno utjecao na boju junećeg mesa kao niti na masu toplih polovica i klasu junećih trupova. Junad ženske pasmine držana na dubokoj stelji imala su veću količinu masnog tkiva usprkos manjoj završnoj tjelesnoj masi u usporedbi s ženskom junadi držanoj na kosoj ploči i rešetkastom podu.

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# Utjecaj polimorfizma MC4R gena u svinja na distribuciju SEUROP klasa

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## Sažetak

Cilj rada je utvrditi utjecaj polimorfizma MC4R gena na svojstva kakvoće polovice i klasa prema SEUROP sustavu ocjene. Tovljenici (n=130) bili su križanci pasmina ♂P x (♂VJ x ♀ŠL), a utovljeni su po konvencionalnoj tehnologiji velikih farmi do prosječne žive mase 110,3±15,66 kg. Nakon klanja utvrđene su mase trupova, metodom "dvije točke" izmjerena je debljina slanine, promjer MLD, postotak mišićne mase i SEUROP trgovačke klase. Genomska DNA je izolirana iz uzoraka krvi (*venae jugularis*), te je potom izvršena genotipizacija na poziciji 1426 (G/A) nukleotidne sekvence MC4R gena koristeći PCR-RFLP TaqI test. U populaciji tovljenika utvrđene frekvencije genotipova AA, AG i GG su bile redom 0,09, 0,43 i 0,48 te su se značajno razlikovale (p<0,05) od očekivanog prosjeka prema Hardy Weinbergovom zakonu. Utjecaj polimorfizma MC4R gena utvrđen je kroz razlike između tovljenika genotipova AA, AG i GG za debljinu slanine (p<0,05) i različite distribucije klasa trupova ocijenjenih prema SEUROP sustavu.

Ključne riječi: MC4R-gen, svinja, polimorfizam, debljina slanine, klase SEUROP.

## Effect of MC4R polymorphism on carcass distribution in pigs according to SEUROP

### Abstract

The aim of this study was to investigate the effect of MC4R polymorphism on carcass quality and distribution according to SEUROP classification. Commercial crossbred pigs (♂P x (♂VJ x ♀SL)) were used and fattened according to conventional farm practices in Croatia to 110.3±15.66 kg of live weight. After slaughter, carcass weight, backfat thickness, depth of *longissimus* muscle and meat percentage was estimated by "Two-point" method. Carcasses were classified according to SEUROP. Genomic DNA was extracted from blood samples (*venae jugularis*) and PCR-RFLP TaqI test was used to identify the SNP at the position 1426 (G/A) in the MC4R gene. The frequencies of MC4R genotypes AA, AG and GG were 0.09, 0.43 and 0.48, respectively, and were out of Hardy W. equilibrium (P<0.05). Significant effect of MC4R polymorphism on backfat thickness (P<0.05) and carcass distribution according to SEUROP class were observed.

Key words: MC4R-gene, pig, polymorphism, backfat thickness, SEUROP

## Uvod

Teorijske spoznaje i primjena populacijske, kvantitativne i molekularne genetike, a posljednjih godina genomike i proteomike u zemljama razvijenog svinjogojstva postaju interes svih sudionika (uzgajivača/selektionera, proizvođača rasplodnih i tovnih svinja, mesne industrije) u svrhu ostvarenja što veće ekonomske efikasnosti. U posljednje vrijeme određivanje i utvrđivanje genetičkih učinaka pojedinih kandidat gena, odnosno SNP-a (single nucleotide polymorphism) imaju važnost u selekciji svinja (marker - assisted selection) za ekonomski važna svojstva kao što su dnevni prirast, debljina slanine odnosno odnosi mišićnog i masnog tkiva, ali i sa zdravstvenog aspekta, te postaju predmet istraživanja u populacijama različitih vrsta životinja (Kim i sur. 2000 i 2004, Salajpal i sur., 2007 i 2009; Kovačik i sur., 2009).

Melanokortin-4 receptor (MC4R) gen nosi informaciju za sintezu melanokortin-4 receptora, jednog od 5 melanokortinskih membranskih receptora u središnjem živčanom sustavu (SŽS), područjima odgovornim za kontrolu unosa hrane i regulaciju energetske ravnoteže. Stoga MC4R gen je vrlo zanimljiv kao kandidat gen za svojstva unosa hrane, dnevnog prirasta, a posredno i mesnatosti kod domaćih životinja (Houston i sur., 2004). U svinja MC4R gen smješten je na prvom kromosomu (SSC1, q22-q27). Mutaciju unutar navedenog gena na poziciji 1426 nukleotidne sekvence karakterizira G → A supstitucija unutar Taq I restrikcijskog mjesta. Za ovu mutaciju utvrđeno je da ima značajnog utjecaja na svojstva dnevnog unosa hrane, dnevnog prirasta i kakvoću trupova kod svinja, ali i da taj utjecaj u značajnoj mjeri ovisi o uzgoju i/ili liniji svinja (Park i sur., 2002; Houston i sur., 2004; Stachowiak i sur., 2005). Nadalje rezultati dosadašnjih istraživanja sugeriraju da učinak ove mutacije na navedena svojstva ovisi o fazi tova/završnoj masi (Ovilo i sur., 2006; Salajpal i sur., 2009) te da je posebno zanimljiv u populacijama gdje se kao terminalni očevi koriste nerastovi pasmine Pietren, pasmine poznate po nešto sporijem rastu, ali sa visokim udjelom mišićnog tkiva u trupu (Van den Maagdenberg i sur., 2007). Budući da se podaci o kakvoći svinjskih polovica na liniji klanja koriste za određivanje prodajne cijene zaklanih svinja cilj je ovoga rada utvrditi utjecaj polimorfizma MC4R gena na svojstva kakvoće polovica i distribuciju klasa prema SEUROP sustavu ocjene u komercijalnih tovljenika.

## Materijal i metode

Istraživanje je provedeno na populaciji tovnih svinja (n=130) tropasminskih križanaca pasmina Pietren, Švedski Landras i Veliki Jorkšir (♂P x (♂VJ x ♀ŠL)). Tovljenici su proizvedeni konvencionalnom tehnologijom tova (prosječna početna masa prasadi 25 kg - 110 kg završna masa tovljenika) uz *ad libitum* napajanje vodom i ishranom smjesama ST<sub>1</sub> sa 17% SP i 13 MJME te ST<sub>2</sub> sa 15% SP i 12.5 MJME. Nakon tova u mesnoj industriji PIK Vrbovec za svakog tovljenika utvrđena je klaonička masa i masa toplih trupova. Prema pravilniku o kakvoći svinjskih trupova i polovica (Narodne novine, 2/2009) metodom dvije točke ("DT") izmjerena je debljina leđne slanine, promjera *Musculus longissimus dorsi* (MLD), te je utvrđen postotak mišićnog tkiva u trupu i ocijenjene trgovačke klase prema SEUROP sustavu. Uzorci krvi uzeti su iz jugularne vene pojedinačno od tovljenika za genomsku analizu. Korišten je standardni vacutainer sustav i epruvete 3 ml ("Venoject EDTA" (K3) Terumo Europe NV Belgium). Izolacija genomske DNA izvršena je iz uzoraka pune krvi (leukociti) po modificiranoj metodi Sambroock i sur. (1989). Polymerase chain reaction (PCR) i Restricted fragment length polimerasae (RFLP-Taq I) test korišteni su za identifikaciju SNP na poziciji 1426 (G/A) MC4R gena, prema protokolu Stachowich i sur. (2005). Statistička obrada podataka obavljena je programom SAS (1999). Utvrđene su frekvencije genotipova (AA, AG i GG) i alela (A i G), a hi-kvadrat ( $\chi^2$ ) testom analizirano je odstupanje frekvencija genotipova od Hardy - Weinbergovog zakona ravnoteže frekvencija u populaciji (Hamilton, 2009). Metoda ANOVA i Tukey - test korišteni su za analizu svojstava kakvoće trupova genotipova AA, AG i GG tovljenika.

## Rezultati i diskusija

Analiza genetske strukture istraživane populacije tovljenika na osnovu MC4R kandidat gena pokazuje veće frekvencije genotipova odnosno broj tovljenika heterozigota AG i homozigota GG nego AA, a što je posljedica odnosa frekvencija alela A i G. Testiranje utvrđenih frekvencija genotipova pokazuju značajno odstupanje od Hardy - Weinbergova zakona ravnoteže frekvencija genotipova u populaciji  $p \leq 0,05$  (tablica 1).

Tablica 1. Broj jedinki i genetska struktura populacije svinja

Genotip	Broj životinja (130)		Frekvencija	
	n	%	Genotip	Alel
AA	12	9,23	0,09	0,31
AG	56	43,08	0,43	-
GG	62	47,69	0,48	0,69

Treba istaći, a i novija istraživanja pokazuju, da je moguće temeljem zakonitosti molekularne i populacijske genetike o promjenama frekvencija gena, u populaciji postići frekvencije genotipova tovljenika po izboru uzgajivača, a koji po svojstvima najbolje odgovaraju proizvodnom cilju (Amaral i sur., 2009; Hamilton, 2009; Hayes i sur., 2009).

Testiranjem rezultata iz tablice 2, između genotipova nisu utvrđene statistički značajne razlike niti za jedno svojstvo osim debljinu leđne slanine. Utvrđene razlike pokazuju tanju leđnu slaninu u tovljenika genotipa GG nego u AA i AG ( $p \leq 0,05$ ). Razlika između homozigota GG i heterozigota AG ukazuje na genetički učinak alela A za to svojstvo, a može se indirektno povezati i s povećanim dnevnim prirastima (Đikić i Jurić, 1996), a to se očituje i u nešto većim apsolutnim vrijednostima za klaoničke mase AA tovljenika iako razlike nisu statistički značajne. Ove činjenice na fenotipskoj razini utvrdili su Jurić i sur. (1993). Dobiveni rezultati sukladno su s literaturnim podacima (Salajpal i sur., 2007 i 2009; Jokubka i sur. 2006; Kim i sur., 2000; Liu i sur. 2009).

Tablica 2. Klaonička masa svinja i svojstva kakvoće trupa

Svojstvo		Genotip		
		AA	AG	GG
		$\bar{X} \pm SD$ n=12	$\bar{X} \pm SD$ n=56	$\bar{X} \pm SD$ n=62
Klaonička masa	kg	112,2±15,1	111,5±16,6	108,9±14,9
Masa (t) trupa	kg	90,2±16,4	87,1±14,2	85,5±11,7
Debljina slanine	mm	17,7±4,6 <sup>a</sup>	15,0±5,8 <sup>ab</sup>	13,5±4,1 <sup>b</sup>
Debljina MLD	mm	72,9±3,2	71,7±5,5	70,7±11,1
Mesnatost	%	54,8±2,5	55,4±8,5	57,7±3,3
Klasa		U	E	E

Debljina slanine kao jedna od mjera za procjenu udjela mišićnog tkiva u trupu (metodom "DT") dala je efekat manjeg udjela mišićnog tkiva odnosno lošiju trgovačku klasu (U) kod genotipova AA, dok je kod genotipova AG i GG utvrđen najveći udio klase E. Genetičke efekte pojedinih alelnih varijanti ne treba promatrati samo s biološkog aspekta kroz promjene svojstava nego i kroz ekonomsku vrijednost jer odnosi tkiva u trupu svinja imaju utjecaj na efikasnost svinjogojске proizvodnje u nekoj zemlji (Đikić i sur. 1994, 2001, 2003 i 2005), uz pretpostavku da postoji sustav vrednovanja na osnovi udjela mišićnog tkiva i klasa mesnatosti trupova.

Prema rezultatima tablice 3 utvrđen je utjecaj MC4R gena na udjel mišićnog tkiva u trupu odnosno na trgovačke klase. Klasama S i E ocijenjeno je 60,8% trupova genotipa AG i 85,5% GG, dok su AA genotipovi bili klase E 66,7% i U 33,3%.

Tablica 3. Raspodjela i mesnatost trupova MC4R genotipova prema SEUROP sustavu

S EUROP sustav		AA			AG			GG		
Kl	M%	N=12		M%	N=56		M%	N=62		M%
		n	%		n	%		n	%	
S	>60			$\bar{X} \pm SD$			$\bar{X} \pm SD$			$\bar{X} \pm SD$
E	55-60	8	66,7	56,1±0,84	25	44,7	57,1±1,38	40	64,5	57,5±1,28
U	50-55	4	33,3	52,8±0,61	18	32,1	54,1±1,37	7	11,3	53,3±1,65
R	45-50				4	7,1	48,9±2,02	2	3,2	48,6±0,12
O	40-45									
P	<45									

N=broj svinja određenog genotipa, n i% = broj i postotak svinja određenog genotipa u klasi. M%=postotak mišićnog tkiva u trupu, metoda "DT".

Unutar genotipova AG visok je postotak nižih klasa U i R. Dobiveni rezultati nameću potrebu dorade Plana i programa uzgoja svinja u RH (Jurić i sur. 1997), kao i uputa za testiranje (Uremović i sur. 2000) ili čak izrade novih dokumenta uz primjenu novih spoznaja iz područja genomike/proteomika, jer za budućnost treba razmišljati sada, premda je u Hrvatskoj u selekciji svinja, posebno na svojstvo mesnatosti ostvaren napredak (Hrvatski stošarski centar, 1997-2010).

### Zaključak

U populaciji tovljenika utvrđene frekvencije genotipova AA, AG i GG kandidat gena MC4R značajno su različite u odnosu na H-W zakon ravnoteže frekvencija genotipova u populaciji. Utvrđen je utjecaj MC4R kandidat gena na svojstvo debljine leđne slanine, a posljedično tome i na SEUROK klase s različitim postotkom mišićnog tkiva u trupu, pa je to rezultiralo različitim distribucijama trgovačkih klasa između skupina tovljenika genotipova AA, AG i GG.

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# Utjecaj genotipa i uzrasta nesilica na deformaciju ljuske kokošnjih jaja

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## Sažetak

U cilju utvrđivanja utjecaja genotipa i uzrasta nesilica na deformaciju ljuske kokošnjih jaja, provedeno je istraživanje na dva laka linijska hibrida kokoši (Hisex Brown i Shaver 579). Krajem svakog 4-tjednog razdoblja obavljeno je ispitivanje vanjskih osobina kvaliteta jaja. Ispitivanje je vršeno na uzorku od 30 jaja za svaki hibrid. Ukupno je izvršeno 10 ispitivanja.

Dobiveni prosjek mjerenja deformacije ljuske jajeta za Shaver 579 nesilice iznosio je 26,27  $\mu\text{m}$  i bio je nešto veći u odnosu na deformaciju koju je imao Hisex Brown (25,82  $\mu\text{m}$ ). Veći raspon variranja deformacije ljuske jajeta po 4-tjednim periodima ispitivanja imale su nesilice Hisex, ali razlike nisu bile signifikantne. Na temelju istraživanja, zapaženo je da se sa uzrastom nesilica deformacija ljuske jajeta povećava.

Prema tome, razlike između dobivenih rezultata za deformaciju ljuske kokošnjih jaja kod ispitivanih nesilica bile su zanemarljivo male.

Ključne riječi: deformacija ljuske, genotip, kokošja jaja, uzrast

## The effect of genotype and age of hen on deformation of egg shell

### Abstract

To determine the influence of genotype and age of hens on the deformation of egg shell, an experiment was conducted at two light hybrids chickens (Hisex Brown and Shaver 579). At the end of each 4-weeks period were examined external egg quality traits. The test was performed on a sample of 30 eggs for each hybrid. There were total of 10 tests.

The resulting average deformation measurements of egg shell for Shaver 579 hens was 26.27 mm and was slightly higher than the strain that had Hisex Brown (25.82 mm). Broader range of deformation of eggs shells per 4-weeks period were found in hens Hisex, but the differences were not significant. Based on research, it was noticed that with age of hens egg shell deformation increases.

Thus, the differences between the results obtained for the chicken egg shell deformation in the investigated layers were negligibly small.

Key words: shell deformation, genotype, eggs, age



## Uvod

Suvremena peradska proizvodnja omogućuje da se za kratko vrijeme i relativno mala ulaganja dobiju veće količine visoko cijenjenih proizvoda za prehranu ljudi, kao što su jaja i peradsko meso.

Kokoške jaje ima izuzetno visoku hranljivu vrijednost, malog je sadržaja energije i lako je probavljivo. U prosjeku kokoške jaje sadrži oko 74% vode i 26% suhe tvari. Jaje je bogat izvor visoko vrijednih proteina, masnih kiselina, željeza, fosfora, vitamina (A, E, K, B i B12, D), minerala, dok ima malo kalcija i vitamina C. Proizvodnja jaja za konzum danas se bazira na iskorištavanju genetskog potencijala lakih i srednje teških linijskih hibrida kokoši. Međutim, pojedini autori (Stolić i sur., 1994; Bogosavljević-Bošković i sur., 1999; Đekić i sur., 2007; Rajičić i sur., 2008) ističu da proizvodnja jaja u industrijskoj peradarskoj proizvodnji koja koristi linijske hibride kokoši za proizvodnju konzumnih jaja ovisi oko 70% od paragenetskih faktora (uvjeta uzgoja i tehnologije proizvodnje jaja), a samo oko 30% od genetskih (nasljednih) osobina nesilica.

Cilj rada je na temelju učinka genotipa i uzrasta nesilica ustanoviti razlike u kvalitetu jaja, odnosno deformaciji ljuske kod različitih provenijenci, s obzirom da se na našem tržištu nalaze jaja različitih genotipova i starosti nesilica.

## Materijal i metode rada

Za ispitivanje su korištena jaja dobivena od nesilica Hisex Brown i Shaver 579. Tijekom razdoblja nošenja (40 tjedna), odnosno u dobi od 19. do 59. tjedna, težilo se da se ispitivanim hibridima osiguraju podjednaki uvjeti smještaja, prehrane i njege. Kokoši su hranjene tvorničkom smjesom za nesilice konzumnih jaja.

Jednom mjesečno od obje provenijence, istog dana, uziman je uzorak od 30 jaja za ispitivanje, po principu slučajnog uzorka. Ukupno je za obje provenijence tijekom deset 4-tjednih razdoblja nošenja ispitano 600 jaja. Za svako jaje pojedinačno je ispitana deformacija ljuske, mjerena instrumentom čiji je princip rada zasnovan na mjerenju deformacije ljuske jajeta pod pritiskom, a proizvod je tvrtke Marius-Utrecht.

Ostvareni rezultati nesilica konzumnih jaja za deformaciju ljuske obrađivani su po provenijencama za svaki uzorak (period), kao i za cijeli period nošenja. Na osnovu dobivenih rezultata istraživanja izračunati su uobičajeni varijaciono statistički pokazatelji: prosječne vrijednosti ( $\bar{x}$ ), greška aritmetičke sredine ( $S\bar{x}$ ), standardna devijacija (S) i koeficijent varijacije (C.V.). Utvrđene razlike deformacije ljuske jajeta između ispitivanih provenijenci testirane su t-testom.

## Rezultati i rasprava

Da starost nesilica utiče na povećanje deformacije ljuske jajeta, kao i osobine kvaliteta- strukture jajeta potvrđuju podaci prikazani u tablici 1.

Tablica 1. Prosječne vrijednosti i varijabilnost deformacije ljuske jajeta

Interval-tjedni	Deformacija ljuske jajeta, $\mu\text{m}$								Značajnost
	$\bar{x}$		$S\bar{x}$		S		C.V.		
	Hisex	Shaver	Hisex	Shaver	Hisex	Shaver	Hisex	Shaver	
I-23	23,24	21,13	0,73	0,60	3,99	3,29	17,16	15,56	*
II-27	13,80	22,87	1,13	0,74	6,17	4,08	44,73	17,86	**
III-31	25,63	28,87	1,10	2,10	6,00	4,72	23,42	16,34	**
IV-35	26,03	26,60	0,69	0,71	3,79	3,88	14,56	14,60	NS
V-39	26,68	25,38	0,69	0,75	3,76	4,13	14,04	16,29	NS
VI-43	23,17	25,43	0,87	0,70	4,77	3,81	20,54	14,99	*
VII-47	22,63	26,63	0,67	0,99	3,66	5,40	16,18	20,27	**
VIII-51	23,82	23,62	1,00	0,95	3,49	5,20	23,06	22,01	NS
IX-55	39,30	28,30	2,18	0,87	11,93	4,79	30,36	16,91	**
X-59	33,90	33,83	1,07	0,97	5,84	5,32	17,22	15,72	NS
Totall	25,82	26,27	1,01	0,94	5,34	4,46	22,13	17,06	NS

t-test razine značajnosti: NS - $P > 0,05$ ; \*  $P < 0,05$ ; \*\*  $P < 0,01$

Na temelju podataka prikazanih u tablici 1 može se konstatirati da je deformacija ljuske jajeta u prosjeku za cijeli period nosivosti kod nesilica Shaver 579 iznosila 26,27  $\mu\text{m}$ , a kod Hisex Brown 25,82  $\mu\text{m}$ . Koeficijent

varijacije kod obje ispitivane provenijence bio je visok i kretao se od 17,06% kod Shaver nesilica do 22,13% kod Hisex Brown hibrida. Kokoši provenijence Hisex Brown imale su nešto veći raspon variranja deformacije ljuske. Ustanovljene razlike sa stanovišta prosječnih vrijednosti deformacije ljuske jajeta, za cio period istraživanja, između ispitivanih provenijenci nisu bile značajne,  $P > 0,05$ .

Najveća deformacija ljuske jajeta kod Shaver 579 hibrida ustanovljena je u III, IX i X 4-tjednom razdoblju istraživanja, dok je kod Hisex Brown hibrida ista bila najveća u IV, V, IX i X 4-tjednom razdoblju istraživanja. Najmanja deformacija ljuske jajeta kod Hisex Brown nesilica je bila u drugom 4-tjednom periodu, dok kod Shaver nesilica u prvom 4-tjednom periodu ispitivanja.

Dobivene prosječne vrijednosti deformacije ljuske u skladu su s rezultatima do kojih su došli Vračar i sur. (1995) i Arapović i sur. (1998), dok su nešto veću deformaciju ljuske za hibrid Shaver 579 ustanovili Perić i sur. (1998) i Pavlovski i sur. (1994).

Oblik i jačina apsolutne i relativne ovisnosti između utjecaja uzrasta nesilica i deformacije ljuske kokošijih jaja, iskazana regresijskom i korelacijskom analizom na osnovu pet tipova funkcije, prikazan je u tablici 2.

Tablica 2. Utjecaj uzrasta na deformaciju ljuske jajeta

Hibrid	Tip funkcije	Regresijski koeficijenti	Korelacija ( $r_{xy}$ )
Shaver 579	Linearna	$\hat{y} = 18,99744 + 0,19129x$	0,649*
	Kvadratna	$\hat{y} = 24,18265 - 0,10907x + 0,00395x^2$	0,663*
	Exponencijalna	$\hat{y} = 19,84392 \cdot e^{0,007168x}$	0,655*
	Logaritamska	$\hat{y} = 2,31665 + 6,67574 \ln x$	0,639*
	Cobb-Douglasova	$\hat{y} = 10,46799x^{0,25419}$	0,655*
Hisex Brown	Linearna	$\hat{y} = 11,34744 + 0,38108x$	0,675*
	Kvadratna	$\hat{y} = 28,07521 - 0,5879x + 0,01275x^2$	0,713*
	Exponencijalna	$\hat{y} = 14,22646 \cdot e^{0,01483x}$	0,653*
	Logaritamska	$\hat{y} = -20,03695 + 12,7844 \ln x$	0,639*
	Cobb-Douglasova	$\hat{y} = 4,07371x^{0,505697}$	0,629*

Na temelju tablice 2 jasno se vidi da kvadratni tip funkcije najvjernije oslikava oblik ovisnosti uzrasta nesilica i deformacije ljuske jajeta kod ispitivanih provenijenci. Definirani koeficijenti korelacije pokazuju srednji stupanj slaganja. Pored toga, kod obje ispitivane provenijence između uzrasta nesilica i deformacije ljuske utvrđeni su pozitivni koeficijenti korelacije. Koeficijent korelacije između uzrasta nesilica i deformacije ljuske jajeta kod provenijence Shaver 579 iznosio je  $r_{xy} = 0,663^*$  i bio je statistički značajan ( $P < 0,05$ ), dok je kod nesilica Hisex Brown utvrđen, također statistički značajan koeficijent korelacije ( $r_{xy} = 0,713^*$ ). Većina studija pokazuje da se sa starošću nesilica povećava deformacija ljuske jajeta. Tako su Vračar i sur. (1995), utvrdili statistički značajnu korelaciju između uzrasta i deformacije ljuske, i koeficijent korelacije se kretao od 0,67 do 0,72. Statistički značajan koeficijent korelacije ( $P < 0,05$ ) između uzrasta nesilica i deformacije ljuske jajeta utvrdili su i Arapović i sur. (1998), Perić i sur. (1998) i Pavlovski i sur. (1994).

### Zaključak

U cilju uporednog ispitivanja kvaliteta jaja lakih linijskih hibrida kokoši izveden je ogled u trajanju od 19. tjedna do 59. tjedna starosti. Istraživanjem su obuhvaćena dva linijska hibrida kokoši, Shaver 579 i Hisex Brown.

Na temelju dobivenih podataka može se konstatovati, da je deformacija ljuske jajeta u prosjeku za cijeli period nosivosti kod nesilica Shaver 579 iznosila 26,27  $\mu\text{m}$ , a kod Hisex Brown 25,82  $\mu\text{m}$ . Ustanovljena razlika značajnosti prosječnih vrijednosti i varijabilnosti deformacije ljuske kokošijih jaja ispitivanih hibrida statistički nije bila signifikantna,  $P > 0,05$ .

Naime, oba hibrida u pogledu kvaliteta jaja dala su zadovoljavajuće rezultate. Pored toga, najprilagođenija linija regresije između uzrasta i deformacije ljuske jajeta bila je kvadratna funkcija i to značajna.

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# Filogenetska analiza međimurskog konja

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## Sažetak

U ovom radu napravljena je usporedba nukleotidnih sljedova duljine 314 pb i 1231 pb, te analizirana mtDNA informativnost s obzirom na duljinu nukleotidnih sljedova. Na slijedu mtDNA od 243 pb analizirana je srodnost međimurskog konja (mađarske i hrvatske populacije) s hrvatskim hladnokrvnjakom i hrvatskim posavcem iz literature. Analizom 73 nukleotidna slijeda duljine 314 pb, nađena su 33 polimorfna mjesta, a identičnom analizom na nukleotidnom slijedu dugom 1231 pb nađeno je 130 polimorfni mjesta. Raznolikost haplotipova iznosila je 0,96, analizom 314 pb, a 0,0994 analizom 1231 pb. U analiziranom nukleotidnom slijedu od 314 pb nađeno je 29 haplotipa, dok je 60 nađeno analizom 1231 pb.

Usporedbom međimurskih konja s međimurskim konjima iz literature, hrvatskim hladnokrvnjakom te posavskim konjem vidljiva su grupiranja koje međimurski konji stvaraju zasebno, ali i filogenetska srodnost s obzirom na blizinu grana u kojima se nalaze hrvatski hladnokrvnjaci kao i, nešto udaljenije, posavski konji. Na temelju analize 243 pb dugog nukleotidnog slijeda između posavskog konja, hrvatskog hladnokrvnjaka i međimurskog konja  $F_{st}$  je 0,05562. Rezultati istraživanja pokazali su da je dulji nukleotidni slijed informativniji. Istraživanje koje se temelji samo na uporabi mtDNA ukazuje na sličnost početnih populacija kobila na kojima se zasnivaju populacije hrvatskog hladnokrvnjaka, međimurskih i posavskih konja.

Ključne riječi: Međimurski konj, mtDNA, genetska varijabilnost

## Phylogenetic analysis of Međimurje horse

### Abstract

In this paper, we have made a comparison of nucleotide sequences of length 314 bp and 1231 bp, and analyzed mtDNA informativeness with respect to the length of nucleotide sequences. On the mtDNA sequence of 243 bp was analyzed relationship Međimurje horse (Hungarian and Croatian population) with the Croatian Coldblood and Posavina horse from literature. By the analysis of 73 nucleotide sequences of 314 bp length, we have found 33 polymorphic sites and on sequence of 1231 bp was found 130 polymorphic sites. Haplotype diversity was 0.96, given by analysis of 314 bp and 0.0994 on 1231 bp analysis. In the analysed nucleotide sequence of 314 bp 29 haplotypes was found, while 60 were found by analyzing 1231 bp. Comparing Međimurje horse with Međimurje horse from literature, Croatian Coldblood and Posavina horse, grouping of horses is visible, Međimurje horse created clusters separately, but with respect to the phylogenetic relationship among other horses. Based on analysis of 243 bp long sequence between the Posavina horse, Croatian Coldblood Međimurje horse  $F_{st}$  is 0.05562. The results

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showed that the longer sequence is more informative. Research that is based solely on the use of mtDNA indicates the similarity of initial population of mares underlying population of the Croatian Coldblood, Međimurski horse and Posavina horse.

Key words: Medjimurje horse, mtDNA, genetic variability

### Uvod

Mitochondrijska DNA konja veličine je 16 660 pb i njen nukleotidni slijed prvi su identificirali Xu i Arnanson (1994) koji su ujedno i dokazali varijabilnost D-loop regije te otkrili ponavljajući slijed od osam baznih parova u velikom konzerviranom nukleotidnom slijedu kontrolne regije. Broj ponavljanja varira između dvije i 29 kopija, iako ih je najviše u rasponu od 22 do 27. Ponavljajući motiv mtDNA konja je GTGCACCT (Xu i Arnanson, 1994), a duljina D-loop regije iznosi prosječno 1125 pb. Kako je najčešće prosječna duljina istraživanog nukleotidnog slijeda mtDNA oko 314 pb, u ovom radu napravljena je usporedba nukleotidnih slijedova duljine 314 pb i 1231 pb, te analizirana mtDNA informativnost s obzirom na duljinu nukleotidnih slijedova. Na slijedu mtDNA od 243 pb analizirana je i srodnost međimurskog konja (mađarske i hrvatske populacije) s hrvatskim hladnokrvnjakom i hrvatskim posavcem iz literature. Za usporedbu su uzeti nukleotidni slijedovi međimurskog konja, noričkog konja, hrvatskog hladnokrvnjaka te hrvatskog posavca.

Prema literaturnim navodima, međimurski konj je nastao križanjem domaćih kobila sa pastusima noričke pasmine, belgijskim hladnokrvnjacima (peršeronskim hladnokrvnjakom, ardenskim hladnokrvnjakom i brabantom) i drugima pasminama. U prošlosti se međimurski konj uzgajao i u Mađarskoj gdje se i danas nalazi određeni broj grla ove pasmine (Frkonja i sur., 2010). Usporedba je izvršena prema objavljenim nukleotidnim slijedovima iz rada Ivanković i sur., (2009) te s nukleotidnim slijedovima dobivenima u istraživanju. Uspoređena je D-loop, tj. najvarijabilnija regija mtDNA međimurskih konja iz Republike Hrvatske s međimurskim konjima iz Mađarske (mađ. muraközi lo) te hrvatskim hladnokrvnjakom i hrvatskim posavcem.

### Materijali i metode

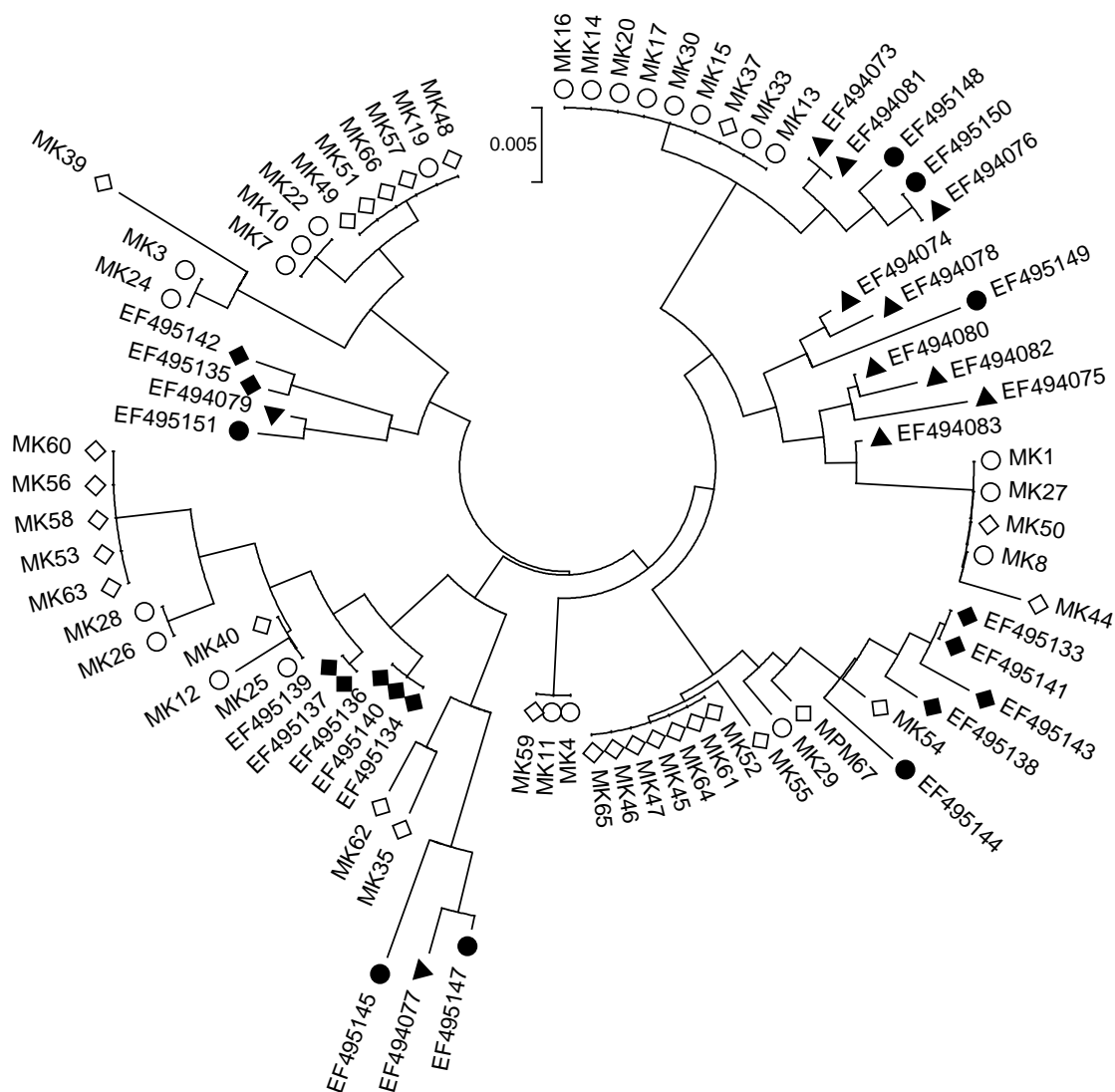
Za ovo istraživanje korišteni su uzorci krvi 23 norička konja iz pokrajine Karintija, devet noričkih konja iz pokrajine Salzburg, tri uzorka dlake hrvatskih hladnokrvnjaka, jedan hrvatskog posavca, 19 uzoraka krvi međimurskog konja iz Hrvatske i 14 uzoraka međimurskih konja iz Mađarske. Ukupna genomski DNA iz pune krvi izdvojena je koristeći komplet reagensija Sigma Gen Elute™ Blood Genomic DNA Kit po uputama proizvođača (Sigma-Aldrich Chemie GmbH, Germany). DNA iz dlake izdvojena je pomoću "Qiagen" DNeasy® Blood & Tissue Kit (250) protokola za izdvajanje DNA iz dlake, nohtiju i perja. Početnice za umnožavanje željenog nukleotidnog slijeda su preuzete iz rada Aberle i sur., (2007). Statistička obrada haplotipova mtDNA je napravljena pomoću programskog paketa MEGA 4.0, a zatim DNAsp 5.10.00 (Rozas, <http://www.ub.edu/dnasp/>, 2009). Analiza varijance provedena je programskim paketom Arlequin 3.0 (Excoffier, 2005).

### Rezultati i rasprava

Analizom 73 nukleotidna slijeda duljine 314 pb, nađena su 33 polimorfna mjesta, od čega je pet bilo prisutno samo jednom ("singelton polimorfna mjesta"), a 28 "parsimono" informativnih nukleotida. Raznolikost haplotipova iznosila je 0,96, a nađeno je 29 haplotipova. Varijanca raznolikosti haplotipova iznosi 0,008. Nukleotidna raznolikost iznosi 0,02083. Prosječni broj nukleotidnih razlika je 6,521. Identična analiza napravljena je pomoću nukleotidnih slijedova istih jedinki no korišten je nukleotidni slijed od 1231 pb. Nađeno je 130 polimorfni mjesta, 58 od njih se pojavljivalo samo jednom. Raznolikost haplotipova iznosi u ovom slučaju 0,994. Usporedbom međimurskih konja s međimurskim konjima iz literature, hrvatskim hladnokrvnjakom te posavskim konjem (pristupni kodovi: hrvatski hladnokrvnjak: EF494073-83, posavski konj: EF495133-42, međimurski konj: EF495144-51) vidljiva su grupiranja ("klasteri") koje međimurski konji stvaraju zasebno, ali i filogenetska srodnost s obzirom na blizinu grana u kojima se nalaze hrvatski hladnokrvnjaci kao i, nešto udaljenije, posavski konji (Slika 1). Usporedba je napravljena na temelju 243 pb dugog nukleotidnog slijeda. Na temelju nukleotidnog slijeda duljine 314 pb dobiven je fiksacijski indeks ( $F_{st}$ ) od 0,04360 ( $P < 0,001$ ). Analizom koja je obuhvaćala 1231 pb dobiven je fiksacijski indeks od 0,02424

( $P < 0,001$ ). Između mađarske i hrvatske populacije  $F_{st}$  je 0,04642 ( $P < 0,001$ ). Na temelju analize 243 pb dugog nukleotidnog slijeda između posavskog konja, hrvatskog hladnokrvnjaka i međimurskog konja  $F_{st}$  je 0,05562 ( $P < 0,001$ ).

Rezultati istraživanja pokazali su da je dulji nukleotidni slijed informativniji. Istraživanje koje se temelji samo na uporabi mtDNA ukazuje na sličnost početnih populacija kobila na kojima se zasnivaju populacije hrvatskog hladnokrvnjaka, međimurskih i posavskih konja. U radu Čubrić-Čurik i sur., (2010) analizirano je 153 nukleotidna slijeda duljine 276 pb. Na temelju ove analize devet haplotipova je bilo jedinstveno za međimurskog konja (šest njih za konje iz hrvatske populacije i tri za konje iz mađarske populacije). Zanimljivo je da među tim jedinstvenim haplotipovima jedan je bio prisutan kod devet konja iz hrvatske populacije, a jedan za pet konja iz mađarske populacije. Ivanković i sur., (2009) analizirajući mtDNA hrvatskog hladnokrvnjaka te međimurskog i posavskog konja pronašli su 26 polimorfni mjesta na nukleotidnom slijedu duljine 323 pb. Raznolikost haplotipova je 0,31% 5,26. Amova analiza pokazuje podjelu između pasmina,  $F_{ST}$  iznosi 0,2004 ( $P < 0,001$ ). Premda je populacija međimurskog konja mala (37 jedinki) haplotipovi dobiveni u ovoj analizi, iako bliski, nisu se u potpunosti poklapali s analiziranim haplotipovima međimurskog konja u istraživanju Ivanković i sur. (2009).



Slika 1. Dendrogram međimurskih konja iz Mađarske, Hrvatske, hrvatskog hladnokrvnjaka i hrvatskog posavca

Legenda: ◇ međimurski konj iz Mađarske; ○ međimurski konj iz Hrvatske; ◆ posavski konj; ▼ hrvatski hladnokrvnjak; ● međimurski konj iz literature

Analiza mtDNA pokazuje nam genetske odnose između populacija koji se odnose na njihovo podrijetlo i to isključivo preko rodova tj. majke. Tako, iako istraživana populacija “hrvatskog” i “mađarskog” međimurskog konja imaju zajedničke haplotipove, a za razliku od ostalih populacija hladnokrvnih hrvatskih konja, ne može se sa sigurnošću utvrditi koja je genetska srodnost analiziranih populacija. Zato je, pored navedene analize, nužno usporediti ove populacije i na temelju nukleotidne DNA i to koristeći mikrosatelitne markere ili upotrebom SNP-sa (engl. single nucleotide polymorphism).

### Zaključci

Na temelju analize 243 pb dugog nukleotidnog slijeda između posavskog konja, hrvatskog hladnokrvnjaka i međimurskog konja  $F_{st}$  je 0,05562. Rezultati istraživanja pokazali su da je dulji nukleotidni slijed informativniji. Istraživanje koje se temelji samo na uporabi mtDNA ukazuje na sličnost početnih populacija kobila na kojima se zasnivaju populacije hrvatskog hladnokrvnjaka, međimurskih i posavskih konja.

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# Učinak promjene vezanog u slobodni sustav držanja na proizvodnost manjih mliječnih farmi

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## Sažetak

Cilj rada je istraživanje učinka uvođenja slobodnog sustava držanja mliječnih krava na pokazatelje proizvodnosti i kakvoće mlijeka. Obuhvaćeno je dvanaest mliječnih farmi u razdoblju od 1999. do 2009. Tijekom prijelaznog razdoblja uočeno je povećanje proizvodnosti stada i udjela holštajna u stadima. Udio holštajna u stadima povećan je s 9% na 72%. Povećana je prosječna mliječnost na farmama (+720,8 kg), te udio mliječne masti i bjelančevina u mlijeku (+0,23; +0,14). Rezultati ukazuju da su pozitivni pomaci proizvodnosti stada rezultat promjene pasminske strukture (rast udjela holštajna;  $p < 0,01$ ) koji ostvaruje veću mliječnost. Promjena sustava držanja nije utjecala na povećanje proizvodnosti.

Ključne riječi: sustav držanja, pasmina, mliječne farme, učinkovitost proizvodnje

## The effect of changing tied to a free housing system on productivity in small dairy farm

### Abstract

The aim of work is research the impact of introducing a free housing system of dairy cows on the indicators of productivity and quality of milk. Research involved twelve dairy farms in the period from 1999 to 2009 year. During the transition period was observed increase of productivity in dairy herds, and the share of Holstein increased from 9% to 72%. Increased average milk production on farms (720.8 kg), and share of fat and protein in milk (+0.23, +0.14). Our results indicated that positive changes in productivity were result of changes in breed structure of dairy herd (increase share of Holstein,  $p < 0.01$ ), which encourages more milk production. We can conclude that changing tied to a free housing system of dairy cows had no significant effect on increase of milk production.

Key words: housing system, breeds, dairy farm, production efficiency

### Uvod

Održiva proizvodnja kravljeg mlijeka konstantno se prilagođava gospodarskom, sociološkom, kulturološkom okruženju, kao i brojem drugim faktorima koji direktno i indirektno utječu na prihodovnu i investicijsku strukturu proizvodnje. Cijeli niz negenetskih i genetskih čimbenika utječe na samu učinkovitost proizvodnje, te ih je u cilju realizacije održive proizvodnje nužno poznavati i menadžmentom im se prilagođavati. Održiva proizvodnja često podrazumijeva približavanje razine proizvodnje mlijeka maksimalnom proizvodnom kapacitetu. Povećanje proizvodnji mlijeka često je u negativnoj korelaciji s plodnošću, potiče javljanje zdravstvenih problema (laminitis, mastitis, endometritis, ketoza i druge), skraćuje proizvodni vijek krave, te



izaziva odstupanja od uobičajenog ponašanja krava (Oltenacu, 2010), što dijelom uvjetuje negativnu percepciju potrošača naspram proizvodnje mlijeka i samog proizvoda. Slobodni sustav držanja je obzirom na dobrobit životinja najprihvatljiviji a u pogledu menadžmenta mliječnih farmi ekonomski najučinkovitiji (Krohn i Munksgaard, 1993).

Liberalizacija cjenovne politike i tržišta mlijeka koja je posebice izražena tijekom protekla dva desetljeća potakla je strukturni preustroj govedarske proizvodnje u cilju postizanja bolje konkurentnosti kroz unapređenje kvantitete i kvalitete proizvoda. Intenzifikacija proizvodnje mlijeka posebice je uočljiva kroz integraciju novih tehnologija u postojeće i nove mliječne farme, povećanje udjela mliječnih pasmina goveda, okrupnjavanje farmskih kapaciteta (površine, objekti, oprema) i ulaganje u znanja. Procesi su uočljivi u gotovo svim zemljama u kojima se događa prilagodba poljoprivredne odnosno stočarske proizvodnje, od čega nije izuzeta ni Republika Hrvatska. Svjedočimo o značajnom padu broja tržno orijentiranih mliječnih farmi, uz zadržavanje isporučene količine mlijeka. Statistički pokazatelji ukazuju na značajno smanjenje (41 100) broja isporučitelja kravljeg mlijeka u razdoblju od 2002. do 2009., dok je količina otkupljenog mlijeka povećana za 161 mil. kg (HPA, 2010). Značajan broj manjih farmi je nestao ili se preustrojio prema preradi mlijeka, a samo je manji dio mliječnih farmi zadržao tržnu proizvodnu orijentaciju uz poduzimanje napora za očuvanje ili povećanje svojih kapaciteta, ulažući u nove tehnologije, objekte, opremu, površine i znanja, istodobno usvajajući norme i načela dobrobiti životinja. U skladu s navedenim, dio manjih mliječnih farmi u Hrvatskoj tijekom preustroja i proširenja kapaciteta uvodi slobodni sustav držanja mijenjajući pri tome i pasminsku strukturu stada u korist mliječnih pasmina (holštajnizacija stada). Neka istraživanja ukazuju da je uvođenje sustava slobodnog držanja ekonomski opravdano za stada veća od 40 muznih krava, uz prosječnu laktacijsku proizvodnju mlijeka u stadu od 8 610 kg (Janžeković i Rozman, 2006). Isti autori navode da je životinjama potrebno minimalno šest mjeseci za potpunu prilagodbu životinja na slobodni sustav držanja.

U Hrvatskoj slobodni sustav držanja mliječnih krava potiskuje ranije dominantni tradicionalni vezani sustav držanja uglavnom na manjim mliječnim farmama u procesu širenja kapaciteta. Slobodni sustav držanja primjenjuje se na svim novim mliječnim farmama. Uvodeći slobodni sustav držanja, osiguravajući povoljnije okruženje mliječnim kravama, uz primjerenu optimiziranje menadžmenta (automatizacija hranidbe, mužnje i higijene) farmeri očekuju snižavanje troškova rada, veću proizvodnost krava, bolju kvalitetu mlijeka, povoljnije odlike fitnesa i zdravlja stada, veću reproduktivnu učinkovitost, te povoljniju socijalnu interakciju jedinki (manje stresa u stadu). Pogodno socijalno okruženje pozitivno djeluje na odnos jedinki naspram generalno stresnih situacija (Bouissou i sur., 2001). Cilj rada je analiza učinaka strukturnih promjena (uvođenje slobodnog sustava držanja) na manjim mliječnim farmama u Hrvatskoj koje se uglavnom događaju tijekom širenja proizvodnih kapaciteta.

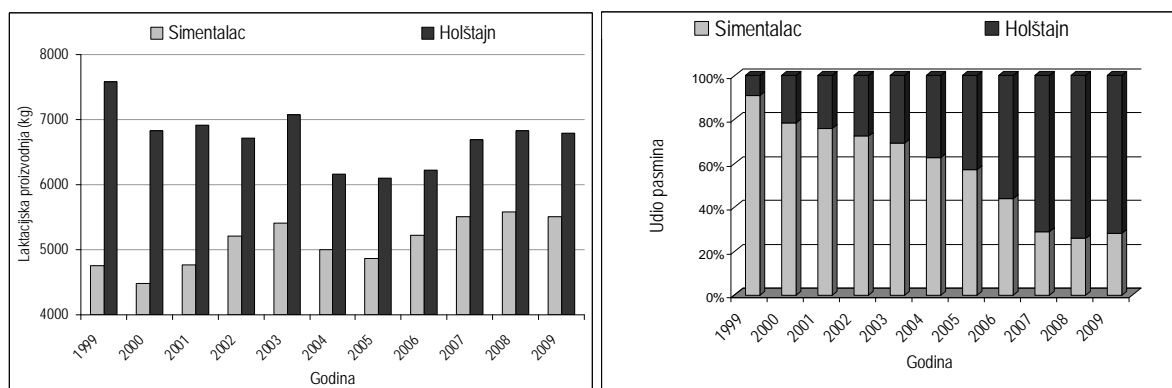
### Materijal i metode rada

Istraživanjem je obuhvaćeno dvanaest mliječnih farmi u razdoblju od 1999. do 2009. kada je u intervalu 2004. do 2006. uveden slobodni sustav držanja. U analizu su uključeno 3920 laktacijskih pokazatelja 1 780 mliječnih krava koje su se nalazile u proizvodnji na promatranim mliječnim farmama tijekom promatranog razdoblja. Zasebno su analizirana 192 laktacijska pokazatelja 42 mliječne krave koje su ostvarile minimalno dvije laktacije u vezanom odnosno slobodnom sustavu držanja. Osnovna struktura obroka mliječnih krava tijekom promjene vezanog u slobodni sustav držanja nije se mijenjala, izuzev činjenice da su u slobodnom sustavu držanja krave imale slobodan cjelodnevni pristup krmnom stolu. Godišnja laktacijska analitička izvješća istraživanjem obuhvaćenih farmi preuzeta su iz arhive Hrvatske poljoprivredne agencije. Praćena je proizvodnja mliječnih krava kroz slijedeće pokazatelje: količina proizvedenog mlijeka u standardnoj (kg/lakt<sub>305</sub>), udio mliječne masti (%), udio bjelančevina u mlijeku (%). Analiza učinka uvođenja slobodnog sustava držanja i promijene pasminske strukture na proizvodne laktacijske pokazatelje učinjena je uz pomoć GLM procedure (SAS, 1999).

### Rezultati i rasprava

Porast prosječnog broja zaključenih laktacija u istraživanjem obuhvaćenom razdoblju sa 9,4 na 45,2 (grafikon 1) ukazuje da su mliječne farme tijekom proteklog desetljeća doživjele značajnu preobrazbu kapaciteta, usmjeravajući se ka tržišno orijentiranoj proizvodnji mlijeka. Osim povećanja broja krava navedenu tvrdnju potkrepljuje i promjena pasminske strukture mliječnih farmi, na kojima se dogodilo značajno povećanje udjela holštajn pasmine (sa 9 na 72%), te smanjenje udjela simentalke pasmine (sa 91 na 28%). Na 9 od 12 promatranih mliječnih farmi holštajn pasmina uključena je u proizvodnju tek nakon uvođenja slobodnog

sustava držanja, a samo na dvije farme krave simentalске pasmine zadržale su dominaciju. Laktacijska proizvodnost tijekom promatranog razdoblja je stagnirala kod krava simentalске pasmine, te pala kod krava holštajn pasmine (grafikon 2), premda treba uzeti u obzir da je za 1999. godinu u izračun uključeno samo 37 zaključnih laktacija krava holštajn pasmine. U godini neposredno prije i nakon uvođenja slobodnog sustava držanja došlo do pada laktacijske mliječnosti, što možemo pojasniti stresom prilagodbe novom okruženju. Janžeković i Rozman (2006) također su zapazili da je životinjama potrebno minimalno šest mjeseci za prilagodbu na slobodni sustav držanja.



Grafikoni 1. i 2. Promjena pasminske strukture i prosječne laktacijske proizvodnje na istraživanim obuhvaćenim mliječni farmama u razdoblju 1999.-2009.

Na istraživanjem obuhvaćenim mliječnim farmama u promatranom razdoblju ostvarena je prosječna laktacijska proizvodnja od 6 030 kg mlijeka, što je značajno više u odnosu na laktacijske prosjeke ukupne populacije goveda u Hrvatskoj (4 399 kg u 2000.; 5 345 kg u 2009.). Udio mliječne masti (4,17%) veći je u odnosu na prosjeke ukupne populacije goveda (3,84% u 2000.; 3,99% u 2009.), kao i udio bjelančevina u mlijeku (3,38%; 3,32% u 2009.). Rezultati analize mliječnosti i kemijskog sastava mlijeka obzirom na sustav držanja i pasminu (simentalac, holštajn) prikazani su u tablici 1.

Tablica 1. Prosječne vrijednosti parametara proizvodnosti i kemijskog sastava mlijeka obzirom na sustav držanja i pasminu

Parametar	Sustav	Pasmina	Prosjek	S.D.	
Količina mlijeka (kg/lakt <sub>305</sub> )	Vezani	Simentalac	5041,46	1317,1	
		Holštajn	7093,24	1660,3	
		Prosjek	5603,66	1754,2	
	Slobodni	Simentalac	5330,42	1462,5	
		Holštajn	6891,11	1775,4	
		Prosjek	6324,49	1829,2	
	Ukupno	Simentalac	5161,59	1386,2	
		Holštajn	6957,81	1798,1	
				Prosjek	6030,00
Mliječna mast (%)	Vezani	Simentalac	3,99	0,477	
		Holštajn	4,13	0,590	
		Prosjek	4,03	0,512	
	Slobodni	Simentalac	4,05	0,593	
		Holštajn	4,38	0,596	
		Prosjek	4,26	0,615	
	Ukupno	Simentalac	4,02	0,529	
		Holštajn	4,33	0,603	
				Prosjek	4,17
Bjelančevine (%)	Vezani	Simentalac	3,29	0,700	
		Holštajn	3,33	0,300	
		Prosjek	3,30	0,621	
	Slobodni	Simentalac	3,52	0,228	
		Holštajn	3,40	0,280	
		Prosjek	3,44	0,268	
	Ukupno	Simentalac	3,38	0,567	
		Holštajn	3,39	0,286	
				Prosjek	3,38

Premda možemo uočiti da je u slobodnom sustavu držanja laktacijska mliječnost veća za 720,8 kg u odnosu na razdoblje vezanog sustava držanja, značajan ( $p < 0,01$ ) utjecaj je izazvalo povećanje udjela holštajn pasmine u stadima, dočim utjecaj promjene menadžmenta nije bio značajan. Tvrdnja je opravdana i razumljiva jer holštajn pasmina je u vezanom odnosno slobodnom sustavu držanja ostvarivala u odnosu na simentalSKU pasminu veću laktacijsku proizvodnju za 2051,8 kg odnosno 1560,7 kg, te se povećanje udjela holštajn pasmine značajno odrazilo na laktacijsku proizvodnost stada. Uočen je značajan utjecaj promjene sustava držanja ( $p < 0,01$ ) na povećanje udjela mliječne masti kod holštajn pasmine (+0,25%) te na povećanje udjela bjelančevina u mlijeku kod simentalSKU pasmine (+0,23%).

Uspoređeni su parametri mliječnosti i kemijske kvalitete mlijeka za 42 mliječne krave koje su ostvarile minimalno po dvije laktacije u vezanom odnosno slobodnom sustavu držanja (tablica 2.). Obzirom na količinu mlijeka u standardnoj laktaciji, uvođenjem slobodnog sustava držanja nije značajno povećana količina mlijeka u standardnoj laktaciji, dok je udio mliječne masti i bjelančevina u mlijeku povećan nakon uvođenja slobodnog sustava držanja (+0,06; +0,05%).

**Tablica 2. Prosječne vrijednost parametara proizvodnosti i kemijskog sastava mlijeka obzirom na sustav držanja na istraživanim mliječnim farmama (n = 42).**

Parametar	Vezani		Slobodni	
	Prosjek	S.D.	Prosjek	S.D.
Količina mlijeka (kg/lakt305)	5905,36	1426,8	5878,68	1597,8
Mliječna mast (kg/lakt305)	237,24	68,92	239,46	75,16
Mliječna mast (%)	3,99	0,475	4,05	0,626
Bjelančevine u mlijeku (kg/lakt305)	199,03	48,779	200,35	52,932
Bjelančevine u mlijeku (%)	3,37	0,268	3,42	0,233

### Zaključak

Istraživanjem nije utvrđen značajan učinak same promijene sustava držanja na rezultate proizvodnosti mliječnih krava na manjim farmama nakon procesa tranzicije vezanog u slobodni sustav držanja. Osiguranje slobode kretanja, unapređenje komoditeta i podizanje dijelova procesa proizvodnje mlijeka (mužnja, hranidba, izgnojavanje) na višu tehnološku razinu nije dostatno za povećanje mliječnosti krava. Držimo da je u cilju povećanja proizvodnosti u slobodnom sustavu držanja nužno usvojiti i primijeniti nova znanja, posebice u pogledu kvalitete i kvantitete obroka mliječnih krava. Povećanje laktacijske proizvodnosti na promatranim mliječnim farmama nakon tranzicijskog razdoblja rezultat je povećanja udjela krava holštajn pasmine u mliječnim stadima.

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# Rast i klaonički pokazatelji janjadi ličke pramenke

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## Sažetak

Cilj istraživanja bio je utvrditi prosječni dnevni prirast i klaoničke pokazatelje ukupno 69 janjadi ličke pramenke (24 ženske i 45 muške) te utjecaj spola i tjelesne mase pri klanju ( $\leq 30$  kg;  $> 30$  kg) na istraživane pokazatelje. Pri prosječnoj tjelesnoj masi janjadi pri klanju od 27,87 kg i dobi od 158 dana utvrđen je prosječni dnevni prirast od 170 g, prosječna klaonička masa 14,56 kg i topli randman 52,31%. Prosječna tjelesna masa prije klanja, prirast, klaonička masa i topli randman nisu se značajnije razlikovali između muške i ženske janjadi. Međutim, utvrđen je značajan utjecaj tjelesne mase janjadi neposredno prije klanja na masu želuca i crijeva ( $P < 0,01$ ) te na prosječni dnevni prirast, masu trupa, pluća i srca te kože ( $P < 0,001$ ). Prosječne vrijednosti randmana između težinskih kategorija ličke janjadi nisu bile statistički značajne.

Ključne riječi: dnevni prirast, spol, klaonički pokazatelji, janjeći trup, lička pramenka

## Growth and carcass characteristics of Lička pramenka lambs

### Abstract

The aim of this research was to determine the average daily weight gain and carcass characteristics on the 69 lambs of Lička pramenka (24 female and 45 male) and the effect of gender and weight at slaughter ( $\leq 30$  kg;  $> 30$  kg) on above mentioned traits. Within average weight of 27.87 kg and average age of 158 days the lambs had an average daily weight gain of 170 g, average carcass weight of 14.56 kg and hot dressing percentage of 52.31%. The average weight at slaughter, average daily weight gain, carcass weight and hot dressing percentage were not significantly different between male and female lambs. There was a significant effect of body weight before slaughtering of lambs on the weight of the stomach and intestines ( $P < 0.01$ ) and on daily weight gain, carcass weight, lungs, heart and skin weight with the lower parts of legs ( $P < 0.001$ ). Average dressing percentage values between weight categories of lambs of Lička pramenka were very similar.

Key words: average daily weight gain, gender, carcass traits, lamb carcass, Lička pramenka

### Uvod

U najvećem broju zemalja meso je temeljni razlog uzgoja ovaca. Proizvodnja ovčjeg mesa u svijetu temelji se na mesnim i mesno-vunskim pasminama (Mioč i sur., 2010). Oko 80% ukupne populacije ovaca u Republici Hrvatskoj čine izvorne pasmine koje odlikuje velika otpornost, skromnost, laka prilagodljivost različitim uvjetima držanja i proizvodnim ciljevima. Tim svojstvima odlikuje se i lička pramenka koja je nastala u planinskim područjima Like i Gorskog kotara gdje se i danas uzgaja. Čistokrvnost uzgoja ličke pramenke bila

je dosta ugrožena dugogodišnjim nastojanjima njenog oplemenjivanja različitim pasminama (travnička pramenka, makedonske ovce, francuski i njemački mesno-vunski ovnovi, određene pasmine ovaca iz Australije) u svrhu povećanja tjelesnog okvira, mesnih odlika te povećanja prinosa i kvalitete vune. Upravo zbog navedenih razloga procjena veličine čistokrvne populacije ličke pramenke ranijih godina bila je dosta nezahvalna. Prema izvješću Hrvatske poljoprivredne agencije za 2009. godinu (HPA, 2010) veličina populacije ličke pramenke procijenjena je na oko 30 000 grla među kojima je selekcijskim radom bilo obuhvaćeno 5 651 grlo. Iako se svrstava u skupinu pasmina kombiniranih proizvodnih svojstava, lička pramenka se posljednjih desetljeća gotovo isključivo uzgaja radi proizvodnje mesa. Na količinu i kakvoću janječeg mesa velik utjecaj imaju genotip, spol, dob, tjelesna masa pri klanju i brojni drugi negenetski čimbenici (Dransfield i sur., 1990; Hoffman i sur., 2003; Mioč i sur., 2007; Purchas i sur., 2002). S obzirom na činjenicu da je lička pramenka kao naša izvorna pasmina vrlo malo istraživana cilj ovog rada bio je utvrditi prosječni dnevni prirast i klaoničke pokazatelje te utjecaj spola i tjelesne mase pri klanju na spomenuta svojstva janjadi.

### Materijal i metode

Predmetnim istraživanjem bilo je obuhvaćeno ukupno 69 janjadi ličke pramenke (24 ženske i 45 muške). Janjad je vagana pri partusu (porodna masa) te je do klanja bila u istim uzgojnim uvjetima. U prva tri do četiri tjedna janjad je hranjena isključivo mlijekom (sisanjem), a nakon toga uz mlijeko je konzumirala pašu i sijeno boraveći zajedno s ovcama na pašnjaku i u staji. Dodatne prihrane janjadi krepkim krmivima nije bilo. Pri prosječnoj dobi od 158 dana janjad je izdvojena iz stada i dopremljena u klaonicu gdje je vagana nakon 12-satnog posta (tjelesna masa janjadi prije klanja). Na temelju prosječne porodne mase, prosječne dobi pri klanju i prosječne tjelesne mase janjadi prije klanja izračunat je prosječni dnevni prirast. Ovisno o tjelesnoj masi koju je postigla janjad je nakon vaganja podijeljena u dvije skupine. Jednu skupinu je činila janjad čija je tjelesna masa bila manja ili jednaka masi od 30 kg, a drugu skupinu janjad tjelesne mase veće od 30 kg. Klanje janjadi obavljeno je u odgovarajuće opremljenoj klaonici, a janjad i njihovi trupovi podvrgnuti su standardnim postupcima obrade (Fisher i de Boer, 1994). Nakon klanja i iskrvarenja s trupova je odstranjena i vagana koža zajedno s donjim dijelovima nogu koje su odvojene ispod karpalnog odnosno tarzalnog zgloba, rogovi te organi trbušne i prsne šupljine. Nakon toga je vagana masa klaonički obrađenog trupa (klaonička masa) i izračunat je topli randman. Dobiveni podaci statistički su obrađeni primjenom statističkog programa SAS (SAS, 2008). Prosječni dnevni prirast janjadi i klaonički pokazatelji analizirani su procedurom MEANS dok su utjecaj spola i klaoničke mase na prethodno spomenuta svojstva analizirani GLM procedurom.

### Rezultati i rasprava

Porodna masa i dob janjadi pri klanju, prosječni dnevni prirast, tjelesna masa janjadi neposredno prije klanja, klaonička masa (masa trupa), topli randman, masa želuca, predželudaca i crijeva, pluća i srca, slezene, jetre i kože s donjim dijelovima nogu prikazani su u tablici 1. U odnosu na porodnu masu janjadi (3,34 kg) ličke pramenke (Jančić, 1964) prosječna porodna masa janjadi u ovom istraživanju bila je neznatno veća (3,67 kg). Navedeno se može pripisati brojnim čimbenicima koji utječu na porodnu masu janjadi od kojih su najvažniji hranidba ovaca tijekom gravidnosti, veličina legla, spol, redosljed janjenja, dob i razvijenost majke, trajanje gravidnosti, hranidba, sezona janjenja i zdravlje ovaca (Mioč i sur., 2007). Prosječna tjelesna masa janjadi ličke pramenke neposredno prije klanja (27,87 kg) slična je onoj koju su utvrdili Bedeković i sur. (2007) za janjad travničke pramenke (28,05 kg), kao i onoj koju navode Macit i sur. (2002) za janjad Tushin (29,1 kg) i Awassi (29,5 kg) pasmine. Prosječni dnevni prirast janjadi ličke pramenke (170 g) utvrđen ovim istraživanjima znatno je niži od onog kojega navodi Macit (2001) za janjad Morkaraman pasmine (270 g) te Esenbuga i sur. (2008) za Awassi janjad (260 g). Niži prosječni dnevni prirasti janjadi ličke pramenke u odnosu na navedene inozemne pasmine, osim genotipa, u najvećoj mjeri pripisuju se lošijim hranidbenim uvjetima. Randman janjadi, iako vrlo varijabilan i uvjetovan brojnim čimbenicima (genotip, dob, spol, sezona klanja, klaonička masa, način obrade trupa i dr.) važan je klaonički pokazatelj (Matika i sur., 2003). Randman janjadi obično je u granicama između 40 i 65% (Mioč i sur., 2007) što je sukladno rezultatima ovog istraživanja. Utvrđeni prosječni topli randman janjadi ličke pramenke (52,31%) bio je nešto veći od randmana janjadi travničke pramenke (49,49%) zaklane u dobi od 110 dana (Bedeković i sur., 2007) te janjadi Tushin (49,1%) i Awassi pasmine (51,4%) zaklane u dobi od 110 dana (Macit i sur., 2002). Masa organa koji nisu sastavni dio trupa (želudac, predželuci i crijeva, jetra, slezena, pluća sa srcem, koža i donji

dijelovi nogu) prosječno je iznosila 12,34 kg (tablica 1) te je bila neznatno manja u odnosu na masu navedenih organa (12,61 kg) janjadi travničke pramenke (Bedeković i sur., 2007). Provedenim istraživanjem utvrđena je i prosječna masa testisa u muške janjadi od 0,15 grama te rogova 0,10 grama (tablica 1).

Tablica 1. Klaonički pokazatelji i prosječni dnevni prirast ličke janjadi

Pokazatelj	n	$\bar{X}$	sd	Min.	Max.	CV,%
Porodna masa, kg	69	3,67	0,73	2,0	5,10	19,20
Prosječna dob, dani	69	158,55	45,23	87,0	273,0	27,88
Prosječni dnevni prirast, kg	69	0,17	0,05	0,06	0,28	31,08
Masa prije klanja, kg	69	27,87	3,98	20,0	41,0	14,20
Klaonička masa, kg	69	14,56	2,03	10,0	20,0	13,92
Topli randman,%	69	52,31	2,63	47,14	57,89	5,05
Želudac i crijeva, kg	69	7,07	1,68	4,59	12,30	23,79
Pluća i srce, kg	69	0,68	0,09	0,51	0,94	13,14
Slezena, g	69	0,12	0,05	0,05	0,23	41,83
Testisi, g	21	0,15	0,07	0,06	0,27	45,87
Jetra, g	69	0,50	0,07	0,37	0,68	13,89
Koža i noge, kg	69	3,97	0,71	2,55	5,70	17,77
Rogovi, g	19	0,10	0,05	0,02	0,20	53,25

n - broj janjadi;  $\bar{X}$  - aritmetička srednja vrijednost; sd - standardna devijacija; Min. - najmanja vrijednost; Max. - najveća vrijednost; CV - koeficijent varijabilnosti.

Utjecaj spola i tjelesne mase janjadi prije klanja na klaoničke pokazatelje prikazan je u tablici 2. Značajne razlike između muške i ženske janjadi utvrđene su samo za masu pluća i srca ( $P < 0,01$ ). Istraživanjem su utvrđene razlike između muške i ženske janjadi za većinu ostalih istraživanih svojstava međutim navedene razlike nisu bile statistički značajne. Tako se, suprotno našim očekivanjima, tjelesna masa prije klanja, prirast, klaonička masa i topli randman nisu značajnije razlikovali između muške i ženske janjadi. Istraživanjem Bedekovića i sur. (2007) provedenog na janjadi travničke pramenke utvrđena je veća tjelesna masa prije klanja, klaonička masa i topli randman u ženske janjadi. Neznatno veću tjelesnu masu prije klanja ženske u odnosu na mušku janjad navode i Díaz i sur. (2003) za Manchega janjad. Pérez i sur. (2002) ističu da ženska Suffolk janjad ima znatno veći randman od muške janjadi zaklane pri istoj dobi.

Tablica 2. Utjecaj spola i tjelesne mase prije klanja na klaoničke pokazatelje (LSM±SE)

Pokazatelj	Spol		Sign.	Masa prije klanja		Sign.
	M (n=45)	Ž (n=24)		≤30 kg	>30 kg	
Prosječni dnevni prirast, kg	0,17±0,05	0,15±0,06	NS	0,15±0,05	0,2±0,03	***
Masa prije klanja, kg	28,33±3,60	27,0±4,55	NS	25,72±2,75	31,21±3,21	-
Klaonička masa, kg	14,77±1,86	14,17±2,31	NS	13,49±1,65	16,23±1,33	***
Topli randman,%	52,16±2,43	52,59±2,97	NS	52,43±2,74	52,11±2,48	NS
Želudac i crijeva, kg	7,18±1,63	6,85±1,98	NS	6,57±1,09	7,83±2,12	**
Pluća i srce, kg	0,70±0,08	0,64±0,10	**	0,65±0,08	0,72±0,08	***
Slezena, kg	0,12±0,05	0,11±0,04	NS	0,11±0,05	0,13±0,04	NS
Jetra, kg	0,50±0,07	0,49±0,06	NS	0,50±0,07	0,49±0,06	NS
Testisi, kg	0,15±0,07	-	-	0,16±0,07	0,13±0,05	NS
Koža i noge, kg	4,07±0,66	3,78±0,79	NS	3,66±0,67	4,44±0,47	***
Rogovi, kg	0,10±0,06	0,10±0,04	NS	0,09±0,05	0,11±0,06	NS

Sign.: razina signifikantnosti; NS: nije signifikantno; \*\*  $P < 0,01$ ; \*\*\*  $P < 0,001$ .

Istraživanjem je utvrđen značajno veći prosječni dnevni prirast, klaonička masa, masa želuca i crijeva, masa pluća i srca te kože s donjim dijelovima nogu u janjadi veće tjelesne mase pri klanju (tablica 2). Naime, kao što je bilo i očekivano, janjad veće tjelesne mase postigla je i veću klaoničku masu i masu pojedinih organa (želuca i crijeva, pluća i srca) od janjadi ličke pramenke manje tjelesne mase. Sukladno rezultatima istraživanja Mioča i sur. (2009) provedenog na creskoj janjadi, tjelesna masa janjadi prije klanja ličke pramenke nije značajno utjecala na randman. Unatoč očekivanjima nisu utvrđene značajne razlike u masi slezene, jetre, testisa i rogova između navedenih težinskih kategorija.

## Zaključak

Općenito je malo znanstvenih spoznaja o odlikama ličke pramenke, osobito onih koji se odnose na rast janjadi i klaoničke pokazatelje. Provedenim istraživanjima se nastoji ukazati na specifičnost dobivenih podataka u odnosu na neke naše autohtone pasmine u ekstenzivnim uzgojnim uvjetima kao i za poznatije svjetske pasmine sličnih (kombiniranih) proizvodnih odlika. S obzirom da je uzgoj ličke pramenke usmjeren prvenstveno ka proizvodnji mesa (lička janjetina) dobiveni podaci su od velike važnosti. Utjecaj spola na klaoničke pokazatelje janjadi ličke pramenke u ovom istraživanju nije utvrđen te ukazuje da se bez izdvajanja janjadi za proizvodnju mesa može postići podjednaka ekonomska dobit. Rezultati istraživanja potvrđuju važnost koju imaju ovčarska tradicija, proizvodni cilj i zahtjevi tržišta na dob janjadi pri klanju, prirast, masu prije klanja i klaoničku masu trupa. Očekuje se da će provedeno istraživanje pridonijeti daljnjim potrebnim istraživanjima kako bi se mogle donijeti cjelokupne spoznaje o klaoničkim osobinama janjadi ličke pramenke.

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# Neke odlike trupova janjadi ličke pramenke

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## Sažetak

Cilj istraživanja bio je utvrditi dimenzije trupova i boju mesa janjadi ličke pramenke (*m. rectus abdominis* i *m. semitendinosus*). Cilj je također bio ispitati utjecaj spola i mase janjadi prije klanja na spomenute pokazatelje. Utvrđeno da trupovi janjadi ličke pramenke pripadaju skupini janjadi srednje razvijenog trupa, a prema utvrđenim L\*, a\* i b\* parametrima boje, meso je svijetlo ružičasto. Značajan utjecaj mase janjadi prije klanja i spola na razvijenost trupa utvrđen je samo za dubinu prsa i dužinu stražnje noge (P<0,01). Utjecaj mase janjadi prije klanja na boju mesa utvrđen je uz različite razine značajnosti za sve parametre boje (osim b\* parametra na *m. semitendinosus*).

Ključne riječi: trup, janjad, lička pramenka, masa prije klanja, spol

## Some carcass traits of Lička pramenka lambs

### Abstract

The aim of this research was to determine some dimensions of the carcasses and meat color parameters on the Lika pramenka lambs (*m. rectus abdominis* and *m. semitendinosus*). The aim was also to examine the effect of gender and weight at slaughter on above mentioned traits. Lika pramenka lambs belong to group of lambs of medium corpulence and according to color parameters L\*, a\* and b\* to category of light pink meat. A significant effect of weight at slaughter and gender on body frame development was found only for the depth of the chest and hind leg length (P < 0.01). The effect of weight at slaughter was determined with different levels of significance for all investigated parameters of meat color (except b\* on the *m. semitendinosus*).

Key words: carcass, lamb, Lička pramenka, weight at slaughter, gender

### Uvod

Iako u hrvatskom ovčarstvu dominiraju pasmine kombiniranih proizvodnih odlika, ovce se u posljednje vrijeme ponajviše uzgajaju radi proizvodnje mesa (mladih janječih trupova). Skupini hrvatskih izvornih pasmina ovaca pripada i lička pramenka koja je nastala i danas se uzgaja na širem području Like i Gorskog kotara. Pokušaji njene dugogodišnje merinizacije i oplemenjivanja ponajviše mesno-vunskim ovmovima uvezenim iz Francuske i Njemačke (Merino Precoce, Ile de France, Merinolandschaf) nisu ostavili značajnijeg traga. Po razvijenosti tjelesnog okvira i proizvodnim odlikama lička pramenka razlikuje se od drugih pramenki (dalmatinska, kupreška, travnička). Izvrсна pasminska prilagodljivost na prirodne nepregledne pašnjake te klimu s mnogo snijega zimi i sušnim razdobljima tijekom ljeta, uz skromnost je osnovni preduvjet učinkovitosti pasmine u proizvodnji janjetine u ekstenzivnim i poluekstenzivnim uvjetima. Drastičan utjecaj na brojnost ove pasmine ostavila su destruktivna zbivanja tijekom Domovinskog rata. Međutim, u prva dva desetljeća po završetku rata stočni fond djelomično je obnovljen, pa se tako prema izvješću Hrvatske poljoprivredne agencije trenutačno uzgaja oko 30 000 grla ličke pramenke. Od toga se u



evidenciji uzgojno valjanih životinja nalazi ukupno 6 195 grla od toga je 5 276 rasplodnih ovaca, 145 ovnova i 774 šilježica što čini 12,77% ukupne uzgojno valjane populacije ovaca u Hrvatskoj. Konzumacija janječeg mesa je na čitavom području Republike Hrvatske uvjetovana tradicijom, običajima i navikama potrošača, a temeljna odlika janjetine je visoka hranjiva i energetska vrijednost (Cvrtila, 2007). Brojna istraživanja upućuju da na količinu i kvalitetu janječeg mesa utječu pasmina (Fisher i sur., 1999., Hoffman i sur., 2003., Safari i sur., 2001), masa prije klanja (Purchas i sur., 2002), spol (Dransfield i sur., 1990) te brojni okolišni čimbenici.

Budući da su trupovi ličke janjadi bili rijetko predmetom dosadašnjim istraživanjima, cilj ovog rada bio je utvrditi razvijenost (veličinu) trupova janjadi ličke pramenke te boju mesa. Tako bi predmetno istraživanje trebalo doprinijeti standardizaciji trupova ličke pramenke i stvoriti temeljne preduvjete za možebitnu zaštitu ličke janjetine nekom od oznaka kvalitete. Istraživanjem utjecaja spola i klaoničke mase na spomenuta svojstva proizvođačima se nastoje osigurati informacije za što učinkovitiju proizvodnju janjetine koja će istovremeno svojim senzornim osobinama u potpunosti zadovoljiti zahtjeve potrošača.

### Materijali i metode

Istraživanjem je bilo obuhvaćeno ukupno 69 janjadi ličke pramenke (24 ženske i 45 muške janjadi) podijeljenih u dvije težinske skupine prema završnoj tjelesnoj masi ( $n=25 \leq 27$  kg;  $n=44 > 27$  kg). Sva janjad je u razdoblju od janjenja do klanja bila u istim uzgojnim uvjetima i u prva tri do četiri tjedna hranjena je isključivo mlijekom (sisanjem), a nakon toga uz mlijeko je konzumirala pašu i sijeno boraveći zajedno s ovcama na pašnjaku i u staji. Janjad nije dodatno prihranjivana krepkim krmivima. Klanje janjadi obavljeno je u adekvatno opremljenim klaonicama pri prosječnoj starosnoj dobi od 160 dana. Nakon klanja i iskrvarenja s trupova je oguljena koža zajedno s donjim dijelovima nogu (odvojenim ispod karpalnih, odnosno tarzalnih zglobova). Iz trupova su odstranjeni organi trbušne (predželuci, želudac, slezena, crijeva i jetra) i prsne šupljine (dušnik s plućima i srce). Nakon toga su provedene standardne izmjere trupova prema metodi koju su razvili Fischer i de Boer (1994). Pojedinačno su izmjerene: dužina trupa, dubina prsa, širina prsa, širina zdjelice i dužina desne stražnje noge. Mjerenja boje mesa obavljena su na mišićima: *m. rectus abdominis* (MRA) i *m. semitendinosus* (MS) pomoću uređaja Minolta Chroma Meter CR-410 prema referentnoj metodi mjerenja boje mesa koja koristi  $L^*$ ,  $a^*$ ,  $b^*$  (Commision Internationale de l'Eclairage, 1976.) spektar boja (Honikel, 1998). Parametar  $L^*$  predstavlja svjetlinu (bljedoću), parametar  $a^*$  predstavlja stupanj crvenila mesa (crveno - zeleni spektar), a parametar  $b^*$  predstavlja stupanj žutila (žuto - plavi spektar). Podaci su statistički obrađeni primjenom statističkog programa SAS (SAS, 2008). Dobiveni podaci razvijenosti trupova i pokazatelji boje mesa analizirani su procedurom MEANS SAS, dok su utjecaji spola i završne tjelesne mase na navedene pokazatelje analizirani GLM procedurom.

### Rezultati i rasprava

Prosječne vrijednosti i odstupanja od prosjeka za klaoničku masu, dužinu trupa, širinu prsa, dubinu prsa, dužinu stražnje noge i širinu zdjelice prikazane su na tablici 1. Klaonička masa, dužina trupa i dubina prsa janjadi utvrđeni ovim istraživanjem u velikoj se mjeri podudaraju s vrijednostima utvrđenim kod janjadi pasmina Chios i Imroz zaklanih pri sličnoj završnoj masi od 26,68 kg odnosno 26,18 kg (Ekiz i sur., 2009).

Tablica 1. Dimenzije klaonički obrađenih trupova janjadi ličke pramenke

Pokazatelj	n	$\bar{x}$	s.d.	Min.	Max.	CV
Klaonička masa (kg)	69	14,56	2,03	10,00	20,00	13,92
Dužina trupa (cm)	69	69,89	4,16	61,50	80,00	5,97
Širina prsa (cm)	69	14,18	0,85	12,10	16,00	5,99
Dubina prsa (cm)	69	25,66	1,12	23,50	28,50	4,22
Dužina stražnje noge (cm)	69	26,71	1,92	23,00	31,00	7,00
Širina zdjelice (cm)	69	14,52	0,69	13,00	16,50	4,65

n - broj janjadi;  $\bar{x}$  - aritmetička srednja vrijednost; s.d. - standardna devijacija; Min. - najmanja vrijednost; Max. - najveća vrijednost; CV - koeficijent varijabilnosti (%).

Nasuprot tome, pri klanju znatno teža janjad Ramlic pasmine (40,40 kg) bila je gotovo identične dužine trupa (69,80 cm), ali trupovi su im bili znatno dublji (30,03 cm), dok su trupovi pasmine Kivircik i Turkish Merino bili razvijeniji od trupova janjadi ličke pramenke (Ekiz i sur., 2009). Isto tako trupovi janjadi ličke

pramenke (69,89 cm) bili su duži od trupova janjadi creske ovce (64,48 cm) i osobito od trupova janjadi paške ovce (Mioč i Vnučec, 2010). Također su utvrđene razlike u širini i dubini prsa između trupova navedenih pasmina. Znatno veći trup janjadi ličke pramenke manifestira se i znatno dužom stražnjom nogom (26,71 cm) u odnosu na janjeće trupove creske ovce (25,36 cm) i osobito trupove janjadi paške ovce (20,67 cm). Izrazita dominacija veličine trupova janjadi ličke pramenke u odnosu na trupove drugih naših izvornih mediteranskih pasmina rezultat je ne samo genetskih razlika nego i razlike u prosječnoj dobi janjadi pri klanju (lička janjad 160 dana, creska janjad 80 dana, paška janjad 33 dana). Uz navedeno, razlika u razvijenosti trupa rezultat je i boljih hranidbenih uvjeta. Na tablici 2 je prikazana razvijenost trupova janjadi ličke pramenke ovisno o spolu i masi prije klanja. Klaonička masa se nije značajno razlikovala između muške i ženske janjadi. Značajan utjecaj spola na razvijenost trupova utvrđen je samo dubinu prsa ( $P < 0,05$ ) i dužinu stražnje noge ( $P < 0,01$ ). Unatoč očekivanjima, širina prsa se nije razlikovala između muške i ženske janjadi što je suprotno rezultatima Mioča i sur. (2009) te Prpića i sur. (2010) u istraživanjima provedenim na creskoj odnosno rapskoj janjadi.

Tablica 2. Utjecaj spola i mase prije klanja na razvijenost trupova janjadi ličke pramenke ( $\bar{x} \pm s.d.$ )

Pokazatelj	Spol		Sign.	Masa prije klanja		Sign.
	M (n=45)	Ž (n=24)		$\leq 27$ kg (n=25)	$> 27$ kg (n=44)	
Klaonička masa (kg)	14,76 $\pm$ 1,86	14,17 $\pm$ 2,33	NS	12,57 $\pm$ 1,63	15,57 $\pm$ 1,46	***
Dužina trupa (cm)	69,67 $\pm$ 4,45	70,37 $\pm$ 3,60	NS	70,30 $\pm$ 4,25	69,66 $\pm$ 4,13	NS
Širina prsa (cm)	14,13 $\pm$ 0,82	14,27 $\pm$ 0,90	NS	14,04 $\pm$ 0,67	14,26 $\pm$ 0,92	NS
Dubina prsa (cm)	25,90 $\pm$ 1,84	25,21 $\pm$ 0,85	**	25,20 $\pm$ 1,25	25,92 $\pm$ 0,96	**
Stražnja noga (cm)	27,06 $\pm$ 1,96	26,02 $\pm$ 1,67	*	25,60 $\pm$ 1,71	27,33 $\pm$ 1,75	**
Širina zdjelice (cm)	14,41 $\pm$ 0,69	14,72 $\pm$ 0,64	NS	14,64 $\pm$ 0,76	14,45 $\pm$ 0,63	NS

$\bar{x}$  - aritmetička srednja vrijednost; s.d. - standardna devijacija; Sign.- razina signifikantnosti; NS - nije signifikantno; \*  $P < 0,05$ ; \*\*  $P < 0,01$ , \*\*\*  $P < 0,001$ ,

Trupovi janjadi različitih završnih masa prije klanja u ovom istraživanju značajno su se razlikovali prema klaoničkoj masi ( $P < 0,001$ ), dubini prsa i dužini stražnje noge ( $P < 0,01$ ). Nepostojanje značajnih razlika u razvijenosti trupova (dužina trupa, širina prsiju i širina zdjelice) između ženske i muške janjadi ličke pramenke suprotno je rezultatima Mioča i sur. (2009) te Prpića i sur. (2010) za janjad manje klaoničke mase. Na tablici 3 prikazani su rezultati boje mesa (*m. rectus abdominis* i *m. semitendinosus*). Parametri boje na istraživanim regijama bili su bitno različiti. Tako je utvrđena veća vrijednost  $L^*$  parametra boje mesa na MRA u odnosu na MS. Vrijednost  $a^*$  parametra boje mesa izmjerena na MRA bila je znatno niža u odnosu na MS, što je sukladno očekivanjima (MS pripada skupini crvenih oksidativnih mišića, a MRA skupini bijelih, glikolitičkih mišića) kao i rezultatima Mioča i Vnučeca (2010) u istraživanju provedenom na paškoj i creskoj janjadi. Mišićna regija MS imala je također značajno veće vrijednosti indeksa žute boje. Utjecaj mase prije klanja na navedene pokazatelje prikazan je na tablici 3.

Tablica 3. Boja mesa ( $L^*$ ,  $a^*$ ,  $b^*$ ) izmjerena na mišićima *m. rectus abdominis* i *m. semitendinosus* te utjecaj mase prije klanja na parametre boje mesa ličke janjadi

Mišićna regija	Pokazatelj	Srednja vrijednost	Masa prije klanja		sign
			$\leq 27$ kg	$> 27$ kg	
<i>m. rectus abdominis</i>	$L^*$	54,63	56,29	53,68	***
	$a^*$	15,24	11,86	17,16	***
	$b^*$	-0,31	-1,11	0,14	**
<i>m. semitendinosus</i>	$L^*$	45,92	47,75	44,87	*
	$a^*$	18,06	17,23	19,52	***
	$b^*$	1,67	1,77	1,61	NS

Sign.- razina signifikantnosti; NS - nije signifikantno; \*  $P < 0,05$ ; \*\*  $P < 0,01$ ; \*\*\* $P < 0,001$ .

Istraživanjem je utvrđeno da povećanjem mase prije klanja dolazi do snižavanja vrijednosti  $L^*$  parametra boje i porasta vrijednosti  $a^*$  parametra boje na oba istraživana mišića. Veće vrijednosti indeksa žutitila pri većim završnim masama utvrđene su na MS-u. Utjecaj mase prije klanja na indeks žutitila MRA nije bio statistički značajan. Teixeira i sur. (2005) su istraživali utjecaj mase prije klanja na boju *m. longissimus thoracis et lumborum* dviju različitih pasmina (Mirandesa i Bragançado) i utvrdili podjednak slijed promjena pokazatelja boje uz izuzetak indeksa žute boje koji je bio viši u trupovima lakše janjadi pri klanju.

## Zaključci

Tehnologija uzgoja ovaca na širem području Like i Gorskog kotara usmjerena prvenstveno k proizvodnji mesa (ličke janjetine) rezultira proizvodnjom srednje razvijenih janjećih trupova, svijetlo ružičaste boje. Trupovi janjadi ličke pramenke znatno su razvijeniji od janjećih trupova hrvatskih primorskih i otočkih pasmina ovaca. Ženska janjad ličke pramenke pri klanju je uglavnom manje tjelesne mase te neznatno manjeg trupa (dužina trupa, širina prsa, širina zdjelice). Tako se odabirom muške janjadi uz kombinaciju s klanjem janjadi veće tjelesne mase može utjecati na dobivanje većih količina mesa po grlu i ostvariti veću dohodovnost od bavljenja ovčarstvom bez dodatnih investicijskih ulaganja.

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# Informativnost kontrolne regije mitohondrijske DNA konja

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## Sažetak

U proteklih trideset godina mitohondrijska se DNA često koristi kao materijal za procjenu evolucijske i demografske prošlosti populacija i blisko srodnih vrsta. Cilj istraživanja bio je utvrditi polimorfizam i učestalost istraživanja fragmenata kontrolne regije mitohondrijske DNA različitih pasmina konja. Ukupno je analizirano 1515 nukleotidnih sljedova konja; 1483 nukleotidna slijeda preuzeta su iz banke gena, a 32 su uzorka prikupljena na gospodarstvima u Republici Hrvatskoj, Bosni i Hercegovini te Mađarskoj. Statistička je obrada haplotipova mitohondrijske DNA konja provedena programskim paketom MEGA 4.0 te SAS-om. Rezultati su pokazali da najviše autora koristi početnice koje umnožavaju zadnjih 1000 parova baza kontrolne regije mitohondrijske DNA (15660-16660), a najviše polimorfni nukleotidni mjesta obuhvaća dio kontrolne regije od otprilike 400 parova baza (15450-15850).

Ključne riječi: mitohondrijska DNA konja kontrolna regija, polimorfizam, nukleotidni slijed

## Informative of mitochondrial DNA control region in horse

### Abstract

DNA is frequently used as material for evolutionary and demographic history of related species, in last thirty years. . The aim of this paper was to identify polymorphism and frequency of investigations of the sequences in control region of mitochondrial DNA at different horse breeds. In total, we analysed 1515 horse sequences; 1483 were taken from GeneBank and 32 were collected from the farms in Croatia, Bosnia and Herzegovina and Hungary. Statistical analyses were performed by MEGA 4.0 and SAS. The results illustrated that most frequently analysis were performed on the last 1000 nucleotides of the control region of mitochondrial DNA (15660-16660) while polymorphic part is referred to 400 base pairs (15450-15850).

Key words: mitochondrial DNA in horses, control region, polymorphism, nucleotide sequence

### Uvod

Divlji su preci današnjih konja u prirodi izumrli no veći se dio tog genoma održao u različitim pasminama pripitomljenih konja. Krajem devetnaestog stoljeća konj gubi svoju važnost kao radna životinja te se danas ponajviše koristi za rekreaciju i sport (Aberle i Distl, 2004). Razumijevanje evolucije i genetske raznolikosti konja te klasifikacija njihovih populacija bitna je za očuvanje i razvijanje divljih i udomaćenih populacija. Mitohondrijska se DNA (mtDNA) koristi kao materijal za procjenu evolucijske i demografske prošlosti populacija i blisko srodnih vrsta (McGahern i sur., 2006). Nasljeđuje se isključivo po majci (Perez Gutiérrez i

sur., 2008). Veličina cirkularne mtDNA u konja je 16660 pb (Xu i Arnason, 1994). Kasamatsu i sur. (1971) su u istraživanju ustanovili da polovica kovalentno vezanih molekula u stanicama s eksponencijalnim rastom sadrži kratki troančani dio DNA regije, koju su nazvali kontrolnom regijom (displacement loop). Veličina kontrolne regije varira između vrsta i kreće se od ~ 200 do 4100 bp (Brown, 1985). Većina autora najčešće istražuju kontrolnu regiju (D-loop), koja se ujedno smatra i najvarijabilnijim djelom mtDNA (Perez-Gutiérrez i sur., 2008). Različiti autori koriste različito dugačke nukleotidne sljedove kontrolne regije. Ishida i sur. (1995) koriste fragment veličine 270 pb, Luis i sur. (2002) koriste veličinu fragmenta 360 pb dok najduži fragment od 1280 pb koriste Aberle i sur. (2007). Najviše se radova temelji na veličini fragmenta od 300 do 500 pb (Keyser-Tracqui i sur., 2005; Kavar i sur., 1999 i 2002; Luis i sur., 2006; Lopes i sur., 2005; Jansen i sur., 2002; Royo i sur., 2005;).

Raznolikost duljine nukleotidnih sljedova kontrolne regije mitohondrijske DNA predstavlja visoko informativni alat za proučavanje veza po majčinskoj liniji unutar vrsta (Vigilant i sur., 1989). Kontrolna je regija mitohondrijske DNA, zahvaljujući visokoj stopi mutacija i nasljeđivanju po majci (nedostatak rekombinacija), vrlo koristan marker sistem za populacijsku i evolucijsku biologiju. Istraživanja mitohondrijske DNA konja pokazala su se vrlo korisna za karakterizaciju unutar-pasminskih i između-pasminskih veza (Ishida i sur. 1995).

Osnovna je ideja ovog rada analizirati frekvenciju kontrolne (analizirane) regije i polimorfizma istraživanih mjesta te utvrditi koji se dio kontrolne regije najčešće koristi u istraživanjima, da li je taj fragment dovoljno informativan te koliko se gubi kada se ostatak kontrolne regije mtDNA izostavi.

### Materijal i metode

Uzorci su dlake i krvi konja prikupljeni na gospodarstvima u sjevernoj Hrvatskoj, Bosni i Hercegovini te mađarskom rezervatu Orsag. U istraživanje je uključeno 16 konja međimurske pasmine iz Republike Hrvatske te osam konja međimurske pasmine iz Mađarske pokrajine Zhala, četiri arapska konja iz Borika te s ergele Nevesinje (Bosna i Hercegovina), dva uzoraka hrvatskog hladnokrvnjaka i tri uzorka posavskog konja prikupljena u Jastrebarskom. Iz banke gena (GenBank, <http://www.ncbi.nlm.nih.gov/genbank/>) su povučeni nukleotidni sljedovi 1483 konja koji predstavljaju različite svjetske pasmine konja. Uzorci su krvi uzeti iz jugularne vene u epruvete od 10 mL u kojima je 7,5%-tna otopina EDTA (BD Vacutainer, BD Vacutainer Systems, Preanalytical Solution, Becton Dickinson and Company, Plymouth, UK) te spremljeni na +4 °C do trenutka izdvajanja DNA. Dlaka uzeta iz grive spremljena je na sobnoj temperaturi do trenutka izdvajanja DNA.

Izdvajanje DNA iz krvi i dlake te lančana reakcija polimerazom obavljena je protokolom preuzetim iz Frkonia (2010).

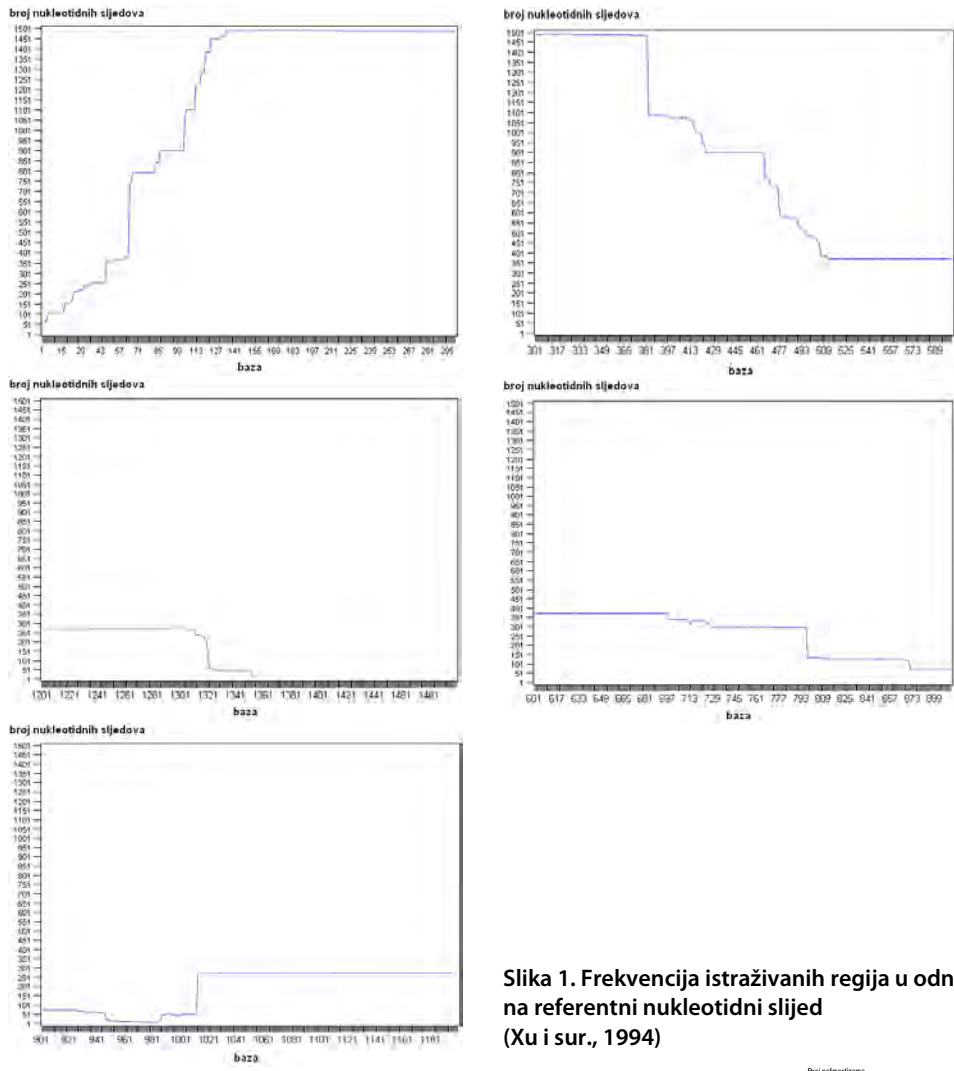
Analiza je dobivenih nukleotidnih sljedova vršena programskim paketom BioEdit version 7.0.9.0., MEGA 4.0 (Tamura, 2008). Statistička je obrada podataka napravljena programskim paketom SAS 9.1 i SAS Enterprise (SAS Institute Inc., 2004).

### Rezultati i rasprava

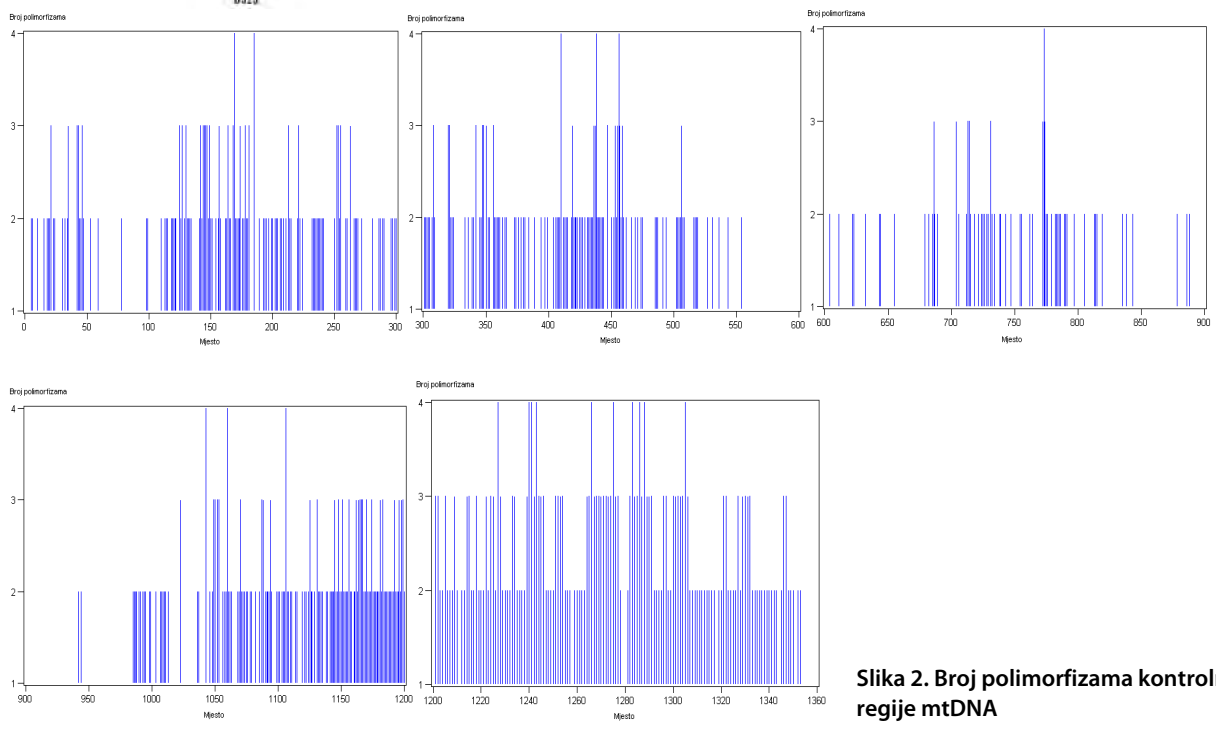
Iz ukupno 32 uzoraka krvi i dlake uspješno je izdvojena DNA dobre količine i kvalitete, 25-50 ng/μl.

Slika 1. prikazuje frekvenciju istraživanih dijelova kontrolne regije mitohondrijske DNA konja različitih autora u odnosu na referentni nukleotidni slijed (Xu i Arnason, 1994). Prikazani dio kontrolne regije obuhvaća 1354 parova baza (mjesto: 15368 - 16718). Vidljivo je da najviše nukleotidnih sljedova obuhvaća regiju od 133. do 380. baznog para (mjesto: 15501 - 15748) te je ta regija najučestalije istraživana od različitih autora. Analizirana 32 nukleotidna slijeda iz ovog istraživanja obuhvaćaju 1226 parova baza (mjesto: 15428 - 16654), što pokriva i najučestalije istraživanu regiju.

Vidljivo je da autori upotrebljavaju kratke nukleotidne sljedove koji pokrivaju samo dio istraživane kontrolne regije.



Slika 1. Frekvencija istraživanih regija u odnosu na referentni nukleotidni slijed (Xu i sur., 1994)



Slika 2. Broj polimorfizama kontrolne regije mtDNA

U slici 2. prikazani su polimorfizmi kontrolne regije mtDNA, gdje se mjesto koje ima više od dvije različite baze može smatrati polimorfnim. Prema slici 2. može se zaključiti da se najvarijabilniji dio (dio s najviše polimorfizama) kontrolne regije mtDNA nalazi između 1050 - 1300 pb (mjesto: 16418 - 16668). Na mjestima od 45 do 130 pb (mjesto: 15413 - 15498), 260 - 310 pb (mjesto: 15628 - 15678), 360 - 410 pb (mjesto: 15728 - 15778), 460 - 680 pb (mjesto: 15828 - 16048) i 760 - 1020 pb (mjesto: 16128 - 16388) nisu uočeni polimorfizmi. Dio kontrolne regije mtDNA koji je najučestalije istraživani (15501 - 15748) ima polimorfizama, no ne može se smatrati najpolimorfnijim dijelom kontrolne regije. Analizirana 32 nukleotidna slijeda ukupno imaju 92 polimorfna mjesta. Polimorfizmi se, osim u dijelu koji se smatra najvarijabilnijim, nalaze i u dijelu kontrolne regije koja ne spada u najučestalije istraživani dio (mjesta: 15800 - 15840; 16 030 - 16160; 16340 - 16400; 16540 - 16570)

### Zaključci

Nakon učinjenog poravnavanja (alignment) na mjestu koje odgovara poziciji 15368 - 16686 kod konja dobivene su informacije o najistraživanijem dijelu kontrolne regije mtDNA.

Nakon statističke obrade podataka zaključujemo da dio kontrolne regije koji ima najviše polimorfizama nije i najfrekventnije istraživani dio. Stoga informativnosti kontrolne regije mtDNA konja u objavljenim radovima nije potpuna.

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# Effect of transport time on meat quality of Simmental bulls and heifers

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## Abstract

The aim of this study was to examine the effect of transport time on meat quality of Simmental bulls and heifers. The study was conducted from October 2008 to September 2009 on 1938 cattles aged from 13 to 16 months. As quality indicators pH, meat colours value were measured 24 h post-mortem on *m. longissimus dorsi*. Bulls transported from a shorter journey had worse pH<sub>24</sub> (P<0.001) and L\* value (P<0.05), compared with bulls transported from medium journey, whereas bulls transported from longer journey had higher L\* value (P<0.01). Heifers submitted to shorter journey had higher pH<sub>24</sub> value (P<0.001). This study shown that shorter journey was physically very demanding and affected on final beef quality product.

Key words: beef, transport time, stress, sex, meat quality

## Utjecaj vremena transporta na kakvoću mesa muške i ženske simentalne junadi

### Sažetak

Cilj ovoga rada je utvrditi utjecaj transporta na kakvoću mesa muške i ženske simentalne junadi. Istraživanje je provedeno u razdoblju od listopada 2008. do rujna 2009. na 1938 jedinki u dobi od 13-16 mjeseci. Mjerenja vrijednosti parametara pH i boje vršena su 24 sata *post-mortem* na *m. longissimus dorsi*. Muška junad transportirana s kraće udaljenosti imala je značajno lošiji pH<sub>24</sub> (P<0,001) i L\* vrijednost (P<0,05) u usporedbi s muškom junadi transportiranom iz srednje duge udaljenosti, dok je muška junad transportirana s duže udaljenosti imala značajno veću L\* vrijednost (P<0,01). Ženska junad transportirana s kraće udaljenosti imala je značajno veću pH<sub>24</sub> vrijednost (P<0,001). Ova studija pokazuje kako je kraći transport bio fizički vrlo zahtjevan i značajno je utjecao na smanjenje kakvoće junećega mesa.

Ključne riječi: juneće meso, vrijeme transporta, stres, spol, kakvoća

### Introduction

Cattle handling before slaughter can have an adverse impact on meat quality. During transfer to the slaughterhouse cattle can be exposed to various stressors such as fast or forced movements, exertion, jostling, breakdown of the social group, strange environment, rough treatment (during loading and unloading), novelty, track movement, noise, vibrations, centrifugal force, climatic condition, shortage of food and water (Grandin, 1997; Swanson and Morrow-Tesch 2001; Broom 2003; Marenčić et al. 2009). When cattle is stressed in the pre-slaughter environment, there is a rapid release of catecholamines (norepinephrine,

epinephrine, dopamine) which result in glycogen depilation (Lacourt and Tarrant 1985) causing lower rate of post-mortem lactic acid synthesis, high ultimate pH, undesirable colour, making such beef dark, firm, dry (DFD). Tatum (2007) reported that in stressful situations bulls and heifers react differently, due to difference in temperament, hormonal effect (endogenous hormonal level) and calpastatin activity. Wulf et al. (1997) also found that bulls were more temperamental than heifers. Shorter transport may lead to weight reduction, drop in glycogen reserves and increased muscle temperature, which is not always reflected in ultimate pH (Agnes et al. 1990; Maria et al. 2003). Prolongation of transport time from the farm to the slaughterhouse has commonly an adverse effect on beef quality but little is known about its direct influence on the texture or colour of beef (Garndin 2000). In some parts of Europe transport period to the slaughterhouse is relatively short, as in Croatian where it is typically less than six hours. Incidence of DFD meat is a serious problem in beef production; hence the objective of this study was to examine the effect of transport time on beef quality and improvement of animal welfare.

### Material and methods

Seven hundred thirty-two Simmental bulls and one thousand two hundred six heifers aged between 13-16 months were used in the study. Cattle were transported in groups of fifteen without any mixing from October 2008 to September 2009. Cattle were submitted into three transport time groups; the first group included 325 bulls and 413 heifers transported from the farm to slaughterhouse in approximately 24 min, the second group included 212 bulls and 388 heifers transported from the farm to slaughterhouse in approximately 92 min, and the third group was made up of 195 bulls and 405 heifers transported from the farm to slaughterhouse in approximately 265 min. The cattle were slaughtered according to the standard procedure, immediately after being unloaded. Carcasses were chilled under commercial condition at 4°C for 24 hours. As quality indicators, pH and meat colours values were measured 24 hours post-mortem (plus 80 min bloom time) on the right side of *m. longissimus dorsi* removed from the area between 6<sup>th</sup> and 7<sup>th</sup> ribs. Concentration of hydrogen ions (pH) was determined with a Eutech CyberScan pH 310 instrument. In order to evaluate the colour pattern, CIE (Comission Internationale de l'Eclairage) value were measured (L\*, a\*, b\*) using a Minolta Chroma Meter CR-410. The colour spectrum was determined under standard D65 illumination. Statistical analysis was carried out using the GLM procedure (SAS 1999). The meat samples were classified into 3 classes according to Buchter (1981): normal meat (pH<sub>24</sub> < 5.8), DFD suspected meat (pH<sub>24</sub> 5.8 to 6.2) and DFD meat (pH<sub>24</sub> >6.2).

### Results and discussion

The average carcass weight of bulls was 363.26±34.17 kg., while the average carcass weight of heifers was 271.65±19.94 kg. During the fattening period of 14.35±0.76 months, heifers had significantly lower average net weight gain 0.623±0.04 kg/d, compared with bulls whose average net weight gain was 0.770±0.07 kg/d, during 15.52±0.73 months of fattening period (P<0.001). According to E U R O P standard, in this study carcass classes E were dominant (47.72%) followed by carcass classes U (42.06%), R (9.96%) and O (0.26%). Heifers produced carcasses with significantly higher fat score (3.26±0.51; 2.99±0.36), compared with bulls (P<0.001). These results confirm previous conclusions that heifers slow down in muscles gain earlier, and also start earlier to accumulate fat thickness, compared with bulls, whose higher final weight produced lower fat score. The effect of different transport time (short journey, medium journey, long journey) on meat quality of bulls and heifers are shown in table 1.

Table 1. Least square mean (±S.E.) of pH<sub>24</sub>, muscle colours in terms of three different transport time.

Parameters	sex	Short journey (24 min)	Medium journey (92 min)	Long journey (265 min)	Significance level
pH <sub>24</sub>	bulls	5.63 <sup>a</sup> ±0.007	5.59 <sup>b</sup> ±0.008	5.61 <sup>ab</sup> ±0.009	***
	heifers	5.59 <sup>a</sup> ±0.004	5.56 <sup>b</sup> ±0.004	5.57 <sup>ab</sup> ±0.004	***
L*	bulls	41.56 <sup>a</sup> ±0.14	42.14 <sup>b</sup> ±0.17	42.40 <sup>b</sup> ±0.18	* and **
	heifers	43.62±0.10	43.91±0.10	43.87±0.10	NS
a*	bulls	29.07±0.10	29.27±0.12	29.27±0.13	NS
	heifers	28.75±0.07	28.94±0.07	28.84±0.07	NS
b*	bulls	11.27±0.07	11.38±0.09	11.49±0.10	NS
	heifers	11.68±0.05	11.82±0.05	11.80±0.05	NS

Different letters in the same row indicate significant differences, NS= not significant; \*(P<0.05); \*\*(P<0.01); \*\*\*(P<0.001).

Transport time had significant influence on beef quality indicators in study sample. Bulls transported from a shorter journey had significantly worse pH<sub>24</sub> (P<0.001) and L\* value (P<0.05), compared with bulls transported from medium journey, whereas bulls transported from longer journey had significantly higher L\* value, compared with shorter journey (P<0.01). Heifers submitted to shorter journey had significantly higher pH<sub>24</sub> value, compared with heifers transported from medium journey (P<0.001). No significant difference were observed for other parameters (a\*, b\*) between different transported bulls, and between different transported heifers (P>0.05). From this result it seems that cattle (bulls and heifers) subjected to shorter journey was more stressful, than cattle transported from medium and longer ones. Our result is in line with several groups also indicating that shorter journey was more stressful than longer journey (Sartorelli et al. 1992; Tarrant et al. 1992; Villarroel et al. 2003). Gregory (1998) and Sanz et al. (1996) concluded that shorter journey gave cattle less time to adapt to the new situation and cattle arrived to slaughterhouse with lower glycogen reserves, causing post-mortem lower rate of lactic acid synthesis, high ultimate pH and undesirable colour. Honkavaara et al. (2003) reported that longer journey gives cattle the opportunity to acclimate and as journey progresses, the environmental inside of the track become less novel and less stressful. In the presented study, in bulls beef longer journey slightly increases pH<sub>24</sub>, while in heifers beef longer journey slightly increases pH<sub>24</sub> and decreases L\*,a\*,b\*, but there were no significant differences compared with medium journey (P>0.05). Maria et al. (2003) and Villarroel et al. (2003) noted that longer journey up to 6 hour slightly increases pH and decreases colour parameters (L\*, a\*, b\*). In cattle, shorter journey (<4 h) does not normally cause severe stress unless there is trauma (Grandin 2000; Tarrant 1989) but little is known about their effect on beef texture or colour (Maria et al. 2003). The lack of effect on ultimate pH could occur when transport is only slightly stressful and animals are in good condition. Some other studies found that longer journey significantly increases pH value, and decreases colours (Brown et al. 1990; Batista et al. 1999; Joaquim 2002).

**Table 2. Effect of transport time on the frequency distribution of beef quality classes.**

Sex	Transport	Normal meat (pH <sub>24</sub> < 5.8)	DFD suspected meat (pH <sub>24</sub> 5.8 to 6.2)	DFD meat (pH <sub>24</sub> > 6.2)	Sign. level
Bulls	Short journey	88%	10.15%	1.85%	***
	Medium journey	94.81%	3.77%	1.42%	NS
	Longer journey	94.36%	4.10%	1.54%	NS
Heifers	Short journey	94.19%	6.05%	-	***
	Medium journey	97.16%	2.84%	-	NS
	Longer journey	96.79%	2.96%	0.25%	NS

\*\*\*(P<0.001); NS= not significant

A considerably higher proportion of DFD suspected and DFD meat was recorded in groups of bulls and heifers transported from shorter journey, whereas the percentage of DFD and DFD suspected meat in groups of bulls and heifers transported from medium and longer journey remained at low level. These results suggest that bulls and heifers subjected to shorter journey have higher tendency to produce DFD and DFD suspected meat than bulls and heifers transported from medium and longer journey. Nanni Costa (2009) concluded that acute stress related to shorter transport and pre-slaughter handling reduce glycogen content, insufficient post mortem acidification and the consequence is DFD beef. Warriss et al. (1995) and Pettiford et al. (2008) observed that loading and the initial stage of transport are the most stressful and after this initial period, animal adapt to the transport conditions. A highly energetic diet seemed to protect cattle from potentially glycogen-depleting stressors (Immonen et al. 2000; Haratung et al. 2003; Marahrens et al. 2003) In the presented study, slightly lower incidence of DFD and DFD suspected meat was determined in the group of bulls transported for a medium journey, compared with longer journey. Joaquim (2002) recorded a significantly higher incidence of DFD suspected beef in cases of longer transport, compared to shorter transport. Longer transport time increases the incidence of DFD meat (Poulanne and Aalto 1981). Brown et al. (1990) reported that long-duration transport (≥ 240 km) increased the incidence of DFD meat.

### Conclusion

The results suggest that shorter journey were physically very demanding leaving cattle less time to adapt on new situation and affected glycogen-depletion, causing lower rate of post-mortem lactic acid synthesis, higher ultimate pH<sub>24</sub>, making beef dark, firm, dray (DFD).

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# Hematological indicators of laying hens kept in different housing systems

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## Abstract

The aim of the study was to compare selected hematological indicators of laying hens kept in three different housing systems (conventional cage, enriched cage according to Europe Council notice 1999/74/EC, and deep litter). The indicators were observed during laying period and the effect of each technology on internal environment indicators of layers was evaluated too. In the experiment 36 ISA BROWN layers were used and they fed complete feeding mixture *ad libitum*. Blood samples were taken at 22, 28, 35, 41, 47, 52, 58, 66 a 75 weeks of age always between 7.00 and 8.00 AM. The red blood cells count (RBC), hematocrit (Hct), hemoglobin concentration (Hgb) white blood cells-count (WBC) and WBC differential count were determined. The examined values in all groups were in physiological range and non-significant influence of any housing system on the monitored indicators was found.

Key words: internal environment, housing system, laying hens

## Introduction

Public concerns about the welfare of laying hens resulted in minimum welfare directives in the European Union, with the ban of conventional cages in 2012 (European Commission, 74/1999). Since then, only enriched cages are allowed with nests, perches, and dust baths, i.e. facilities that improve the behavioral repertoire of the birds (Wall and Tauson 2002). Group size has been shown to have a significant effect on production traits. The general trend in layer strains is higher mortality, more feather and skin damage, and lower egg production as group size increases (Tauson 1998, Bilcik and Keeling 1999). De Boer and Cornelissen (2002) consider the battery cage system, particularly from the perspective of production and several health indicators, to be more beneficial than the aviary systems. Determination of the parameters of internal environment is one of the methods of evaluating the effect of the factors of housing environment on health and production of farm animals. It provides valuable information about relations between the internal environment of the organism, nutrition, age and performance. The objective of this study was to determine and compare hematological indicator caged in different housing system during the laying cycle.

## Materials and methods

### Animals and breeding conditions

*Conventional cage technology* - four-tier, total (available) area 550 cm<sup>2</sup>/bird (2 birds kept on 1120 cm<sup>2</sup> - 32×35×45cm), 2 nipple drinkers, belt feeder 15 cm/bird, device for claw shortening, *Enriched technology* according to Council Directive 74/99/EC - three-tier, total area 945 cm<sup>2</sup>/bird (8 birds kept on an area of 7560 cm<sup>2</sup> - 180×42×45 cm), available area 643 cm<sup>2</sup>/bird, 6 nipple drinkers, belt feeder 20 cm/bird, nest (30×35×45 cm), perching area 15 cm/bird, devices for dust bathing and scratching, device for claw shortening, *Deep litter technology* - available area 2000 cm<sup>2</sup>/bird (20 birds kept on an area of 40000 cm<sup>2</sup> - 200× 200× 180 cm), tube feeder 5 cm/bird, cylindrical drinker 2cm/bird, wood shavings in depth 10-15 cm. All of the housing technologies were situated in the same building with central system of ventilation and temperature regulation. For each technology, experimental group consisting of 12 birds were established with the mean

body weight of  $1300 \pm 50$  g. Throughout the study, the hens were fed with balanced diets that contained 875 g.kg<sup>-1</sup> dry matter, energy content ME<sub>N</sub> 11.1 MJ.kg<sup>-1</sup>, content of nitrogen substances 170.7 g.kg<sup>-1</sup>, Ca 35.9 g.kg<sup>-1</sup> and P 6.3 g.kg<sup>-1</sup>. A constant light-dark (L:D) cycle (15:9, switching on at 4.00 AM, switching off at 19.00 PM) was maintained in all three technologies as recommended in technological instructions for ISA BROWN. The temperature of housing was in the range from 18 to 20 °C; relative humidity of air was ranging from 65 to 70%. No red mite and other parasite or viral infection was presented during experimental period.

### Collection of blood samples and analyses

Blood samples (2 ml) of all hens in experimental groups were collected from brachial vein at 15, 22, 28, 35, 41, 47, 52, 58, 66 and 75 weeks of age, always between 7.00 and 8.00 AM. EDTA was used as anticoagulant. The red blood cells count (RBC), hematocrit (Hct), hemoglobin concentration (Hgb) and white blood cells-count (WBC) were determined by automatic analyser Medonic CA 620 (Clinical Diagnostic Solutions, USA). WBC differential count was ascertained from blood smear according to the Pappenheim method.

### Statistical analysis

Changes in hematological parameters were analysed by repeated measures ANOVA for factors housing technology as independent variable and age of hens as dependent variable. ANOVA was followed by post-hoc Fischer LSD test for pairwise comparisons, when appropriate. All statistical analyses were performed by Statistica 8.0 statistical software (StatSoft Inc., Tulsa, USA).

## Results and discussion

All results are shown in Table 1. The RBC count in all groups during the experimental period ranged among 2.44 and 3.08 T.l<sup>-1</sup>. Lower, but not significant average erythrocytes counts, as compared with other technologies, were established in hens in enriched cages technology. Hemoglobin content increased during the laying cycle in all groups till 58 week of age, subsequently decreased to the end of observation. At 58 and 75 week of age the significant ( $P < 0.05$ ) differences between hemoglobin content in hens housed in conventional and deep litter technology were established. Hematocrit increased significantly ( $P < 0.05$ ) in conventional and enriched cages in week 58 and in deep litter technology in week 66. Significantly higher ( $P < 0.01$ ) was hematocrit in conventional cage compared to deep litter in week 58. There were no significant differences between all of group in WBC count. In week 47 the leukocytes number increased significantly in all monitored groups ( $P < 0.05$ ) and subsequently decreased till end of experiment. Sporadically were found significant differences in WBC differential count between the monitored groups during the reproductive cycle, but there was no evident tendency higher or lower leukocytes proportions.

Erythrocyte count found in monitored housing technologies differed slightly and ranged in physiological values according to Freeman and Bell (1983), Jerabek et al. (1993), Tumova et al. (2004). There were some non-significant differences between the groups, which can be due to different egg production in particular technologies as a factor influencing erythropoiesis rate as mentioned Vecerek et al. (2002) and Suchy et al. (2004). Fluctuating tendency of changing average values during laying period recorded also Strakova et al. (2001). Hemoglobin concentration increased at the end of laying cycle in all groups. Suchy et al. (1989) and Strakova et al. (2001) determined similar tendency and they assume association between increased hemoglobin concentration and decreased laying intensity. Average leukocytes counts were in a physiological range in all groups. Although, slightly higher WBC number were found in cage technologies compared to deep litter and this could predicate disturbance of physiological function owing to stressful condition in cage, according to Gross and Siegel (1983). Also Bell et al. (1983) recorded higher WBC count in caged laying hens compared to hens in free range.

**Table 1. Hematological indicators in laying hens housed in conventional cage (C), enriched cage (E) and deep litter (DL) during the laying period.**

	Housing system	Week of age								
		22	28	35	41	47	52	58	66	75
RBC [T.l <sup>-1</sup> ]	C	2.81	2.64	2.79	2.83	2.63	2.56	2.96	3.03	2.99
	E	2.74	2.44	2.46	2.79	2.61	2.68	2.94	2.93	3.01
	DL	2.66	2.50	2.85	2.60	2.55	2.65	2.86	3.08	2.79
Hgb [g.l <sup>-1</sup> ]	C	72.25	76.59	75.67	77.81	73.64	76.42	91.81 <sup>a</sup>	91.37	90.27 <sup>a</sup>
	E	69.73	67.14	74.36	76.13	74.42	74.19	87.29	82.89	84.22
	DL	68.45	74.79	83.42	79.65	75.36	76.24	80.68 <sup>b</sup>	86.65	77.28 <sup>b</sup>
PCV [l.l <sup>-1</sup> ]	C	0.298	0.287	0.286	0.278	0.280	0.270	0.313 <sup>A</sup>	0.311	0.307
	E	0.284	0.267	0.270	0.278	0.281	0.283	0.304	0.306	0.310
	DL	0.272	0.272	0.295	0.273	0.271	0.284	0.270 <sup>B</sup>	0.310	0.276
WBC [G.l <sup>-1</sup> ]	C	20.05	23.42	27.83	26.33	31.50	27.92	22.08	19.17	24.83
	E	18.68	23.42	24.58	20.91	31.00	29.67	23.67	21.75	28.90
	DL	18.90	22.00	23.33	23.50	29.67	27.25	20.17	22.82	25.75
Lym [%]	C	74.00	77.27	76.08	74.67	70.42	67.33	72.73	75.25	68.92
	E	72.73	75.00	70.50	71.60	71.10	66.73	78.33	73.00	75.33
	DL	75.67	73.21	71.67	71.58	69.42	69.90	72.70	71.64	74.27
Het [%]	C	17.42	15.64	16.00	16.00	19.33	18.83	16.18	17.25	21.58
	E	19.27	16.83	19.75	19.40	18.10	18.64	13.42	18.83	17.58
	DL	16.92	17.67	19.17	18.75	21.00	19.00	19.00	19.55	16.00
Mono [%]	C	5.00	3.36	4.42	5.83	6.67	9.83	6.82	3.50	5.42
	E	4.27	4.25	6.25	5.40	6.40	11.09	4.58	4.17	5.50
	DL	4.08	2.83	5.58	5.83	6.17	7.00	4.11	4.45	4.91
Eo [%]	C	2.27	2.41	1.91	2.13	1.86	2.46	2.63	2.30	2.48
	E	2.60	2.48	2.17	2.50	2.20	1.96	2.30	2.23	2.06
	DL	1.87	2.54	2.14	1.91	2.01	2.12	2.54	2.91	2.46
Ba [%]	C	1.31	1.32	1.59	1.37	1.72	1.55	1.64	1.70	1.60
	E	1.13	1.44	1.33	1.10	2.20	1.63	1.37	1.77	1.53
	DL	1.46	1.29	1.44	1.93	1.40	1.48	1.65	1.85	2.36

a,b .... (P&lt;0.05); A, B ..... (P&lt;0.01)

## Conclusion

On the basis of our results we can conclude, that parameters monitored in all groups were in physiological range and there were not found significant effect of housing technology on hematological indicators.

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# Microbiologic water quality for dairy cows in rural households and farms from Transylvania

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## Abstract

The aim of this paper was the microbiological quality assessment of water consumed by dairy cows in rural households and farms. We analyzed 60 water samples, comparing the results with our country's legal provisions. The total bacterial count ranged from 0 to  $3.24 \times 10^4$  cfu/mL, and the numbers of total and fecal coliforms from 0 to  $1.60 \times 10^3$  cfu/100 mL, and from 0 to  $3.48 \times 10^2$  cfu/100 mL, respectively. In 70% of samples total coliform and in 63.33% fecal coliform were found; with statistically insignificant differences between the farm- and household samples. Dairy cows consumed both in farms and in rural households of Transylvania qualitatively improper water, due to its microbial contamination.

Key words: total bacterial count, total coliform, fecal coliform, drinking water

## Introduction

Water is the most important nutrient for dairy cattle but its importance has been commonly forgotten in dairy systems (Hole et al., 2006). It is required for all of life's processes - transport of nutrients and other compounds to and from cells; digestion and metabolism of nutrients; elimination of waste materials (urine, feces, respiration and excess heat from the body); maintenance of a proper fluid and ion balance in the body and provision of a fluid environment for the developing fetus (Murphy, 1992).

In conformity with the recommendations regarding the dairy cows' welfare, the animals should have permanent access to fresh drinkable water in sufficient quantity, to satisfy all metabolic processes essential for life and performance. In our country it is recognized that the water consumed by animals must be of the same quality than the water consumed by humans but in some countries special recommendations exists for the quality of the water consumed by animals. Water quality might cause poor production or nonspecific diseases and should be one aspect of the procedures used to investigate such problems (Jemison and Jones, 2002). Water quality is often overlooked, even though research clearly shows that performance decreases when certain components of water quality reach threshold levels. Poor water quality also affects consumption, which may limit food intake and animal health (Loneragan et al., 2001; Socha et al., 2003). Microbiological analysis of water for total bacteria and coliform bacteria is necessary to determine sanitary quality. The possible consequences of microbiologically contaminated water's consumption are of such severity than its control is always very important and should be never compromised.

The aim of this work was the determination of the microbiological quality of the water consumed by dairy cows in rural households and farms.

## Material and methods

A total number of 60 water samples (30 from rural households and 30 from farms) were collected and analysed over December 2009 - March 2010. The sampling was made using sterile recipients, in quantity of 0.5 L. The samples were analyzed within 4 hours from collection, in the laboratory. The microbiologic water quality was appreciated based on the total bacterial count (TB) and the numbers of coliform bacteria and

fecal coliform bacteria. The total number of bacteria was determined by inoculation on culture medium in Petri dishes and 48 hours incubation on 37 C°. For the samples derived from local sources previous decimal dilutions were made in culture tubes. After incubation the grown colonies were calculated by a mechanical optic colony counter and the total number of bacteria was calculated with the help of a formula (Popescu and Borda, 2008). In order to assess water quality, samples were analyzed for total coliforms (TC), using a multiple-tube fermentation technique based on lactose fermentation with acid and gas production, within 48 hours, in a lauryl tryptose broth. If the water sample yielded presumptively positive results, simultaneous inoculation into brilliant green lactose bile broth, for total coliform and EC broth for fecal coliform (FC) was required. Positive result for EC broth, incubated at 44.5 C° for 24 hours, was considered as positive completed test response. Parallel positive brilliant green lactose bile broth with negative EC broth cultures indicated the presence of nonfecal coliform. The number of coliform bacteria per 100 mL of water was then calculated from the distribution of positive and negative tubes in the test by referring to an appropriate table. The total bacteria number was expressed in cfu/mL and the coliform in cfu/100 mL.

The results were compared to the values set out by the Law 458/2002 modified and completed by the Law 311/2004. Data were processed using the GraphPad InStat version 3 (GraphPad Software Inc. USA) software. The descriptive statistical indicators (mean, standard deviation, median, minimum and maximum) were calculated for the microbiological parameters of the water quality from the rural households and farms. The Dunn's Multiple Comparisons Test was used to compare the data.

### Results and discussion

The descriptive statistical indicators (mean, standard deviation, median, minimum and maximum) for the microbiologic parameters determined in the water samples collected from rural households (30 samples) and farms (30 samples) are shown in table 1.

The total bacterial count and the numbers of total and fecal coliforms varied widely in the water samples collected from farms and households. The mean values of total bacterial count in the samples collected from households are very close to those in the samples from farms, ranging between 0 and  $3.24 \times 10^4$  cfu/mL. The total coliforms recorded also similar values in the water collected from rural households and farms. In the majority of the analysed water samples fecal coliforms were found, with a mean value of  $4.6 \times 10$  cfu/100mL in the cows' drinking water in rural households and of  $6.4 \times 10$  cfu/100mL in the water consumed by cows in the farms. Although the mean values were slightly higher in the water samples from farms, the difference was statistically insignificant (Dunn's Multiple Comparisons Test,  $p > 0.05$ ). According to our country's legislation regarding the drinking water quality (Law 458/2002 and Law 311/2004) this should not contain any bacteria and coliform. For water consumed by animals in some countries there are different recommendations. For example, Looper and Waldner (2002) suggests as safe levels for cattle: 5000/L for the total bacterial count, 150/L for total coliform bacteria and 100/L for fecal coliform bacteria, while Socha et al., (2001) considers as threshold levels 10 total bacteria/L and 0 total and fecal coliforms/100mL.

Within all of the analyzed water samples in 91.67% bacteria, in 70% total coliform and in 63.33% fecal coliform were found, respectively. The comparative analysis of the water samples from farms and rural households shows that in 83.33% of the samples from farms and in 100% of the samples from the water consumed by cows in rural households bacteria were present. Moreover, total coliform bacteria were identified in 50% of the samples collected from farms and in 45% of household water samples. Fecal coliform bacteria were found in 76.67% of the household samples and in 50% of the farm samples (Figure 1).

**Table 2. Descriptive statistic indicators for the microbiologic parameters of the analyzed water samples**

Parameter	Farms			Rural households		
	TB cfu/mL	TC cfu/100mL	FC cfu/100mL	TB cfu/mL	TC cfu/100mL	FC cfu/100mL
n	30	30	30	30	30	30
Mean	$2.91 \times 10^3$	$2.28 \times 10^2$	$6.4 \times 10$	$2.81 \times 10^3$	$3.08 \times 10^2$	$4.6 \times 10$
SD	$6.61 \times 10^3$	$4.84 \times 10^2$	$1.70 \times 10^2$	$3.39 \times 10^3$	$4.94 \times 10^2$	$8.60 \times 10$
Minimum	0.00	0.00	0.00	1.00	0.00	0.00
Maximum	$3.24 \times 10^4$	$1.60 \times 10^3$	$9.18 \times 10^2$	$1.28 \times 10^4$	$1.60 \times 10^3$	$3.48 \times 10^2$
Median	$8.57 \times 10^2$	8.50	4.50	$1.44 \times 10^3$	$1.09 \times 10^2$	$1.7 \times 10$

TB = total bacteria; TC = total coliform; FC = fecal coliform

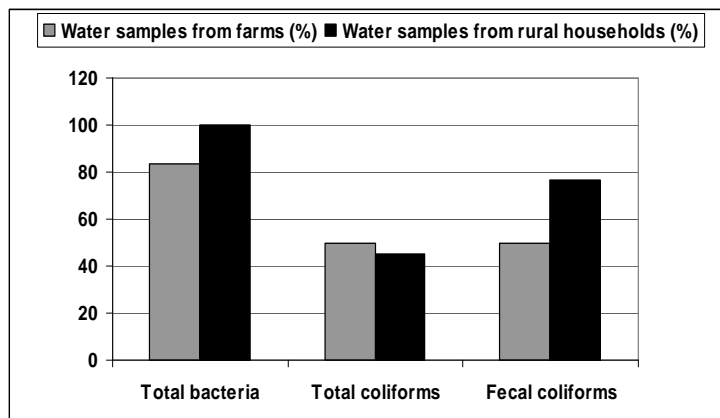


Fig 1. The proportion of water samples which contains total bacteria, total and fecal coliform bacteria

Total bacteria, total coliform and fecal coliform are all indicators of drinking water quality. The total bacterial count measures virtually all pathogenic as well as non-infectious bacteria that use organic nutrients for growth. Total bacterial counts in excess of 500/100mL may indicate water quality problems (Wagner et al., 2001). Water sources with total bacterial counts in excess of  $1 \times 10^6$ /100mL should be avoided for all classes of livestock. Most water supplies will continuously have counts below 200/100mL. Bacteria polluted water may increase susceptibility or contribute to a variety of calf and cow disease problems (Ensley, 2000). Drinking bowls, cups and troughs should be kept relatively clean. A raised base around tanks helps to keep manure contamination problems to a minimum. Cleaning tanks and water bowls to prevent build-up of old feed and other debris is important.

The total coliform group is a large collection of different kinds of bacteria. Fecal coliform bacteria are a subgroup of total coliform bacteria that mostly exist in feces. If total coliform is present, the sample will also be tested for either fecal coliform. Total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is probably environmental and fecal contamination is not likely. However, if environmental contamination can enter the system, there may also be a way for pathogens to enter. Therefore, it is important to find the source and resolve the problem. Fecal coliform bacteria appear in great quantities in the intestines and feces of people and animals. The presence of fecal coliform in a drinking water sample often indicates recent fecal contamination, meaning that there is a greater risk that pathogens are present than if only total coliform bacteria is detected. There is evidence that livestock can tolerate relatively high bacterial loads in drinking water (Jemison and Jones, 2002) although there are actually very little data available.

Our results show intense microbial contamination of the water consumed by dairy cows, being in accordance with other studies (LeJeune et al., 2001; Popescu et al., 2005, 2010; Wagner et al., 2001). A large US study of livestock drinking water (LeJeune et al., 2001) investigated 473 water troughs in 98 dairy farms. The authors concluded that troughs are a major source of exposure of cattle to enteric bacteria, including a number of food-borne pathogens, and the degree of bacterial contamination appeared to be associated with potentially controllable factors. The results of the study indicated that drinking water offered to cattle is often of poor microbiological quality with total coliform and *E. coli* counts of around 105 and 104cfu/L, respectively. Interestingly, metal troughs had significantly lower coliform and *E. coli* counts compared to other construction materials respectively concrete, plastic and other materials. The group also found that bacterial contamination was higher in troughs that were closest to the feed-trough. Proximity of the water troughs to the feed-trough may have permitted a greater amount of food to enter the water trough, thus increasing the level of contamination, as well as providing a nutrient-rich substrate for bacterial growth at the bottom of the water trough. LeJeune et al. (2001) also noted the association between the water quality and the ecological parameters measured, suggesting that many of the same factors that influence the survival and proliferation of bacteria in natural aquatic ecosystems have parallels in water trough environments. Bacterial contaminants in troughs may arise from multiple sources (e.g. cud or fecal material and extraneous matter including dust or feed). In some instances, depending on the source, water may be heavily contaminated before it enters the trough. Overland and sub-surface flow of feces into waterways is also likely to play a part in bacterial dissemination as *E. coli* can survive in bovine feces for several weeks (Wang et al., 1996). Sediments within a trough may have much higher levels of microbial contamination.

The presence of the coliform, especially of fecal coliform, in the majority of the water samples analyzed indicates also a high risk of waterborne diseases.

### Conclusions

The water consumed by dairy cows both in farms and in rural households in Transylvania is qualitatively improper due to its microbial contamination. Intake of low quality water will affect cows' health and milk yield.

### Acknowledgments

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# Prevalencija i etiologija subkliničkog mastitisa u istočnofrizijskih ovaca

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## Sažetak

Cilj istraživanja bio je utvrditi periodičku prevalenciju i etiologiju subkliničkog mastitisa u 80 muznih istočnofrizijskih ovaca od druge do četvrte laktacije. U tu svrhu aseptički je prikupljeno i mikrobiološki pretraženo 464 uzorka mlijeka. Tijekom istraživanog razdoblja iz svake polovice vimena, u jednakim vremenskim intervalima, uzeta su tri uzorka mlijeka. Periodička prevalencija inficiranih mliječnih žlijezdi iznosila je 40,6%, dok su koagulaza-negativni stafilocoki (CNS) izolirani iz 55,3% inficiranih polovica vimena. Osim CNS, najčešći uzročnik subkliničkog mastitisa bio je *Micrococcus* spp. (15,7%). S povećanjem redoslijeda laktacije utvrđen je porast prevalencije subkliničkog mastitisa ( $P>0,05$ ).

Ključne riječi: mastitis, mliječna žlijezda, mužnja, ovčje mlijeko, zdravlje vimena

## Prevalence and etiology of subclinical mastitis in East Friesian sheep

### Abstract

The aim of this study was to investigate period prevalence and etiology of subclinical mastitis in eighty milked East Friesian sheep, from second to fourth lactation. For this purpose, 464 milk samples were aseptically collected for bacterial analysis. Namely, during investigated period of lactation totally three samples of milk were taken from every udder half in equal time periods. Period prevalence of infected mammary glands was 40.6%, while coagulase-negative Staphylococci (CNS) were the most prevalent bacterial group. Beside CNS, the most causative agent of subclinical mastitis was *Micrococcus* spp. (15.7%). Prevalence of subclinical mastitis increased ( $P>0.05$ ) with the lactation number.

Key words: mastitis, mammary gland, milking, sheep milk, udder health

### Uvod

Upala vimena ili mastitis je najučestalija bolest vimena, u zavisnosti od izvora i načina prenosa, uzrokovana zaraznim mikroorganizmima ili mikroorganizmima iz okruženja (Bergonier i Berthelot, 2003). Prema Rupiću (1988) upale vimena u preživača mogu se klinički različito manifestirati s obzirom na intenzitet upale, trajanje poremećaja i konačan ishod upalnog procesa. Razlikuju se subklinički oblici, bez vidljivih znakova na vimenu i bez organoleptičkih promjena mlijeka te klinički (vidljivi) oblici upala s jasno izraženim simptomima na vimenu (crvenilo, otok, bolnost na dodir, povišena temperatura organizma i vimena i dr.) i organoleptičkim promjenama mlijeka (sadrži pahuljice ili grudice).

Skriveni (subklinički) oblici upala vimena su najučestalije upale vimena u ovaca (u mliječnih ovaca prosječna učestalost iznosi od 20 do 30%, a u mesnih od 5 do 30%), dok je prosječna učestalost klinički vidljivih upala uglavnom manja od 5%, pa su stoga i štete od prikriivenih i kroničnih kataralnih upala vimena znatno veće

negoli onih od kliničkih upala (Bergonier i sur., 2003).

Naime, štete nastale zbog upala mliječne žlijezde očituju se smanjenjem sekrecije mlijeka, kao i pogoršanom kvalitetom i siromašnijim kemijskim sastavom proizvedenog mlijeka. Uz to, upala vimena može rezultirati prijevremenim izlučenjem ovaca iz uzgoja, sporijskim rastom i uginućem sisajuće janjadi, velikim utroškom lijekova potrebnih za liječenje mastitisa te neupotrebljivošću mlijeka za prehranu i daljnju preradu (Bergonier i sur., 2003; Contreras i sur., 2007; Raynal-Ljutovac i sur., 2007) što doprinosi povećanju troškova i smanjenju prihoda ovčarske proizvodnje.

Dakle, s obzirom na važnost subkliničkog mastitisa u današnjem mliječnom ovčarstvu, kao i na činjenicu da je istočnofrizijska ovca jedna od najmliječnijih pasmina ovaca u svijetu, cilj ovog rada bio je utvrditi prevalenciju subkliničkog mastitisa te determinirati uzročnike njegova nastanka u stadima istočnofrizijskih ovaca uzgajanih u Hrvatskoj.

### Materijal i metode

Istraživanjem je bilo obuhvaćeno ukupno 80 čistokrvnih, muznih istočnofrizijskih ovaca, u razdoblju od druge do četvrte laktacije, s dva obiteljska poljoprivredna gospodarstva sa šireg područja grada Bjelovara. Za istraživanje su odabrana grla sa simetričnim i pravilno razvijenim vimenom, bez vidljivih (kliničkih) znakova mastitisa, što je utvrđeno neposredno prije mužnje, pojedinačnim kliničkim pregledom vimena i organoleptičkim pregledom prvih mlazeva mlijeka na crnoj podlozi (Havranek i Rupić, 2003).

Za istraživanje su odabrana gospodarstva slične tehnologije uzgoja (hranidba, sustav i uvjeti držanja, način i broj dnevnih mužnji (ručna mužnja), higijenski postupci tijekom mužnje i čuvanja mlijeka, sezona janjenja i početak laktacije, trajanje sisnog i muznog razdoblja laktacije i dr.).

Neposredno prije mužnje (uzimanja sekreta vimena za mikrobiološku analizu), provedeno je pranje vimena mlakom vodom i brisanje papirnatim rupčićima za jednokratnu uporabu te nakon toga dezinficiranje sisa uranjanjem u otopinu dezinficijensa, koji je zatim obrisao papirnatim rupčićem. Nakon izmuzivanja prvih mlazova mlijeka u posebnu posudu, ulaz u sisni kanal je dezinficiran vatom umočenom u 70%-tni alkohol.

Tri puta tijekom laktacije, odnosno u pravilnim vremenskim razmacima od po 60 dana, počevši od 70. dana laktacije (odbiće janjadi provedeno je u prosječnoj dobi od 60 dana), za potrebe mikrobiološke (bakteriološke) pretrage, u sterilne i unaprijed označene epruvete volumena 10 mL, iz svake pojedine mliječne žlijezde (polovice vimena - sise), uzet je po jedan uzorak mlijeka. Istraživanjem su obuhvaćena grla na kojima su provedene barem dvije kontrole zdravstvenog stanja vimena (mliječne žlijezde). Tijekom istraživanog razdoblja ukupno je prikupljeno 464 uzoraka mlijeka. Nakon prikupljanja, uzorci su pohranjeni u prijenosnom hladnjaku na temperaturi od +4 °C te dostavljeni u laboratorij unutar 12 sati od uzimanja.

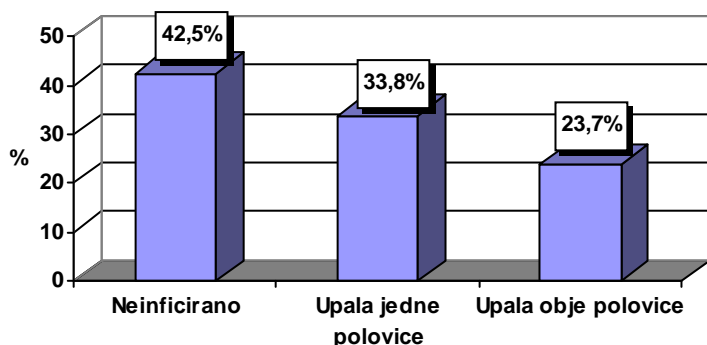
Mikrobiološka pretraga prikupljenih uzoraka sekreta vimena obavljena je u Laboratoriju za mastitise i kakvoću sirovog mlijeka u Hrvatskom veterinarskom institutu u Zagrebu prema uputama navedenim u "Laboratory handbook on bovine mastitis" (National Mastitis Council, 1999).

Periodička prevalencija subkliničkog mastitisa utvrđena ovim istraživanjem podrazumijevala je ukupan broj oboljelih ovaca (mliječnih žlijezdi) u istraživanom vremenskom razdoblju podijeljen s brojem istraživanih ovaca (mliječnih žlijezdi) sredinom istraživanog razdoblja.

Statistička obrada dobivenih podataka provedena je korištenjem statističkog programa SAS V8 (SAS STAT, 1999). Za procjenu utjecaja redoslijeda laktacije na prevalenciju inficiranih mliječnih žlijezdi korišten je  $\chi^2$  test (procedura GENMOD).

### Rezultati i rasprava

Tijekom istraživanjem obuhvaćenog razdoblja laktacije utvrđena periodička prevalencija mliječnih žlijezdi sa dijagnosticiranim subkliničkim mastitisom iznosila je 40,6% (65 od ukupno 160 polovica vimena), odnosno u 57,5% istraživanih ovaca (46 od 80 ovaca) tijekom istraživanog razdoblja utvrđena je infekcija vimena (jedne ili obje polovice). Naime, periodička prevalencija ovaca s dijagnosticiranom infekcijom jedne polovice vimena iznosila je 33,8% (27 od 80 ovaca), dok je u 23,7% (19 od 80) ovaca utvrđena infekcija obje polovice vimena (grafikon 1).



Grafikon 1. Periodična prevalencija (%) istočnofrizijskih ovaca s obzirom na zdravstveno stanje vimena

Od ukupno 464 mikrobiološki pretražena uzorka mlijeka uzetih iz zasebnih polovica vimena, u njih 121 ili 26,1% izoliran je patogeni mikroorganizam. González-Rodríguez i sur. (1995) su, istražujući učestalost intramamarnih infekcija u mliječnim pasmina Assaf, Churra i Castellana, utvrdili prosječnu učestalost bakteriološki pozitivnih uzoraka od 52,7%, što je neusporedivo više nego je utvrđeno ovim istraživanjem.

Kao što je vidljivo na tablici 1, kao uzročnici subkliničkog mastitisa u istraživanjem obuhvaćenih istočnofrizijskih ovaca izolirani su koagulaza negativni stafilokoki (CNS), *Staphylococcus aureus*, *Streptococcus D*, *Streptococcus uberis*, *Corynebacterium spp.*, *Micrococcus spp.*, *Escherichia coli* i *Pseudomonas spp.*

Tablica 1. Učestalost izoliranih bakterija iz mliječnih žlijezdi istočnofrizijskih ovaca

Uzročnik	n uzoraka	%
CNS	67	55,3
<i>Staphylococcus aureus</i>	11	9,1
<i>Streptococcus D</i>	2	1,7
<i>Streptococcus uberis</i>	4	3,3
<i>Corynebacterium spp.</i>	7	5,8
<i>Micrococcus spp.</i>	19	15,7
<i>Escherichia coli</i>	4	3,3
<i>Pseudomonas spp.</i>	7	5,8
Ukupno pozitivnih uzoraka	121	100,0

Bergonier i sur. (2003) navode da su koagulaza negativni stafilokoki najučestalija skupina uzročnika subkliničkog mastitisa (25 do 93%) u stadima mliječnih ovaca. Naime, kao što je vidljivo iz podataka prikazanih na tablici 1, prosječna učestalost CNS utvrđena predmetnim istraživanjem (55,3%) odgovara njihovoj prosječnoj učestalosti u Comisana (Fruganti i sur., 1985) i Assaf ovaca (González-Rodríguez i sur., 1995). Bergonier i Berthelot (2003) su u tipičnih mliječnih pasmina ovaca (Awassi, Assaf i istočnofrizijska) utvrdili veću prevalenciju koagulaza negativnih stafilokoka nego u mesnih i kombiniranih pasmina ovaca.

Osim CNS, najučestaliji uzročnik subkliničkog mastitisa u istočnofrizijskih ovaca je *Micrococcus spp.* (15,7%). Sukladno ovim rezultatima, Fthenakis (1994; 1996) je istraživanjem različitih mliječnih pasmina ovaca utvrdio da, osim koagulaza negativnih stafilokoka, subklinički oblik mastitisa najčešće uzrokuje *Micrococcus spp.*

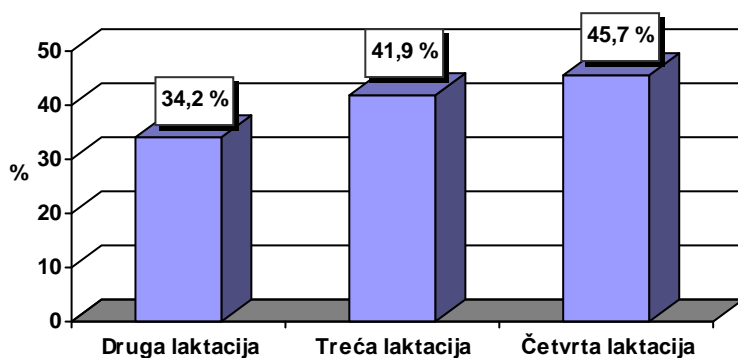
Prema Contreras i sur. (2007), infekcija mliječne žlijezde bakterijom *Staphylococcus aureus* zahtjeva osobitu pozornost jer navedena bakterija uzrokuje kliničku (akutnu) i subkliničku upalu vimena. Navedena bakterija luči i nekoliko toksina koji su važni za razvoj upala mliječne žlijezde, a u isto vrijeme predstavljaju opasnost za zdravlje ljudi jer su neki otporni na pasterizaciju. To je, primjerice, osobito važno u slučajevima kad se svježe ovčje mlijeko prerađuje u sir bez prethodne toplinske obrade, ili je temperatura toplinske obrade vrlo niska.

Prosječna učestalost izoliranih streptokoka (*Str. D* i *Str. uberis*) utvrđena ovim istraživanjem (5,0%) slična je rezultatima dobivenim za neke mediteranske mliječne pasmine ovaca (Bergonier i Berthelot, 2003), dok je učestalost ostalih izoliranih bakterija podjednaka (od 3,3 do 5,8%).



Premda razlike u periodičkoj prevalenciji subkliničkog mastitisa između grla različitog redoslijeda laktacije nisu bile statistički značajne ( $P > 0,05$ ), s povećanjem redoslijeda laktacije istočnofrizijskih ovaca, kao što je vidljivo na grafikonu 2, došlo je do povećanja prevalencije subkliničkog mastitisa (od 34,2% u drugoj laktaciji do 45,7% u četvrtoj laktaciji).

Schalm i sur. (1971) ističu da povećanjem redoslijeda laktacije dolazi do produžavanja i proširivanja sisnog kanala krava čime se stvaraju uvjeti za lakši ulazak mikroorganizama u sisni kanal i mliječnu žlijezdu. Međutim, povećana prevalencija intramamarnih infekcija u ovaca treće, odnosno četvrte laktacije može, također, biti posljedica kroničnih infekcija iz prijašnje laktacije koje nisu izliječene tijekom razdoblja suhostaja. Međutim, ovim istraživanjem nisu prikupljeni podaci o zdravstvenom stanju mliječne žlijezde iz prethodnog suhostaja ili prethodne laktacije kako bi se sa sigurnošću mogla poduprijeti navedena pretpostavka.



Grafikon 2. Periodička prevalencija subkliničkih upala mliječne žlijezde istočnofrizijskih ovaca s obzirom na redoslijed laktacije

### Zaključci

Na osnovu rezultata utvrđenih ovim istraživanjem može se zaključiti kako je istočnofrizijska ovca, kao visoko mliječna pasmina, osjetljiva na nastanak subkliničkog mastitisa. Najčešći uzročnici subkliničke upale mliječne žlijezde istraživanih istočnofrizijskih ovaca su, kao i u većine drugih mliječnih pasmina ovaca, koagulaza negativni stafilokoki. U starijih ovaca, odnosno u grla višeg reda laktacije utvrđena je izraženija prevalencija subkliničkih upala mliječne žlijezde negoli u mlađih ovaca (u drugoj laktaciji).

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# Utjecaj primjene otopine cink sulfata kao ekološki prihvatljivog sredstva u terapiji i profilaksi zarazne šepavosti ovaca

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## Sažetak

Zarazna šepavost je najčešća bolest akropodijuma-papaka (laminitis-pododeramtitis) koja nanosi značajne ekonomske štete u proizvodnji ovaca u cijelom svijetu. Primarni živi agens je *Dichelobacter nodosus*, sa više varijetata sa aspekta virulentnosti, što korelira sa težinom kliničke slike. Primjena antibiotika sistemski nema naročit utjecaj i ne preporučuje zbog rezidua u mesu. Imunoprofilaksa daje različite rezultate, uglavnom loš imunski odgovor. Do danas su korištena mnoga antibakterijska sredstva za lokalni tretman u vidu kupki za papke, kao što je bakar sulfat, kreolin, formalin i cink sulfat, ali sa različitim terapijskim efektom. Sa povećanjem koncentracije otopine bakar sulfata raste i rizik od toksičnosti. U našim istraživanjima provedeni su komparativni tretmani sa otopinom bakar i cink sulfata, sa različitim koncentracijama, različitog vremena trajanja po tretmanu, u više ponavljanih procedure, u stadima ovaca Wurrtemberg rase (n=120 i n=170), u grupama sa i bez triminga. Nakon provedenog ispitivanja ustanovljeno je da 20% otopina cink sulfata ima statistički značajno bolji utjecaj ( $p < 0.01$ ) na smanjenje broja oboljelih nogu, odnosno smanjenje šepavosti u stadu. Cink sulfat ima baktericidan utjecaj i nisku toksičnost, zbog čega je svrstan u ekološki prihvatljiva sredstva. Stabilan je u otopini i jeftiniji je od drugih sredstava. Naša preporuka je da korištenje otopine cink sulfata najmanje dva puta godišnje i bez obrezivanja (triming) papaka može biti dobra prevencija zarazne šepavosti u stadima, a time se osigurava bolja biosigurnost i ekonomičnost uzgoja ovaca.

Ključne riječi: zarazna šepavost ovaca, terapija, profilaksa, cink sulfat

## Effect of zinc sulfate solution as ecological drug in therapeutic and prophylactic treatment of ovine foot rot

### Abstract

Ovine foot rot is very serious and very frequent disease of locomotory system (laminitis-pododermatitis) with important economical losses in ovine production in worldwide. Many drugs used in local footbath treatment, about cooper sulphate, creoline, formalin, and zinc sulphate, all drugs with different therapeutic results. With increased cooper sulphate concentration we have increases of toxicity during treatment. Formalin is danger drug for human health, but zinc sulphate has efficacy antibacterial effect, and important lower level of toxicity. In our investigation we provided comparative treatment with copper and zinc sulphate solution in different solution, and different time for each treatment, in cases of ovine foot rot, with or without trimming in two flocks ovine Wurrtemberg breed (n=120 and n=170). The after obtained results we determined that use of 20% zinc sulphate solution have statistical

important effect ( $p < 0.01$ ) without lesions of legs, fast and good penetration and absorption into horn, bactericide effect, and lower risk of toxicity. Zinc sulphate as ecological drug, with good stability in the solution. We are recommend that using zinc sulphate solution minimum in two treatments per year, without trimming, should be good influence of prevention flocks ovine foot rot, economical benefits and better biosecurity in ovine production.

Key words: ovine foot rot, therapeutic, prophylactic treatment, zinc sulphate, ecological drug

## Uvod

Zarazna šepavost ovaca je oboljenje akropodijuma (papka) veoma rasprostranjeno u cijelom svijetu, ali sa vrlo različitim postotkom zastupljenosti u stadima ovaca. Bolest nanosi značajne ekonomske štete u uzgoju ovaca. Kompleksne je etiologije ali primarni agens je *Dichelobacter nodosus* (stari naziv *Bacteroides nodosus*) sa više varijeteta od kojih prisutnost virulentnog soja dovodi do "izuvanja papka" *ex ungulatio* koja je i nateži stupanj oboljenja (Abbot and Egerton, 2003a). U profilaksi i terapiji ove bolesti se koristilo više antimikrobnih sredstava sa više i manje uspjeha, ali zbog svoje toksičnosti, odnosno kancerogenosti neka od njih su potisnuta (bakar sulfat i formalin). Danas se uglavnom preporučuje i koristi upotreba otopine cink sulfata u vidu lokalnih kupki za papke, različite koncentracije, različitog vremena trajanja jedne procedure i veoma različitog broja dana između ponavljana tretmana (Malecki 1987, Gavrić 2007, Radojičić 2009). Primjena otopine cink sulfata u Republici Srbiji u vidu lokalnih kupki za papke na velikom broju stada i ovaca, ili sa dodatkom natrij-lauril sulfata, pokazala je značajno smanjenje šepavosti u stadima (Radojičić i sar., 2005, 2007)

## Patogeneza i klinička slika zarazne šepavosti ovaca

Bolest najčešće počinje kao laminitis i/ili interdigitalni dermatitis, sa posljedično više ili manje izraženim šepanjem (Fig. 1). Primarne lezije na papcima su posljedica lošeg terena ispaše (strništa, oštro bilje, meka i vlažna zemlja, meka i vlažna stelja u torovima), dok od živih uzročnika primarnu ulogu ima *Dichelobacter nodosus*, sam ili u sinergističkom dejstvu sa *Fusobacterium necrophorum*. U zavisnosti od prisutnosti virulentnog soja *D. nodosus* oboljenje nastaje i kod mladunčadi, a dominantna klinička manifestacija je šepanje na jednu ili dvije noge, kada ovce zaostaju za stadom, ili čak prinudno liježe. Ukoliko je procesom zahvaćeno više nogu životinja leži ili ako je nastalo *ex ungulatio* životinja se izlučuje iz stada (Radojičić i sar., 2007).



Slika 1. Podizanje noge (izražena bol) kod zarazne šepavosti ovaca

### Aktualni pristup u terapiji i profilaksi zarazne šepavosti ovaca

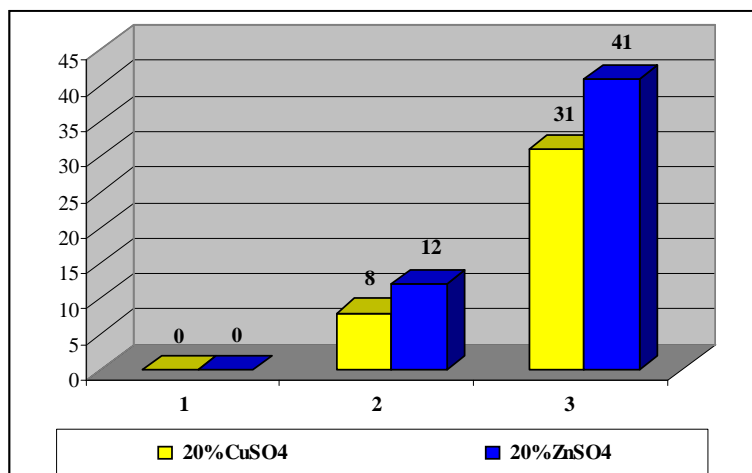
Primjena antimikrobnih sredstava sistemski u domaćih životinja kao što su ovce je vrlo delikatna a neka od sredstava su čak i zabranjena za upotrebu zbog rezidua u mesu i mlijeku. Njihova primjena nema ni značajan terapijski utjecaj, jer vrlo teško mogu da dopru do mjesta koja su kao "džepovi" ispod rožine. Međutim, primjena antibiotika lokalno u vidu spreja se često koristi jer ima određene terapijske utjecaje. Stoga se uglavnom pored poznatih mjera profilakse: redovne promijene prostirke, trijaže zdravih od bolesnih životinja, obrade preraslih i deformiranih papaka, preporučuje imunoprofilaksa i kupke u vidu lokalnog tretmana papaka sa otopinom cink sulfata. Mnogi istraživači su koristili različite postotke otopine, kao i različito vrijeme po tretmanu i broju ponovljenih tretmana, ali uglavnom su preporuke da treba koristiti 10 do 20 postotnu otopinu cink sulfata, u trajanju od pola sata po tretmanu (Malecki 1987, Gavrić 2005, Radojičić 2007).

### Vlastita istraživanja

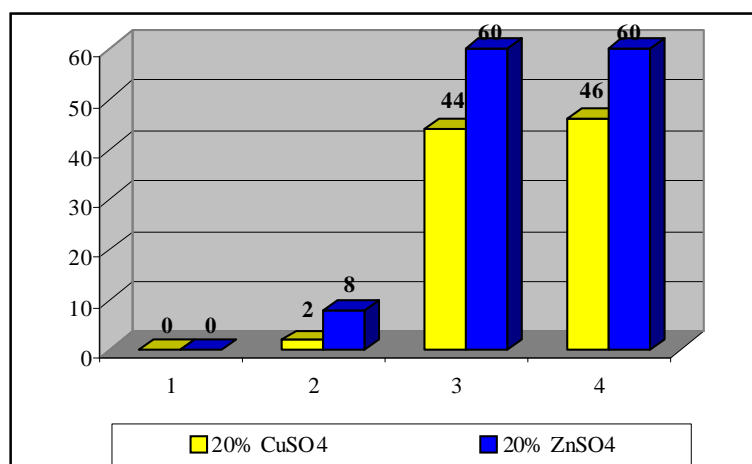
Otopina cink sulfata u Republici Srbiji je primijenjena u vidu lokalnih kupki na velikom broju stada i životinja, sam ili u paraleli sa bakar sulfatom. Komparativni tretman proveden je na farmi A n=120 i farma B n=170 ovaca u stadu, Würtemberg pasmine, sa visokim postotkom zastupljenosti (preko 50 posto na obje farme) zarazne šepavosti. Ovce su nakon kliničkog pregleda papaka, podijeljene u podgrupe sa prethodnim obrezivanjem preraslih i deformiranih papaka (triming) i bez triminga. Korištena je otopina 20 postotnog cink sulfata, dok je u komparativnoj paraleli primjenjivana otopina 20 postotnog bakar sulfata. Procedura lokalnog tretmana se provodila u betonskom bazenu veličine 300x200x10 cm, u koji je moglo da stane između 18 do 20 ovaca (Fig. 2). Ovce su stajale u otopini pola sata, a tretmani su ponavljani 1., 5., i 10. dana. Nakon provedenog tretmana ovce su držane sat vremena na suhoj prostirci. Ponovljenim kliničkim pregledom pokazalo se da je primjena 20 postotnog cink sulfata dovela do značajnog smanjenja ( $p < 0.01$ ) broja oboljelih nogu-bez šepanja, za razliku od primjene bakar sulfata. U toku ispitivanja primjenjivana su različita vremena, od pola i sat vremena po tretmanu. Sve je ponavljano u tri i/ili četiri tretmana u rasponu od po pet dana između tretmana, što je bio zahtjevan posao za radnike i farmere. Međutim, veći broj primijenjenih tretmana niti duže vrijeme od pola sata nije pokazalo veći terapijski utjecaj. Kod životinja koje su imale teže ozljede na papcima, je nakon obrezivanja, u kupke sa otopinom cink sulfata dodavan i natrijum-laluril sulfat, u cilju boljeg terapijskog utjecaja. Nakon provedenih tretmana ustanovili smo da je boji učinak postignut primjenom otopine 20 postotnog cink sulfata za razliku od primjene otopine bakar sulfata u istom postotku i istoj proceduri (Grafikon 1). Nije ustanovljena značajne razlike ni kod životinja koje su imali 4 tretmana u trajanju od sat vremena po tretmanu (Grafikon 2). U toku tretmana sa otopinom 20 postotnog bakar sulfatom, neke ovce su pokazale znakove suženja i kašlja kao manifestacije toksičnosti na bakar sulfat, dok u otopini cink sulfata u istom postotku te pojave nisu zapažene, što ide u prilog objašnjenju, da cink sulfat ima manju toksičnost, odnosno ekološku prihvatljivost (Gavrić 2007, Radojičić i sur., 2007). U posebnom ogledu sa kod dvije životinja kod kojih su promjene bile na obje prednje noge, individualno je vršeno obrezivanje papaka i postavljanje spužvica natopljenih u otopini cink sulfata, a preko njih plastificirani zavoji. Nakon kratkog vremena po obradi papaka i tretmanu ovce su hodale bez šepanja (Fig. 3, 4 i 5).



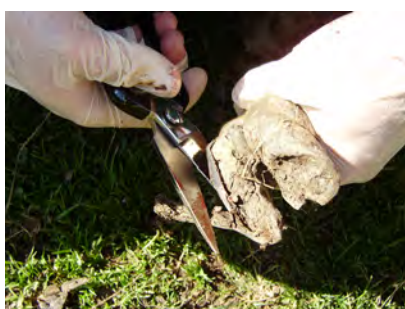
Slika 2. Kupke za papke (300x200x10 cm)



Grafikon 1. Tri komparativna tretmana u razmaku od pet dana u trajanju od 30 minuta po tretmanu



Grafikon 2. Četiri komparativna tretmana u razmaku od pet dana i u trajanju od sat vremena po tretmanu



Slika 3. Orezivanje preraslog i deformiranog papka



Slika 4. Zavoji sa spužvama natopljenim u cink sulfatu nakon obrezivanja papaka



Slika 5. Hod bez šepanja nakon tretmana

## Zaključak

Primjena 20 postotne otopine cink sulfata ima značajno bolji terapijski utjecaj od primijenjene otopine bakar sulfata u istom postotku. Nakon upotrebe otopine cink sulfata u koncentraciji od 20 posto i više, nisu izražene kliničke manifestacije toksičnog djelovanja, zbog čega se cink sulfat smatra ekološki prihvatljivim antimikrobnim sredstvom. Terapijski tretman u otopini cink sulfata u koji je dodat natrijum-lauril sulfat značajno smanjuje postotak zarazne šepavosti u stadu, ali postupak treba da bude proveden u tri tretmana, u razmaku od pet dana između tretmana, i u trajanju od pola sata po svakom tretmanu. Cink sulfat brzo prodire i dobro se apsorbira kroz rožinu, baktericidan je, stabilan je u otopini, i ista otopina može da posluži za sva tri tretmana u kupkama za papke, što ga čini jeftinijim od drugih sredstava. Za profilaktički tretman zarazne šepavosti otopinu cink sulfata upotrijebiti najmanje dva puta godišnje po jedan tretman, prije izгона i po povratku sa ispaše. U terapijskom i profilaktičkom tretmanu zarazne šepavosti ovaca treba koristiti 22 do 35 postotni monohidratni cink sulfat, uz napomenu da pripremljena otopina može duže vremena biti stabilna i efikasna, ali se ne smije čuvati u metalnim posudama.

## Zahvala

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# Heritabilitet za veličinu legla crne slavonske svinje

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## Sažetak

Cilj rada je bio odrediti heritabilitet za veličinu legla crne slavonske pasmine svinja uporabom modela s ponavljanjima. Sistematski dio modela uključivao je sljedeće utjecaje: uzgojna organizacija, redni broj prasenja, sezona prasenja i utjecaj nerasta. Slučajni dio modela uključivao je direktni aditivni genetski utjecaj i stalni okolišni utjecaj. Podaci za veličinu legla dobiveni su za 5792 legala od 1817 krmača. Potpuno podrijetlo je uključivalo 1862 trijade (životinja-otac-majka). Dobivene vrijednosti heritabiliteta za broj živooprasene prasadi (0.08) i broj odbite prasadi (0.04) su niske. Primjena nekih drugih modela u procjeni heritabiliteta zahtijevaju dostupnost većeg broja podataka za svojstva veličine legla ove pasmine svinja.

Ključne riječi: svinje, lokalna pasmina, genetski parametri, veličina legla

## Heritability of litter size in Black Slavonian pigs

### Abstract

Genetic progress in litter size in local pig breeds is limited mainly due to low heritability and inbreeding depression. After increase of population size of Black Slavonian (BS) pig breed in recent years, there is opportunity to renew a breeding programme including some new breeding goals related to litter size. Aim of study was to determine genetic parameters for litter size in BS pigs. Litter size was presented as number of piglets born alive (NBA) and number of piglets weaned (NW). Genetic parameters were estimated using a univariate repeatability models. Fixed part of the model included breeding organization, parity, farrowing season and service sire as class effects. Random part of the model included direct additive genetic effect and permanent environmental effect. Litter size records proceeded from 5792 litters from 1817 sows. The complete pedigree file contained 1862 triads (animal-sire-dam). Heritability estimates for NBA and NW were lower than average values of 0.10 - 0.15, and ranged for both traits between 0.04 and 0.08. Implementation of some others models in breeding scheme (particularly multivariate and random regression models) requires availability of large set of reproductive traits for this local breed.

Key words: pigs, local breed, genetic parameters, litter size



## Uvod

Crna slavonska svinja je jedna od dvije autohtone pasmine svinja u Hrvatskoj. Pasma je nastala u drugoj polovici 19. stoljeća u području istočne Hrvatske nedaleko Osijeka. Sve do sredine 20. stoljeća to je bila najraširenija pasmina svinja u zemlji, a tada počinje njeno zapuštanje i nestajanje. Razdoblje nestajanja ove pasmine traje sve do sredine devedesetih godina kad je 1996. godine registrirano svega 60 krmača i pet nerasta (Uremović i sur., 2001). Od 1996. godine veličina populacije crne slavonske svinje raste, prije svega zahvaljujući mjerama zaštite od strane nadležnog ministarstva i poticajima za držanje ove pasmine te također zahvaljujući individualnim naporima uzgajatelja svinja ove pasmine. Svinje ove pasmine su prilagođene tradicionalnom sustavu držanja na otvorenom, a meso crne slavonske se koristi uglavnom za proizvodnju lokalnih suhomesnatih proizvoda (Karolyi i sur., 2007). U zadnjih nekoliko godina, veličina populacije svinja crne slavonske pasmine se povećava i kreće između 600 i 700 krmača i oko 70-tak nerasta. Isto tako, pasmina je osim izvornog područja uzgoja raširena i u druge dijelove Hrvatske (Banovina, okolica Varaždina). Iako se s početkom rada na zaštiti crne slavonske svinje provodio i određeni uzgojni program, povećanje veličine populacije otvara mogućnosti za određene promjene u uzgojnom programu ove naše lokalne pasmine svinja.

Veličina legla je jedno od ekonomski najvažnijih svojstava u svinjogojskoj proizvodnji. Veličina legla krmača crne slavonske pasmine je niža u odnosu na krmače plemenitih pasmina i kreće se između 6 i 7 živooprasene prasadi u leglu (Senčić i sur., 2001). Povećanje veličine legla u svinja crne slavonske pasmine ograničeno je genetskim kapacitetom, uvjetima držanja i uzgojem u srodstvu kao posljedicom ograničene veličine populacije. Povećanje veličine legla ove pasmine je izrazito bitno za dovoljnu proizvodnju lokalnih suhomesnatih proizvoda, kao što su kulen, kulenova seka, kobasice i drugi proizvodi. Registriranje proizvodnih podataka u zadnjih petnaest godina, prije svega veličine legla i kreiranje podrijetla za ovu pasminu omogućuje primjenu suvremenih metoda kvantitativne genetike. Cilj istraživanja je bio odrediti genetske i okolišne parametre, odnosno heritabilitet za veličinu legla crne slavonske svinje te razmotriti mogućnosti povećanja veličine legla selekcijom.

## Materijal i metode

Podaci o plodnosti crne slavonske svinje dobiveni su u Odjelu za razvoj svinjogojstva Hrvatske poljoprivredne agencije. Veličina legla je prikazana kao broj živooprasene prasadi (BZOP) i broj prasadi odbite (BOP) sa 21. danom. Zapisi o veličini legla su prikupljeni u razdoblju od siječnja 1998. do prosinca 2009. godine. Ukupno je u analizi korišteno 5792 zapisa veličine legla od 1817 krmača (Tablica 1). Podaci su obuhvaćali samo legla dobivena od prvog do desetog prasenja. Potpuno podrijetlo je sadržavalo ukupno 1862 trijade (životinja-otac-majka).

Tablica 1. Osnovna statistika za broj živooprasene prasadi (BZOP) i broj odbite prasadi (BOP)

Svojstvo	Minimum	Maksimum	Srednja vrijednost	Standardna devijacija
BZOP	1	16	6.14	1.75
BOP	1	15	4.76	2.60

Genetski i okolišni parametri su analizirani uporabom modela s ponavljanjima pretpostavljajući potpunu genetsku korelaciju između veličine legla u pojedinim prasenjima, i to za svako svojstvo posebno. Sistematski dio modela je uključivao uzgojnu organizaciju, redni broj prasenja, sezonu prasenja te utjecaj nerasta - oca legla. Zapisi veličine legla su prikupljeni u osam uzgojnih organizacija, dok je sezona prasenja prikazana kao interakcija mjesec unutar godine. U promatranom razdoblju od 12 godina prasad iz legala su potomci od ukupno 241 nerasta. Slučajni dio modela uključivao je direktni aditivni genetski utjecaj te stalni okolišni utjecaj. Model s ponavljanjima prikazan u matricnom obliku izgleda prema jednadžbi (1):

$$y = X\beta + Z_p p + Z_a a + e \quad (1),$$

gdje je  $y$  - vektor opažanja,  $X$  - matrica događaja za sistematske utjecaje,  $\beta$  - vektor nepoznatih parametara za sistematske utjecaje,  $Z_p$  - matrica događaja za stalni okolišni utjecaj,  $p$  - vektor parametara za stalni okolišni utjecaj,  $Z_a$  - matrica događaja za direktni aditivni genetski utjecaj,  $a$  - vektor parametara za direktni aditivni genetski utjecaj,  $e$  - vektor ostatka ili greške.

U razvoju sistematskog dijela modela korištena je GLM procedura statističkog paketa SAS (SAS Inst. Inc., 2001), dok je za izračunavanje varijanci i heritabiliteta korišten VCE6 programski paket (Groeneveld i sur., 2008).

### Rezultati i rasprava

Procijenjene vrijednosti varijanci i heritabiliteta za BZOP i BOP (Tablica 2) u svinja crne slavonske pasmine primjenom modela s ponavljanjima su izrazito niže u odnosu na vrijednosti dobivene u genetskim analizama plemenitih genotipova kod kojih su se heritabiliteti za svojstva veličine legla kretali uglavnom između 0.10 i 0.15 (Luković, 2006). Osobito niske vrijednosti za stalnu okolišnu varijancu ukazuju na lošu strukturu podataka, odnosno mali broj legala po pojedinoj krmači. Fenotipska varijanca za broj odbite prasadi je dvostruko veća u odnosu na fenotipsku varijancu za broj živooprasene prasadi što je posljedica sličnog povećanja varijance greške kod broja odbite prasadi.

Slične vrijednosti heritabiliteta za broj živooprasene prasadi dobili su istraživači koji su proučavali genetske parametre za veličinu legla za španjolsku iberijsku pasminu svinja (Perez-Enciso i Gianola, 1992; Fernandez i sur., 2008). Croveti i sur. (2005) su dobili slične vrijednosti heritabiliteta, odnosno odnos između heritabiliteta za broj živooprasene prasadi i broj odbite prasadi kod talijanske lokalne pasmine Cinta Senese. Croveti i sur. (2005) napominju da teškoće u selekciji na veličinu legla kod lokalnih pasmina svinja, pored niskog heritabiliteta, mogu biti i posljedica teškoća u mjerenju i registriranju svojstava u ekstenzivnim uvjetima proizvodnje. Međutim, za razliku od našeg istraživanja i istraživanja Croveti i sur. (2005) u kojem smo dobili heritabilitet za broj odbite prasadi na razini jedne polovine u odnosu na heritabilitet za broj živooprasene prasadi, Fernandez i sur. (2007) su utvrdili dvostruko veći heritabilitet za broj odbite prasadi prema heritabilitetu za broj živooprasene prasadi. Na temelju dobivenih rezultata navedeni autori utvrđuju da je moguće ostvariti veći genetski napredak za svojstva majčinske sposobnosti (mliječnost) u odnosu na veličinu legla. Fernandez i sur. (2007) napominju također da u slučaju kad imamo podatke iz prvih i viših legala za procjenu genetskih i okolišnih parametara preporučljivo je primijeniti model s više svojstava umjesto modela s ponavljanjima. Isti autori navode da se model za veličinu legla u kojem se prvo leglo tretira kao jedno, a kasnija legla kao drugo svojstvo čini prihvatljivijim u odnosu na model s ponavljanjima.

Tablica 2. Varijance i heritabiliteti ( $h^2$ ) za broj živooprasene prasadi (BZOP) i broj odbite prasadi (BOP)

Svojstvo	Var (a)	Var (p)	Var (e)	Var (ph)	$h^2$
BZOP	0.21	0.02	2.27	2.50	0.08
BOP	0.22	0.01	5.50	5.73	0.04

Var (a) - direktna aditivna genetska varijanca; Var (p) - stalna okolišna varijanca; Var (e) - varijanca greške; Var (ph) - fenotipska varijanca.

### Zaključci

Vrijednosti varijanci i heritabiliteta za svojstva veličine legla dobivene u istraživanju primjenom modela s ponavljanjima nisu mnogo obećavajuće za selekcijske svrhe. Neki drugi pristupi u procjeni genetskih i okolišnih parametara poput modela s više svojstava i modela sa slučajnom regresijom morat će se uzeti u obzir u budućim studijama. Dodatna pozornost mora se usmjeriti prema kakvoći podataka, a posebno prema kontroli podrijetla i registraciji reproduktivnih podataka.

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# Svojstva, poznavanje i potrošnja sira turoša

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## Sažetak

Cilj je ovog rada istražiti kemijski sastav i fizikalne osobine te poznavanje i potrošnju sira turoša koji se proizvodi u Međimurju. Turoš pripada skupini polutvrđih, masnih sireva sa dodatkom crvene paprike i soli. Sir je stožastog oblika prosječne visine 6,5 cm, širine 5,6 cm i mase 81,2 g. Veliki udio ispitanika (85%) poznaje sir turoš od čega je značajno ( $p < 0,01$ ) veći broj onih koji dolaze iz ruralnog područja. Stariji ispitanici kupuju i konzumiraju sir češće od mlađih ( $p < 0,05$ ). Ispitanici turoša konzumiraju jednom tjedno (31%) ili jednom mjesečno (34%). Muškarci češće konzumiraju sir turoš od žena ( $p < 0,01$ ). Cijena jednog komada sira turoša prema 49% ispitanika trebala bi biti 10 kn.

Ključne riječi: turoš, kemijska i fizikalna svojstva, potrošnja

## Properties, cognition and consumption of Turoš cheese

### Abstract

The aim of this paper was to investigate chemical composition, physical properties, cognition and consumption of Turoš cheese. Turoš cheese belongs to the group of semi hard, fat cheeses with added red pepper and salt. The cheese contain cone form with high of 6.5 cm, width 5.6 and weight of 81.2 g. Significant percentage of examinee (85%) knew about Turoš cheese among them significant ( $p < 0.01$ ) number come from rural areas. Older examinees consume Turoš cheese much often in comparison to younger ( $p < 0.05$ ). Turoš cheese is consumed once a week (31%) or once a month (34%). Men more often consume Turoš cheese in comparison to women ( $p < 0.01$ ). The price of Turos cheese could be 10 kn according to 49% of examinees.

Key words: Turoš cheese, chemical and physical properties, consumption

### Uvod

Sir turoš pripada skupini svježih kiselinskih, sušenih sireva pripremljenih tradicionalnim postupkom na širokom području sjeverozapadne Hrvatske (Podravina, Međimurje, Prigorje, Moslavina, Posavina) i susjednih zemalja (Mađarska i Slovenija) (Kirin, 2004). U Podravini takav sir nazivaju prge ili prgice, a u Moslavini i Posavini sušeni sir (Andrić i sur., 2003). U bjelovarskom, odnosno bilogorskom kraju nazivaju ih kvargli. Prema tome, iako se radi o istoj skupini sireva, pojavljuju se pod različitim lokalnim nazivima i u različitim oblicima i svojstvima (Kirin, 2004).

Turoš je sir koji se izrađuje od svježeg sira dobivenog spontanom zakiseljavanjem sirovog kravljeg mlijeka. Ono se ostavlja dan-dva u zemljanoj posudi na toplom mjestu da se usiri. Nakon što se mlijeko ukiseli, vrhnje se obire, sirni gruš se prebacuje u cijedilo, te se ostavlja cijediti do dva dana (Andrić i sur. 2003). Ocijeđeni sir začini se solju i paprikom, izmiješa i oblikuje u stošce koji se suše na suncu ili iznad peći. Na 1000 g sira dodaje se 20 g soli i 10 g crvene paprike (Tišlarić, 1992).

S obzirom da se na području sjeverozapadne Hrvatske proizvodi više vrsta sireva koji pripadaju skupini

svježih, sušenih sireva, cilj je ovog rada istražiti kemijski sastav i fizikalne osobine te poznavanje i potrošnju sira turoša čija se proizvodnja odvija na području Međimurja na obiteljskim poljoprivrednim gospodarstvima (OPG). Ovaj rad je doprinos standardizaciji sira turoša, a dio je istraživanja razlikovnih osobina svježih, sušenih sireva sa područja sjeverozapadne Hrvatske koji se proizvode na tradicionalan način pod različitim lokalnim nazivima.

### Materijal i metode

#### 1. Prikupljanje uzoraka sira turoša

Uzorci sira turoša prikupljeni su s petnaest obiteljskih poljoprivrednih gospodarstava u Međimurju. Prikupljanje uzoraka trajalo je od 5. studenog 2008. godine do 15. studenog 2009. godine. Prikupljeno je tri uzorka sira po gospodarstvu u cilju provođenja kemijskih i fizikalnih analiza. Trajanje sušenja sira bilo je jednako za sve sireve proizvedene u pokusnim uvjetima i trajalo je sedam dana. Uzorci sira su potom zamrznuti na  $-18\text{ }^{\circ}\text{C}$  do analize. Zamrznuti uzorci sira za potrebe kemijskih i fizikalnih analiza dostavljeni su u Referentni laboratorij Zavoda za mljekarstvo Agronomskog fakulteta Sveučilišta u Zagebu.

#### 2. Kemijska i fizikalna analiza turoša

Količina masti u siru izmjerena je metodom po Van Gulik-Gerber-u (HRN EN ISO 3433:1999). Količina proteina u siru određena je metodom po Kjeldahl-u (HRN ISO 8968-2:2003). Količina suhe tvari u siru izmjerena je sušenjem na  $102 \pm 2^{\circ}\text{C}$  (HRN EN ISO 5534:2008). Količina soli u siru izmjerena je metodom po Mohr-u (Sabadoš 1996). Vrijednost pH izmjerena je na pH-metru (Mettler Toledo, Seven Multi) i elektrodom Mettler Toledo Inlab Expert Pro. Masa sira određena je na gospodarstvu digitalnom vagom FA-6406 (preciznost 1 g).

#### 3. Istraživanja potrošača

U istraživanju potrošača je rabljena metoda osobnog ispitivanja, a kao instrument strukturirana anketna upitnica. Ispitivanje je provedeno u lipnju 2010. godine s 399 slučajno odabranih posjetitelja sajma MESAP u Nedelišću (Međimurje). Anketno ispitivanje je obuhvatilo, između ostalog, pitanja o poznavanju sira turoša, podatke o kupovnom ponašanju i potrošnji turoša, te sociodemografska obilježja ispitanika (spol, dob i mjesto stanovanja).

Prikupljeni podaci su obrađeni jednovarijantnim i dvovarijantnim statističkim metodama, a u analizi je korišten statistički program SPSS.

### Rezultati i rasprava

#### Kemijski sastav i svojstva sira turoša

Prema pravilniku o sirevima i proizvodima od sireva (NN 20/09) turoš proizveden na OPG-u, s obzirom na udjel vode u bezmasnoj tvari sira (Tablica 1.) pripada skupini polutvrđih sireva čiji se sadržaj vode u bezmasnoj tvari sira nalazi između 54% i 69%, a prema udjelu mliječne masti u suhoj tvari sira, ovaj sir pripada skupini masnih sireva čiji je sadržaj masti u suhoj tvari sira između 25% i 45% (Pravilnik, NN, br.20/2009.).

Sir turoš je stožastog oblika prosječne visine 6,5 cm i prosječne širine 5,6 cm. Prosječna masa mu je 81,2 g.

Utvrđena je velika varijabilnost ostalih istraženih parametara kemijskog sastava sira kao posljedica ne ujednačenih postupaka proizvodnje sira turoša između istraženih gospodarstava izražena standardnom devijacijom i varijacionim koeficijentom.

Tablica 1. Kemijski sastav i svojstva sira turoša (n = 15)

Vrijednosti	Srednja vrijednost	Min.	Max.	Standardna devijacija	Varijacioni koeficijent
Mliječna mast (g/100g)	15,6	7,5	27,5	4,99	49,94
Bjelančevine (g/100g)	28,23	20,65	38,28	5,16	14,12
Suha tvar (g/100g)	57,26	38,95	71,07	9,52	15,56
pH	4,46	4,16	4,69	0,13	2,84
Sol (%)	3,98	2,49	4,81	0,86	33,98
Udjel vode u bezmasnoj tvari sira (%)	58,34	43,93	68,55	7,12	14,58
Udjel mliječne masti u suhoj tvari sira (%)	26,93	16,35	40,95	6,13	37,5
Masa (g)	81,2	46	106,4	18	22,17
Visina (cm)	6,5	5	8	0,78	11,99
Širina (cm)	5,6	4	6,5	0,73	13,09

### Poznavanje i potrošnja sira turoša

U anketnom ispitivanju je sudjelovalo 59% muških i 41% ženskih ispitanika dobi između 16 i 76 godina. Oko 70% ispitanika živi na selu, a ostali u gradu.

Veliki udio ispitanika (85%) je rekao da pozna sir turoš, 8% ispitanika nije čulo za njega, a 7% ispitanika djelomično pozna turoš. Ovakvi podaci ne iznenađuju budući da su posjetitelji sajma bili uglavnom iz Međimurja i okolice

Ženske ispitanice bolje poznaju turoš nego muški ispitanici (90% žena te 81% muškaraca dobro pozna turoš;  $p < 0,05$ ). Značajno veći broj ispitanika koji žive na selu (89%) dobro poznaju turoš u odnosu na udio takvih ispitanika iz grada (72%,  $p < 0,01$ )

Na pitanje "Gdje se proizvodi sir Turoš? U kojim regijama?" polovica ispitanika (53%) je navela samo Međimurje, daljnjih 30% ispitanika je uz Međimurje navelo i neki drugu regiju u Hrvatskoj (najčešće Zagorje i Podravinu) te Sloveniju. Ostalih 17% ispitanika nije znalo gdje se proizvodi turoš, te nisu niti odgovorili na ovo pitanje.

Nešto više žena smatra da se turoš proizvodi isključivo u Međimurju (68%) dok je među muškima značajan udio (42%) onih koji misle da se turoš uz Međimurje proizvodi i u drugim regijama ( $p < 0,05$ ). Isto tako, ispitanici sa sela uglavnom misle da se turoš proizvodi samo u Međimurju (63%), dok veliki udio ispitanika koji žive u gradu (43%) uz Međimurje navode i neku drugu regiju ( $p < 0,05$ ).

Relativno mali udio ispitanika kupuje turoš svaki tjedan (16%), dok najveći udio ispitanika kupuje turoš mjesečno (30%). Nešto više od četvrtine ispitanika (29%) turoš kupuju rjeđe od jednom mjesečno. Čak 25% ispitanika turoš nikad ne kupuju; jedan dio tih ispitanika ima vlastitu proizvodnju ili dobivaju turoš od rodbine ili prijatelja, dok dio ispitanika turoš ne konzumira u vlastitom domu.

Na učestalost kupnje utječe dob ispitanika; stariji ispitanici kupuju češće sir turoš od mlađih ispitanika ( $p < 0,05$ ). Prosječna dob ispitanika koji kupuju turoš barem jednom tjedno je 46 godina, onih koji turoš kupuju mjesečno 44 godine, dok je prosječna dob ispitanika koji kupuju turoš rjeđe od jednom mjesečno 42 godine. Ispitanici koji ne kupuju turoš u prosjeku imaju 39 godina.

Turoš se uglavnom kupuje na tržnicama (30% ispitanika) i u supermarketima (21%). Čak 25% ispitanika ima vlastitu proizvodnju turoša, a daljnjih 18% turoš dobiva od rodbine i prijatelja. Manji broj ispitanika je rekao da kupuje turoš izravno od proizvođača na njihovom gospodarstvu.

Nešto manje od trećine ispitanika (31%) jede turoš svaki tjedan, daljnjih 34% turoš jede jednom ili nekoliko puta mjesečno, dok 35% ispitanika turoš jede rjeđe od jednom mjesečno.

Muškarci češće jedu turoš od žena ( $p < 0,01$ ); čak 37% muških ispitanika je reklo da turoš jedu svaki tjedan, dok je udio takvih ispitanika 22%. Stariji ispitanici češće jedu turoš ( $p < 0,01$ ); prosječna dob ispitanika koji jedu turoš svaki dan je 45 godina, onih koji turoš jedu mjesečno 44 godine, a ispitanika koji turoš jedu rjeđe od jednom mjesečno je 39 godina.

Značajno veći udio ispitanika sa sela jede turoš svaki tjedan (35%) u odnosu na ispitanike iz grada (21%;  $p < 0,05$ )

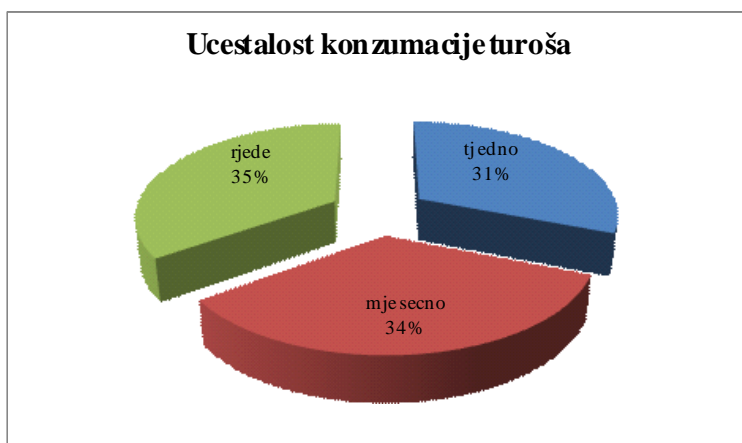
## Svojstva, poznavanje i potrošnja sira turoša

Ispitanici su naveli da se turoš često jede uz vino (42% ispitanika, veći udio muškaraca), te uz nareske (45% ispitanika, veći udio žena). Od ostalih prigoda navode proslave i poslovne ručkove.

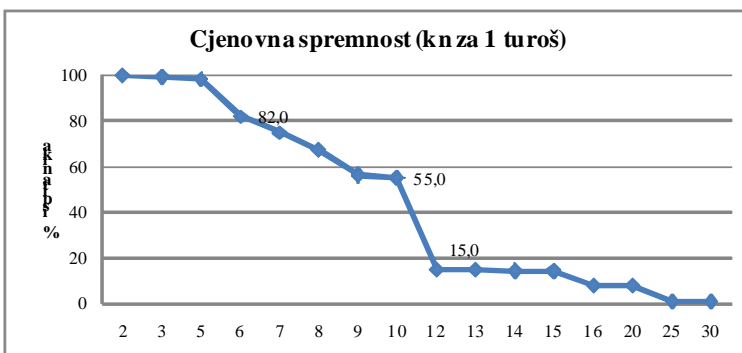
Najveći broj ispitanika (oko 49%) je izjavilo da bi cijena jednog turoša u trgovini trebala biti 10 kuna. Čak jedna četvrtina ispitanika misle da bi turoš trebao koštati 6 i manje kuna. Oko 15% ispitanika smatra da bi cijena turoša u trgovini trebala biti 15 ili više kuna. Cijena turoša u trgovini s 3.11.2010.g. za 100 grama iznosila je 12,49 kuna.



Grafikon 1. Učestalost kupnje turoša (n = 399)



Grafikon 2. Učestalost konzumacije turoša (n = 399)



Grafikon 3. Cjenovna spremnost potrošača (n = 200)

## Zaključci

Istraživani sir turoš pripada skupini polutvrdih, masnih kiselinskih sušenih sireva sa začinom crvene paprike uz dodatak soli. Sir je stožastog oblika prosječne visine 6,5 cm, širine 5,6 cm i mase 81,2 g. Polovica ispitanika (53%) proizvodnju turoša veže uz Međimurje dok 30% uz Međimurje još navodi i Zagorje, Podravinu, te Sloveniju. Turoš se uglavnom kupuje na tržnici (30%), u supermarketima 21%, a čak 25% ispitanika sami proizvode turoš. Stariji ispitanici kupuju i konzumiraju turoš češće od mlađih ( $p < 0,05$ ). Ispitanici turoša konzumiraju jednom tjedno (31%) ili jednom mjesečno (34%). Muškarci češće konzumiraju sir turoš od žena ( $p < 0,01$ ). Cijena jednog komada sira turoša prema 49% ispitanika trebala bi biti 10 kn. Ovaj sir je dobro poznat lokalnoj populaciji stanovništva (85% ispitanika), osobito starijem dijelu populacije iz ruralnog područja. Stoga je potrebna edukacija mlađe populacije stanovništva iz urbanog područja o značajkama sira turoš i važnosti njegove potrošnje kao i o očuvanju tradicije njegove proizvodnje.

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# Klaonički pokazatelji i odlike trupa janjadi i jaradi u ekstenzivnom sustavu uzgoja

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## Sažetak

Cilj istraživanja bio je utvrditi klaoničke pokazatelje i odlike trupova janjadi i jaradi u ekstenzivnom sustavu uzgoja. Istraživanjem je bilo obuhvaćeno ukupno 49 (25 ♂ i 24 ♀) janjadi dalmatinske pramenke i 52 (24 ♂ i 28 ♀) jaradi hrvatske šarene koze podjednagog stupnja dozrelosti. Randman janjadi dalmatinske pramenke bio je veći negoli onaj jaradi hrvatske šarene koze (51,5 : 48,1%). Janjad je imala značajno manju masu želuca sa crijevima te veću masu svih vaganih organa osim testisa. Utvrđen je značajan utjecaj spola na masu tjelesnih organa. Janjeći trupovi bili su znatno razvijeniji od jarećih, dok su u obje vrste trupovi muških grla imali veću dubinu prsiju i dužu stražnju nogu u odnosu na trupove ženskih grla.

Ključne riječi: dalmatinska pramenka, hrvatska šarena koza, klaonički pokazatelji, trup

## Slaughter traits and carcass measurements of lambs and kids raised under extensive production system

### Abstract

The aim of this research was to determine slaughter traits and carcass measurements of equally mature lambs and kids raised under extensive production system. A total of 49 (25 ♂ and 24 ♀) Dalmatian Pramenka lambs and 52 (24 ♂ and 28 ♀) Croatian multicoloured kids were used in this experiment. Lambs had greater dressing percentage than kids (51.5%:48.1%). Also, lambs had significantly lower weight of stomach and intestines but greater weight of other weighed organs except testicles. A significant influence of gender on the weight of body organs was determined. Lambs' carcasses were more developed than that of kids. The males had greater carcass chest depth and hind leg length than females.

Key words: Dalmatian Pramenka, Croatian multicoloured goat, slaughter traits, carcass measurements

## Uvod

Proizvodnja ovčjeg i kozjeg mesa u Hrvatskoj pretežno se temelji na izvornim pasminama priviknutim na oskudnu vegetaciju, različite klimatske uvjete, siromašno tlo i nedostatak oborina (Mioč i sur., 2007; Prpić i sur., 2010). U ukupnoj hrvatskoj populaciji ovaca najbrojnija je dalmatinska pramenka, a u populaciji koza hrvatska šarena koza (HPA, 2010) koje uglavnom obitavaju u istom širem uzgojnom području (Mioč i sur., 2008; Širić i sur., 2009). Glavna odlika uzgoja navedenih pasmina je izrazita ekstenzivnost koja se očituje minimalnim ulaganjima, odnosno troškovima tijekom godišnjih proizvodnih faza ili fizioloških ciklusa. Iako su dalmatinska pramenka i hrvatska šarena koza pasmine kombiniranih proizvodnih odlika, uzgajaju se prvenstveno radi proizvodnje mesa, ponajviše janjetine i jaretine (Mioč i sur., 2008; Vnućec i sur., 2009). U svijetu, pa tako i u Hrvatskoj, dob i tjelesna masa janjadi i jaradi pri klanju rezultat su ponajviše ovčarske i kozarske tradicije, proizvodne namjene i navika potrošača. Glavnina proizvodnje janjetine i jaretine u nas se tradicionalno zasniva na klanju lagane janjadi i jaradi (20-25 kg žive vage) u dobi od 90 do 120 dana. Navedena dob i tjelesna masa životinja pri klanju rezultiraju klaonički obrađenim trupovima teškim od 10 do 13 kg kakvi su najtraženiji na hrvatskom tržištu (Mioč i sur., 2007; Prpić i sur., 2010).

Do sada je provedeno više istraživanja s ciljem usporedbe sastava trupa i kvalitete mesa ovaca i koza (janjadi i jaradi) podjednake tjelesne mase pri klanju ili iz identičnog sustava uzgoja i hranidbe (Tshabalala i sur., 2003; Sen i sur., 2004; Lee i sur., 2008). Dob i/ili živa masa pri klanju su najčešći kriteriji usporedbe u istraživanjima sastava trupa i kvalitete mesa. Ukoliko se vrste ili pasmine uspoređene pri jednakoj tjelesnoj masi ili dobi razlikuju po masi odraslih, tjelesno dozrelih jedinki, tada se dobiveni rezultati mogu smatrati kao zbudjujuća kombinacija genetskih razlika u tjelesnoj masi odraslih jedinki i razlika u stupnju dozrelosti (Mahgoub i Lodge, 1998). Stoga je cilj ovog istraživanja bio usporediti klaoničke pokazatelje i odlike trupova janjadi i jaradi podjednake dozrelosti, uzgojene u sličnim tehnološkim i okolišnim uvjetima.

## Materijal i metode

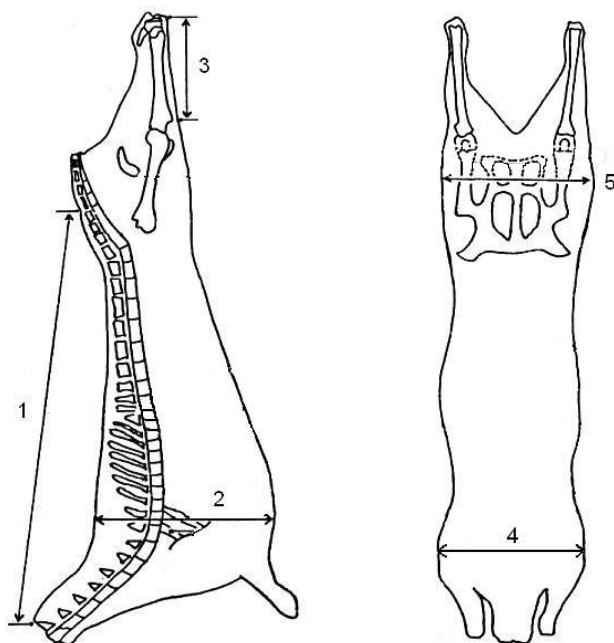
Istraživanjem je bilo obuhvaćeno 49 (25 muške i 24 ženska) janjadi dalmatinske pramenke i 52 (24 muške i 28 ženske) jaradi hrvatske šarene koze. Janjad i jarad je cijelo vrijeme, od partusa do klanja, boravila zajedno s majkama u staji i na pašnjaku te uz mlijeko konzumirala pašu i brst. Istraživanjem obuhvaćena janjad i jarad podvrgnuta je klanju pri tjelesnoj masi između 22 i 26 kg, što odgovara dozrelosti od približno 51%. Stupanj dozrelosti izračunat je na slijedeći način: (klaonička masa/prosječna tjelesna masa odraslih jedinki iz istog stada) x 100 (Fitzhugh i Taylor, 1971).

Klanje i klaonička obrada pokusne janjadi i jaradi obavljene su u ovlaštenim klaonicama prema uobičajenom postupku. Klasična metoda klanja janjadi i jaradi te obrada trupova uključuje iskrvarenje obostranim presijecanjem velikih krvnih žila vrata (*v. jugularis externa* i *a. carotis communis*), odsijecanje rogova (u rogatih grla), odvajanje kože i donjih dijelova nogu (odreznih u karpalnom, odnosno tarzalnom zglobu), vađenje iznutrica (probavnog sustava, jetre, pluća, srca i slezene). Glava nije odvajana i bila je sastavni dio trupa. Neposredno nakon klanja obavljena su pojedinačna vaganja organa (želuca i crijeva, pluća s dušnikom i srcem, jetara, slezene i testisa u muških grla), rogova, kože s donjim dijelovima nogu i obrađenog toplog trupa. Na trupovima su obavljena slijedeća mjerenja (shema 1):

1. dužine trupa (od kaudalnog ruba zadnjeg sakralnog kralješka do dorzo-kranijalnog ruba prvog vratnog kralješka)<sup>m</sup>,
2. dubine trupa u prsnom dijelu (najveća dubina, mjerena u vodoravnoj ravnini visećeg trupa)<sup>š</sup>,
3. dužine stražnje noge (od sredine kvrgaste izbočine na proksimalnom kraju tibije do distalnog ruba tarsusa)<sup>m</sup>,
4. širine prsiju (širina prednjeg dijela: najveća širina, mjerena u vodoravnoj ravnini na sredini lopatica)<sup>š</sup>,
5. širine zdjelice (širina stražnjeg dijela: najveća širina, mjerena u vodoravnoj ravnini visećeg trupa)<sup>š</sup>.

m - mjereno savitljivom mjernom vrpcom

š - mjereno šestarom za mjerenje šupljina



Shema 1.  
Mjere janječeg i jarećeg  
trupa

Dobiveni podaci statistički su obrađeni primjenom statističkog programa SAS (SAS, 2008). Prirast i klaonički pokazatelji janjadi analizirani su procedurom MEANS dok su utjecaj vrste i spola na prethodno spomenuta svojstva analizirani GLM procedurom.

### Rezultati i rasprava

Na tablici 1. prikazan je sažet pregled podataka koji uključuje broj trupova i prosječnu tjelesnu masu živih životinja, stupanj dozrelosti te mase trupova po skupinama.

Tablica 1. Klaonička masa (KLM), dozrelost i masa trupa (MT) muške i ženske janjadi i jaradi (prosjeck±SE)

Vrsta	Spol	n	KLM, kg	Dozrelost,%	MT, kg
Janjad	Muški	25	25,2 ± 0,27	49,5 ± 0,54	12,8 ± 0,22
	Ženski	24	23,8 ± 0,23	51,8 ± 0,60	12,4 ± 0,15
Jarad	Muški	24	25,5 ± 0,17	49,6 ± 0,34	12,1 ± 0,16
	Ženski	28	23,5 ± 0,24	53,5 ± 0,54	11,4 ± 0,12

Janjad dalmatinske pramenke imala je značajno veći randman ( $P < 0,001$ ) od jaradi hrvatske šarene koze (tablica 2) ponajviše zahvaljujući znatno manjem udjelu mase želuca i crijeva ( $P < 0,001$ ). Slične rezultate navode Mahgoub i Lodge (1998) i Tshabalala i sur. (2003) u komparativnom istraživanju navedenih dviju vrsta slične tjelesne mase, uzgajanih u različitim proizvodnim sustavima. Međutim, Sen i sur. (2004) tvrde da se randman, izražen u postotku tjelesne mase bez sadržaja želuca i crijeva, ne razlikuje značajno između ovaca i koza uzgojenih u polupustinjskim uvjetima. Čini se da su razlike u randmanu rezultat usporedbe ovaca i koza uzgojenih u različitim sustavima i podvrgnutih različitim razdobljima posta prije klanja. U janjadi je nakon klanja također utvrđena značajno veća masa pluća sa srcem ( $P < 0,001$ ), jetre i slezene ( $P < 0,01$ ), kože s nogama ( $P < 0,001$ ) i rogova ( $P < 0,01$ ) u odnosu na jarad. Istraživanjem nije utvrđena značajna razlika u randmanu između spolova, što je u skladu s rezultatima Santos i sur. (2008). Međutim, muška janjad i jarad imala su značajno veću masu želuca sa crijevima ( $P < 0,01$ ), pluća sa srcem i jetre ( $P < 0,05$ ), kože s nogama ( $P < 0,01$ ) i rogova ( $P < 0,001$ ) te manju masu slezene ( $P < 0,05$ ) nego ženska grla.

Janječji trupovi bili su znatno razvijeniji od jarećih što zorno pokazuju prosječne mjere dužine i širine trupa prikazane na tablici 3. Najveća razlika utvrđena je za dužinu trupa (6 cm), dok je najmanja razlika bila u dužini stražnje noge (0,7 cm). Navedeni rezultati nisu u skladu s onima Santos i sur. (2008) koji su utvrdili bolju razvijenost trupa sisajuće jaradi u odnosu na janjad iste kategorije. Međutim, rezultate izmjera trupova

janjadi iz predmetnog istraživanja teško je uspoređivati s podacima iz literature, ponajviše zbog razlika u klaoničkim masama i genotipovima janjadi te metodama korištenim prilikom mjerenja trupova. Primjerice, janjad dalmatinske pramenke imala je, u usporedbi s janjadi španjolske pasmine Segureña zaklane u rasponu tjelesne mase od 19 do 25 kg, gotovo identične vrijednosti mjera dužine stražnje noge i dubine prsiju (Peña i sur., 2005). Međutim, janjad iz ovog istraživanja je po dužini trupa i dubini prsiju prednjačila, a po širini prsiju i zdjelice zaostajala za Apenninica janjadi podjednake tjelesne mase (Russo i sur., 2003).

Spol životinja je značajno ( $P < 0,01$ ) utjecao samo na dubinu prsiju i dužinu stražnje noge koje su bile veće u muške nego u ženske janjadi i jaradi. Vrijednosti dužine trupa te širine prsiju i zdjelice bile su također, ali neznatno, više u trupova muških grla.

Tablica 2. Klaonički pokazatelji muške i ženske janjadi i jaradi (LSM±SE)

Pokazatelj	Vrsta		Spol		Signifikantnost	
	Janjad (n=49)	Jarad (n=52)	Muški (n=49)	Ženski (n=52)	Vrsta	Spol
Randman,%	51,5±0,38	48,1±0,37	49,3±0,46	50,0±0,42	***	NS
Želudac i crijeva, kg	6,4±0,12	7,6±0,11	7,3±0,15	6,8±0,13	***	**
Pluća i srce, kg	0,59±0,01	0,48±0,01	0,56±0,01	0,51±0,01	***	*
Jetra, kg	0,50±0,01	0,46±0,01	0,50±0,01	0,46±0,01	**	*
Slezena, g	0,08±0,01	0,07±0,01	0,07±0,01	0,08±0,01	**	*
Testisi, g	0,20±0,03	0,19±0,03	-	-	NS	-
Koža i noge, kg	3,2±0,04	2,2±0,03	2,9±0,08	2,6±0,07	***	**
Rogovi, g	0,15±0,01	0,11±0,01	0,16±0,01	0,10±0,01	**	***

<sup>a,b</sup> prosječne vrijednosti za vrstu ili spol u istom redu označene različitim slovom značajno se razlikuju.

NS: nije signifikantno; \*  $P < 0,05$ ; \*\*  $< 0,01$ ; P\*\*\*  $P < 0,001$ .

Tablica 3. Prosječne mjere (cm) janječih i jarećih trupova (LSM±SE)

Pokazatelj	Vrsta		Spol		Signifikantnost	
	Janjad (n=49)	Jarad (n=52)	Muški (n=49)	Ženski (n=52)	Vrsta	Spol
Dužina trupa	67,1±0,43	61,1±0,41	64,6±0,61	63,3±0,56	***	NS
Dubina prsiju	24,8±0,14	23,8±0,13	24,6±0,15	24,0±0,14	***	**
Dužina stražnje noge	25,8±0,16	25,1±0,15	25,8±0,16	25,1±0,15	***	**
Širina prsiju	14,3±0,09	11,4±0,09	12,9±0,24	12,6±0,22	***	NS
Širina zdjelice	15,0±0,19	13,0±0,18	14,2±0,24	13,7±0,22	***	NS

<sup>a,b</sup> prosječne vrijednosti za vrstu ili spol u istom redu označene različitim slovom značajno se razlikuju.

NS: nije signifikantno; \*  $P < 0,05$ ; \*\*  $P < 0,01$ ; P\*\*\*  $P < 0,001$ .

### Zaključak

Na osnovu rezultata utvrđenih ovim istraživanjem može se zaključiti kako su utvrđene značajne razlike u klaoničkim pokazateljima i odlikama trupa janjadi i jaradi podjednagog stupnja dozrelosti. Navedene razlike se, najvjerojatnije, mogu pripisati pripadnošću vrsti, uz napomenu da bi se vrijednost randmana točnije procijenila kada bi bio izražen u postotku tjelesne mase životinje bez sadržaja želuca i crijeva. Uz to, ženska janjad i jarad u odnosu na mušku pri približno jednakoj klaoničkoj masi imaju podjednak randman te neznatno manje razvijen trup.

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# Procjena kvalitete krme na uzorcima fecesa sa NIR spektroskopijom

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## Sažetak

Cilj istraživanja bio je utvrditi mogućnosti korištenja NIR spektroskopije za procjenu hranjivosti krme skeniranjem uzoraka fecesa. Korišteno je 66 uzoraka fecesa kastriranih ovnova hranjenih fermentiranom voluminoznom krmom. Uzorci su skenirani na NIRS aparatu (Foss, Model 6500) u rasponu valnih duljina 1100-2500 nm. Nakon pridruživanja referentnih vrijednosti spektralnim podacima, model je razvijen modificiranom metodom parcijalnih najmanjih kvadrata (MPLS).

Obzirom na determinacijski koeficijent ( $R^2$ ), standardnu grešku kalibracije (SEC) i standardnu grešku unakrsne validacije (SECV), razvijeni model se pokazao najprihvatljivijim za procjenu pH vrijednosti (0,82; 0,52 i 0,28, respektivno), zatim za probavljivost suhe tvari (ST) (0,78; 57,03 g kg<sup>-1</sup> ST i 65,57 g kg<sup>-1</sup> ST, respektivno), probavljivost organske tvari (OT) (0,76; 59,79 g kg<sup>-1</sup> ST i 70,37 g kg<sup>-1</sup> ST, respektivno) i sadržaj ST (0,76; 61,01 g kg<sup>-1</sup> svježeg uzorka i 68,69 g kg<sup>-1</sup> svježeg uzorka, respektivno).

Relativno niske  $R^2$  vrijednosti i visoke SEC vrijednosti vjerojatno su rezultat korištenja seta uzoraka koji nije zadovoljio uobičajene kriterije odabira uzoraka za razvoj primjenjive kalibracije (premalen broj uzoraka, prevelika varijabilnost krme) što je ograničilo razvoj pouzdanijeg kalibracijskog modela.

Ključne riječi: NIR spektroskopija, hranidbena vrijednost krme, feces

## Faecal NIR for predicting forage quality in sheep

### Abstract

The objective of the research was to determine the potential of NIR spectroscopy for prediction of fermented forage quality from sheep faeces. Sixty-six faecal samples originated from wether sheep fed fermented forage were used in the experiment. Samples were analyzed by chemical and NIRS procedures (1100-2500 nm). A calibration equation was established using modified partial least square (MPLS) procedure.

Based on the coefficient of determination ( $R^2$ ), standard error of calibration (SEC) and standard error of cross validation (SECV) reliable estimates were developed for pH prediction (0.82; 0.52 and 0.28, respectively), dry matter (DM) digestibility (0.78; 57.03 g kg<sup>-1</sup> DM and 65.57 g kg<sup>-1</sup> DM, respectively), organic matter (OM) digestibility (0.76; 59.79 g kg<sup>-1</sup> DM and 70.37 g kg<sup>-1</sup> DM, respectively), DM concentration (0.76; 61.01 g kg<sup>-1</sup> fresh sample and 68.69 g kg<sup>-1</sup> fresh sample, respectively).

A development of more reliable calibration models was limited due to low number of samples highly variable in regard to nutrient concentration and feeding value.

Key words: NIR spectroscopy, feeding value, faeces

## Uvod

Refleksijska spektroskopija u bliskom infracrvenom području (engl. Near Infrared Reflectance Spectroscopy) (NIRS), bazira se na pozitivnoj korelaciji između kemijskih osobina uzoraka utvrđenih klasičnim kemijskim metodama ("mokra" kemija) i apsorpciji svjetla na različitim valnim duljinama u bliskom infracrvenom području, mjereno pomoću refleksije koja se za procjenu kemijskog sastava oslanja na kalibracije (Batten, 1998).

NIR spektroskopija je brza, fizikalna, nedestruktivna metoda koja može davati precizne i točne rezultate uz minimalnu ili nikakvu pripremu uzoraka, a nakon analize uzorci ostanu sačuvani. Osim toga, NIR spektroskopija je multikomponentna tehnika budući da paralelno procjenjuje nekoliko kemijskih i/ili bioloških parametara. Kod primjene NIR spektroskopije nema korištenja kemikalija, pa je ekološki potpuno prihvatljiva.

Osnova hranidbenih programa je analiza krme koju će životinje konzumirati, ali ukoliko se želi utvrditi hranjivost konzumiranih obroka, pouzdanim se pokazalo NIR spektroskopijom razvijati kalibracijske modele skeniranjem uzoraka fecesa. S tim u svezi su provedena brojna istraživanja korištenjem fecesa goveda (Boval i sur., 2004), ovaca (Li i sur., 2007) i koza (Landau i sur., 2004), koja ukazuju na visoki potencijal NIR spektroskopije za procjenu kemijskih i bioloških parametara konzumirane krme.

Hipoteza istraživanja bila je da se skeniranjem uzoraka fecesa, NIR spektroskopijom, može procjenjivati hranjivost krme koju je životinja konzumirala. Cilj istraživanja bio je skeniranjem uzoraka fecesa utvrditi mogućnosti korištenja NIR spektroskopije za procjenu hranjivosti krme.

## Materijal i metode

U Centru za travnjaštvo Agronomskog fakulteta je tijekom 2005. godine provedeno istraživanje utjecaja dodatka kukuruzne silaže (33% vs. 67% bazirano na ST) travnoj silaži različitih rokova košnje na *in vivo* probavljivost obroka u hranidbi kastriranih ovnova, a 2007. godine istraživanje utjecaja dodatka aditiva sjenazi crvene djeteline i lucerne na hranjivost obroka u hranidbi kastriranih ovnova.

Prikupljeni uzorci (66 uzoraka hrane, 66 uzoraka ostataka hrane, 66 uzoraka fecesa) su osušeni na temperaturi od 60°C radi utvrđivanja sadržaja ST, zatim su samljeveni na mlinu čekičaru kroz sito promjera 1mm i analizirani referentnim kemijskim metodama radi utvrđivanja laboratorijske suhe tvari (ST) po ISO 6496, sadržaja organske tvari (OT) po ISO 5984, sadržaja N po ISO 5983, pH vrijednosti (Serale, 1984), sadržaja neutralnih detergent vlakana (NDV) i sadržaja kiselih detergent vlakana (KDV) (Van Soest i sur., 1991).

Ukupno 66 uzoraka fecesa (50 iz prvog istraživanja i 16 iz drugog istraživanja) je dosušeno tijekom 5 sati na temperaturi od 105°C, a zatim skenirano na NIR aparatu (Foss, Model 6500), u ISI SCAN programu u rasponu valnih duljina od 1100 do 2500 nm. Svaki uzorak je skeniran po dva puta, a spektralni podatci su bilježeni svaka 2 nm, čime je dobiveno po 700 podataka po jednom spektru. Spektralni podatci skeniranih uzoraka su obrađeni u WIN ISI III programskom paketu gdje su im dodijeljene referentne vrijednosti praćenih kemijskih i bioloških parametara hranjivosti krme.

Korišteno je 66 uzoraka fecesa, poznatih referentnih vrijednosti, koji su odabrani metodom slučajnosti pomoću WIN ISI III programa. Za modeliranje rezultata istraživanja je primijenjena modificirana metoda parcijalnih najmanjih kvadrata (MPLS) koja koristi sve valne duljine za razvoj kalibracije i najčešće se primjenjuje za razvoj kalibracija za poljoprivredne proizvode.

Pouzdanost razvijene kalibracije je ocijenjena statističkim parametrima; standardnom greškom kalibracije (SEC), koeficijentom determinacije ( $R^2$ ), standardnom greškom unakrsne validacije (SECV) i standardnom greškom procjene (SEP).

## Rezultati i rasprava

U prikazu hranjivosti uzoraka krme, od koje su porijeklom skenirani uzorci fecesa, (tablica 1) vidljive su varijacije sadržaja svih utvrđivanih parametara hranjivosti radi različitosti vrsta krme: 5 uzoraka su kukuruzne silaže, 15 uzoraka su travno-djetelinske sjenaze, 30 uzoraka su kombinacije travno-djetelinskih sjenaza i kukuruzne silaže, 8 uzoraka su sjenaze lucerne (4 silirane bez aditiva, a 4 silirane s dodatkom aditiva), a 8 uzoraka su sjenaze crvene djeteline (4 silirane bez aditiva, a 4 silirane s dodatkom aditiva).

Tablica 1. Kemijski sastav korištenih uzoraka krme utvrđen "mokrom" kemijom i *in vivo* istraživanjima hranjivosti (n=66)

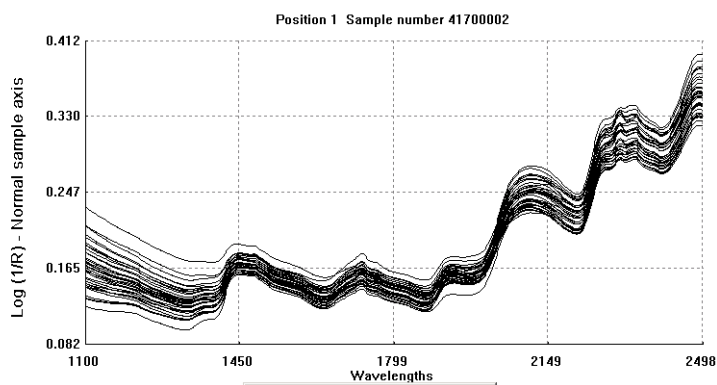
Kemijski parametar	minimalno	maksimalno	srednja vrijednost	STD
ST (g kg <sup>-1</sup> svježeg uzorka)	214,2	744,59	430,53	127,22
OT (g kg <sup>-1</sup> ST)	867,06	971,25	918,86	15,66
SP (g kg <sup>-1</sup> ST)	64,02	143,59	103,76	22,3
pH vrijednost	3,63	6,93	4,59	0,64
NDV (g kg <sup>-1</sup> ST)	540,66	856,52	669,52	83,53
KDV (g kg <sup>-1</sup> ST)	268,48	482,8	398,87	46,39
Probavljivost ST (g kg <sup>-1</sup> )	300,09	487,43	418,37	163,41
Probavljivost OT (g kg <sup>-1</sup> )	330,96	766,5	588,67	120,12

ST, suha tvar; OT, organska tvar; SP, sirovi proteini; NDV, neutralna detergent vlaknina; KDV, kisela detergent vlaknina; STD, standardna devijacija

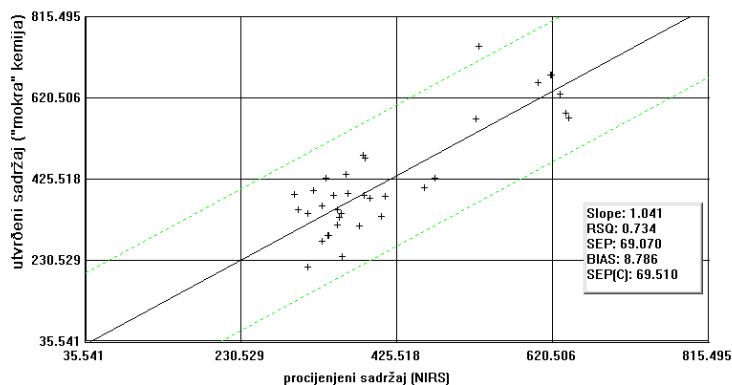
Tablica 2. Procjena kemijskih i bioloških parametara hranjivosti krme pomoću MPLS metode

Kemijski parametar	N	Srednja vrijednost	SD	Minimalna vrijednost	Maksimalna vrijednost	SEC	RSQ	SECV
ST (g kg <sup>-1</sup> svježeg uzorka)	33	414,21	126,07	36,02	792,52	61,01	0,76	68,69
OT (g kg <sup>-1</sup> ST)	32	916,58	10,26	885,79	947,37	9,38	0,16	10,90
SP (g kg <sup>-1</sup> ST)	35	106,03	22,70	37,93	174,13	15,08	0,55	15,93
pH	33	4,53	0,59	2,76	6,31	0,25	0,82	0,28
NDV (g kg <sup>-1</sup> ST)	24	660,98	76,79	430,61	891,35	56,44	0,45	66,75
KDV (g kg <sup>-1</sup> ST)	35	397,29	48,77	250,96	543,62	41,07	0,29	45,90
Probavljivost ST (g kg <sup>-1</sup> )	34	574,55	122,45	207,18	941,93	57,03	0,78	65,57
Probavljivost OT (g kg <sup>-1</sup> )	34	591,22	122,53	223,61	958,83	59,79	0,76	70,37

ST, suha tvar; OT, organska tvar; SP, sirovi proteini; NDV, neutralna detergent vlaknina; KDV, kisela detergent vlaknina; STD, standardna devijacija; SEC, standardna greška kalibracije; RSQ, koeficijent determinacije; SECV, standardna greška unakrsne validacije.



Grafikon 1. Spektralni prikaz uzoraka fecesa korištenih za razvoj kalibracije



Grafikon 2. Utvrđeni i procijenjeni sadržaj suhe tvari



Da bi bio prihvatljiv, minimalni determinacijski koeficijent ( $R^2$ ) NIR kalibracijskog modela treba biti  $>0,80$ . U ovom istraživanju (tablica 2) je visoki  $R^2$  utvrđen za pH vrijednost ( $R^2=0,82$ ).

Za probavljivost OT je  $R^2$  iznosio 0,76 što je nešto niže od  $R^2$  u sličnom istraživanju koje su korištenjem PLS metode proveli Li i sur. (2007) ( $R^2=0,80$ ) ili Boval i sur. (2004.) skeniranjem fecesa goveda ( $R^2 = 0,98$ ).

Za sadržaj ST uzoraka krme je utvrđen viši  $R^2$  (0,78) nego u istraživanju koje su proveli Landau i sur. (2004) ( $R^2=0,72$ ) korištenjem fecesa ovaca. Nizak  $R^2$  je utvrđen za sadržaj OT ( $R^2=0,16$ ).

### Zaključci

Procjena kemijskih i bioloških parametara hranjivosti krme pomoću NIR spektroskopije je relativno jeftina i brza metoda u usporedbi s "mokrom" kemijom. Potrebna je mala količina uzorka za analiziranje, nekoliko kemijskih parametara može procijeniti paralelno, ne koriste se kemikalije, a uzorak ostane sačuvan nakon analize. Pouzdanost NIR analiza najvećim je dijelom ovisna o odabiru i točnosti analiza "moke" kemije uzoraka koji se koriste za razvoj kalibracije.

Procjena kemijskog sastava i hranjive vrijednosti krme koje su konzumirale ovce govori o visokom potencijalu NIR spektroskopije a procjenu pH vrijednosti ( $R^2=0,82$ ) u ovom istraživanju. Visoke SEC vrijednosti za pojedine istraživane parametre su vjerojatno rezultat odabira seta uzoraka koji nije zadovoljio uobičajene kriterije odabira uzoraka za razvoj šire primjenjive kalibracije (visoka varijacija hranjivosti između krmiva, te mali broj korištenih uzoraka), što je ograničilo razvoj modela.

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# Influence of yoghurt cultures on some chemical parameters of sheep's milk yoghurt during storage

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## Abstract

The aim of this study was to determine the influence of two different commercial yoghurt cultures (L811 and X11) on the changes of some chemical parameters of sheep's milk yoghurt during storage over a period of 21 days. Chemical parameters were determined in yoghurts on the 1<sup>st</sup>, 7<sup>th</sup>, 14<sup>th</sup> and the 21<sup>st</sup> day of storage at the temperature of  $4 \pm 1^\circ\text{C}$ . The results showed that the pH, titratable acidity and protein content had changed significantly ( $P < 0.05$ ) during the whole storage period in the yoghurts produced with both used yoghurt cultures. On the other hand, the content of fat, lactose and total solids remained statistically unchanged ( $P < 0.05$ ). It can be concluded that both used yoghurt cultures are capable of producing yoghurt which maintains characteristic content of chemical parameters during whole storage period.

Key words: sheep's milk yoghurt, chemical parameters, yoghurt culture, yoghurt storage

## Utjecaj mljekarskih kultura na određene kemijske parametre ovčjeg jogurta tijekom čuvanja

### Sažetak

Cilj ovog rada bio je odrediti određene kemijske parametre čvrstog ovčjeg jogurta ( $n=8$ ) proizvedenog pomoću dvije različite komercijalne mljekarske kulture (L811 i X11) tijekom vremena čuvanja od 21 dan. Kemijski parametri su određeni 1., 7., 14. i 21. dana čuvanja na temperaturi od  $4 \pm 1^\circ\text{C}$ . Rezultati su pokazali da su se pH, titracijska kiselost i sadržaj bjelančevina značajno promijenili ( $P < 0,05$ ) tijekom čuvanja u jogurtu proizvedenom korištenjem obje mljekarske kulture. Nasuprot tome, u oba jogurta nije utvrđena statistički značajna promjena ( $P < 0,05$ ) sadržaja mliječne masti, laktoze i ukupne suhe tvari. Na temelju rezultata analiza može se zaključiti da se obje mljekarske kulture mogu upotrijebiti za proizvodnju čvrstog ovčjeg jogurta koji, tijekom vremena čuvanja, posjeduje karakteristične vrijednosti istraživanih kemijskih parametara.

Ključne riječi: ovčji jogurt, kemijska svojstva, jogurtna kultura, čuvanje jogurta

### Introduction

Sheep's milk is widely used in different regions of the world for the production of yoghurt. In comparison with cow's milk sheep's milk contains significantly higher content of total proteins, casein, calcium, magnesium, phosphorus and significantly higher content of metabolically valuable short and medium chain fatty acids (Park et al., 2007; Raynal-Ljutovac et al., 2008). Consequently, sheep's milk yoghurt possesses better versatile nutritional and functional properties than cow's milk yoghurt. During refrigerated storage

sheep's milk yoghurt undergoes microbiological, enzymatic and abiotic changes that can negatively affect its overall quality and shelf life. The cause of microbiological changes are microorganisms which are capable to survive low storage temperatures, low pH and create colonies and/or films on the yoghurt surface and therefore diminish yoghurt quality (Rašić and Kurmann, 1978; Tamime and Robinson, 1999). Moreover, bacterial enzymes cause negative changes of yoghurts consistency and texture during storage. Those enzymes mostly originate from yoghurt culture bacteria but also from microorganisms that contaminates milk and/or yoghurt. Abiotic processes includes chemical reactions which causes changes of fat, proteins, carbohydrates, vitamins and salts in yoghurt during storage. The outcome of those processes can be formation of unwanted changes on the yoghurt surface and degradation of overall quality. Depending on the quality of sheep's milk used for the yoghurt production, ratio between the number of viable yoghurt culture bacteria, final pH and storage conditions, above mentioned negative changes can be more or less expressed (Rašić i Kurmann, 1978.; Tratnik, 1998.).

The aim of this study was to determine the influence of two different commercial yoghurt cultures on the changes of some chemical parameters of sheep's milk yoghurt during storage.

### Material and methods

The whole sheep's milk (milk) from East Friesian breed was collected from a farm located in Varazdin, Croatia. Milk quality has been established according to European legislation which sets out the microbiological quality parameters for the production and placing on the market of raw milk, heat-treated milk and milk-based products (European Commission 1992). Two commercial FD-DVS yoghurt cultures L811 and X11 (starters) (Christian Hansen, Denmark), were used for the inoculation of milk. Both starters are available on the Croatian market and mostly used on Croatian dairy plants for the production of cow's milk set yoghurt. It is assumed that use of those starters will also be appropriate for the production of sheep's milk set yoghurt (yoghurt). Starters were mixed cultures consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*.

The milk for yoghurt production was neither standardised nor homogenised. The experiment was designed in a way that the collected milk (4 l) was divided into two equal portions for the production of two yoghurt sets using two different starters. After thermal treatment (90°C/5 minutes) the milk was cooled to 42°C and inoculated with starter in the concentration of 0,02%. The inoculated milk (2 l per set) was then poured into 100 ml glass flasks (flasks), corked and left for fermentation at a temperature of 42°C until pH 4.60 was attained. The flasks were then transferred to cold storage (4 ± 1°C). All steps of yoghurt production were carried out in the sterile environment.

Twenty flasks of yoghurt made by starter L811 (Set L811) and twenty flasks made by starter X11 (Set X11) were produced. Yoghurt analysis was conducted in a way that five flasks of each yoghurt set were taken out on the 1<sup>st</sup>, 7<sup>th</sup>, 14<sup>th</sup> and 21<sup>st</sup> day of cold storage and used for chemical analysis. The number of samples (n) used in this study was 8 (n = two portions for the production of L811 and X11 yoghurt set x four different days of storage).

The pH of milk was measured using a pH meter (SevenMulti, Mettler Toledo, Switzerland). Titratable acidity (TA) was determined by the titration method (Sabadoš 1996a). The content of milk fat, protein, lactose, total solids (TS) and solids non fat (SNF) were determined by the infrared method (ISO 1999).

The pH of yoghurts was measured using a pH meter (SevenMulti, Mettler Toledo, Switzerland). TA was determined by the titration method (Sabadoš 1996b). The content of milk fat (fat), protein, carbohydrates and total solids (TS) were determined by the infrared method on the instrument Milkoscan FT 120 (FossElectric, Denmark). All measurements were taken in five parallel determinations.

One-way analysis of variance (ANOVA) was used to analyse the data, Bartlett's test for equal variances testing and Tukey's test for multiple comparisons at 95% confidence interval. The data was analysed using Prism software (GraphPad Software, San Diego CA).

### Results and discussion

The average composition of milk used for yoghurt production was as follows: TA 9.50 °SH, pH 6.67, fat 5.54 g/100g, protein 4.48 g/100g, lactose 4.70 g/100g, TS 15.50 g/100g and SNF 10.21 g/100g. The content of fat, protein, lactose, TS and SNF of milk were lower than reported by Anifantakis (1986) for East Friesian breed

and roughly equal to the results reported by Niznikovski (1992). It must be emphasised that the reported results from these two authors were averages for a whole lactation period and not only for a segment of lactation period as is the case in this study.

The results for pH and TA (Table 1) were significantly ( $P<0.05$ ) affected by storage in both yoghurt sets and decreased continuously. This can be attributed to acid production during cold storage as a result of the conversion of lactose to lactic acid by the bacterial cultures (Katsiari et al., 2002). Similar results for a total storage period of 14 days were reported by Dave and Shah (1997), Birollo et al., (2000), Bonczar et al., (2002) and Güler-Akin (2005). Different starters significantly influenced ( $P<0.05$ ) TA of yoghurts on the 14<sup>th</sup> and the 21<sup>st</sup> day of storage. On the other hand, different starters did not significantly influence the pH in yoghurts during whole storage period.

**Table 1. Titratable acidity and pH values of yoghurt during storage<sup>1</sup>**

Yoghurt set	Day of storage	Titratable acidity ( <sup>0</sup> SH)	pH
L-818	1	39,77±0,08 <sup>a</sup>	4,62±0,02 <sup>a</sup>
	7	42,58±0,21 <sup>b</sup>	4,54±0,03 <sup>b</sup>
	14	47,02±0,10 <sup>c</sup>	4,24±0,05 <sup>c</sup>
	21	48,23±0,08 <sup>d</sup>	4,12±0,04 <sup>d</sup>
X-11	1	39,72±0,09 <sup>a</sup>	4,62±0,03 <sup>a</sup>
	7	42,71±0,11 <sup>b</sup>	4,54±0,04 <sup>b</sup>
	14	47,40±0,18 <sup>e</sup>	4,27±0,04 <sup>c</sup>
	21	47,90±0,08 <sup>f</sup>	4,09±0,04 <sup>d</sup>

<sup>1</sup> presented values are the means ± standard deviations of five parallel results.

<sup>a, b, c, d, e, f</sup>, values in the same in the same column for the same property having different superscripts differ significantly ( $P<0.05$ ).

There was no observed significant ( $P<0.05$ ) change in the fat content within both yoghurt sets (L-818 and X-11) (Table 2). This indicates that there was no significant lipolysis during storage period. Normally, lipolysis tends to cause negative changes in yoghurt due to the combination of factors such as low pH, low storage temperature and relatively short shelf life (Deeth, 2002) which was not the case in this study. Moreover, there was no significant difference ( $P<0.05$ ) in the concentration of fat between yoghurt sets L-818 and X-11 which indicates that used starters do not have influence on the degradation of fat.

The content of protein (Table 2) was statistically the same ( $P<0.05$ ) in both used yoghurt sets during the 1<sup>st</sup> and 7<sup>th</sup> day of storage. On the 14<sup>th</sup> and the 21<sup>st</sup> day of storage the proteolysis was more expressed in yoghurt set L818 than in the X-11 ( $P<0.5$ ) probably due to the higher proteolytic activity of starter microorganisms. Furthermore, Serra et al., (2009) determined hydrolysis of casein and increase in soluble nitrogen at the end of storage of yoghurt which consequently means decrease of total protein content which was not the case in this study.

**Table 2. Some chemical parameters of sheep's milk yoghurt during storage<sup>1</sup>**

Yoghurt set	Day of storage	Fat (g/100g)	Protein (g/100g)	Lactose (g/100g)	Total solids (g/100g)
L-818	1	5,50±0,02 <sup>a</sup>	4,72±0,04 <sup>a</sup>	4,64±0,04 <sup>a</sup>	15,23±0,05 <sup>a</sup>
	7	5,49±0,02 <sup>a</sup>	4,62±0,02 <sup>b</sup>	4,64±0,02 <sup>a</sup>	15,23±0,06 <sup>a</sup>
	14	5,49±0,03 <sup>a</sup>	4,58±0,01 <sup>c</sup>	4,63±0,02 <sup>a</sup>	15,23±0,06 <sup>a</sup>
	21	5,49±0,02 <sup>a</sup>	4,49±0,04 <sup>d</sup>	4,62±0,02 <sup>a</sup>	15,22±0,07 <sup>a</sup>
X-11	1	5,50±0,03 <sup>a</sup>	4,70±0,02 <sup>a</sup>	4,65±0,02 <sup>a</sup>	15,23±0,04 <sup>a</sup>
	7	5,50±0,02 <sup>a</sup>	4,62±0,03 <sup>b</sup>	4,63±0,03 <sup>a</sup>	15,22±0,05 <sup>a</sup>
	14	5,50±0,02 <sup>a</sup>	4,62±0,02 <sup>b</sup>	4,63±0,03 <sup>a</sup>	15,23±0,05 <sup>a</sup>
	21	5,50±0,02 <sup>a</sup>	4,62±0,03 <sup>b</sup>	4,63±0,03 <sup>a</sup>	15,22±0,06 <sup>a</sup>

<sup>1</sup> presented values are the means ± standard deviations of five parallel results.

<sup>a, b</sup> values in the same in the same column for the same property having different superscripts differ significantly ( $P<0.05$ ).

Unexpectedly, there was no statistically significant ( $P<0.05$ ) change in the content of lactose between and within sets during whole storage period (Table 2). It was assumed that the concentration of lactose would decrease due to its fermentation by starter bacteria. Katsiary et al., (2002) reported the 6% decrease of lactose concentration on 14<sup>th</sup> day of storage of ovine yoghurt which is not in compliance with the results of this

study. It must be emphasised that the measurement uncertainty of the IR method used in this study for the detection of lactose was 1.08% of the total lactose content.

There was no statistically significant change ( $P < 0.05$ ) in the total solids content between and within sets of yoghurt (L-818 and X-11) during whole storage period. The total solids content was unaffected by the decrease of protein content because of the permanent presence of hydrolysed protein and other nitrogen compounds in yoghurt.

### Conclusion

The results of this study indicate that the pH, titratable acidity and protein content significantly ( $P < 0.05$ ) changed during storage ( $4 \pm 1^\circ\text{C}$ ) over a period of 21 days in sheep's milk yoghurts produced with both used yoghurt cultures (L-818 and X-11). On the other hand, the content of fat, lactose and total solids remained statistically unchanged ( $P < 0.05$ ) meaning that both used yoghurt cultures are capable of producing set type sheep's milk yoghurt which maintains acceptable chemical parameters during whole storage period.

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# Stabilnost ampelografskih značajki izabranih genotipova cv. Plavina i Debit (*Vitis vinifera* L.) u postupku klonske selekcije

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## Sažetak

Plavina i Debit su gospodarski značajne autohtone sorte podregije Sjeverna Dalmacija. Posebice su važne na drniškom području gdje su dvije glavne sorte. Klonska selekcija ovih dvaju kultivara započela je 2006. godine u okviru istraživačkog projekta "Unutarsortna raznolikost vinove loze i unaprjeđenje metoda klonske selekcije". Na temelju masovne pozitivne selekcije izdvojeno je po deset genotipova od svake sorte koji su pokazali pozitivna gospodarska svojstva. Klonski kandidati su testirani ELISA testom na prisutnost gospodarski značajnih, zakonom propisanih virusa: GFLV - *Grapevine fanleaf virus*, ArMV - *Arabis mosaic virus*, GLRaV - 1 i GLRaV - 3 - *Grapevine leafroll virus*. U 2007., 2008. i 2009. godini provedena je detaljna ampelografska evaluacija matičnih trsova klonskih kandidata koja je uključivala utvrđivanje parametara prinosa grožđa i kakvoće mošta. Utvrđena je velika varijabilnost ampelografskih i gospodarskih svojstava u populaciji ovih dvaju kultivara što je važan pokazatelj i nužan preduvjet za daljnji nastavak selekcije. Klonski kandidati koji su pokazali najbolje rezultate i najmanje odstupanje promatranih svojstava između godina istraživanja odabrani su kao najperspektivniji za daljnji nastavak selekcije, tj. dobivanje klonova ove sorte.

Ključne riječi: vinova loza, klonska selekcija, Plavina, Debit

## Stability of ampelographic characteristics of the chosen genotypes cv. Plavina and Debit (*Vitis vinifera* L.) in the process of clonal selection

### Abstract

Plavina and Debit are two important autochthonous grapevine cultivars in the sub-region of North Dalmatia. These two cultivars are especially important in the Drniš area. Clone selection of these two cultivars started in the year 2006. as a part of an research project "Intravarietal variability of grapevine cultivars and the improvement of the methods of clone selection". Based on the mass positive selection ten candidate clones of each cultivar were chosen and tested by the ELISA test for the presence of economically imporant, legally requested viruses (*Grapevine fanleaf virus* - GFLV; *Arabis mosaic virus* - ArMV, *Grapevine leafroll virus* -1 and 3 - GLRaV-1, GLRaV-3). In 2007, 2008. and 2009. detailed ampelographic evaluation of clone candidate mother vines was made: yield/vine and must quality assessment. Great variability of the ampelographic and economically important characteristics was determined and showed as valuable information for the continuation of the selection. Clone candidates with best average result and minimum variation in observed characteristics between years of the research were chosen as the ones with the most perspective for the continuation of the selection - getting the clones of this cultivar.

Key words: grapevine, clone selection, Plavina, Debit

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## Uvod

Proizvodnja grožđa i vina u svijetu bazira se na uzgoju sorata europske loze - *Vitis vinifera* L. Poznato je kako kod dugotrajnog uzgoja neke sorte bez sustavne selekcije kod vegetativnog razmnožavanja dolazi do pojave unutar sorte varijabilnosti, najčešće je tomu razlog pojava mutacija koje mogu pozitivno ili negativno utjecati na gospodarski važna svojstva (Mullins i sur., 1992.). Virus i virusima slične bolesti imaju negativan utjecaj na proizvodne osobine vinove loze, a također mogu uzrokovati određenu varijabilnost unutar sorte (Walter i Martelli, 1998.) zbog čega se sanitarnom selekcijom genotipovi koji su njima zaraženi moraju isključiti iz daljnjeg razmnožavanja.

Klonska selekcija je proces kojim se nastoje izdvojiti genotipovi unutar sorte kod kojih je došlo do mutacija, koje su rezultirale u pozitivnoj promjeni nekih od gospodarski važnih svojstava (Maletić i sur. 2008.) Provođenje postupka selekcije nužan je preduvjet za proizvodnju kvalitetnog sadnog materijala poboljšanih sortnih svojstava i garantirane zdravstvene čistoće.

U okviru istraživačkog projekta "Unutar sorte raznolikost vinove loze i unaprjeđenje metoda klonske selekcije" započela je po prvi put selekcija više hrvatskih autohtonih sorata vinove loze za koje na tržištu još ne postoji certificirani sadni materijal. Među njima odabrane su i sorte Debit i Plavina.

Godine 2006. u uzgojnom području Debita i Plavine u okolini Drniša odabrani su matični trsovi na kojima su primijećene neke pozitivne karakteristike, a nisu očitovali simptome zaraze gospodarski značajnim virozama. U naredne tri godine provedena su ampelografska istraživanja odabranih matičnih trsova *in situ* kako bi se utvrdila stabilnost svojstava zbog koje su izabrani.

Cilj ovog istraživanja je u trogodišnjem periodu (berbe 2007., 2008., i 2009.) utvrditi stabilnost ampelografskih karakteristika matičnih trsova kultivara Debit i Plavina izabranih u postupku masovne selekcije, a konačni cilj je dobivanje klonova kod kojih su jasno izražene pozitivne promjene proizvodnih svojstava te koji su slobodni od gospodarski štetnih viroza. Na ovaj način se uspješno povećao prinos i kvaliteta Rizlinga rajnskog u Njemačkoj i Pinota crnog u Francuskoj (Jackson, 1993.), kao i brojnih drugih sorata.

## Materijal i metode

Klonska selekcija kultivara Plavina i Debit je počela 2006. godine masovnom klonskom selekcijom na širem drniškom području. Odabrani su trsovi koji su pokazivali određene pozitivne promjene gospodarskih karakteristika u odnosu na ostatak populacije sorte, i koji nisu pokazivali znakove oboljenja od viroza i sličnih bolesti

Od 2007. godine provode se detaljnija ampelografska istraživanja na odabranim trsovima. U ovom istraživanju prikazani su rezultati devet odabranih klonskih kandidata kultivara Debit i deset odabranih klonskih kandidata kultivara Plavina.

Nakon berbe koja je obavljena u punoj zrelosti izmjeren je prinos po trsu (kg/trsu), te su napravljene osnovne kemijske analize mošta: sadržaj šećera (Oe°) i kiselina (g/l) u moštu.

Tablica 1. Popis lokaliteta sa šiframa izdvojenih klonskih kandidata sorata Debit i Plavina

Klonski kandidati Debit-šifra			Klonski kandidati Plavina-šifra		
Debit-šifra	Lokacija	Položaj	Plavina-šifra	Lokacija	Položaj
VV - 221	Mratovo	Đžaja	VV - 224	Mratovo	Đžaja
VV - 223	Mratovo	Đžaja	VV - 242	Mratovo	Radasi
VV - 226	Mratovo	Đžaja	VV - 254	Mratovo	Đžaja
VV - 227	Mratovo	Radasi	VV - 259	Mratovo	Radasi
VV - 246	Mratovo	Radasi	VV - 281	Mratovo	Radasi
VV - 265	Mratovo	Đžaja	VV - 264	Mratovo	Radasi
VV - 271	Mratovo	Radasi	VV - 283	Mratovo	Radasi
VV - 275	Mratovo	Radasi	VV - 285	Mratovo	Radasi
VV - 279	Mratovo	Đžaja	VV - 287	Mratovo	Radasi
			VV - 289	Mratovo	Radasi

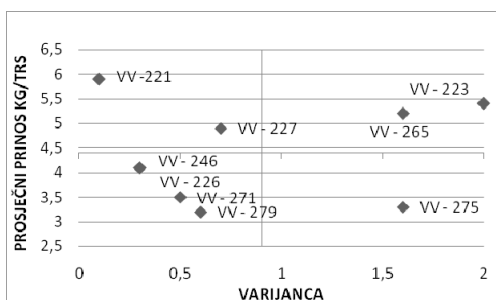
Kako bismo imali bolji uvid u stabilnost između pojedinih klonskih kandidata u trogodišnjem ispitivanju prinosa i kakvoće mošta, koristili smo odnose prosjeka i varijance za prinos, te sadržaj šećera i kiselost mošta. Ovi odnosi odražavaju važne karakteristike klonskih kandidata koji bitno utječu na njihove proizvodne karakteristike. Ove odnose prikazat ćemo grafički i to korištenjem "scatter plot" koji ćemo podijeliti na četiri kvadranta korištenjem prosječne vrijednosti za promatrano svojstvo te prosječne vrijednosti varijance svih klonskih kandidata. Svakom kvadrantu pridružit će se broj (1-4) pri čemu će broj jedan dobiti kvadrant u kojem su klonski kandidati sa najvećom prosječnom vrijednosti i najmanjom varijancom, a u četvrtom kvadrantu će biti klonski kandidati sa najmanjom prosječnom vrijednosti i najvećom varijancom. Kako bismo odredili najbolje klonske kandidate sa aspekta prinosa i sadržaja šećera i kiselina u moštu koristit ćemo sustav bodovanja zbrajanjem vrijednosti kvadranta za promatrana svojstva pri čemu će najbolji klonski kandidati biti oni sa najmanjim brojem bodova.

## Rezultati i rasprava

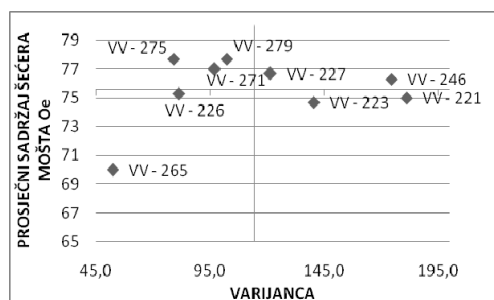
U grafu 1 prikazani su klonski kandidati kultivara Debit s obzirom na odnos između prosječne vrijednosti i varijance prinosa u trogodišnjem ispitivanju. Iz grafikona vidimo da su najstabilniji oni klonski kandidati koji se nalaze u 1. i 2. kvadrantu, a to su: VV-221, VV-226, VV-227, VV-246, VV-271, VV-279.

U grafu 2 prikazani su klonski kandidati kultivara Debit s obzirom na odnos prosječne vrijednosti i varijance sadržaja šećera u moštu u trogodišnjem ispitivanju. Iz grafikona je vidljivo da su najstabilniji oni klonski kandidati koji se nalaze u 1. i 2. kvadrantu, a to su: VV-226, VV-227, VV-265, VV-271, VV-275, VV-279.

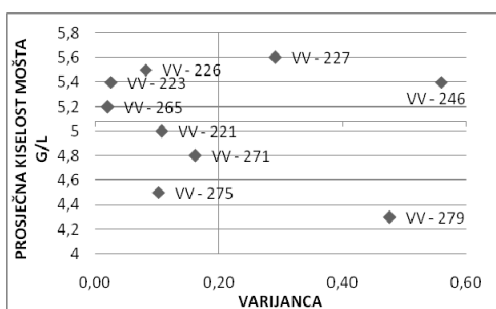
U grafu 3 prikazani su klonski kandidati kultivara Debit s obzirom na odnos prosječne vrijednosti i varijance sadržaja kiselina u moštu u trogodišnjem ispitivanju. Iz grafikona je vidljivo da su najstabilniji oni klonski kandidati koji se nalaze u 1. i 2. kvadrantu, a to su: VV-221, VV-223, VV-226, VV-265, VV-271, VV-275.



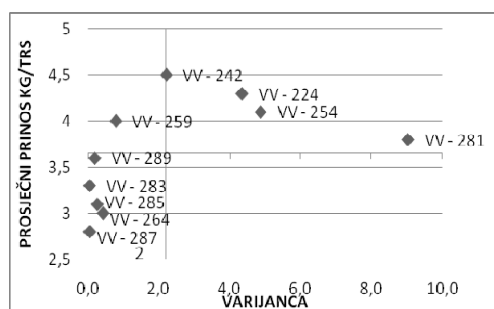
Graf 1 Odnos prosječne vrijednosti i varijance prinosa kultivara Debit u trogodišnjem ispitivanju



Graf 2 Odnos prosječne vrijednosti i varijance sadržaja šećera u moštu u kultivara Debit u trogodišnjem ispitivanju



Graf 3 Odnos prosječne vrijednosti i varijance sadržaja kiselina u moštu kultivara Debit u trogodišnjem ispitivanju

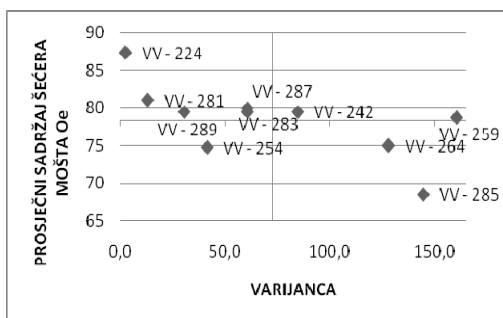


Graf 4 Odnos prosječne vrijednosti i varijance prinosa kultivara Plavina u trogodišnjem ispitivanju

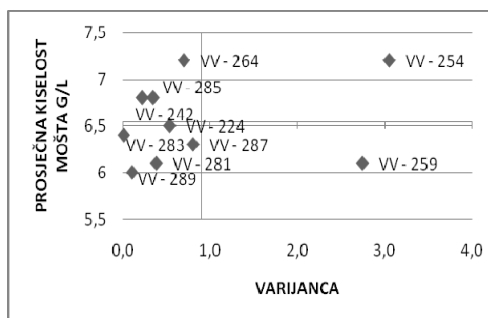
U grafu 4 prikazani su klonski kandidati kultivara Plavina s obzirom na odnos između prosječne vrijednosti i varijance prinosa u trogodišnjem ispitivanju. Iz grafikona vidimo da su najstabilniji oni klonski kandidati koji se nalaze u 1. i 2. kvadrantu, a to su: VV-242, VV-259, VV-264, VV-283, VV-285, VV-287, VV-289.

U grafu 5 prikazani su klonski kandidati kultivara Plavina s obzirom na odnos prosječne vrijednosti i varijance sadržaja šećera u moštu u trogodišnjem ispitivanju. Iz grafikona je vidljivo da su najstabilniji oni klonski kandidati koji se nalaze u 1. i 2. kvadrantu, a to su: VV-224, VV-254, VV-281, VV-283, VV-289.

U grafu 6 prikazani su klonski kandidati kultivara Plavina s obzirom na odnos između prosječne vrijednosti i varijance sadržaja kiselina u moštu u trogodišnjem ispitivanju. Iz grafikona je vidljivo da su stabilni svi klonski kandidati s obzirom na promatrano svojstvo osim klonskog kandidata VV-259.



Graf 5 Odnos prosječne vrijednosti i sadržaj šećera u moštu kultivara Plavina u trogodišnjem ispitivanju



Graf 6 Odnos prosječne vrijednosti i varijance sadržaja kiselina u moštu kultivara Plavina u trogodišnjem ispitivanju

Tablica 2 Rangiranje klonskih kandidata na temelju stabilnosti promatranih svojstava u trogodišnjem istraživanju

Klonski kandidati Debit-šifra	Broj bodova	Klonski kandidati Plavina-šifra	Broj bodova
VV - 221	7	VV - 224	6
VV - 223	8	VV - 242	5
VV - 226	5	VV - 254	8
VV - 227	6	VV - 259	8
VV - 246	8	VV - 281	6
VV - 265	7	VV - 264	7
VV - 271	5	VV - 283	5
VV - 275	7	VV - 285	7
VV - 279	7	VV - 287	7
		VV - 289	6

Iz tablice 2 vidljivo je da su najbolji oni klonski kandidati koji imaju najmanji broj bodova. To su kod kultivara Debit VV- 226 i VV - 271 dok su kod kultivara Plavina najbolji klonski kandidati VV-242 i VV-283.

### Zaključak

Na temelju rezultata evaluacije klonskih kandidata Debita i Plavine u 2007., 2008. i 2009. možemo zaključiti da u populaciji Debita i Plavine postoji značajna vrijabilnost gospodarskih svojstva, a posebice se ovo odnosi na Plavinu kod koje je utvrđeno veće variranje promatranih svojstava između klonskih kandidata u istraživanju. Temeljem dobivenih rezultata kao nužnost se nameće daljnji nastavak klonske selekcije gdje će ispitivanje klonskih linija u ujednačenim uvjetima omogućiti njihovu objektivniju ocjenu.

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# Effect of early basal leaf removal on grape structure and quality of Prokupac (*Vitis vinifera* L.)

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## Abstract

Defoliation is a measure directly regulating the ratio of the vine leaf surface, as the assimilator producer (source), and the grape bunches, as the consumers of such assimilators (sink). Depending on the phase in which the above measure is carried out, the influence on berry development and grape quality differs. The goal of the present paper is to examine influence of the assimilation surface decrease on the grape bunch and berry structure, and therefore on the grape quality, implementing the three-phase defoliation: flowering, berry set and veraison. Results of the two-year examination of cultivar Prokupac indicate that defoliation carried out during the flowering and 3-5 mm berry diameter most considerably influences decrease in the number of berries, decrease of the berry size, increase of the dry matter content in must, while increase in the content of total phenols and anthocyanins in berry skin has occurred only with the flowering phase defoliation.

Key words: defoliation, leaf area/crop weight, dry matter, total anthocyanins, total phenols.

## Utjecaj rane defolijacije bazalnih listova na strukturu i kvalitetu grožđa sorte Prokupac (*Vitis vinifera* L.)

### Sažetak

Defolijacija je mjera koja izravno regulira omjer površine listova vinove loze, kao izvora asimilativa (source) i grozdova, kao potrošača (sink). Ovisno o fazi u kojoj se mjera provodi, utjecaj na razvoj bobica i kvalitetu grožđa se razlikuje. Cilj ovog rada je ispitati utjecaj smanjenja asimilacione površine provođenjem defolijacije u tri termina: cvatnja, oplodnja i šara, na strukturu grožđa, a time i na njegovu kvalitetu. Rezultati dvogodišnjih ispitivanja sorte Prokupac ukazuju na to da defolijacija provedena tijekom cvatnje i u fazi promjera bobica od 3-5 mm, najviše utječe na znatno smanjenje broja bobica, smanjenje veličine bobica, povećanje suhe tvari u moštu, dok je do porasta u sadržaju ukupnih fenola i antocijana u koži bobica došlo samo u fazi cvatnje.

Ključne riječi: defolijacija, lisna površina / vegetativna masa, suha tvar, ukupni antocijani, ukupni fenoli

## Introduction

Partial removal of leaves from the shoots in the zone of bunches within flowering phenophase is the standard measure which should improve canopy microclimatic conditions; in fact, it should primarily improve bunch sensitivity which prompts accumulation of dry matter in must, anthocyanins and polyphenol compounds in berry skin (Kliwer 1970; Hunter et al.1991). In addition to that, better airing of bunches lowers the degree of damage caused by grey rot (Smart et al.1990; Gubler et al.1991). Defoliation carried out within this phase does not considerably influence the berry number and size within a bunch, nor the yield per vine.

Early defoliation, carried out within the intensive shoot growing phase, causes the total shoot photosynthesis level to decrease up to 70%, due to the removal of the photosynthetically active surface. The photosynthetic shock caused in such manner causes a halt in the sink organs development, which shows through the decreased number of berries within bunches, smaller berry size and change in the skin to pulp ratio (Poni et al.2005, 2006). Such grape structure changes are related to the increased accumulation of dry matter in must and phenol content in berry skin. The most prominent changes in the grape and berry structure occur when defoliation is carried out during the phase of intensive berry cell division after the end of flowering. Within that phase, the number of pericarp cells is determined and each halt in assimilator inflow results in a decreased cell number. Especially beneficial effects are achieved with the wine cultivars characterized by bigger bunches and berries, such as cultivar Prokupac. These cultivars, after defoliation, produce smaller and looser bunches, less yield and more beneficial berry skin to pulp ratio (Intrieri et al., 2008).

## Material and methodes

Cultivar Prokupac (*Vitis vinifera* L.) was examined in the production vineyard in village Rivica near Irig, Vojvodina, during 2008-2009. According to the location, the cultivar belongs to vineyards of Fruška Gora, characterized as a moderate continental climate.

The vineyard was established in 2003 with the planting space of 3 × 0.5 m. The short-cutting Lyra, composed of eighth spurs, with one winter bud per spur, was established as the trellising system.

The experiment was set as a random block design with 20 vines per experiment treatment, each vine representing an observation unit. The vines were tagged and randomly assigned to the following treatments: (a) non-defoliated (control) labelled as K; (b) hand removal of the first six basal leaves at the phenological stage 65 (full flowering: 50% of flowerhoods fallen according to BBCH scale, Lorenz et al.1994) labelled as I; (c) hand removal of the first six basal leaves at the phenological stage 73 (berries groat sized, ovary diameter varying from 2-5 mm according to BBCH scale, Lorenz et al.1994) labelled as II; (d) hand removal of the first six basal leaves at the stage 79 (majority of berries touching, according to BBCH scale, Lorenz et al.1994) labelled as III.

Berry size was monitored by measuring equatorial diameter of 30 randomly chosen berries per treatment, using an electronic caliper.

Cluster compactness was visually estimated using OIV (Organisation Internationale de la Vigne et du Vin) code 204 (OIV 1983), which ranks "berries in grouped formation with many visible pedicels" as 1 and "misshaped berries" as 9.

After the grape harvest, a representative sample of 3-5 kg of grape was taken from each experimental version and used for must and berry epidermis chemical analysis. Must quality was determined from representative samples during the grape harvest. Concentration of the total soluble solids (Brix) was determined by refractometer. Titratable acidity (TA) was measured by titration with 0.1 N NaOH to a pH 8.2 and point. Total anthocyanins and phenolics were determined by Vis-spectrophotometry.

## Results and discusion

Decrease in the assimilation inflow during the first 3-4 weeks of berry development, caused by early defoliation, was influenced on the berry size in treatments I and II to decrease in comparison with the version III and the control, which all persisted until the moment of harvest. Irreversible decrease in the berry size was caused due to the decreased assimilator inflow during the cell division phase, taking place within the first phase of berry development only (Mullins et al.1992; Ollat and Gaudillere, 1998).

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Defoliation carried out in flowering (stage 65) and fruit set (stage 73) phases caused statistically relevant differences in the number of berries due to the decrease in the degree of full blossomed berries (Table 1). This caused decrease in bunch compactness during the first two defoliation terms. The decreased assimilation surface during the flowering and fruit set phenophases resulted in a small number of set berries, as the consequence of the increased degree of flower abortions which has also been confirmed by other authors (Caspari and Lang 1996; Clingeleffer et al.2001; Poni et al.2005; Intrieri et al.2008).

Since the yield per vine depends on the number of bunches, as well as on the berry number and size, yield fluctuations per experiment version might be expected. Therefore, within treatments I and II, when the berry number and weight decreased, the yield and average bunch weight (Table 1) were also decreased, which was in accordance with similar examinations of Poni et al. (2006).

Influence of the defoliation time on the change in the skin to pulp ratio, has not been recorded within the present experiment. The size of skin and seed tissue grows simultaneously and proportionally to the berry (Roby and Matthews 2004; Matthews 2007).

**Table 1. Average value of the yield's elements, grape and berry structure depending on the defoliation timing (2008-2009)**

	Yield (kg per vine)	Bunch weight (g)	Berry number per bunch	Berry weight (g)	Cluster compactness (OIV code 204)	Skin to pulp ratio
I	0.97 <sup>a</sup>	142.0 <sup>a</sup>	65 <sup>a</sup>	2.33 <sup>a</sup>	3	0.046 <sup>a</sup>
II	1.79 <sup>b</sup>	303.0 <sup>b</sup>	102 <sup>b</sup>	2.59 <sup>ab</sup>	3-5	0.056 <sup>a</sup>
III	2.54 <sup>c</sup>	369.5 <sup>bc</sup>	146 <sup>c</sup>	2.63 <sup>bc</sup>	7	0.050 <sup>a</sup>
k	2.25 <sup>c</sup>	417.3 <sup>c</sup>	149 <sup>c</sup>	2.84 <sup>c</sup>	7	0.044 <sup>a</sup>
Lsd <sub>0,05</sub>	0.43224	79.9711	19.2311	0.242041	-	0.0123611

The content of soluble solids was statistically considerably different between the treatments I and II and the treatment III and the control (Table 2). The highest total acid content was recorded within the control. Chemical analysis of skin indicated that the statistically considerably higher content of total anthocyanins was recorded in the treatment I only, and total phenols in treatment I and II (Table 2). Many investigations have confirmed that the light exposure of bunches positively influences increase in the content of dry matter, total anthocyanins and phenols, decrease in the total acids and pH and the malate content (Kliewer 1970; Smart et al.1985; Morrison and Noble 1990; Dokoozlian and Kliewer 1996). Increase in the content of dry matter, the total anthocyanins and phenols in skin, due to early defoliation, may be a consequence of the source:sink ratio disorder between the assimilation surface and bunches. Previous studies have shown that removal of a part of the leaves from shoots directs assimilator transportation to bunches (Koblet et al.1993). According to the Poni et al.(2005), the early defoliation treatment influences development of more lateral shoots, which younger leaves have higher photosynthetic intensity during the ripening period. However, in our case it remains unclear why the anthocyanin content increased only within defoliation in the flowering phase, but not within the two other terms. The reason is not a very small berry within the I treatment, since its size has not influenced the more beneficial skin to pulp ratio (Table 1). The reason may be the fact that, within the treatments II and III, bunches get exposed to the temperatures higher than optimum for anthocyanin and phenols accumulation, causing berry overheating and its disintegration. Examinations of the Cabernet Sauvignon exposure to light, carried out by Bergqvist et al.(2001) indicate that influence of sunlight to the berry content depends on the berry temperature. At high temperatures, many metabolic processes cease or get less intensive (Jones, 1992). Temperature about 30°C is considered critical for grapevine (Coombe, 1987). Temperatures which exceed 30°C cause inhibition of anthocyanin accumulation in berries (Kliewer 1970; Mori et al., 2004).

**Table 2. Influence of defoliation time on the cultivar Prokupac must and epidermis chemical content in 2008-2009.**

	Soluble solids (Brix%)	Total acids (g l-1)	Total anthocyanins (mg g-1FW)	Total phenols (mg l-1 GAE)
I	23.5 <sup>a</sup>	7.0 <sup>a</sup>	6.35 <sup>a</sup>	632.4 <sup>a</sup>
II	23.3 <sup>a</sup>	7.0 <sup>a</sup>	5.69 <sup>b</sup>	573.1 <sup>b</sup>
III	22.6 <sup>b</sup>	7.1 <sup>a</sup>	5.61 <sup>b</sup>	524.8 <sup>c</sup>
K	22.2 <sup>b</sup>	7.3 <sup>b</sup>	5.69 <sup>b</sup>	518.13 <sup>c</sup>
Lsd <sub>(0,05)</sub>	0.612985	0.184976	0.65261	28.935

## Conclusion

This examination has confirmed considerable defoliation influence on the bunch structure and chemical content. Defoliation carried out during the period of pericarp cell division and growth causes irreversible decrease in the berry size in comparison with the later defoliation terms (flowering) and the control. Early defoliation has also influenced the lower degree of fruitset, resulting in looser grape bunches of less average weight. Therefore, the average yield within the early defoliation treatment has been lower. Early defoliation causes higher soluble solids content in must, higher content of the total phenols and anthocyanins in skin and lower content of the total acids.

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# Effect of gibberellic acid GA<sub>3</sub> on technological properties of Smederevka, Chaouch Blanc and Italia grape vine varieties

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## Abstract

The effect of GA<sub>3</sub> on three varieties, including Smederevka (wine variety), Chaouch Blanc (table grape variety of local importance) and Italia (table grape variety of significance to the table grape industry) was evaluated in this study. Gibberellic acid had a significant effect on the growth and development of grapevine organs. Depending on the concentration of gibberellic acid and stage of organ and variety development, different effects were achieved, including an increase in petiole length, blossom drop or an increase in berry size. Test results showed the strong influence of gibberellic acid in all three varieties on berry growth, uniformity of berry size, and earlier maturation. Moreover, GA<sub>3</sub> induced a substantial increase in berry size in var. Chaouch Blanc.

Key words: GA<sub>3</sub> - gibberellic acid, Smederevka, Chaouch Blanc, Italia

## Introduction

Gibberellic acid is known to have a substantial effect on grape quality. Depending on the date and rate of application, it leads to an increase in petiole length, blossom drop i.e. berry thinning as well as in an increase in berry size. The clusters produced are branched, loose, easy to pack and arrange, and highly attractive to customers. GA<sub>3</sub> is most commonly used in seedless varieties, but in other varieties as well (Sarooshi, R.A., 1977). The rate of GA<sub>3</sub> and application method are dependent upon variety and vine development stage. Gibberellic acid is applied before, during and after flowering when grain size reaches 2-3 mm or 7-8 mm (Dokoozlian et al. 2001). The application is made using an atomiser, a backpack sprayer or small vessels into which flowers or clusters are submerged. Method of application is largely dependent upon variety. Therefore, long-term research should be conducted in order to determine the most optimum application date. If applied incorrectly, gibberellic acid will lead to yield loss in seeded varieties in the following year. The grape vine variety Sultanina can serve as the most evident example of adequate use of gibberellic acid. A variety having a long large cluster and small-sized berries will yield a short branched loose cluster with large berries. The variety Sultanina is grown on 90,000 ha of land in California as the most important variety used to produce table grapes and raisins.

Three varieties, including Italia, Chaouch Blanc and Smederevka, are evaluated in this study. The objective of the study was to use gibberellic acid to reduce the number of small-sized berries in var. Italia, and reduce berry shedding in var. Chaouch Blanc, while increasing the berry size that does not satisfy standards for table varieties. An increase in berry size in var. Smederevka will lead to its increased table consumption, thereby resulting in finding a reasonable solution to the surplus problem of the wine grape market.

## Material and methods

The gibberellic acid used in this study was Berelex GA<sub>3</sub> product manufactured by Nufarm, BioSciences, packed in tablet form, with each tablet containing 1 g gibberellic acid. A tablet of the acid was dissolved in one litre of water and diluted to 80 ppm. There were two applications of the said concentration in each variety, the first at berry size of 7-8 mm and the second one 7 days upon the initial treatment. The treatments were employed in three varieties - Smederevka, Chaouch Blanc and Italia - in ten vines of each variety. The same number of untreated vines served as the control. Grape harvest of both treated and untreated vines was conducted at the same date, according to full grape maturity reached by any of the treatments. The study also involved measurement of grape yield per vine, mechanical analysis of both cluster and berry, and analysis of the chemical composition of grape must in terms of the sugar and acid content. Methods of the OIV - International Organisation of Vine and Wine - were employed. Statistical analysis was based on a completely randomised design at the significance level of 0.05 and 0.01.

## Results and discussion

### Effect of gibberellic acid on var. Italia

Gibberellic acid induced a 1g increase in berry weight of var. Italia, the increase being from 8.1 g in the control to 9.1 g in the treated vines. In clusters of var. Italia treated with GA<sub>3</sub>, visual signs of berry size uniformity were also observed.

Table 1 Technological properties of clusters and berries

Variety	Indicators	Italia			Chaouch Blanc			Smederevka		
		K	GA <sub>3</sub>	GA <sub>3</sub> -K	K	GA <sub>3</sub>	GA <sub>3</sub> -K	K	GA <sub>3</sub>	GA <sub>3</sub> -K
Cluster weight g		800.5	909	108.9	294.4	575	280.6**	491	564	73
100 berry weight		8.15	9.11	0.96	4.9	7.5	2.6**	345	425	79.7
Berry length mm		25.7	26.0	0.3	23.7	27.5	3.8**	1.86	2.15	2.9**
Berry width mm		22.1	22.8	0.7	17.0	18.2	1.2*	1.64	1.96	3.2**
Cluster petiole%		1.7	1.5	-0.2	3	1.3	-1.7	3	3.5	0.5
Skin%		5	4.9	-0.1	5.7	4.2	-1.5	7.3	10.5	3.2
Seeds%		2.2	1.4	-0.8	1.7	0.8	-0.9	3.3	2.7	-0.6
Flesh%		91.1	92.2	1.1	89.6	94	4.2	86.4	83.3	-3.1
Integument		6.6	6.4	-0.2	8.8	5.4	-3.4	10.2	14	3.8
Solid residue		8.9	7.8	-1.1	10.4	6.2	-4.2	13.6	16.7	3.1
Structural indicator		10.3	11.9	1.6	8.6	15	6.5	6.4	5	-1.4
Sugar content g/dm <sup>3</sup>		140	183	43**	122	148	26*	156	167	11
Total acid content g/dm <sup>3</sup>		7.1	5.7	-1.4	5.6	4.4	-1.2	7.3	6.8	-0.5
Sweet index		20	32	12	22	34	12	21	25	4

\* Lsd at 0.05

\*\* Lsd 0.01

The most important change was observed with respect to time of maturity, with the treated grapes having 183 g/l sugar and 5.7 g/l total acids i.e. as much as 43 g/l sugar more as compared to the control value of 140 g/l. The 1.4 g/l difference in the total acid content was not statistically significant.

### Effect of gibberellic acid on var. Chaouch Blanc

The gibberellic acid treatment had produced a very significant effect on var. Chaouch Blanc in that a very significant increase (by 2.6 g) in berry weight was induced. Berry weight was 7.5 g and 4.9 g on average in GA<sub>3</sub> treatment and untreated control, respectively. Furthermore, the treated vines matured significantly earlier. Their sugar content was 148 g/l and the total acid content was 4.4 g/l, as opposed to the 122 g/l sugar and 5.6 g/l total acids in the untreated control. The very significant differences in cluster and berry weight were due to an increase in flesh percentage from 89.6% in the control to 93.8% in the treatment with gibberellic acid, which reflected in the structural indicator, the value thereof being 8.6 in the control and 15.1 in the treatment with GA<sub>3</sub>.

### Effect of gibberellic acid on var. Smederevka

The gibberellic acid treatment in var. Smederevka led to a highly significant increase in cluster and berry weight from 491- 564 g, and 3.4 g - 4.2 g, respectively. However, the treatment gave a higher berry skin weight (10.5%) as compared to the control (7.3%), thereby leading to a decrease in flesh percentage - 83.3% in the treated grapes relative to the 86.4% of flesh in the control. The berries of the treated clusters were visually observed to be of uniform and larger size as compared to the control.



GA<sup>3</sup>

Control

Figure 1 Berry of var. Chaouch Blanc



Control

GA<sup>3</sup>

Figure 2 Cluster of var. Smederevka

### Conclusion

The varieties tested were very significantly affected by two applications of high rates of gibberellic acid made after flowering, mostly in terms of berry weight of var. Chaouch Blanc. In var. Smederevka and Italia, the treatment had a very significant effect on berry length and width and size uniformity within the cluster, and induced earlier maturity. The results on var. Chaouch Blanc show that gibberellic acid, despite being recommended for use in seedless varieties, can have substantial effects on seed varieties as well. Necessary steps should include analysis of each variety under particular growing conditions and evaluation of the most optimal method of application.

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# Ampelografske i gospodarske karakteristike dva varijeteta sorte Traminac u uvjetima niške podregije

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## Sažetak

Ampelografska ispitivanja rađena su na Traminu bijelom i Traminu mirisavom varijetetima sorte Traminac. Ispitivanja su obavljena u kolekcijskom nasadu Centra za vinogradarstvo i vinarstvo u Nišu. Istraživanja su trajala tri godine (2004-2006), a obuhvatila su rodnost varijeteta, kvalitetu grožđa i vina. Dat je i detaljan ampelografski opis varijeteta sorte Traminac prema deskriptorima OIV. Najveći prinos u razdoblju ispitivanja evidentiran je u Traminca bijelog, a najbolji kvalitet vina dobiven je u Traminca mirisavog. Također u okviru ispitivanih varijeteta izdvojeni su najbolji trsovi koji će poslužiti za daljnja proučavanja i umnožavanja.

Ključne riječi: ampelografski opis, rodnost, traminac, varijetet

## Ampelographic and productivity characteristics of two forms of the Traminer cultivar in the conditions of Niš vine subregion

### Abstract

An ampelographic investigation was carried out on Traminer White and Traminer Muscat forms of the cultivar Traminer. The study was done in the collection vineyard of the Center of Viticulture and Enology, Nis. The investigation lasted three years (2004-2006), and it included grape yield of the investigated forms, grape quality, as well as wine quality. This paper also gives a detailed ampelographic description of Traminer cultivar forms, according to O.I.V. descriptors. The highest grape yield was observed in Traminer White, and the best wine quality was found in Traminer Muscat. Within the forms, the best vines were identified for the use in further studies and for multiplication purposes.

Key words: ampelographic description, yielding, Traminer, form

## Uvod

Traminac je veoma cijenjena i široko rasprostranjena sorta. Starost sorte nije poznata, a prvi pisani podaci datiraju iz XV stoljeća (Goethe, 1887). Unutar ove sorte uočena je značajna varijabilnost. Riječ je o heterogenoj sorti sa mnoštvom varijeteta i klonova koji posjeduju genetičku i genotipsku varijabilnost svojih karakteristika. Bilo je pokušaja da se pojedini varijeteti proglašavaju sortama. Traminac mirisavi po botaničkim karakteristikama identičan je traminu crvenom, ali ga pojedini autori opisuju kao posebnu sortu (Pospisilova, 1981). U mnogim radovima Hillebrand (1984) ne spominje traminac crveni već traminac mirisavi. Nasuprot njemu Nemeth (1975) mirisavi traminac ne smatra posebnom sortom, već varijacijom sorte traminac crveni. Traminac bijeli porijeklom je iz Tirola u Italiji odakle je introduciran u mnoge europske zemlje. Posebno je ispitivan i rado gajen u Francuskoj u pokrajini Franche Compté gdje je dobio i posebno ime savagnin blanc. Imazio i sur. (2002) navode da je savagnin blanc sinonim za traminac bijeli, što je u suglasnosti sa ampelografskim istraživanjima do kojih je došao Galet (1990) koji navodi da je savagnin odnosno traminac bijeli jedan od varijeteta sorte traminac. Traminac mirisavi je najveći uspjeh postigao u Alzasu gdje se proizvode nadaleko čuvena vina poznata po snažnom aromatičnom mirisu. Pored Francuske, Italije i Njemačke, traminac bijeli i mirisavi uzgajaju se i u Španjolskoj, Hrvatskoj, Austriji, Mađarskoj. U vinogorjima Srbije traminac bijeli i mirisavi srećemo samo u kolekcijskim nasadima, dok ih u proizvodnim nasadima ima malo u Vojvodini i mjestimično u drugim dijelovima Srbije.

Cilj rada bio je da se standardnim ampelografskim metodama evidentiraju razlike između ispitivanih varijeteta, provjeri rodnost, prinos i kvaliteta grožđa i vina u ispitivanim uvjetima. Time bi doprinijeli upoznavanju bioloških osobitosti a naročito biološke rodnosti pupova i mladica, te kvalitete grožđa i vina koji se može ostvariti u ekološkim uvjetima niške podregije.

## Materijal i metode

Ispitivanja su obavljena tijekom 2004-2006. godine u dijelu vinograda sa varijetetima sorte traminac (*Vitis vinifera* L.) koji je u sastavu Centra za vinogradarstvo i vinarstvo u Nišu. Po svojoj lokaciji, nasad pripada niškoj podregiji u kojem prevladava umjereno-kontinentalna klima sa prosječnom godišnjom temperaturom zraka 11.8 °C i srednjom vegetacijskom od 18.1 °C. Apsolutno minimalne temperature zraka u razdoblju ispitivanja nisu premašile granične vrijednosti na kojima dolazi do izmrzavanja pupova. U drugoj (2005) godini u veljači, zabilježena je apsolutno minimalna temperatura zraka od - 18.2 °C, ali nije izazvala veće izmrzavanje pupova ispitivanih varijeteta. Prosječna godišnja količina padalina je oko 750 mm od čega u razdoblju vegetacije padne 422 mm. Tlo na kojem je podignut vinograd je u tipu gajnjače relativno homogene reakcije. Vinograd je podignut 1995. godine s razmakom sadnje 3 x 1.2 m, a broj trsova po hektaru iznosi 2777 što predstavlja standardnu vrijednost za sve sorte u ovom nasadu. Kao uzgojni oblik formiran je karlovački uzgoj sa kombiniranom rezidbom. U pokusu je primjenjena mješovita rezidba s opterećenjem od 20 pupova po trsu, odnosno 6.6 pupova po m<sup>2</sup> površine. U okviru ispitivanih varijeteta sorte traminac pratilo se po 12 trsova po RCBD metodi (Random Complete Block Design), gdje se ponavljanje sastojalo od tri trsa. Statistička obrada podataka izvršena je primjenom matematičko-statističkih metoda: analize varijance, F-testa, t-testova, korelacijske analize i regresijske analize. Ampelografski opis ispitivanih varijeteta izvršen je na temelju deskriptora OIV-a (1983) odnosno po Codes sistemu koji nalaže UPOV za opis novih genetičkih resursa vinove loze. Kvaliteta mošta, izražena preko prosječnog sadržaja šećera i ukupnih kiselina, utvrđena je na reprezentativnim uzorcima pri berbi grožđa. Sadržaj šećera je određen Oechslovim moštomjerom, a sadržaj ukupnih kiselina metodom neutralizacije, titracijom sa n/4 NaOH. Miniviniifikacija i kemijska analiza vina provedene su u enološkom laboratoriju Centra za vinogradarstvo i vinarstvo u Nišu. Kvaliteta vina određena je na temelju kemijskog sastava vina i organoleptičke ocjene od strane degustacijske komisije Poljoprivrednog fakulteta u Beogradu.

## Rezultati i rasprava

Prema ampelografsko - botaničkom opisu ispitivani varijeteti nisu ispoljili velike razlike. Vrh mladice u oba varijeteta je (001-7) otvoren, slabo obojen antocijanima (003-3), a pravac vrha mladice blago povijen (006-3). List je u oba varijeteta mali (065-3), prosječne dužine 7.22 cm u traminca bijelog, a 8.41 cm u traminca mirisavog. Oba varijeteta imaju okrugao list (067-4). List je u traminca bijelog trodijelan, a uočeni su i peterodijelni listovi (068-2-3), tamno zelene boje (069-7). U traminca mirisavog list je trodijelan (068-2), srednje zelene boje (069-5). Sinus peteljke je u oba varijeteta V oblika (080-2). Nervi na naličju lista su jako

dlakavi (086-7) u oba varijeteta. Peteljka lista je vrlo kratka u traminca bijelog (092-1), prosječne dužine 5.46 cm, a u mirisavog peteljka je kratka, prosječne dužine 6.45 cm (092-3). Rozgva je u oba varijeteta nepravilno okruglasta (101-2), tamno smeđe boje (103-3), kratkih nodija (353-3). Cvijet je morfološki i funkcionalno hermafroditan (153-3). Grozd je u traminca bijelog vrlo kratak 9.97 cm, zbijen (204-7), u prosjeku ima 81 bobicu, peteljka grozda je kratka (1.99 cm). U traminca mirisavog grozd je vrlo kratak 10.42 cm, zbijen (204-7), u prosjeku ima 83 bobice, peteljka grozda je kratka (1.97 cm). U traminca bijelog bobice su male (220-3), ujednačene (222-2), okruglog oblika (223-3), zeleno žute boje. Masa jedne bobice je mala 1.39 g (503-3). Bobice u traminca mirisavog su male (220-3), ujednačene (222-2), okruglog oblika (223-3), zeleno žute boje, male prosječne mase 1.65 g (503-3). U oba varijeteta sjemenka je srednje dužine (242-5), a masa 100 sjemenki vrlo mala (243-1).

U tablici 1. prikazane su vrijednosti osnovnih elemenata rodnosti ispitivanih varijeteta. Analiza varijance prosječnog broja razvijenih i rodni mladica po trsu, u ispitivanih varijeteta, bez obzira na godinu promatranja pokazuje statistički visoko značajnu razliku. Tako je najmanji broj rodni mladica po trsu dobiven u traminca mirisavog (11.81), vrlo ( $F=10.99$ ;  $P<0.01$ ) značajno manji broj u odnosu na traminac bijeli (15.31). Ekološki uvjeti u promatranim godinama značajno su utjecali na diferencijaciju rodni pupova i razvoj rodni mladica. Najveći broj rodni mladica u oba varijeteta zabilježen je u 2006. godini vrlo ( $F=17.85$   $P<0.01$ ) značajno veći nego u 2005. godini. Ispoljene razlike u prosječno većem broju rodni mladica u 2006. i 2004. godini u odnosu na 2005. godinu, mogu se objasniti relativno nepovoljnim uvjetima za rast i razvoj. Naime, niske temperature na početku vegetacije u veljači ( $-18.2$  °C) kao i obilne oborine tijekom zamatanja bobica utjecale su na pojavu manjeg broja rodni mladica u oba varijeteta sorte traminac. Svi navedeni elementi rodnosti (broj grozdova po pupu, razvijenoj i rodnoj mladici, broj grozdova po trsu) u varijeteta traminac bijeli bili su vrlo značajno veći nego u varijeteta traminac mirisavi.

Tablica 1. Osnovni elementi rodnosti ispitivanih varijeteta sorte Traminac

Pokazatelji	Traminac bijeli				Traminac mirisavi			
	2004	2005	2006	Prosjek	2004	2005	2006	Prosjek
BRaM	18.42	16.50	18.33	17.75	16.50	14.75	17.92	16.39
BRoM	16.00	13.83	16.08	15.31	12.25	8.67	14.50	11.81
BGP	1.30	0.99	1.41	1.23	0.93	0.55	1.09	0.86
BGRa	1.38	1.20	1.53	1.37	1.09	0.74	1.22	1.02
BGRo	1.61	1.48	1.72	1.60	1.52	1.27	1.52	1.44
BGT	26.17	19.92	28.33	24.81	18.58	11.00	21.83	17.14
MG	109.60	107.96	105.90	107.82	98.39	107.22	97.56	101.05

BRaM - Broj razvijenih mladica; BRoM - Broj rodni mladica; BGP - Broj grozdova po pupu; BGRa - Broj grozdova po razvijenoj mladici; BGRo - Broj grozdova po rodnoj mladici; BGT - Broj grozdova po trsu; MS - Masa grozda u g.

Masa grozda nije značajno ( $F=0.42$ ;  $P>0.05$ ) varirala između varijeteta sorte traminac. Cindrić i sur. (2000) navode da je prosječna masa grozda traminca bijelog u uvjetima fruškogorskog vinogorja u desetogodišnjem prosjeku iznosila 139 g, a u traminca mirisavog 129 g. U našim istraživanjima traminac bijeli (107.82 g) i mirisavi (101.05 g) imali su manju masu grozda u odnosu na vrijednosti koje navode Cindrić i sur. (2000).

Ispitivani varijeteti ispoljili su značajne razlike u prinosu grožđa (tablica 2.). Svi pokazatelji prinosa (prinos grožđa po pupu, razvijenoj i rodnoj mladici, po trsu) u varijeteta traminac bijeli bili su vrlo značajno veći nego u traminca mirisavog. Najveći prinos po trsu, uvjetovan brojem grozdova dobiven je u traminca bijelog (2.67 kg), vrlo ( $F=9.14$ ;  $P<0.01$ ) značajno veći nego u mirisavog traminca (1.70 kg). Prinos kao apsolutni pokazatelj rodnosti u najvećoj mjeri ovisi od broja grozdova i prosječne mase grozda. Imajući ovo u vidu možemo istaći da je u našim istraživanjima prinos u većoj mjeri ovisio o broju grozdova nego o prosječnoj masi grozda. Malim prinosom (do 6000 kg/ha) odlikuje se traminac mirisavi (4742 kg/ha), a srednjim prinosom (6000-12000 kg/ha) traminac bijeli (7441 kg/ha).

Tablica 2. Osnovni elementi prinosa i kvalitete grožđa varijeteta sorte Traminac

Pokazatelji	Traminac bijeli				Traminac mirisavi			
	2004	2005	2006	Prosjek	2004	2005	2006	Prosjek
PGP	145.63	107.90	148.46	133.99	91.38	59.83	104.96	85.39
PGRa	156.16	131.11	160.54	149.27	106.67	81.52	117.71	101.97
PGRo	178.54	155.62	180.43	171.53	145.96	136.60	145.00	142.52
PGT	2.912	2.157	2.969	2.679	1.827	1.196	2.099	1.707
PGH	8088	5992	8245	7441	5074	3322	5829	4742
SŠ	23.59	21.18	22.41	22.39	24.40	21.56	23.13	23.03
SUK	7.48	7.88	7.50	7.62	7.13	7.19	8.20	7.50

PGP - Prinos grožđa po pupu u g; PGRa - Prinos po razvijenoj mladici u g; PGRo - Prinos po rodnoj mladici u g; PGT - Prinos po trsu u kg; PGH - Prinos po hektaru u kg; SŠ - Sadržaj šećera u%; SUK - Sadržaj ukupnih kiselina u g/l.

Najveći sadržaj šećera u moštu dobiven je u traminca mirisavog (23.03%), koji je ostvario najmanji prinos u razdoblju promatranja. U traminca bijelog izmjeren je visok udio šećera u moštu (22.39%). Najniži prinos grožđa u drugoj (2005) godini nije uvjetovao i najveći sadržaj šećera u moštu. Naime, količina oborina u ovoj godini u srpnju, kolovozu i rujnu mjesecu bila je veća u odnosu na druge dvije godine što se očigledno nepovoljno odrazilo na sazrijevanje grožđa. Sadržaj kiselina se tijekom razdoblja istraživanja kretao u prosjeku od 7.50 g/l u traminca mirisavog do 7.62 g/l u traminca bijelog.

Analiza podataka u tablici 3. pokazuje da je, analogno visini sadržaja šećera u moštu, adekvatno izražen i sadržaj alkohola u vinu, koji se kretao u prosjeku od 13.33% u vinu traminca bijelog do 14.19% u vinu traminca mirisavog. Ukupni sadržaj kiselina u vinu varirao je u granicama vrijednosti od 6.5 g/l u vinu traminca bijelog do 8.6 g/l u vinu traminca mirisavog.

Tablica 3. Kemijski sastav i organoleptička ocjena vina ispitivanih varijeteta (2004/2006)

Pokazatelji	Traminac bijeli	Traminac mirisavi
Relativna gustoća	0.9893	0.9893
Alkohol%	13.33	14.19
Ukupni ekstrakt g/l	17.25	19.95
Redukujuće tvari g/l	1.0	1.2
Ekstrakt bez šećera g/l	17.25	19.75
Titraciona kiselost g/l	6.5	6.8
Hlapljive kiseline g/l	0.35	0.51
Ukupnu SO <sub>2</sub> mg/l	69.5	59.5
Slobodni SO <sub>2</sub> mg/l	10.0	11.0
Pepeo g/l	1.64	1.82
Fenolne tvari g/l	0.16	0.14
Organoleptička ocjena	17.39	18.21

Organoleptička ocjena vina kretala se od 17.39 bodova (traminac bijeli) do 18.21 bod (traminac mirisavi) što se može smatrati veoma zadovoljavajućim.

### Zaključci

Na temelju trogodišnjih rezultata praćenja ampelografskih i gospodarskih karakteristika varijeteta sorte traminac došlo se do sljedećih zaključaka: Prema ampelografsko - botaničkom opisu ispitivani varijeteti sorte traminac nisu iskazali velike razlike.

Od ukupnog broja razvijenih mladica najveći broj rodni mladica dobiven je u traminca bijelog (15.31), a vrlo značajno manje u traminca mirisavog (11.81). Broj grozdova po trsu bio je veći u traminca bijelog (24.81). Malim prinosom odlikuje se traminac mirisavi (4742 kg/ha), a srednjim prinosom traminac bijeli (7441 kg/ha). Elementi kemijskog sastava vina, ispitivanih varijeteta pokazuju da su u pitanju vina vrlo visoke kvalitete, sa dosta alkohola i sa povoljnim sadržajem ukupnih kiselina. Prosječna degustacijska ocjena za vino traminac mirisavi iznosi 18.21 bod, po kojoj se vino mirisavog traminca svrstava u kategoriju vrhunskih vina. Degustacijska ocjena za vino traminac bijeli iznosi 17.39 bodova, po kojoj se vino traminca bijelog svrstava u kvalitetno sa tendencijom ka vrhunskom vinu.



### **Napomena**

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# Utjecaj primjene različitih koncentracija giberelina (GA<sub>3</sub>) na mehanički sastav grozda i bobice sorte Cardinal u mostarskom vinogorju

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## Sažetak

U radu su prikazani rezultati utjecaja primjene različitih koncentracija giberelina (GA<sub>3</sub>) na mehanički sastav grozda i bobice sorte Cardinal uzgajane u mostarskom vinogorju. Pokus je obuhvaćao kontrolu i tri različite varijante tretiranja giberelinima.

Na povećanje visine i širine grozda, te mase cijelog grozda i bobice najveći učinak je imala dvokratna primjena GA<sub>3</sub> u koncentraciji 10 ppm. Vrijednosti ostalih ispitivanih parametara (broj bobica u grozdu i broj sjemenki u bobicama) statistički se nisu značajno razlikovale, neovisno o varijanti primjene giberelina.

Ključne riječi: giberelin, mehanički sastav, stolno grožđe, Cardinal

## Effect of different concentrations of gibberellins (GA<sub>3</sub>) on the mechanical composition of grape and berry cultivar Cardinal in Mostar vineyards

### Abstract

This paper presents the results of the impact of applying different concentrations of gibberellins (GA<sub>3</sub>) on the mechanical composition of grape and berry cultivars Cardinal grown in Mostar vineyards. The experiment include a control and three different treatments with gibberellins. The increase in height and width of the cluster, and the mass of the whole bunch and berries had the greatest impact is twice the application of GA<sub>3</sub> at a concentration of 10 ppm. The values of other measured parameters (number of berries in a cluster and the number of seeds per berry) were not statistically significantly different, regardless of the application of gibberellins variants.

Key words: gibberellic acid, mechanical composition, table cultivar, Cardinal

## Uvod

Giberelini su biljni hormoni koji se sintetiziraju unutar biljke, a na fiziološke reakcije u biljci iskazuju većinom stimulativni karakter. Biljka proizvodi gibereline u tkivima koja aktivno rastu; najviše u mladim listovima vršnih pupoljaka, ali i u meristemskim tkivima stabljike i korijena, te nezrelim sjemenima i plodovima. Nezrela sjemena predstavljaju bogat izvor giberelina, tako da se današnja znanja o sintezi i djelovanju giberelina najvećim dijelom zasnivaju na proučavanju procesa koji se zbivaju za vrijeme rasta i razvoja sjemena (Nešković i sur., 2003).

Najinteresantnije fiziološko djelovanje giberelina je stimuliranje izduživanja stabljike biljaka po čemu su isti i prepoznatljiviji. Djelovanje giberelina u izduživanju biljaka se zasniva na poticanju transkripcije određenih gena odgovornih za produženi rast stanica internodija. Tamo gdje giberelini nisu prisutni, ti geni se ni ne uključuju, te reakcije produženog rasta ni ne započinju (Hedden, 2004).

Kako je sastav i osnovni način djelovanja giberelina već odavno poznat, proizvedeno je niz sintetskih proizvoda koji pokazuju sličan efekt kao prirodni giberelini (GA<sub>3</sub>). S tim proizvodima moguće je utjecati na tijek fizioloških procesa, a biljka ih, u odnosu na prirodne gibereline, pomoću svojih enzima ne može razgraditi ili inaktivirati. Stoga, sintetski proizvedeni giberelini imaju vrlo praktičnu primjenu u poljoprivredi, posebno u vinogradarskoj proizvodnji gdje efekt njihove primjene može vrlo brzo doći do izražaja.

U vinogradarstvu, kod uzgoja stolnih sorti, giberelini se najčešće koriste za povećanje veličine grozdova pri čemu dolazi i do izduživanja bobica, a navedene promjene su vrlo često praćene i povećanjem prinosa. To se posebno odnosi na razvoj grozdova kod besjemenih stolnih sorti jer je kod njih sinteza prirodnih giberelina zbog nedostatka sjemena znatno ograničena.

Cilj ovog istraživanja je bio ispitati kako će se primjena različitih koncentracija giberelina (GA<sub>3</sub>) odraziti na prinos i mehanički sastav grozda i bobice sorte Cardinal uzgajane u mostarskom vinogorju. Istraživanja su provedena na sorti Cardinal iz više razloga: visokoproduktivna je, nije osobito izbirljiva po pitanju položaja, dugog je vremena zrenja, vrlo privlačnog izgleda, a ističe se ukusnim i vrlo kvalitetnim plodovima. Zbog navedenih karakteristika sorta Cardinal je jedna od najviše zastupljenih stolnih sorti u mostarskom vinogorju, te su pokušaji poboljšanja i unapređenja njene proizvodnje od velikog interesa, kako za proizvođača, tako i za krajnjeg konzumenta.

## Materijal i metode

Istraživanje je provedeno 2010 godine u plantažnim nasadima vinove loze sorte Cardinal smještenim na području mostarskog vinogorja, lokalitet Vrapčići. Pokus je postavljen po metodi slučajnog blokno rasporeda sa tri varijante tretiranja u tri ponavljanja, uz prisutnu kontrolu. Varijante tretiranja su bile sljedeće:

1. varijanta - primjena GA<sub>3</sub> u koncentraciji 10 ppm (dva puta u razmaku od 7 dana),
2. varijanta - primjena GA<sub>3</sub> u koncentraciji 20 ppm (dva puta u razmaku od 7 dana),
3. varijanta - primjena GA<sub>3</sub> u koncentraciji 40 ppm (jednokratna primjena),
4. varijanta - kontrolna (bez primjene GA<sub>3</sub>).

Svaka varijanta u svakom ponavljanju bila je zastupljena sa pet trsova (osnovna parcela), iz čega proizlazi da je pokusom ukupno bilo obuhvaćeno 60 trsova vinove loze (4 varijante x 5 trsova x 3 ponavljanja). Životna dob trsova (pet godina starosti), razmaci sadnje (1.20 x 2.80), uzgojni oblici (jednokraki kordonac), kao i primijenjene agrotehničke mjere (obrada zemljišta i gnojidba) u svim ispitivanim parcelama su bile identične.

Prvo tretiranje biljaka giberelinskom kiselinom (GA<sub>3</sub>) obavljeno je 17. lipnja, odmah po zametanju bobica, a drugo (kod varijante 1 i 2) sedam dana kasnije kada su bobice bile veličine promjera 3 - 4 mm. U cilju izbjegavanja brze dehidracije otopine GA<sub>3</sub> sa tretirane površine, prskanje biljaka je bilo obavljeno u predvečerje ručnom prskalicom od jedne litre.

Mjerenje parametara rasta i razvoja biljke koji su se odnosili na uvometriju i mehanički sastav grozda i bobice obavljeno je 6. kolovoza u fazi tehnološke zrelosti ploda. Mjerenjem su bili obuhvaćeni svi grozdovi na ispitivanim trsovima.

Metode koje su korištene u navedenim mjerenjima bile su sljedeće:

- za određivanje veličine grozda i bobice (visina i širina) korišteno je mjerno ravnalo i digitalno pomično mjerilo,
- broj bobica po grozdu određen je vizualno,
- masa grozda i ukupni prinos po trsu određeni su vaganjem.

Dobiveni podaci obrađeni su primjenom standardnih statističkih metoda analize varijance (ANOVA) i multipli testova (LSD) uz korištenje programa Microsoft Excel 2003 i Statistica 5.0. Na temelju analize podataka, izvršena je interpretacija rezultata, te su izvedeni zaključci o rezultatima istraživanja.

### Rezultati i rasprava

Rezultati uvometrije i mehaničke analize grozda i bobice sorte Cardinal u ovisnosti o varijanti tretiranja GA<sub>3</sub> prikazani su u tablici 1.

Tablica 1. Rezultati uvometrije i mehaničke analize grozda i bobice

Varijanta tretiranja sa GA <sub>3</sub>	Svojstvo						
	Visina grozda	Širina grozda	Masa grozda	Broj bobica u grozdu	Masa bobice	Broj sjemenki u bobici	Prinos po trsu (kg)
10 ppm x 2	28.26 a	16.83 a	497.67 a	52	9.20 a	3.0	2.37 a
20 ppm x 2	26.35 b	15.93 b	421.34 b	49	7.43 b	3.1	2.07 b
40 ppm x 1	25.50 b	16.03 b	415.00 b	50	7.46 b	2.9	2.09 b
kontrola	25.27 b	15.93 b	406.67 b	51	7.40 b	3.0	1.92 b
F test	*	*	*	ns	*	ns	*
LSD <sub>0.05</sub>	1.49	0.50	16.06		0.18		0.17

\* - signifikantan, ns - nije signifikantan

Prema podacima iz tablice 1 može se vidjeti da je dvokratna primjena GA<sub>3</sub> u koncentraciji 10 ppm signifikantno utjecala na povećanje visine i širine grozda, te mase cijelog grozda i bobice u odnosu na sve druge ispitivane varijante. Takav slučaj nije zabilježen kada je parametar ispitivanja bio broj bobica u grozdu i broj sjemenki u bobici. U vrijednostima zadnjih dvaju navedenih parametara nije postojala statistički značajna razlika neovisno o primijenjenoj varijanti tretiranja.

Pozitivan učinak višekratne primjene giberelina u koncentraciji 10 ppm na masu bobice i veličinu grozda ustanovio je u svom istraživanju iz 1992. godine Wolf i Loubser, ali na sorti Waltham, koja isto kao i Cardinal sadrži sjemenke u svojim bobicama. Kod besjemenih sorti je pozitivan učinak GA<sub>3</sub> na mehanički sastav grožđa već odavno poznat. Nabila i sur. su za sortu Sultaninu (Thomson seedless) u svom radu iz 2004 godine čak naveli i optimalne koncentracije za postizanje izduženja i povećanja mase bobice. Oni smatraju, a u svojim pokusima su to i potvrdili, da je koncentracija od 10 do 20 ppm optimalna za izduženje, a 30 ppm za povećanje mase bobice.

Vrlo je važno navesti, a što nije vidljivo iz navedenih rezultata u tablici, da je u varijanti 3, gdje je primijenjena veća koncentracija GA<sub>3</sub>, zamijećena veća rehljavost grozda sa izražajnom disperzijom bobica. U berbi je zbog toga došlo i do pucanja bobica, što je znatno umanjilo estetsku i tržišnu vrijednost grozdova.

### Zaključci

Na osnovu provedenog istraživanja o utjecaju giberelinske kiseline GA<sub>3</sub> na mehanički sastav grozda i bobice sorte Cardinal uzgajane u mostarskom vinogorju može se zaključiti sljedeće:

- na povećanje visine i širine grozda, te mase cijelog grozda i bobice najveći učinak je imala dvokratna primjena GA<sub>3</sub> u koncentraciji 10 ppm (prva varijanta),
- u svim varijantama ispitivanja, bio je ujednačen broj bobica u grozdu,
- broj sjemenki u bobicama nije statistički značajno odstupao neovisno o varijanti primjene,
- prinos grožđa po trsu je bio najveći u prvoj varijanti, što je i logično ako se uzme u obzir da je većina ispitivanih parametara mehaničkog sastava grozda i bobice u toj varijanti imala najveću vrijednost.

## Utjecaj primjene različitih koncentracija giberelina (GA3) na mehanički sastav grozda i bobice sorte Cardinal u mostarskom vinogorju

Rezultati provedenog istraživanja upućuju na zaključak da je primjena giberelinske kiseline vrlo svrsishodna u kontekstu povećanja vrijednosti mehaničkog sastava grozda i bobice sorte Cardinal, ali pri izvođenju tretmana treba voditi računa o količini primijenjene koncentracije. Prevelike koncentracije giberelinske kiseline (iznad 40 ppm) mogu dovesti do pucanja i otpadanja bobica, što se odražava negativno na kvalitet i prinos grožda.

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# The impact of early leaf removal on polyphenol/anthocyanin content and *in vitro* antioxidant potential of 'Pinot Noir' grapes from Vipava Valley

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## Abstract

The impact of early leaf removal (at berry-set) on polyphenol and anthocyanin formation in grapes of Pinot Noir (*Vitis vinifera* L.) variety was investigated, aiming to improve their phenolic profile and colour characteristics for its later wine production. Therefore, the content of total phenol and total anthocyanin levels during grape maturation till the harvest time was monitored for both trial treatments of defoliated and non-defoliated (control) vines, and results were compared to an air/grapes surface temperature and precipitation data obtained. Phenolic compounds were analysed by HPLC-UV/VIS and Folin-Ciocalteu analysis, while extracts' *in vitro* AOP characterization was based on scavenging of DPPH free radicals. Our results revealed a highly significant impact of early leaf removal on polyphenol/anthocyanin grape composition, where a much higher impact on total phenols content was observed in comparison to the one of anthocyanins. However, the highest concentrations were found in grapes sampled 9 days before the harvest time, where the levels of total phenol and anthocyanin concentrations reached the values of 1763 and 867 mg/kg, and hence increased their final grapes content for 24% and 25% in comparison to control, respectively. A similar trend was observed in the case of grapes *in vitro* antioxidant potential assessment, where the values of AOP have clearly correlated ( $r = 0.88$ ) with the total phenol content, confirming the antioxidant activity of phenols present. Although both of them have later decreased by the time of harvest (22%), their final values were still significantly higher as compared to that of control (24%), suggesting the early leaf removal as successful tool for a phenol profile regulation of Pinot Noir grapes under conditions present.

Key words: early leaf removal, Pinot Noir, total phenols/anthocyanins, *in vitro* antioxidant (AOP) potential

## Introduction

The wine colour is directly dependent on both quali- and quantitative profile of grape polyphenols such as anthocyanins, flavonols and hydroxycinnamic acids and/or on their enrolment into polymerization and copigmentation reactions (Tarara et al., 2008). While the latter is genetically defined by the cultivar itself, it can be modified/influenced also by the others *i.e.* environmental factors such as light, temperature, water stress and UV radiation exposure (Cortell et al., 2006).

Several viticulture practises have been already tested/proposed with an attempt to improve the polyphenol/anthocyanin grape composition, including leaf removal based on a canopy microclimate control, typically performed at veraison using manual or mechanical approaches (Poni et al., 2006). Although its application has been traditionally used for reducing grapes microbiological contaminations (e.g. *Botrytis cinerea*, *Sour rot*) and/or obtaining their better ripening characteristics, its potential at stage of berry set has not been yet fully exploited for improving the grapes polyphenol/anthocyanin profiles and hence their overall antioxidant (AOP) potential.

Pinot Noir *cv.* is known as grape variety of low natural colour potential accompanied with low colour stability of its wines during aging/storage. In an effort to investigate the impact of early leaf removal on polyphenol/anthocyanin formation in grapes of Pinot Noir (*Vitis vinifera* L.) variety, the present study was carried out with an aim to improve the phenolic profile and its related colour characteristics for the later wine production.

## Materials and methods

### Experimental plot

The study was conducted in vintage 2009 within a 4-year old *V. Vinifera* L. Pinot Noir vineyard (Guyot trained, 6940 plants/he (0.8 m x 1.8 m), 220 m a.s.l.) located at Vipava Valley (Slovenia). A completely randomized experimental design was set up with 16 plots of 5 vines within a 4 rows with N-S orientation (Table 1). The early leaf removal (ELR) was performed at berry set (5<sup>th</sup> June) removing the basal 5-6 leaves of all shoots manually, while the control (C) remained non-defoliated. Air temperature and precipitations data for the time of experiment were obtained from a local weather station (Zevs), while in situ measurements of berry surface temperatures were monitored using a Volt craft IR-380 thermometer.

**Table 1: Experimental plot; early leaf removal (ELR) and non-defoliated control (C) vines**

1 <sup>st</sup> row	C	ELR	C	ELR	C	ELR	C	ELR	ELR	C	
2 <sup>nd</sup> row	C		ELR	C	ELR	ELR	C		ELR	C	
3 <sup>rd</sup> row		C	ELR	C	ELR	C		ELR	C	ELR	
4 <sup>th</sup> row			ELR	C		ELR	C	ELR	C	C	ELR

### Grapes

Random samples of 100 berries were collected with stalk peaces at weekly intervals of August 2009 (1, 8, 15, 23 and 24) immediately frozen and stored in freezer (−30 °C) prior to extract preparation.

### Phenols extraction

Extracts were prepared according to Mattivi et al. (2006), where the skins of 20 frozen berries were peeled and subjected to extraction for 24 h in methanol (100 mL). Then, the extract was separated and 50 mL of methanol was added to the skins, which were subjected to further extraction for 2 h. Both extracts were combined and stored in freezer (−25 °C) until further HPLC-UV/VIS analysis.

### HPLC-UV/VIS analysis

Extracts were diluted with 1% TFA in H<sub>2</sub>O (1:1, v/v), filtered through 0.45 µm PTFE filters (Macherey-Nagel, Germany) and analysed by HPLC-UV/VIS under chromatographic conditions, specified in Table 2.

**Table 2: HPLC-UV/VIS analytical conditions**

	HPLC-UV/VIS
Instrument	Waters system; binary pump (510), autosampler (717+), UV/VIS detector (2487)
Column	Atlantis (150 x 3.9 mm, 3 µm)
Flow rate	0.5 mL/min
V <sub>inj</sub>	20 µL
Detection	UV/VIS (520 nm)
Mobile phase	A = H <sub>2</sub> O/CH <sub>3</sub> CN/TFA(89.8:10.0:0.2, v/v/v) B = H <sub>2</sub> O/CH <sub>3</sub> CN/TFA (49.8:50.0:0.2, v/v/v)
Gradient	0 min (10% B), 20 min (25% B), 40 min (55% B), 41 min (90% B)

Identification of anthocyanins was obtained by comparison of  $R_f$ , UV-VIS and ESI-MS spectra with those of authentic standards when available, while the tentative identity of others was confirmed by comparison of UV-VIS and ESI-MS<sup>2</sup> spectra with those from the literature (Košir et al., 2004). Each of them was quantified separately based on external 6-point calibration of malvidin-3-glucoside (1–1000  $\mu\text{g mL}^{-1}$ ), summed and expressed as total anthocyanins in  $\text{mg g}^{-1}$  of berry, respectively.

#### Total phenol analysis

Measurements were carried out according to a previously published protocol of Amerine and Ough (1988) employing Folin-Ciocalteu method. Absorbance at 765 nm was measured on HP UV/VIS spectrophotometer 8453 (Agilent Technologies, Santa Clara, USA) after 2 h reaction, and the final results were expressed in mg of gallic acid equivalents (GAE) per g of berries.

#### In vitro antioxidant potential (AOP) assessment

The samples AOP was evaluated according to Obied et al. (2007) with minor modifications as follows. Various aliquots of phenol extracts were diluted to final volume (20  $\mu\text{L}$ ) and added to a DPPH daily prepared  $\text{meOH}$  solution (80  $\mu\text{M}$ , 2 mL) in small glass containers (3 mL). The samples were covered, well shaken, and kept in the dark for 60 min, and then the absorbance was measured at 515nm. The scavenging% of DPPH was calculated according to  $\% \text{DPPH}_{\text{rem}} = [(A_0 - A_{\text{sample}})/A_0] \times 100$ , where  $A_0$  and  $A_{\text{sample}}$  stand for absorbances of control and sample, respectively. The concentration resulting in 50% inhibition was referred as  $\text{EC}_{50}$ , and extracts' AOP was calculated according to equation;  $\text{AOP} = 1/\text{EC}_{50}$ .

### Results and discussion

Both extracts of defoliated (ELR) and non-defoliated control (C) vines exhibited similar qualitative phenol profile (Figure 1) composed of five known anthocyanins present in Pinot Noir grape skins namely; delphinidin 3-glucoside (Del-3-Glu), cyanidin 3- glucoside (Cy 3-Glu), petunidin 3-glucoside (Pet 3-Glu), peonidin 3-glucoside (Peo 3-Glu) malvidin 3-glucoside (Mal 3-Glu).

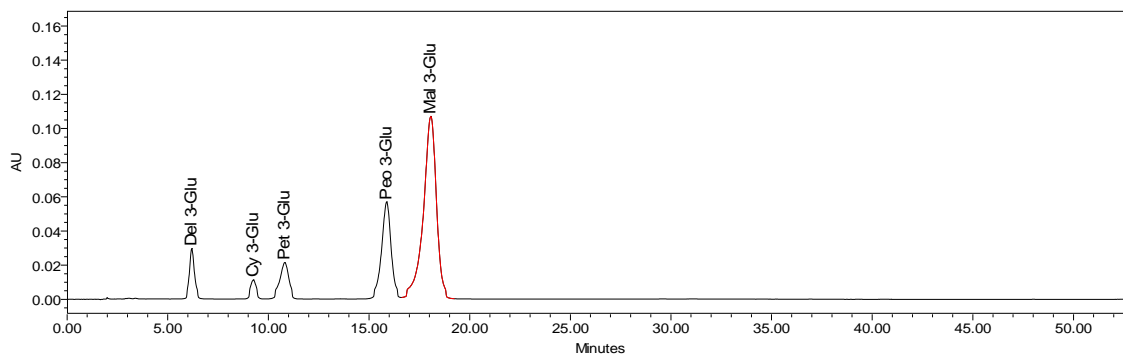


Figure 1: HPLC-UV/VIS chromatogram of grape skin extracts cv. Pinot Noir monitored at 520 nm.

Though the phenolic profile was qualitatively maintained among the extracts analysed, a highly significant ( $P \leq 0.001$ ) differences were observed at the quantitative level (Figure 2) where the amount of phenols recovered from ELR was notably larger than those from control (C). As seen, the concentrations of both groups studied *i.e.* total anthocyanins and polyphenols were strongly affected by berry-set leaf removal, suggesting its positive impact on grapes phenols formation/accumulation. While the increases were on average lower for total anthocyanins (15%), the latter were much higher in the case of total polyphenols (29%), reaching maximum in the mid of August with up to 50% higher yields (1763  $\text{mg kg}^{-1}$ ) obtained *vs.* control (1196  $\text{mg kg}^{-1}$ ). Early leaf removal is known to ensure a longer and higher canopy light exposure, easily reaching clusters and hence mostly likely attributing to higher/better synthesis of phenols, if not to extreme temperatures are attained (Tarara et al., 2008).

However, from a harvest date perspective, a typical maturation time - phenol content dependent curve was obtained for both trials performed (ELR *vs.* C), where the levels of total anthocyanins and polyphenols have gradually increased till the mid of August (15<sup>th</sup> August), followed by a sudden drop before the time of harvest



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(24<sup>th</sup> August). This type of biphasic behaviour is rather usual for grape maturation, and although maximum yields were not consistent with fruits harvest time, the final phenol concentrations obtained were significantly larger than those in control. In other words, early leaf removal has promoted the phenols yields rise of both *i.e.* total anthocyanins and polyphenols at harvest time for 25% and 24% on average, confirming its positive impact on a phenol grape accumulation.

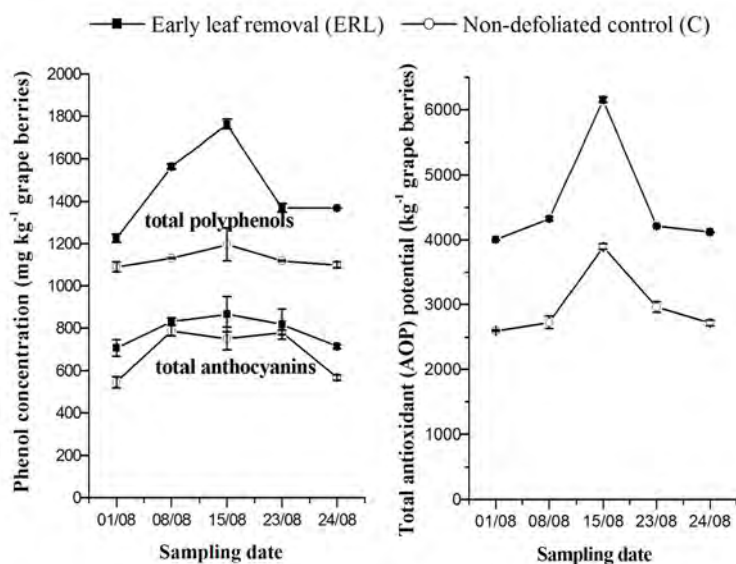


Figure 2: The impact of early leaf removal (ERL) on total anthocyanin and polyphenol grape content (left) and their antioxidant (AOP) potential (right) during Pinot Noir grapes maturation in comparison to a non-defoliated control (C).

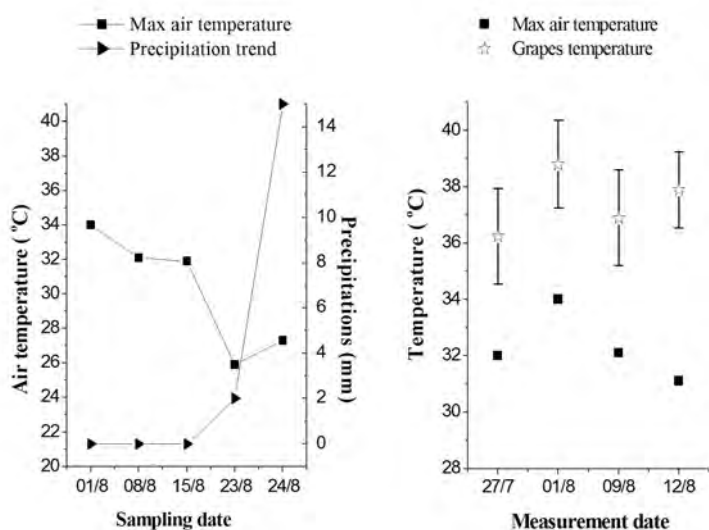


Figure 3: Maximum air temperature and precipitation data (left) and maximum air/grape temperature data comparison (right) during Pinot Noir grapes maturation

A similar trend was also observed in case of extracts' *in vitro* antioxidant potential (AOP) assessment, where the latter have clearly correlated ( $r = 0.88$ ) with the total phenols content, confirming antioxidant activities of the phenols present (Figure 2, right). Although trend of AOP results were less comparable to anthocyanin and/or more to polyphenol content, the former have importantly contributed to overall AOP *via* high free radical scavenging abilities and the fact that anthocyanins present more than half (54%) of grapes total phenol content.

As the phenol profile can be influenced by environmental conditions (Cortell et al., 2006), we consequently followed an air temperature/precipitation behaviour in addition to a grapes surface temperature monitoring during experimental trial (Figure 3). As seen from results, the maximum air temperature data were not

comparable with berries temperatures measured, which is in line previous report of Tarara et al. (2006). In fact, the temperatures of grapes were consistently higher (4°C on average) in comparison to atmospheric ones (Figure 3, right), but has in spite of high extremes attained (> 35°C) apparently not affected synthesis of phenols, since the increases of both studied groups (total anthocyanins/polyphenols) till the mid of August were observed. Interestingly, their concentrations have decreased afterwards, most likely due to a precipitation related grape phenols dilution effect.

### Conclusions

The early leaf removal (at berry set) has shown to be a highly efficient tool for improving anthocyanin/polyphenol grapes composition in terms of higher yields (15/29% on average) and antioxidant activities (53% on average) obtained for Pinot Noir grapes of Vipava Valley vineyards (Slovenia, 2009), and is therefore recommended for further field experiments of more seasons and vineyard location/exposition tests prior to its extrapolation to other Pinot Noir vineyards grown under similar geo-climatic conditions.

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# Fermentation rate in White Riesling (*Vitis vinifera* L.) grape juice as affected by vineyard nitrogen fertilization

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## Abstract

Nitrogen (N) fertilizer (urea) was applied by hand to vineyard of White Riesling grapes at rates of 0, 23, 70 or 117 kg N/ha/year from 2006 to 2009. Fermentation rate increased with increasing N fertilization, although only one of four juices from 0 kg N/ha completed fermentation, while only two of four 23 kg N/ha completed fermentation. All juices from 70 and 117 kg N/ha completed fermentation, but fermentation rate was unacceptably slow. Long fermentation time was strongly correlated with low free amino nitrogen levels in all juices, varying from 13 to 40 mg/L. Nitrogen fertilization rate affected higher titratable acidity.

Key words: fermentation rate, fertilization, grape juice, nitrogen

## Utjecaj dušične gnojidbe na brzinu i tijek fermentacije mošta Rizlinga rajnskog (*Vitis vinifera* L.)

### Sažetak

Dušično gnojivo (urea) aplicirano je ručno u vinograd Rizlinga rajnskog u količinama od 0, 23, 70 ili 117 kg N/ha u periodu od 2006 do 2009 godine. Brzina fermentacija je rasla sa intenziviranjem dušične gnojidbe, iako su samo jedan mošt od 0 kg N/ha, odnosno dva mošta od 23 kg N/ha uspješno odfermentirala. Svi moštevci od 70 i 117 kg N/ha uspješno su odfermentirali, ali je fermentacija trajala neprihvatljivo dugo. Produženo trajanje fermentacije u uskoj je vezi sa niskom razinom slobodnog amino dušika u moštu, koji je varirao od 13 do 40 mg/L. Dušična gnojidba utjecala je i na višu razinu ukupne kiselosti u moštu.

Ključne riječi: brzina fermentacije, dušik, gnojidba, mošt

### Introduction

It is well known that nitrogen (N) is required by yeast for growth and completion of alcoholic fermentation in grape juice (Bisson, 1991). Sluggish or stuck fermentations may result from nitrogen deficiencies of grape juice (Bell et al., 1979; Ingledew and Kunkee, 1985). Many producers utilize to fertilize the vineyard to avoid this problems, although this does not always assure sufficient content of nitrogen compounds in the grape (Bell and Henschke, 2005). Agenbach (1977) reported that concentrations greater than 140 mg/L of assimilable nitrogen were required for sufficient yeast growth to complete fermentation. Free amino nitrogen (FAN) content has been used as an indicator of total available nitrogen in juice (Amerine and Ough, 1980), although chemical determinations of FAN do not discriminate between those free amino nitrogen containing

compounds that can be utilized by *Saccharomyces cerevisiae* for their nitrogen content and those that cannot. Concentration of nitrogenous compounds in grape juice is influenced by viticultural practice such as vineyard nitrogen fertilization (Agenbach, 1977; Bell et al., 1979), cultivar (Huang and Ough, 1989), rootstock (Huang and Ough, 1989) and growing season (Spayd et al., 1994). Many studies examined the impact of vineyard nitrogen fertilization on the fermentation kinetics (Agenbach, 1977; Bell et al., 1979). Overall fermentation rate is linearly related to must total nitrogen. Application of N fertilizer to Thompson Seedless grapevines increased fermentation rate of juices which was found to be related to must total N concentration (Bell et al., 1979). Pre-harvest application of N fertilizer increased juice total N concentration, and fermentation time to dryness decreased linearly as the total N concentration in juice increased. However, this viticultural practice could create some problems as the high vineyard nitrogen application can result in reduced grape colour and total soluble solids concentration.

Difficult fermentations of Riesling musts in north-western region of Croatia are fairly frequent. Spayd et al. (1994) reported that N concentration in Riesling juice are increased by even moderate (56 kg N/ha) applications of N fertilizer. The purpose of this study was to investigate the impact of the N fertilizer applications on fermentation rate in Riesling must.

### Materials and methods

Research was laid out during four growing seasons (2006-2009). Grape harvest as well as vinification process happened in the experimental field of Department of enology and viticulture, Faculty of Agriculture in Zagreb, which is placed on the hills near Zagreb. The White Riesling grapevines were grafted on Vitis Berlandieri x Vitis Riparia SO4 rootstock. Nitrogen application rates were 0, 23, 70 or 117 kg N/ha and were replicated three times in the field using a randomized complete block design. Each treatment comprised 36 grapevines, so there were total 124 White Riesling grapevines included in the experiment.

Vines were spaced 1.2 m apart within rows and 2.1 m apart between rows. Nitrogen in the form of urea was applied by hand within 30-cm band on each side of each experimental row. Fertilizer application were made in spring, immediately after bloom.

The fruits were harvested according to usual technological ripeness, and before harvest the vines were berry-sampled several times to determine maturity. Each replication was destemmed and crushed separately, and immediately pressed. The juice was collected in 25-L glass containers, SO<sub>2</sub> added and the juice settled per 24 hours. The samples of must were taken and analyzed before fermentation started. The musts were analyzed for total acidity and sugar content according to the official O.I.V. methods (2001). Free amino nitrogen (FAN) content was determined according to the NOPA procedure (Butzke and Dukes, 1998)

The clear juice was racked from the lees, yeast inoculum of *Saccharomyces cerevisiae* 228B was added, and the must was fermented at 16°C.

Fermentation progress was determined by measuring changes in sugar content. Fermentation rate were determined as days for the must to ferment to <1 g/L of residual sugar. Data were analyzed by ANOVA, with nitrogen fertilization rate as variability source.

### Results and discussion

Must composition at harvest: Nitrogen fertilization didn't delayed fruit maturation regarding soluble solids content (Table 1). Moreover, the sugar content increased when nitrogen fertilizer was applied. In 2006 and 2009 the sugar content was the lowest in control musts, without nitrogen fertilization. Fertilization with 23 kg N/ha influenced the highest must sugar content in three of four experimental years, but statistical significance showed up only in 2006 and 2009 years.

Peacock et al. (1991) stated that nitrogen fertilization generally influenced lower sugar content in grape must. Christensen et al. (1994) also found that fertilization with 112 kg N/ha reduced sugar content in grape juice. But there are also authors finding no differences in grape sugar content due to rate of nitrogen fertilization (Bell et al., 1979).

Nitrogen fertilization rate affected higher titratable acidity (TA). The lowest content of titratable acidity was found in control musts in all growing seasons, but only in 2006 with statistical significance.

**Fermentation rate in White Riesling (*Vitis vinifera* L.) grape juice as affected by vineyard nitrogen fertilization**

Bell et al. (1979) reported that total acidity increased significantly with increasing nitrogen fertilization. The explanation is the probable increase in vine vigor and leaf surface area due to increasing nitrogen fertilization. So, there is an increased production of acids in leaves and subsequent translocation to the grapes. The increased acidity may be due also to the denser leaf canopy that accompanied nitrogen fertilization, resulting in greater shading of fruit and lower fruit temperature than on unfertilized vines. Christensen et al. (1994) investigated nitrogen fertilization among 4 cultivars, and reported higher total acidity content but only in Grenache and Chenin blanc juices. According to Bavaresco et al. (2001) nitrogen fertilization affected higher acidity content, but without significant statistical differences.

**Table 1. Effect of nitrogen fertilization rate on sugar content of White Riesling grape juice, 2006-2009.**

kg N/ha	2006	2007	2008	2009	$\bar{x}$
0	95.7	88.3	99.7	86.3	92.5
23	104.7	90.3	100.0	92.0	96.8
70	100.7	87.7	98.7	89.0	94.0
117	103.3	88.3	100.7	87.7	95.0

**Table 2. Effect of nitrogen fertilization rate on total acidity of White Riesling grape juice, 2006-2009.**

kg N/ha	2006	2007	2008	2009	$\bar{x}$
0	10.15	8.66	7.17	8.97	8.74
23	13.63	8.92	7.31	8.98	9.71
70	13.40	9.43	7.35	9.36	9.89
117	11.17	9.57	7.20	9.26	9.30

Free amino nitrogen (FAN): In all four years, when compared with no N fertilization, juice FAN concentrations were higher when N fertilizer was applied, especially rates of 70 and 117 kg N/ha (Table 2). Statistical significant differences were observed in all years except 2007. Linear increase in FAN concentration with increasing N fertilization was detected only in 2009 year. In the other three growing seasons fertilization with 117 kg N/ha had no significant effect compared with 70 kg N/ha.

However, Spayd et al. (1994) found that juice FAN concentration at least doubled when 56 kg N/ha were applied to the vines, and increased lineary till maximum fertilization rate of 224 kg N/ha.

It is also worth to note that the FAN concentrations in this investigation are significantly lower than those recommended for completion of alcoholic fermentation. Several authors (Agenbach, 1977; Ingledew and Kunkee, 1985) found that the level of 140 mg N/L (meaning yeast assimilable nitrogen (YAN), that can be assimilated by wine yeasts) is necessary for completion of alcoholic fermentation. Spayd et al. (1996) examined 142 must samples of White Riesling from Washington state, and found an average of 156 mg/L of FAN. The same authors stated that in 96% samples of White Riesling was found less than 400 mg/L of FAN, and in 77% samples even less than 200 mg/l, claiming that White Riesling among all white cultivars had the lowest FAN concentration in must.

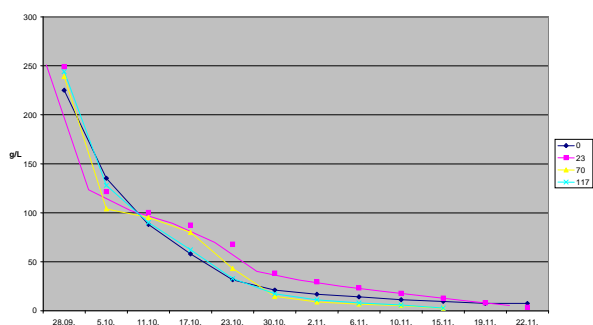
When comparing with our results it is obvious that the FAN content in White Riesling musts is significantly lower, and far away from recommended and necessary concentrations for good alcoholic fermentation.

**Table 3. Effect of rate of nitrogen fertilization on free amino nitrogen in must (mg/L) of White Riesling, 2006-2009.**

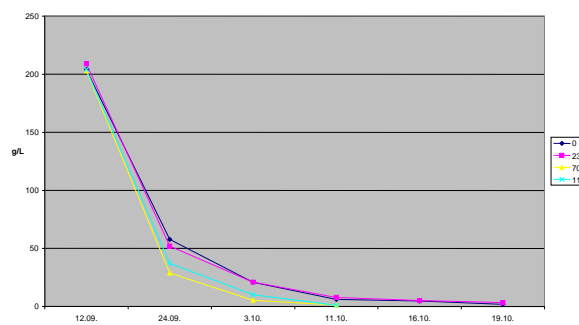
kg N/ha	2006	2007	2008	2009	$\bar{x}$
0	13.22	24,05	27,23	14,51	19,75
23	23.92	25,58	30,11	18,95	24,64
70	29,02	34,28	40,52	19,03	30,71
117	21,79	30,92	37,25	22,57	28,13

Fermentation rates: The effect of nitrogen fertilization is shown in Figures 1-4. It is obvious that only in 2007 all must completed fermentation to dryness, with 70 and 117 kg N/ha in 29 days, and 0 and 23 kg N/ha in 37 days. That was the only year in which control treatment (without N fertilization) completed fermentation. Must treated with 23 kg N/ha completed fermentation only in 2006 and 2007 years, while 70 and 117 kg N/ha completed fermentations in all experimental years. Average number of days needed for completing fermentation for 70 and 117 kg N/ha treatments was 32 and 34 days respectively, which can be considered as a quite long term fermentation. Other two treatments showed no capability for completing fermentation, which was prolonged for even 52 or 56 days, and stuck with 6-8 g/L of residual sugar.

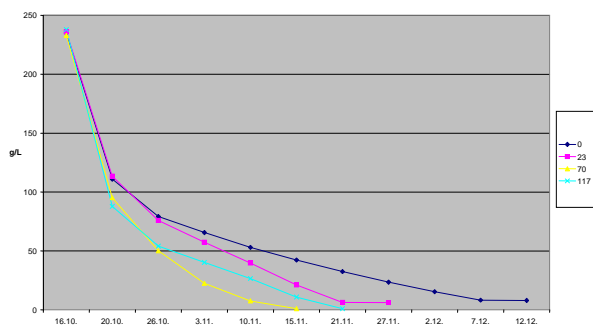
The length of fermentation time is not strongly related to the FAN level in the juice, especially when looking year by year FAN levels. The explanation is in fact that FAN as a chemical definition do not discriminate between those free amino nitrogen containing compounds that can be utilized by *Saccharomyces cerevisiae* for their nitrogen content and those that cannot.



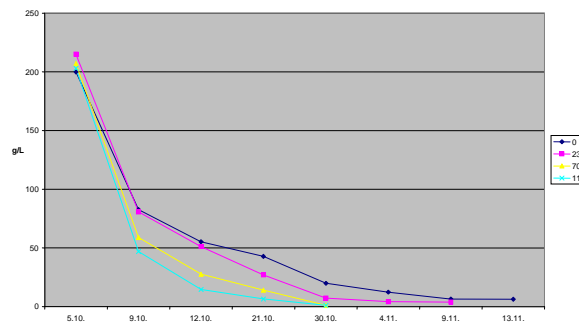
Graf 1. Fermentation rate, White Riesling, 2006



Graf 2. Fermentation rate, White Riesling, 2007.



Graf 3. Fermentation rate, White Riesling, 2008.



Graf 4. Fermentation rate, White Riesling, 2009.

### Conclusions

Nitrogen fertilization delayed fruit maturity as indicated by total acidity concentrations. The impact of nitrogen fertilization on FAN concentration varied from year to year, but was higher in fertilization treatments. In fact, in all treatments the FAN concentrations were extremely low, that can not assure adequate conditions for completing alcoholic fermentations in the appropriate time. Application of sufficient N fertilizer in the soil immediately after bloom, and in form of urea to assure complete fermentation of White Riesling juice produced from Zagreb vineyard hills is not possible, especially when considering very high partitioning of clay in the soil. It is necessary to examine possibility of leaf (foliar) application of N fertilizers, as well as other timings of nitrogen fertilizers application.

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# Photosintetic activity in leaves on laterals and top leaves on main shoots of Sila cultivar before grape harvest

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## Abstract

Photosynthesis takes place in all green parts of the grapevine plant, but it is most intensive in the leaves of main shoots and laterals. Importance of various strata and categories of leaves is still not quite clear, even to experts. With this in mind, an investigation was undertaken of photosynthetic activity in leaves of main shoots and laterals of a newly developed Serbian grape variety Sila, which was grown under the ecological conditions of Fruška Gora mountain. An LSpro+ instrument was used to measure the rates of photosynthesis and transpiration in the top leaf of the main shoot, and in the third leaf from the base of the lateral, that developed in the axilla of that leaf. Measurements were made just before grape harvest, on intact control vines and the vines from which shoots, that emerged from secondary and tertiary latent buds, were removed in the spring and, later on, grape bunches were removed from laterals. The leaves on the laterals had a higher rate of photosynthesis than the leaves on the top of the main shoots (7.9 and 6.9  $\mu\text{mol CO}_2 \times \text{m}^{-2} \times \text{s}^{-1}$ , respectively). The leaves on the laterals also had a higher transpiration rate than the leaves on the top of the main shoots (2.5 and 2.4  $\text{mmol H}_2\text{O m}^{-2} \text{s}^{-1}$ , respectively).

Key words: grapevine, photosynthesis, lateral, main shoot

## Fotosintetska aktivnost listova zaperaka i vršnih listova glavnih lucnjeva kod sorte Sila pred berbu grožđa

### Sažetak

U svim zelenim djelovima trsa vinove loze se odvija fotosinteza, ali su listovi glavnih lucnjeva i zaperaka najvažniji. Važnost pojedinih katova i kategorija listova još uvijek nije jasna čak i stručnjacima. Zbog toga je i poduzeto ispitivanje fotosintetske aktivnosti listova na glavnim lucnjevima i zapercima, kod novostvorene srpske sorte Sila, u agroekološkim uvjetima Fruške Gore. Aparatom LSpro+ mjereno je intenzitet fotosinteze i transpiracije na vršnom listu glavnog lucnja, a na zaperku, izašlom iz njegovog pazuha, na trećem listu od osnove. Mjerenja su vršena neposredno pred berbu grožđa, na kontrolnim trsovima, i onima sa kojih su s proljeća uklonjeni lucnjevi iz suočica, a kasnije i rod sa zaperaka. Listovi na zapercima su imali viši intenzitet fotosinteze (7,9  $\mu\text{molCO}_2 \times \text{m}^{-2} \times \text{s}^{-1}$ ) u odnosu na one sa glavnih lucnjeva (6,9  $\mu\text{molCO}_2 \times \text{m}^{-2} \times \text{s}^{-1}$ ). Isto je i sa transpiracijom, listovi na zapercima su imali intenzitet transpiracije 2,5  $\text{mmolH}_2\text{O m}^{-2} \text{s}^{-1}$ , dok je kod listova sa glavnih lucnjeva ona iznosila 2,4  $\text{mmolH}_2\text{O m}^{-2} \text{s}^{-1}$ .

Ključne riječi: vinova loza, fotosinteza, zaperak, glavni lucanj

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## **Introduction**

Although photosynthesis takes place in all green parts of the plant, leaves, as plant parts with largest surface, are main producers of carbohydrates. They are the most important source of organic matter in grape plants too. On the other side, all parts of the grapevine with no photosynthetic activity receive the carbohydrates they need from leaves. These plant parts drain leaves of photosynthetic products (Chaumont et al., 1994). For grape growers, berries in the grape bunch are most important sinks of photosynthetic products, especially sugars. However, in the course of their development, the berries do not have a uniform demand for organic matter. Inflorescences and newly developed bunches are not important sinks, since they start an intensive sugar accumulation with the approach of the veraison stage (Edson et al., 1995; Hale and Weaver according to Edson et al., 1995; Keller and Koblet according to McArtney and Ferre, 1998). Sugar accumulation in grape juice is particularly intensive during the ripening stage, so that is the time when it is necessary to have a sufficiently large and active leaf area capable of meeting the requirements for organic matter. During that period, the leaves in the middle and upper parts of the shoots and those on the laterals are most important (Edson et al., 1995; Kastori, 1998; Poni and Giachino, 2000; Vasconcelos and Sastagnoli, 2001). These leaves are younger, and therefore photosynthetically more active, than the leaves in the middle and near the base of the shoots.

In general, after reaching one third of their full size, young leaves start producing excess photoassimilates which are then translocated to other parts of the vine (Kastori, 1998). With further growth and development of leaves, their photosynthetic productivity increases and reaches its peak, which is maintained for some time. As the leaves age, their photosynthetic activity and their contribution to the production of organic matter decrease (Kriedeman according to Hirano et al., 1994).

An experiment of Edson et al. (1995a) showed that, just before harvest, photosynthetic activity was highest in leaves that were last to reach full development, and that their activity was positively correlated with the total photosynthetic activity of the vine. Thus they concluded that the photosynthetic activity in a single leaf can be used as an indicator of impact of yield load on the photosynthetic activity of the entire vine.

It seems necessary to point out the important role of leaves on the laterals in sugar accumulation in grape juice, because complete removal of laterals or their pruning to a small number of leaves is a frequent practice in vineyards in Serbia. It is exactly the objective of this research - to measure the photosynthetic activity of leaves on the laterals and main shoots in order to demonstrate that the laterals are not unnecessary but useful plant parts that help the vine, at the time of grape ripening, to accumulate sufficient amounts of organic matters in grape juice and vine.

When they have only two fully developed leaves, laterals produce excess photoassimilates that may be translocated to other parts of the vine (Hale and Weaver according to Vasconcelos and Sastagnoli, 2001).

Measurements of the leaves on laterals and main shoots, conducted by Hirano et al. (1994) at the time of grape ripening, indicated that the leaves on laterals had a higher rate of photosynthesis than the leaves on main shoots.

In addition to age, leaf productivity depends, among other factors, on shoot fertility and water status of tissues. Kastori (1998) found that fertile shoots had higher photosynthetic activity in leaves than barren shoots. He explained it by a rapid transport of photosynthetic products through fertile shoots, from leaves to grape bunches. Soil water deficit reduces the rates of photosynthesis and transpiration in leaves [Al-Hazmi (1997), Kastori (1998), Flexas et al. (2005), Poni et al. (2009)].

## **Material and Method**

The experiment was conducted on 12-year-old cv Sila vines, which had been grafted on Berlandieri x Riparia Kober 5BB rootstock. Planting in pairs of grafts was applied. The spacing was 3.0 x 1.6 m. Vine training system was the single Guyot with arched canes. Canes and spurs were left with bud loads of 13 and 2 buds, respectively, so that the bud load per unit area was 6.25 buds. The vineyard was established in 1998 at the Experimental field of the Faculty of Agriculture, Novi Sad, located in Sremski Karlovci.

Sila is a new domestic grape cultivar intended for production of white wine. Because of its late maturation and a relatively slow accumulation of sugars (Cindrić et al., 2000), this cultivar was selected for the study of the role of individual leaves in the production of sugars at the time of grape ripening.

Two types of vine treatment were used for the measurements:

- In the variant "treatment", additional green pruning operations were applied: the shoots that emerged from secondary latent buds were removed (while the shoots were about 15 cm long), and inflorescences were removed from laterals.
- In the variants "control", the above green pruning operations were not performed.

Each variant was planted in three density replications, with 20 vines per replication. A difference between the means of the two experimental variants was assessed by the t-test.

The rates of photosynthesis and transpiration were measured with an LCpro+ portable photosynthesis system (ADC BioScientific Ltd.). Light conditions were adjusted, by means of a Lcpro+ unit, at a photosynthetically active radiation level of  $1000 \text{ mmol m}^{-2} \text{ s}^{-1}$ . Ambient air was pumped into the leaf chamber at a constant rate of  $100 \text{ mmol s}^{-1}$ . Air humidity was maintained at 10.  $\text{CO}_2$  temperature and concentration in the chamber depended on the ambient conditions.

Three vines were selected from each replication and a single shoot was randomly chosen from each of them. The shoots' top leaf (the first one below the place of topping) was used for measurement. Measurements were also done on the third leaf from the base of the lateral that emerged in the axilla of the top leaf. In the control variant, on the lateral, there was always a grape bunch on the opposite side of the measured leaf. The measurements were performed on 24 September 2009.

## Results and Discussion

In the control variant, the rates of photosynthesis and transpiration were significantly higher in the leaves from laterals than in those from main shoots (Table 1).

In the treatment variant, there were no statistically significant differences in the rates of photosynthesis and transpiration between the leaves from laterals on those from main shoots. In both variants, the rate of photosynthesis was higher in the leaves from laterals than in the leaves from main shoots. This is in agreement with the findings reported by Hirano et al. (1994).

The significantly higher photosynthetic activity and the rate of transpiration of the leaves from main shoots in the treatment variant compared with the control variant was the consequence of better light interception resulting from shoot pruning.

The higher rate of photosynthesis in the leaves of laterals in the control variant compared with the treatment variant confirm the finding of Kastori (1998) that the leaves of fertile shoots had a higher photosynthetic activity than the leaves on unfertile shoots.

Table 1. Rates of photosynthesis and transpiration in individual leaves of the cultivar Sila, 2009

Replication	Control				Treatment			
	Lateral		Main shoot		Lateral		Main Shoot	
	A	E	A	E	A	E	A	E
I	8.9	2.5	7.6	2.3	9.4	2.5	8.1	2.6
II	7.1	2.5	6.2	2.3	7.0	2.2	6.9	2.5
III	7.9	2.7	5.3	2.2	7.2	2.8	7.5	2.7
Average*	8.0 a	2.6a	6.4 b	2.3 b	7.9 a	2.5a	7.5 a	2.6 a

A - Rate of photosynthesis ( $\mu\text{mol CO}_2 \times \text{m}^{-2} \times \text{s}^{-1}$ ).

E - Rate of transpiration ( $\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$ ).

\* Different letters stand for statistical difference at 0.05 significance level.

Table 2 shows the measured parameters while disregarding the experimental variants, in order to compare the leaves from lateral with apical leaves of main shoots. The data presented in Table 2 show that the rate of photosynthesis was significantly higher in the leaves of laterals, which was in agreement with the reports of Edson et al. (1995a) and Hirano et al. (1994). The increased rate of transpiration in leaves with high rate of photosynthesis is consistent with the results of Chaumont et al. (1994). The rate of transpiration was higher in the leaves from laterals, but the differences was not statistically significant because grape bunches were removed of laterals in the treatment variant.

**Photosintetic activity in leaves on laterals and top leaves on main shoots of Sila cultivar befor grape harvest**

**Table 2. Differences in the rates of photosynthesis and transpiration between laterals and main shoots regardless of experimental variant**

	A ( $\mu\text{mol CO}_2 \times \text{m}^{-2} \times \text{s}^{-1}$ )	E ( $\text{mmol H}_2\text{O m}^{-2} \text{s}^{-1}$ )
Lateral	7.9	2.5
Main shoot	6.9	2.4
Statistical significance of difference	**	ns

\*\* - Statistically significant difference at 0.01 significance level

ns - No statistically significant difference

A - Rate of photosynthesis ( $\mu\text{mol CO}_2 \times \text{m}^{-2} \times \text{s}^{-1}$ ).

E - Rate of transpiration ( $\text{mmol H}_2\text{O m}^{-2} \text{s}^{-1}$ ).

### Conclusion

Immediately before grape harvest, the leaves from laterals had higher rates of photosynthesis and transpiration than the top leaves from main shoots, although the latter were believed to be most active part of the main shoot.

The leaves on the top part of the main shoots and on the laterals were most important sources of photosynthetic products at the time of grape ripening. Therefore, they should be maintained in suitable quantity and in good health condition.

Further research should confirm the viability of the above claims, and possibly provide explanation of the effect of the applied treatment on the quantity and quality of grape yield.

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# Distribucija kalija u organima vinove loze pri različitim dozama kalijevih gnojiva

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## Sažetak

Cilj istraživanja je utvrditi distribuciju kalija u organima vinove loze pri primjeni različitih doza kalijevih gnojiva. U pokusu su primijenjeni sljedeći tretmani gnojidbe: kontrola (bez gnojidbe) i tretmani s dozama gnojiva od 50, 100 i 150 kg K<sub>2</sub>O/ha. Nakon primjene gnojiva obavljena je analiza kemijskog sustava lišća i mladica gdje je utvrđen sadržaj kalija. U prvoj godini primjene gnojiva, razina kalija u lišću nije se značajno mijenjala u odnosu na kontrolu (1,36% K<sub>2</sub>O), dok se u narednim godinama ispitivanja značajno mijenjala (1,31-1,61% K<sub>2</sub>O). Sadržaj kalija u mladica značajno je varirao u skladu s dozama gnojiva (0,58-1,25% K<sub>2</sub>O).

Ključne riječi: distribucija, gnojivo, kalij, list, mladica

## Potassium distribution in grapevine organs at different potassium fertilizers doses

### Abstract

The aim of this research was to determine the distribution of potassium in organs of grapevine in the application of different doses of potassium fertilizer. In this experiment the following variants were used: control (without fertilization) and variants with fertilizer were it used doses of 50, 100 and 150 kg K<sub>2</sub>O/ha. Analysis of the chemical composition of leaves and shoots were the potassium content determined was conducted after the application of fertilizers. In the first year application of fertilizers, potassium level in the leaves has not change significantly compared to control (1.36% K<sub>2</sub>O), while in the next two years of research was significantly changed (1.31-1.61% K<sub>2</sub>O). Content of potassium in the shoots was significantly varied in accordance with the doses of the fertilizers (0.58-1.25% K<sub>2</sub>O).

Key words: distribution, fertilizer, potassium, leaves, shoot

### Uvod

Vinogradi podignuti na tlima koja su dobro opskrbljena kalijem daju veće i kvalitetnije prinose pošto se utjecaj kalija direktno ispoljava na povećanje inteziteta fotosinteze i ubrzani transport organskih tvari iz lista u druge organe, a prije svega u okca čime se prospješuje njihova bolja diferenciranosti i rodnost. Kalij utječe na aktiviranje enzimskih reakcija koji omogućavaju metabolitičke procese koji utječu na sintezu ATP-a (Creasy i Creasy, 2009). Na pjeskovitim tlima jasno je uočljiva tendencija njegovog ispiranja dok na glinovitim tlima dolazi do pojačanog vezivanja u mineralima gline. Kako njegov sadržaj u tlu varira, tako varira i njegov sadržaj u organima vinove loze, kao i u kasnije proizvedenom vinu gdje može doći do neutralizacije organskih kiselina uslijed veće koncentracije K<sup>+</sup> iona. Zato se mora posvetiti veća pažnja pravilnoj primjeni adekvatnih doza kalijevih gnojiva na različitim tipovima tla kao i problemu distribucije

kalija u organe vinove loze, a posebno ako se ima u vidu da je vinova loza kaliofilna biljka (Ličina, 2009).

U lišću vinove loze najviše se kalija nakuplja u fenofazi cvatnje i na početku sazrijevanja grožđa, a zatim se njegov sadržaj smanjuje do potpunog sazrijevanja lastara i završetka vegetacijskog perioda. Sadržaj kalija u lisnim peteljka se kreće oko 4%, dok u plojkama on prosječno iznosi oko 2,5%. Visok sadržaj kalija evidentan je u bobicama, grožđanom soku i vinu, gdje sudjeluje sa 50% u ukupnom mineralnom sustavu (Nakalamić i Marković, 2009).

Doze kalijevih gnojiva koje se preporučuju u nekim vinogradarskim zemljama su veoma različite. U Njemačkoj se preporučuje doza od 200 kg K<sub>2</sub>O/ha na lakim, a 360 kg K<sub>2</sub>O/ha na teškim tlima (Platz, 1980). U Francuskoj se međutim kod vinskih sorti primijenjuju znatno manje količine kalija oko 60 kg K<sub>2</sub>O/ha (Delas i sur., 1990), dok je u Italiji razina kalija prilikom gnojidbe dosta visoka i kreće se od 100 do 200 kg K<sub>2</sub>O/ha (Fregoni, 2005).

### Materijal i metode

Ispitivanja su obavljena u vinogradu pokusnog dobra "Radmilovac" Poljoprivrednog fakulteta u Zemunu na sorti Sauvignon blanc koja je okalemljena na podlozi Berlandieri x Riparia Kober 5BB. Sva ispitivanja vezana za tlo obavljena su prije i nakon podizanja vinograda, a ispitivanja listova i mladica u trogodišnjem periodu po stupanju vinograda u rod. Međuredni razmak u vinogradu je 3 m, a razmak između trsova u redu 1 m. Tip tla u vinogradu je eutrični kambisol. Uzgojni oblik je dvokraki asimetrični kordonac (Nakalamić, 1991). Pokus je postavljen po blok sustavu gdje je u svakom tretmanu osamnaest čokota koji su raspoređeni u tri ponavljanja sa po šest čokota. U pokusu su svake godine primijenjene sljedeći tretmani gnojidbe kalijevim gnojivima (korišten je 50% KCl): kontrola (bez gnojidbe) i tretmani sa dozama gnojiva od 50, 100 i 150 kg K<sub>2</sub>O/ha, a istovremeno dodan je i dušik u količini od 30 kg N/ha i fosfor 50 kg P<sub>2</sub>O<sub>5</sub>/ha. Prije primjene gnojiva, obavljena je agrokemijska analiza tla, a nakon primjene različitih doza gnojiva obavljena je i kemijska analiza listova i mladica. Tlo je uzorkovano sa četiri dubine (0-30, 30-60, 60-90 i 90-120 cm) prije zasnivanja vinograda i nakon zasnivanja po primjeni gnojiva na kraju svake vegetacije u godinama ispitivanja. U okviru svakog tretmana otvarana su po dva profila između redaka radi uzorkovanja zemljišta. Listovi su uzorkovani u kolovozu sa svih trsova unutar tretmana pokusa i to sa donjih, srednjih i gornjih dijelova mladica. Mladice su uzorkovane po obavljenoj rezidbi i svaka je analizirana posebno sa svih trsova. Podaci ovih analiza u tablicama predstavljaju prosjek ponavljanja za svaki tretman pokusa. Lakopristupačni kalij u tlu određen je Al-metodom po Egner-Riehm-u, a u lišću i mladicama metodom mokrog razaranja sa dušičnom kiselinom nakon čega je u ekstraktu određivan plamenfotometrijski (Džamić i sur., 1996). Prikupljeni podaci su statistički obrađeni primjenom metode varijance.

### Rezultati i rasprava

Neposredno prije primjene odgovarajućih doza gnojiva po tretmanim pokusa izvršena je detaljna agrokemijska analiza tla sa četiri dubine (0-30, 30-60, 60-90 i 90-120 cm), što je prikazano u tablici 1.

Tablica 1. Agrokemijske karakteristike ispitivane parcele prije gnojidbe K gnojivima

Dubina (cm)	pH	pH	Humus	N	NH <sub>4</sub>	NO <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca
	H <sub>2</sub> O	nKCL	%	%	mg/kg	mg/kg	mg/100g	mg/100g	mg/100g
0-30	7.4	6.5	3.30	0.21	10.5	3.50	15.0	11.95	464
30-60	7.4	6.5	2.11	0.19	10.5	5.25	8.7	14.15	404
60-90	6.7	5.4	1.88	0.16	10.0	5.25	7.8	12.75	354
90-120	6.9	5.7	1.64	0.16	12.1	7.00	8.7	12.25	399

Dobiveni rezultati ukazuju da se radi o tlu neutralne pH reakcije, čija se kiselost blago povećava s dubinom. U površinskom sloju pH vrijednost iznosi 7,4 u H<sub>2</sub>O, dok je blaga kiselost (6,7-6,9 pH u H<sub>2</sub>O), zastupljena u slojevima na dubini od 60-90 cm i 90-120 cm. Postotak ukupnog N kreće se od 0,16% do 0,21% i sa dubinom blago opada, čime se ovo zemljište klasificira kao srednje opskrbljeno dušikom (0,1-0,2%), što odgovara većini eutričnih kambisola u Srbiji. Razina ukupnog dušika, međutim, ne korenspondira sa nivoom pristupačnih oblika dušika (NH<sub>4</sub> + NO<sub>3</sub>) koji je u profilu dosta visok (210 kg N/ha na dubini 0-120 cm), pa je primijenjena manja doza dušičnih gnojiva u ispitivanom razdoblju (30 kg N/ha). Sadržaj humusa je

zadovoljavajući za uzgoj vinove loze. Prema sadržaju pristupačnog fosfora, tlo u dubljim slojevima pripada siromašnim, dok je površinski sloj srednje opskrbljen fosforom. Razina kalija je varirala od 11.95-14.15 mg K<sub>2</sub>O/100 g tla tako da ovo tlo pripada srednje opskrbljenim tlima kalijem. Sadržaj kalcija bio je najviši u sloju od 0-30 cm (464 mg/100 g tla), a najniži u sloju od 90 do 120 cm (399 mg/100 g tla). Tlo je po svom mehaničkom sustavu na dubini 0-30 cm sitno grudvaste strukture, na dubini od 30-90 cm prisutna je ilovača do pjeskovita ilovača orašasto grudvaste strukture, a na dubini 90-100 cm tlo je ilovastog sustava.

Ako se promatra utjecaj gnojidbe na sadržaj pristupačnog kalija u tlu (tablica 2) za cijeli pokusni period, onda se vidi da je gnojidba kalijem pridonijela povećanju sadržaja pristupačnog kalija u svim tretmanima, a posebno u tretmanima III i IV gdje je sadržaj pristupačnog kalija bio značajno veći nego u tretmanu I i II. Razlike između tretmana naročito su izražene u sloju tla na dubini 0-30 cm (13,50-26,05 mg/100 g tla).

Tablica 2. Utjecaj gnojidbe na sadržaj pristupačnog kalija u tlu

Tretmani (I-IV)	Profil (dubina u cm)	Pristupačni K <sub>2</sub> O u mg/100 g tla			Prosjek
		I godina ispitivanja	II godina ispitivanja	III godina ispitivanja	
I Kontrola	0-30	13.63	19.55	17.80	16.76
	30-60	14.65	18.40	16.55	16.53
	60-90	13.95	16.70	14.20	14.95
	90-120	13.00	15.40	17.70	15.36
	Prosjek	13.63	17.51	16.56	15.90
II 50 kg K <sub>2</sub> O/ha	0-30	13.50	20.70	16.90	17.03
	30-60	14.90	19.50	16.80	17.06
	60-90	15.30	17.10	17.65	16.68
	90-120	14.30	17.75	19.30	17.12
	Prosjek	14.50	18.76	17.66	16.97
III 100 kg K <sub>2</sub> O/ha	0-30	15.00	20.80	17.55	17.78
	30-60	14.60	18.15	19.85	17.53
	60-90	15.85	20.30	16.25	17.46
	90-120	14.60	19.65	16.75	17.00
	Prosjek	15.01	19.72	17.60	17.44
IV 150 kg K <sub>2</sub> O/ha	0-30	16.60	26.05	18.57	20.41
	30-60	17.90	18.35	18.05	18.10
	60-90	16.55	18.15	13.30	16.00
	90-120	13.75	15.85	14.60	14.73
	Prosjek	16.20	19.60	16.30	17.31
Prosjek I-IV		14.83	18.92	16.98	16.90
LSD <sub>0.05</sub>		1.42	3.07	2.64	
LSD <sub>0.01</sub>		2.04	4.41	3.79	
	Godine	Tretmani		Godine x Tretmani	
LSD <sub>0.05</sub>	1.29	1.49		2.58	
LSD <sub>0.01</sub>	1.73	2.00		3.47	

Nakon primjene kalijevih gnojiva po tretmanima ispitivanja (kontrola, 50, 100 i 150 kg K<sub>2</sub>O/ha) uzorkovani su listova i mladice te je obavljena kemijska analiza (tablica 3).

Promatrajući razinu kalija u lišću kontrolnih biljaka tijekom trajanja pokusa (1,36% K<sub>2</sub>O u prvoj godini ispitivanja; 1,36% K<sub>2</sub>O u drugoj godini ispitivanja i 1,46% K<sub>2</sub>O u trećoj godini ispitivanja) može se reći da se on i bez primjene gnojiva nalazio na optimalnoj razini. Do sličnih rezultata došli su i Fregoni (1980) i Bergmann (1986). Gnojidba kalijevim gnojivima dozama od 50, 100 i 150 kg K<sub>2</sub>O/ha u prvoj vegetaciji nije statistički značajno utjecala na nivo kalija u listovima.

U drugoj godini pokusa razina kalija u listovima je znatno veća u tretiranim tretmanima pokusa (1,52-1,61%) u odnosu na kontrolu (1,36% K<sub>2</sub>O) što je potvrđeno veoma visokom značajnošću razlika pri testiranju u odnosu na kontrolu. Pri gnojidbi kalijevim gnojivima u trećoj godini ispitivanja došlo je do smanjenja sadržaja kalija pri primjeni doza gnojiva od 50, 100 i 150 kg K<sub>2</sub>O/ha u odnosu na kontrolu što se tumači time da je izostao učinak gnojidbe. Testiranjem je potvrđena značajnost razlika između tretmana s kalijevim gnojivima i kontrole.

Na temelju dobivenih rezultata može se konstatirati da visok nivo sadržaja kalija u tlu ne mora biti parametar za visok sadržaj kalija u lišću vinove loze. Ovo je, smatra se posljedica redistribucije tj. unutarnje prerspodjele kalija između listova i drugih organa (korijen i stablo) gdje kalij zauzima drugu metaboličku ulogu (Ličina i sur.,1997).

Tablica 3. Sadržaj kalija u uzorcima lišća (%K<sub>2</sub>O)

Tretman pokusa	I godina ispitivanja		II godina ispitivanja		III godina ispitivanja	
	(%K <sub>2</sub> O)	Izneseno (g)	(%K <sub>2</sub> O)	Izneseno (g)	(%K <sub>2</sub> O)	Izneseno (g)
Kontrola	1,36	0,52	1,36	1,46	1,46	4,30
50 kg K <sub>2</sub> O/ha	1,38	0,31	1,60	1,90	1,37	4,50
100 kg K <sub>2</sub> O/ha	1,38	0,66	1,52	1,73	1,38	4,60
150 kg K <sub>2</sub> O/ha	1,26	0,62	1,61	2,85	1,31	5,54
LSD <sub>0,05</sub>		0,0390		0,0392		0,0393
LSD <sub>0,01</sub>		0,0649		0,0650		0,0651

Kad je u pitanju sadržaj kalija u mladicama on odražava stupanj ishranjenost biljke mineralnim elementima (tablica 4).

Tablica 4. Sadržaj kalija u uzorcima mladica (%K<sub>2</sub>O)

Tretman pokusa	I godina ispitivanja	II godina ispitivanja	III godina ispitivanja
	(%K <sub>2</sub> O)	(%K <sub>2</sub> O)	(%K <sub>2</sub> O)
Kontrola	1,20	0,68	0,58
50 kg K <sub>2</sub> O/ha	1,25	0,75	0,65
100 kg K <sub>2</sub> O/ha	1,20	0,75	0,70
150 kg K <sub>2</sub> O/ha	1,25	0,78	0,75
LSD <sub>0,05</sub>	0,1456	0,0392	0,0393
LSD <sub>0,01</sub>	0,2414	0,0650	0,0651

Iz dobivenih rezultata vidi se da su vrijednosti kalija u mladicama neovisno o godini istraživanja statistički značajno veće u gnojidbenim tretmanima (50, 100 i 150 kg K<sub>2</sub>O/ha) u odnosu na kontrolni tretman. Mladice vinove loze se također mogu smatrati skladišnim organom za biljna hraniva, te pokazatelj koji se dobiva kao umnožak mase mladica odbačenih rezidbom i koncentracije K<sub>2</sub>O u mladicama može biti pouzdaniji pokazatelj od sadržaja kalija samo u listovima. Tako, u 3. godini pokusa u listovima kontrole mi imamo 1,46% K<sub>2</sub>O, dok pri primjeni najveće doze gnojiva (150 K<sub>2</sub>O/ha) on iznosi 1,31% K<sub>2</sub>O, dok iznošenje kalija masom mladica odbačenih rezidbom kod kontrole je samo 4,3 g K<sub>2</sub>O, a u ovoj najviše gnojenom tretmanu on iznosi 5,54 g K<sub>2</sub>O.

### Zaključci

Analizirajući sadržaj pristupačnog kalija u tlu u sve tri godine ispitivanja, može se zaključiti da je značajno varirao ovisno o primijenjenim dozama gnojiva. Gnojidba s dozom od 100 i 150 kg K<sub>2</sub>O/ha je značajno utjecala na povećanje sadržaja pristupačnog kalija u tlu, a naročito u sloju 0-30 cm (13,50-26,05 mg K<sub>2</sub>O/100 g tla).

Sadržaj kalija u lišću bio je najveći i najviše je varirao u drugoj godini ispitivanja (1,36-1,61%K<sub>2</sub>O).

Sadržaj kalija u mladicama povećavao se s povećanjem doza gnojidbe kalijem u svim godinama ispitivanja.

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# Influence of cultivar characteristics of muscat table grapevine cultivars (*Vitis vinifera L.*) on grape brandy composition and quality

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## Abstract

The goal of this paper has been to examine influence of a cultivar on the quality of a grape brandy produced from the muscat table cultivars: Demir kapija, Early muscat, Radmilovački muskat, Banatski muskat, Muscat Hamburg, Smederevski muskat, Italy and Afuz-ali. In terms of the content of methyl alcohol as well as of the total evaporable ingredients, grape brandies made of the fermented grape mash of investigated cultivars meet the prescribed standards stipulated by the Rulebook on the Quality of Alcoholic Beverages.

Key words: cultivar, sugar content, total acidity, grapevine brandy, methanol, higher alcohols, Esters, Aldehydes.

## Introduction

Grape brandy, “lozovača” or “lozova rakija”, was produced by means of fermentation and distillation of the whole, non-squeezed mash of noble grapevine cultivars *Vitis vinifera L.* (Paunović and Nikićević, 1988). Grape brandy quality depends on many factors, but primarily on cultivar characteristics of grape, the grape processing manner, the alcoholic fermentation process as well as on the implemented distillation procedure (Versini et al., 1993, Nikićević et al., 2000, Mojmir, W., Berović, M., 2001, Sanja Radeka et al., 2008).

Water and ethanol are basic ingredients, apart from them, grape brandy also contains many other ingredients, the concentration of which mainly depends upon the cultivar, that is on the raw material content and the technological procedure implemented (fermentation manner, distillation procedure etc.). Pursuant to the Rulebook on the Quality of Alcoholic Beverages and other requirements (“The Official Gazette of Serbia and Montenegro”, no. 24/2004) grape brandy is to contain at least 40%v/v of alcohol (ethanol). The methanol content should be restricted from 1 to 4 g/l a.a., while the concentration of evaporable ingredients (other than ethanol and methanol) should be 1180 mg/l a.a.

Almost all alcoholic beverages contain methanol. According to Peinado et al. (2004), it is generated by the enzyme hydrolysis of pectin methoxy groups during the fermentation, while its content depends upon the maceration degree of solid berry part. Since methanol is toxic, its concentration with spirit drinks is limited by regulations. The upper limit of methanol concentration in grape marc spirits is 1530 mg / 100 ml ethanol, according to Luiz Silva et al. (1996).

The group of higher alcohols has the highest concentration in distillates, giving them bouquet and fundamental characteristics (Soufleros et al. 2004). Esters considerably contribute to the distillate taste with a pleasant fruity and floral aroma, which indicates beverage quality (Soufleros et al., 2004). According to Luiz Silva et al. (1996), aldehydes are to be found in distilled beverages, and they are regarded to indicate spontaneous oxidation or the activity of undesirable contaminating germs. Paunović i Đurišić (1981) point out that a higher share of aldehydes of 250 mg/l a.a. adversely influences the grape brandy aroma and taste.

## Material and methods

Examinations have been carried out in grapevine table cultivar collection nurseries, at the experimental estate Radmilovac of the Faculty of Agriculture in Zemun. During the experiment, the nursery was eight years old. Examinations lasted for 3 years (2007 /09).

The brandy production technological procedure was unified and implemented as follows: grape was harvested fully ripe (ripeness was determined through the sugar accumulation dynamic monitoring). 10 kg of grape were sampled from each cultivar. After the harvest, grape was disintegrated (pressed) and stems separated. Fermentation was carried out in plastic containers of 20 litres, using the standard procedure, that is within the autochtone microflora without sulphuring. Fermentation was carried out at the temperature of 20 °C with the immersed cap. After the alcoholic fermentation, the fermented mash was distilled using a simple brass charante-type device. The fermented mash was distilled without separating the first brandy, in order to provide maximum transfer of aromatic ingredients to the raw crude distillate. Soft grape brandies were produced by distillation. They were also re-distilled by the charante-type device of the volume of 5 liters in order to produce double-distilled brandy. During the second distillation, the first fraction of distillate was separated at the amount of 1% of the initial quantity of the raw crude distillate. Accumulation of the middle fraction was carried out until the average concentration (in the mass) decreased to the minimum 65% vol.

The produced distilled grape brandies were put to gradual harmonization for 3 weeks, after which gradual grape brandy adjustment or diluting was carried out until the final alcoholic strength of 45% vol. was achieved. After that, the quantitative chemical analysis of the final grape brandies were carried out. The usual analytical methods stipulated by the Rulebook on the Alcoholic Beverage Sampling and Performance of Chemical and Physical Analyses (The Official Gazette of the Republic of Serbia no. 401-23/2004) were used in order to determine the quantitative chemical composition of the produced grape brandies.

Experimental data of the three-year examination of grape brandies were processed within the statistical package STATISTIKA (version 6.0) through implementation of multivariate analysis of variance (MANOVA).

## Results and discussion

Results of the average grape quality expressed through the sugar content and total acids in the examined table cultivars are presented in table 1.

One of the most relevant grape quality indicators is its chemical composition expressed through the content of sugar and total acids. Grape juice of cultivar Muscat Italy has had the lowest sugar content (15.83%) while cultivar Muscat Hamburg has had the highest one (21,76%). The lowest content of total acids has been recorded with cultivar Smederevski muskat (4,90 gl-1) while the highest one has been recorded with cultivar Muscat Italy (7,91 gl-1). The results concerning the content of sugar and total acids are within the limits stipulated also by other authors (Pavlović, 1983; Žunić, 1993; Korać et al.,1998).

**Table 1. Average values of the grape must quality expressed through the sugar content (Brix%) and total acids (gl-1) of muscat table cultivars of grapevine (*Vitis vinifera* L.)**

Cultivar	Sugar (Brix%)	Total acidity (gl <sup>-1</sup> )
Demir kapija	16.60b	6.51b
Early muscat	19.70b	7.46a
Radmilovački muskat	19.43b	6.45b
Banatski muskat	20.83a	5.13b
Muskat hamburg	21.76a	5.39b
Smederevski muskat	18.66b	4.90b
Italy	15.83b	7.91a
Afuz - ali	16.16b	5.92b
Lsd <sub>0,05</sub>	1.081	1.041

Data followed by same letter are not significantly different

The produced distilled brandies of the average alcoholic strength from 44.8 to 45.2 vol% have not shown considerable differences concerning the methanol content, the concentration of which has in average been the highest within the distilled brandy of cultivar Muscat Hamburg (0.1146 vol%), which is statistically much higher than within the distilled brandies of the majority of other cultivars except for the ones of cultivar Radmilovački muskat (table 2). The methanol content in grape brandies of all examined cultivars is somewhat smaller when compared to the values stipulated by Paunović and Đurišić (1981) and they comply with the results provided by Nikićević and associates (1996). Differences in the methanol content within the examined distilled brandies may be due to the influence of a cultivar (Petrović et al., 1996), as well as due to the circumstances of fermentation and distillation itself (Da Porto et al., 2004).

Average concentration of the total higher alcohols have been from 0.114 vol% with the grape brandy made of cultivar Afuz-ali to 0.1593 vol% with the grape brandy made of cultivar Demir kapija, which has had considerably higher content of the total higher alcohols than the brandies made of other examined cultivars. Average values of the total higher alcohols content are somewhat smaller or within the limits stipulated by other authors (Nikićević et al., 1996, 2000; Da Porto et al., 2004; Peinado et al., 2004). The grape brandy made of cultivar Afuz-ali has had the lowest content of total acids (282 mg/l a.a.), while the grape brandy of cultivar Banatski muskat has had the highest value of the relevant indicator (2735.00 mg/l a.a.), which is considerably higher content when compared to the distilled brandies of other cultivars. Such a high content of total acids may be explained by inadequate procedures within the fermentation process, since within other samples there have been no such differences among the examined cultivars. Results of other authors also indicate relevant differences in the content of total acids of grape brandies. Paunović and Đurišić (1981) point out great differences in the content of total acids with grape brandies.

The lowest content of the total esters in average has had the grape brandy made of cultivar Afuz-ali (4232.33 mg/l a.a.), while the highest one has had the distilled brandy of cultivar Smederevski muskat (6007,00 mg/l a.a.). Grape brandy produced of cultivar Smederevski muskat has statistically had considerably higher content of total esters than the distilled brandies made of cultivars Demir kapija, Muscat Hamburg and Afuz-ali.

**Table 2. Average values of basic ingredient concentrations within the grape brandies made of the examined muscat table cultivars (vol%; mg/L a.a.) (*Vitis vinifera* L.)**

Cultivar	Alcohol (vol%)	Methanol (vol%)	Higher alcohols (vol%)	Total acidity (mg/l a.a)	Esters (mg/l a.a)	Aldehydes (mg/l a.a)	Total extract (g/l)	TotalSO <sub>2</sub> (mg/l)
Demir kapija	45.0ab	0.0454a	0.1593e	762.33ab	4497.33ab	189.790bc	0.183c	5.119ab
Early Muscat	45.1ab	0.0663ab	0.1263cd	2292.33ab	5600.00bc	226.173d	0.163b	4.693a
Radmilovački muskat	45.2b	0.0926cd	0.1305d	2435.33ab	5509.33bc	225.963d	0.180c	5.760b
Banatski muskat	44.9a	0.0704bc	0.1209bcd	2735.00b	5646.33c	217.120d	0.163b	4.480a
Muscat Hamburg	45.0ab	0.1146d	0.1302cd	315.33a	4367.33a	184.003b	0.180c	5.119ab
Smederevski muskat	45.0ab	0.0770bc	0.1192ab	2148.00ab	6007.00c	213.770cd	0.153ab	5.119ab
Italy	45.2b	0.0795bc	0.1206bcd	749.00ab	5266.00abc	218.46d	0.153ab	5.119ab
Afuz-ali	44.8a	0.0827bc	0.1144a	282.00a	4232.33a	143.393a	0.143a	5.119ab
Lsd <sub>0,05</sub>	0.25483	0.02297	0.011159	2283.02	1113.26	24.2102	0.01368	0.71506

Data followed by same letter are not significantly different

The ester content has considerably increased with particular samples of distilled brandies probably due to distillation within the acidic environment, since grape brandies made of particular cultivars have had considerably higher content of acids than other cultivars (Nikićević, 2000). The total aldehyde average content concerning the examination period has been from 143.393 mg/l a.a (Afuz-ali) to 226.173 mg/l a.a (Early Muscat). The grape brandy produced from cultivar Afuz-ali has statistically had considerably lower average concentration of total aldehydes than the rest of the cultivars. The aldehyde content with other cultivars has complied with the quality standards stipulated by the Rulebook on the Quality of Alcoholic Beverages.

During the examination period, the total extract with all distilled brandies has fluctuated from 0.143 to 0.183 g/l, while the total SO<sub>2</sub> has been from 4.693 to 5.760 mg/l. The total extract and total SO<sub>2</sub> content has complied with the prescribed standards stipulated by the Rulebook on the Quality of Alcoholic Beverages.

## Conclusion

In terms of the content of methyl alcohol as well as of the total evaporable ingredients, grape brandies made of the fermented grape mash of cultivars Demir kapija, Early Muscat, Radmilovački muskat, Banatski muskat, Muscat Hamburg, Smederevski muskat, Italy and Afuz-ali, meet the prescribed standards stipulated by the Rulebook on the Quality of Alcoholic Beverages. In terms of their chemical composition, grape brandies made of cultivars Demir kapija and Muscat Hamburg have considerably differed from grape brandies made of the rest of the cultivars.

## Note

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# Utjecaj uzgojnog oblika na urod i kakvoću kultivara Syrah

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## Sažetak

Cilj istraživanja bio je utvrditi, kako utječe na kakvoću grožđa i prirod kratka rezidba račvastog uzgojnog oblika sa tri reznika i opterećenjem od šest pupova u odnosu na uzgojni oblik Guyot i opterećenje od deset pupova po trsu kultivara Syrah. Istraživanje je provedeno u Vinogorju Kutjevo na nastavnom objektu Veleučilišta u Požegi, tijekom 2010. godine. Pokus je postavljen po slučajnom bloknom rasporedu u tri repeticije sa po deset trsova u svakoj repeticiji, a svi rezultati su statistički obrađeni. Rezultati su pokazali da nije bilo opravdanih razlika u kakvoći grožđa osim u pogledu ukupnih kiselina koje su značajno veće kod račvastog uzgojnog oblika.

Ključne riječi: vinova loza, Kutjevo, Syrah, uzgojni oblik

## Effect of training system on yield and quality of the cultivars Syrah

### Abstract

The aim of this study was to determine, how does it affect the quality of grape yield and short pruning forkedly tree forms with three vine-shoot and load six buds in relation to the training system Guyot and ten buds per vine stock on cultivar Syrah. The study was conducted in Kutjevo vineyards on the teaching facility of the Polytechnic of Požega, during the 2010<sup>th</sup> year. The experimental design was a randomized block design with three replications of ten vines in each repetition, and all results were statistically analyzed. The results showed that there were no significant differences in the quality of grapes, except in respect of the total acids were significantly higher in forkedly tree forms.

Key words: grapevine, Kutjevo, Syrah, training system

### Uvod

Kultivar vinove loze Syrah crni vjerojatno potječe iz Irana odakle su ga rimski legionari preneli na Siciliju (Mirošević i Turković, 2003.). Novija ampelografska istraživanja pod vodstvom Carole Meredith sa zavoda za vinogradarstvo i vinarstvo Sveučilišta Davis iz Kalifornije pokazala su da Kultivar Syrah potječe iz područja Francuske. Naime DNA analizom je utvrđeno da oba roditelja Syraha dolaze iz malog područja u sjeveroistočnoj Francuskoj, veoma blizu sjeverne pokrajine Rhône, gdje je Syrah postao poznat i gdje se i danas nalazi većina nasada (Merdeith, 2010). Ovaj kultivar se uzgaja gotovo u svim vinogradarskim zemljama svijeta, u Europi najviše u Francuskoj, zatim Australiji, Južnoj Africi, Sjevernoj i Južnoj Americi, a u novije vrijeme i u Republici Hrvatskoj. Osim naziva Syrah često se ovisno o području uzgoja koristi naziv Shiraz koji je karakterističan za zemlje južne hemisfere. U Kutjevačkom vinogorju je vrlo slabo zastupljen i uzgaja se gotovo isključivo kao sorta koja se kupažira sa Merlotom i Cabernet Sauvignonom. Većina nasada podignuta je posljednjih desetak godina. Ovo je kultivar koji najbolje rezultate postiže na toplim tlima

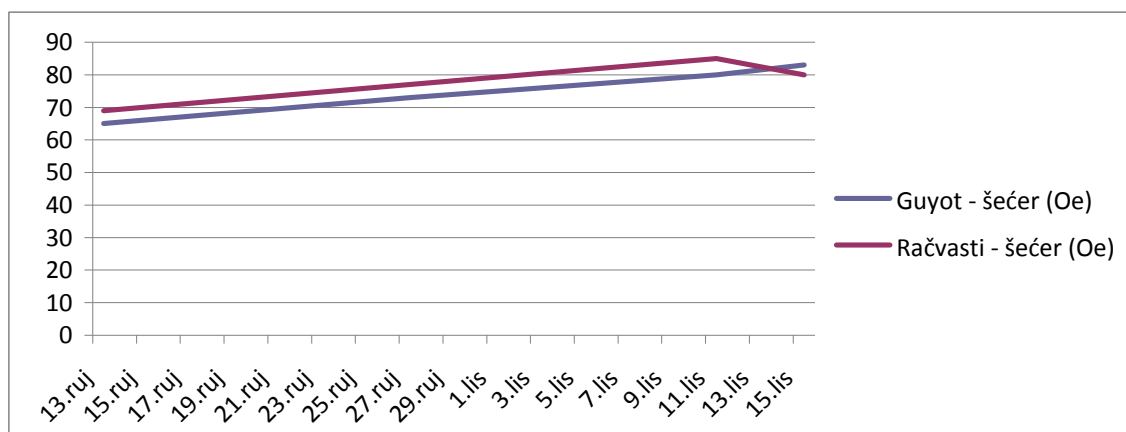
dobrog vodozračnog odnosa, u uvjetima toplije klime. Syrah je vinska sorta koja daje vina osrednje do visoke kakvoće ovisno o okolinskim uvjetima i načinu uzgoja. Uspješno se uzgaja primjenom kratkog reza na niskim i povišenim sustavima uzgoja, a slabije rezultate daje pri mješovitom rezu (Mirošević i Turković, 2003).

### Materijali i metode

Istraživanje je provedeno na nastavnom objektu Veleučilišta u Požegi u općini Kaptol u Vinogorju Kutjevo koje se nalazi u sklopu vinogradarske podregije Slavonija, regija Kontinentalna Hrvatska. Položaj pokusnog nasada nalazi se u području umjereno kontinentalne klime. Južne je ekspozicije i blagog nagiba terena na 350 m nadmorske visine. Redovi pokusnog nasada pružaju se u smjeru sjever jug. Vinograd je posađen kao pokusna parcela crnih kultivara vinove loze. Srednja godišnja temperatura zraka za područja Požeštine iznosi 10,9 °C. Godišnje padne prosječno od 700 do 900 mm oborina, većinom tijekom vegetacije te može imati nepovoljan utjecaj na pojedine faze razvoja vinove loze (Maletić i sur., 2008), što je i bio slučaj u godini istraživanja, 2010. Podloga je *Vitis berlandieri x Vitis riparia* SO4 koja je i selekcionirana za sjevernije vinogradarske krajeve, budući da utječe na ranije dozrijevanje drva (Mirošević i Karoglan Kontić, 2008). Razmak sadnje je 2,1 x 0,8 m. Armatuta se sastoji od metalnih stupova i plastičnih kolčića te pet žica raspoređenih u tri reda. Tlo se tijekom vegetacije obrađuje kultiviranjem, a osim zelene rezidbe svi zahvati se obavljaju ručno. Istarživanje je obavljeno 2010 godine na dva uzgojna oblika: račvastom uzgojnom obliku sa tri reznika i dva pupa po svakom rezniku i Guyot sa reznikom koji ima dva pupa i lucnjem sa osam pupova. Opterećenje trsova pupovima na račvastom uzgojnom obliku iznosi 6, a na Guyot-u 10 pupova. Količina sladora određena je refraktometrom sa skalom °Oe, a ukupna kiselost određena je metodom neutralizacije sa 0,1 M NaOH i indikatorom bromtimol plavo, te izražena u g/l kao vinska kiselina. Prikupljanje podataka vršeno je tijekom dozrijevanja grožđa u rujnu i listopadu te u vrijeme berbe grožđa (15. 10. 2010.)

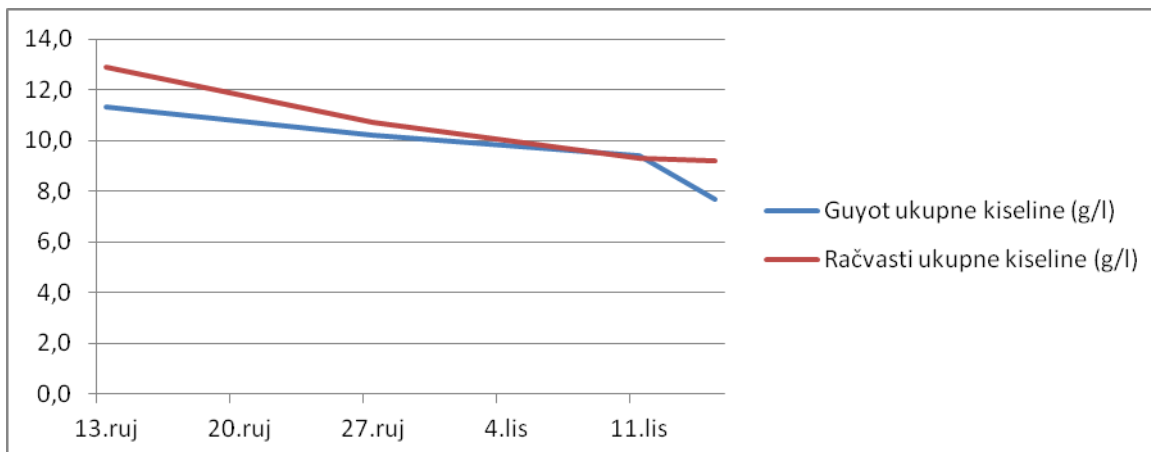
### Rezultati i rasprava

Rezultati istraživanja prikazani su u tablicama 1 i 2 te u grafikonima 1 i 2. Grafikon 1 i 2 prikazuju dinamiku dozrijevanja grožđa od 13.rujna do trenutka berbe (15. listopada). Od početka uzorkovanja razina šećera ravnomjerno se povećavala kod oba uzgojna oblika, ali izmjerena razlika nije i statistički značajna, te ne možemo tvrditi da je nastala pod utjecajem uzgojnog oblika. Iz grafikona je vidljivo da je tijekom zriobe uzgojni oblik Guyot imao nešto niži udio šećera u grožđu do zadnjeg uzorkovanja tj. trenutka berbe.



Grafikon 1: dinamika kretanja prosječnog sadržaja šećera u grožđu (°Oe), Syrah crni, berba 2010. godine

## Utjecaj uzgojnog oblika na urod i kakvoću kultivara Syrah



**Grafikon 2: dinamika kretanja sadržaja ukupne kiselosti u grožđu (g/l), Syrah crni, berba 2010. godine**

Grafikon 2 prikazuje dinamiku kretanja ukupne kiselosti u grožđu (g/l) Syrah crni tijekom dozrijevanja. Uzgojni oblik Guyot tijekom prikupljanja uzoraka imao je niži sadržaj ukupnih kiselina u odnosu na račvasti oblik uzgoja od početka uzorkovanja 13. rujna do berbe grožđa.

Tablica 1 prikazuje je prosječni sadržaj šećera u moštu ( $^{\circ}\text{Oe}$ ), sadržaj ukupne kiselosti izražen kao vinska kiselina (g/l) i pH vrijednosti mošta kultivara Syrah crni u trenutku berbe grožđa 2010 godine. Iz tablice je vidljivo da je sadržaj šećera kod uzgojnog oblika Guyot iznosio  $83^{\circ}\text{Oe}$  te je neznatno veći u odnosu na račvasti oblik uzgoja i ta razlika nije statistički opravdana. Naprotiv, ukupna kiselost se značajno razlikovala i sadržaj ukupnih kiselina povoljniji je kod uzgojnog oblika Guyot u okolinskim uvjetima koji su prevladavali tijekom 2010. godine. Suprotno tome razlike u pH vrijednosti nisu značajne i iznose 3,0 za Guyot i 2,9 za račvasti oblik uzgoja.

Tablica 2 prikazuje urod grožđa u vidu broja grozdova po trsu, prosječne mase grozdova izražene u gramima i prosječan urod po trsu izražen u gramima po trsu. Iz tablice je vidljivo da je račvasti oblik imao znatno manji broj grozdova po trsu. Zbog velikog odstupanja u broju grozdova u jednoj pokusnoj parceli račvastog uzgojnog oblika razlika nije statistički opravdana. Primjetna je razlika u prosječnom urodu po trsu, dok je razlika u prosječnoj masi grozdova neznatna i iznosi 126 g za uzgojni oblik Guyot i 134 g za Račvasti oblik uzgoja.

**Tablica 1. Prosječni sadržaj šećera u moštu ( $^{\circ}\text{Oe}$ ), sadržaj ukupne kiselosti izražen kao vinska kiselina (g/L), pH vrijednosti mošta Syrah crni, 2010. godina**

	Šećer ( $^{\circ}\text{Oe}$ )	Ukupne kiseline (g/l)	pH
Guyot	83 a	7,9 a	3,0 a
Račvasti	80 a	9,2 b	2,9 a
LSD P=5%	10,5 ns	0,98*	0,1 ns

**Tablica 2. Prosječan broj grozdova po trsu, prosječna masa grozda (g), prosječan urod po trsu, Syrah crni, 2010. godina**

	Broj grozdova po trsu	Prosječna masa grozda (g)	Prosječan urod po trsu (g/trs)
Guyot	16,8 a	126 a	2056 a
Račvasti	12,2 a	134 a	1640 a
LSD P=5%	7,52 ns	62,77 ns	943,97 ns

## Zaključak

Istraživanje je provedeno na jednogodišnjem pokusu u klimatski vrlo nepovoljnoj 2010. godini za kultivar Syrah crni što svakako implicira potrebu za nastavkom istraživanja i uvođenja novih uzgojnih oblika kao što su kordonci kratkog reza, da bi dobili što jasniju sliku optimalnog uzgojnog oblika za ovaj relativno novi kultivar Vinogorja Kutjevo. Buduća istraživanja potrebno je usmjeriti na proučavanje različitih ampelotehničkih zahvata zelene rezidbe s ciljem postizanja čim kvalitetnijeg priroda te se prvenstveno usredotočiti na zahvate defolijacije, vršikanja i uklanjanja grozdova u različitim stadijima vegetacije (prije cvatnje, nakon cvatnje, u šari bobica...) na različitim uzgojnim oblicima vinove loze. Posebno treba obratiti pozornost na odabir trsova pri postavljanju pokusa kako bi čim više umanjili samu pogrešku pokusa.

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# Effects of pectolytic enzyme treatments on white grape mashes of *Smederevka* on polyphenolic content of wines

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## Abstract

The aim of this work was to study the effect of the use of pectolytic enzymes on the phenolic composition of young white wines made of white grape *Smederevka* (*V. vinifera* L.). White grape mash from *Smederevka* were macerated for 4 hours at 18 to 20 °C with addition on one commercial pectolytic enzyme preparation (Vinozym Process, Trenolin Mash DF, Rohavin LX). The obtained results of laboratory trials showed decreased concentration of total phenolics by 37.8% and results of industry trials decreased by 39.2%. These enzyme treatments resulted in clarified the white grape juice, degraded the grape mash, reduced juice viscosity and total phenols and elicited an improvement in the visual aspect of the wine.

Key words: pectolytic enzymes, wine-making, total phenolics, flavonoids, catechins

## Utjecaj pektolitičkih enzima u masulju grožđa *Smederevka* na koncentraciju polifenola u vinu

### Sažetak

Cilj ovog rada bio je odrediti utjecaj pektolitičkih enzima na fenolni sastav mladih vina *Smederevka* (*V. vinifera*). Masulj grožđa *Smederevka* maceriran je 4 sata na 18 do 20 °C sa dodatkom jednog komercijalnog pektolitičkog enzimskog preparata (Vinozym Process, Trenolin Mash DF and Rohavin LX). Dobiveni rezultati laboratorijskog pokusa pokazali su smanjenje koncentracije ukupnih fenola od 37.8%, a rezultati industrijskog pokusa smanjenje od 39.2%. Primjena pektolitičkih enzima utjecala je na bistroću mošta, smanjenje viskoziteta i ukupnih fenola te su pozitivno utjecali na vizualni izgled vina.

Ključne riječi: pektolitički enzimi, vino, polifenoli, *Smederevka*

## Introduction

*Smederevka* is a variety of white grape cultivated in Republic of Macedonia used for production of quality wines. Although the composition of the grape depends on its variety, the soil and climatic conditions, there is little variation in the actual cell structure of the plant. Wines and grapes contain a number of polyphenolic constituents classified as flavonoids (anthocyanins, flavan-3-ol-monomers and polymers, flavonols and dihydroflavonols) and non-flavonoids (hydroxybenzoic acid and hydroxycinnamic acid and their derivatives, stilbenes and phenolic alcohols) that play a mayor role in enology. Red wines contain all the above phenolics, while white wines contain mainly phenolic acids and flavanols (Ribéreau-Gayon et al., 2000). Wine phenolics are important quality components that contribute to the colour, taste, and feel of wines. Pectolytic enzyme preparations are the most widely used in fruit and wine processing industry and in general are the most efficient at degrading polysaccharide. Numerous studies have reported on the use of commercial enzymes in white grape juice clarification, enzyme treatment effects on quality of white grape musts and wines, effects of different commercial pectolytic enzyme preparations on white grape musts and wines et al. (Ough C. and Crowell E., 1979; Brown M. and Ough C., 1981; Sreenath H. and Krishnaswamy S., 1992; Lao et al., 1997). Treating crushed white grapes with pectic enzyme increases juice yield, sensory tests indicate that wine quality is either enhanced or unchanged (Ough C. and Crowell E., 1979). White grape musts of eight different varieties were treated with pectic enzyme preparations. These treatments resulted in increases in total juice yields, clarify of the wine, filterability, methanol production, wine quality, browning capacity and amounts of solids that settled (Brown M. and Ough C., 1981). A commercial pectinase from *Aspergillus niger* containing various polysaccharases clarified the white grape juice to an extent of 98-99% and also degraded the grape mash by 25-30%. After pectinolytic juice clarification, both juice viscosity and total phenols were reduced by 25% and 32% respectively (Sreenath H. and Krishnaswamy S., 1992). Grapes of three white cultivars were treated with a commercial pectic enzyme preparation on an industrial scale. Pectic enzyme treatment increased the higher alcohols, free hydroxycinnamic acids and volatile phenols, whereas amounts of most esters, herbaceous alcohols and hydroxycinnamate derivative esters were reduced. When tasted by an expert panel, differences were found in sensory characteristics, with wines from untreated judged higher quality than those from treated grapes (Lao et al., 1997). Enzyme treatments on mushes speed up settling and ensure efficient sediment compaction (Cruess et al., 1951; Höhn et al., 2005; Trepo, 2008). The clear must is then racked from the lees without problems.

## Material and methods

### Commercial pectolytic enzyme preparations

In this study were used for laboratory trials three commercial macerating pectolytic enzyme preparations with four doses:

Vinozym Process, Novozymes A/S, Bagsvaerd, Denmark;

Doses: 3, 4, 5, and 6 g/100 kg grapes (I-1, I-2, I-3, I-4)

Trenolin Mash DF, Erbslöh Geisenheim AG, Geisenheim, Germany);

Doses: 1, 2, 3, and 4 mL/100 kg grapes (II-1, II-2, II-3, II-4)

Rohavin LX, AB Enzymes GmbH, Darmstadt, Germany;

Doses: 2, 3, 4, and 5 mL/100 kg grapes (III-1, III-2, III-3, III-4)

and for industrial trials used one commercial pectolytic enzyme preparation (Trenolin Mash DF, 2 mL/100 kg grapes) along with controls with no added enzyme(IV). These enzyme preparations are derived from cultures of *Aspergillus niger* which is a species accepted as G.R.A.S. (Generally Recognized As Safe) (Canal-Llauberes, 1993).

### Grape samples for laboratory trials

The white grape cultivar *Smederevka* (*Vitis vinifera*), cultivated in the Ovce pole vineyard, the Povardarie region, Republic of Macedonia, were harvested at optimal maturity (2009 vintage), at 170-190 g L<sup>-1</sup> sugar, 6.0-7.0 g L<sup>-1</sup> total acids, and pH from 3.0 to 3.2, and transported to the private winery "Imako Vino" Stip, Republic of Macedonia.

### Grape samples for industrial trials

The white grape cultivar *Smederevka* (*Vitis vinifera*), cultivated in the Veles vineyard, the Povardarie region, Republic of Macedonia, were harvested at optimal maturity (2009 vintage), at 180-200 g L<sup>-1</sup> sugar, 6.0-7.0 g L<sup>-1</sup> total acids, and pH from 3.0 to 3.2, and transported to the private winery "Tristo" Veles, Republic of Macedonia.

### Vinification

The grapes were weighed, destemmed, crushed and divided in 5 liters plastic reservoirs for laboratory trials, and for industrial trials were placed in a stainless steel fermentor (4 t.). All laboratory treatments were performed in triplicate and industrial in duplicate. White grape mash made from *Smederevka* were macerated for 4 hours at 18 to 20 °C with addition on one commercial pectolytic enzyme preparation. Control laboratory trials were in all same with experimental trials only without added pectolytic enzyme preparation. After maceration the pomace was removed and each must are pour into the funnel and collect musts in 5 liters plastic reservoirs (3 for enzyme treatments musts and 1 for control must (no-treatment)). In each reservoir are add 30 ppm SO<sub>2</sub> and are kept musts cool (15-16 °C) and allow to stand overnight, so that suspended material will fall to the bottom. The clear must is then racked from the lees without problems. In each musts (reservoir) are add yeast (*Saccharomyces cerevisiae*) NEUTRE SC (Lallemand) (200 mg/kg grapes) at ~25 °C to completion of fermentation. The bottled wines (0.5 l) were stored at 4 - 6 °C, and phenolic compounds were measured after 6 months wine maturation.

### Instrumentation and reagents

Analysis of polyphenolic components was carried out with a Aglient 8453 UV-Vis spectrophotometer. All analyses were performed in duplicate. The reagent p-(dimethylamino)cinnamaldehyde (*p*-DMACA), standards of gallic acid and (+)-catechin were from Fluka, and the Folin-Ciocalteu reagent was from Merck. All other used reagents were of analytical purity grade.

### Total phenolics assay

The Folin-Ciocalteu method was used for the determination of the total phenolics (Ivanova et al., 2010).

### Total flavonoids assay

Total flavonoids were determined using the colorimetric assay with aluminium chloride and (+)-catechin as standard for calibration according to Zhishen et al., (1999).

### Total catechins assay

The concentration of total catechins in wines was determined using the method of Di Stefano et al. (1989) with the reagent *p*-DMACA.

## Results and discussion

Spectrophotometric determinations of total phenolics (TP), total flavonoids (TF), total catechins (TC), were performed for the *Smederevka* wines obtained with pre-fermentation enzyme maceration (4 hours) on grape mashes, and after alcoholic fermentation to completion of fermentation. Measurements were performed in order to study the effects of three different macerating enzymes on polyphenol contents of *Smederevka* wines from Macedonia compared to control wines no added enzyme. The obtained results of laboratory trials (Table 1) showed decreased concentration of total phenolics (TP) from 699.1 mg L<sup>-1</sup> to 422.5 mg L<sup>-1</sup> (37.8%) compared to the control samples from 679.1 mg L<sup>-1</sup>. Pectolytic enzyme preparation Vinozym Process (from 699.1 mg L<sup>-1</sup> to 558.8 mg L<sup>-1</sup>, decreased 17.7%) Trenolin Mash DF (from 550.2 mg L<sup>-1</sup> to 488.1 mg L<sup>-1</sup>, decreased 28.1%) and Rohavin LX (from 483.7 mg L<sup>-1</sup> to 422.5 mg L<sup>-1</sup>, decreased 37.7%), depend of used doses.

**Table 1. Effects of pectolytic enzyme treatments on white grape mashes of *Smederevka* on phenolic content of wines (TP: total phenolics, TF: total flavonoids, TC: total catechins). Laboratory trials: 5 kg grape**

Enzyme preparations	Dose	aTP mg L <sup>-1</sup>	aTF mg L <sup>-1</sup>	aTC mg L <sup>-1</sup>
Vinozym Process 3;4;5;6 g/100kg grapes	I-1	558.8 ± 0.25	54.83 ± 0.02	5.70 ± 0.06
	I-2	699.1 ± 1.35	91.46 ± 0.01	8.49 ± 0.15
	I-3	595.2 ± 0.00	83.06 ± 0.17	7.39 ± 0.00
	I-4	604.0 ± 0.45	64.91 ± 0.03	6.37 ± 0.28
Trenolin Mash DF 1;2;3;4 ml/100kg grapes	II-1	550.2 ± 0.50	66.17 ± 0.08	6.99 ± 0.03
	II-2	488.1 ± 0.95	39.86 ± 0.02	4.26 ± 0.02
	II-3	521.9 ± 1.40	40.30 ± 0.02	4.06 ± 0.03
	II-4	512.5 ± 1.75	62.05 ± 0.03	7.21 ± 0.02
Rohavin LX 2;3;4;5 ml/100kg grapes	III-1	449.6 ± 0.35	38.63 ± 0.03	3.65 ± 0.01
	III-2	422.5 ± 1.30	33.40 ± 0.02	3.48 ± 0.07
	III-3	483.7 ± 0.55	38.43 ± 0.12	4.49 ± 0.01
	III-4	453.5 ± 1.25	33.33 ± 0.02	3.84 ± 0.00
Control-no added enzyme	IV	679.1 ± 2.55	80.12 ± 0.99	8.74 ± 0.03

a the values are average from 2 replicates±SD

**Table 2. Effects of pectolytic enzyme treatments on white grape mashes of *Smederevka* on phenolic content of wines (TP: total phenolics, TF: total flavonoids, TC: total catechins). Industrial trials: 1220 kg grape. Private winery "Tristo" Veles**

Enzyme preparations	Dose	aTP mg L <sup>-1</sup>	aTF mg L <sup>-1</sup>	aTC mg L <sup>-1</sup>
Trenolin Mash DF 2 ml/100kg grapes	II-2	341.6 ± 2.65	40.81 ± 0.12	4.09 ± 0.03
Control-no added enzyme	IV	562.3 ± 2.50	87.63 ± 0.16	11.55 ± 0.07

a the values are average from 2 replicates±SD

The obtained results of industry trials (Table 2) showed decreased concentration of total phenolic (TP) from 341.6 mg L<sup>-1</sup> compared to the control sample from 562.3 mg L<sup>-1</sup> (decreased 39.2%). These enzyme treatments resulted in clarified the white grape juice, degraded the grape mash, reduced juice viscosity and total phenols and elicited an improvement in the visual aspect of the wine. The obtained results for the analysed wines were in agreement with previously published data (Ough C. and Crowell E., 1979; Brown M. and Ough C., 1981; Sreenath H. and Krishnaswamy S., 1992; Lao et al., 1997).

## Conclusion

The application of pectolytic enzymes would facilitate break up of the grape cell wall and aid juice and wine clarification by breaking-down the released grape pectins. Enzyme treatment also resulted in white wines with reduced juice viscosity and total phenols and elicited an improvement in the visual aspect of the wine.

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# Effects of pectolytic enzyme treatments on white grape mashes of *Smederevka* on grape juice yields and volume of lees

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## Abstract

The aim of this work was to evaluate the effect of the use of pectolytic enzyme treatments on white grape mashes of *Smederevka* on grape juice yields and volume of lees. White grape mash from *Smederevka* were macerated for 4 hours at 18 to 20°C with addition on one commercial pectolytic enzyme preparation (Vinozym Process, Trenolin Mash DF, Rohavin LX). After maceration, the pomace was removed, and each musts are pour into the funnel and collect musts. Results of trials showed increased on free run juice yields by 7,12% and drastic reduction in the volume of gross lees by up 47,3% compared with control trials. Increase juice yields and reduction volume of gross lees, leading to a higher volume of clear must, and this in the more produced wine and on end the more profit.

Key words: pectolytic enzymes, free run juice yields, volume of lees, *Smederevka*

## Utjecaj pektolitičkih enzimatskih tretmana na količinu samootoka i taloga u masulju grožđa *Smederevka*

### Sažetak

Cilj ovog rada bio je odrediti efekt upotrebe pektolitičkih enzimskih tretmana smjese bijelog grožđa *Smederevka* na prinos soka i zapreminu ukupnog taloga. Smjesa bijelog grožđa *Smederevka* bila je macerirana 4 sata na 18-20°C sa dodatkom jednog komercijalnog pektolitičkog enzimskog preparata (Vinozym Process, Trenolin Mash DF, Rohavin LX). Nakon maceracije, čvrsti ostaci se odstranjuju, a svaka šira se prebacuje inkom i sakuplja u rezervoare. Rezultati opita pokazali su povećan prinos samotoka do 7,12% i drastično smanjenje ukupne zapremine taloga do 47,3% uspoređeno sa kontrolnim probama. Povećan prinos soka i smanjena zapremina ukupnog taloga, vodi u veću proizvodnju vina i na kraju više profita.

Ključne riječi: pektolitički enzimi, prinos samotoka, zapremina taloga, *Smederevka*

### Introduction

*Smederevka* is an important white grape for Macedonia. It is capable of producing high quality white table wines in this country. Although the composition of the grape depends on its variety, the soil and the climatic conditions, there is little variation in the actual cell structure of the plant. Pre-fermentation enzyme maceration or skin contact with added enzyme besides aroma release, increase juices yields and eases

pressing and filtration operations (Haight G. and Gump H., 1994; Ganga et al., 2001). Grape skin cell walls are a physical barrier on this aroma and juice diffusion. As pectic polysaccharides play a major role in cell walls rigidity they are the main limiting factor. To the main polysaccharide chains other shorter or longer, straight or branched, saccharide chains are attached. The pectic enzymes play an important role in braking down grape pulp and skin cells and are able to split those chains and saccharide bonds between the chains (Whitaker, 1984). Enzymes cannot act on grapes if they are whole. Therefore, grapes should always be crushed before enzymes are added to enhance extraction. By weakening the cell walls of the pulp and hydrolyzing the soluble pectin, the enzymes in white grape maceration facilitate juice release and thus increase the free run juice yield, which avoids excessively harsh pressing (Brown R. and Ough S., 1981; Ribereau-Gayon et. al., 2000). First of all, as the must is less viscous thanks to the degradation of pectins and other cell wall components such as cellulose, hemicellulose, and pressure applied to the grapes can be lower. Therefore, keep musts cool (15-16°C) and allow to stand overnight, so that suspended material will fall to the bottom. The clear must is then racked from the lees. Enzyme treatments on musts reduce viscosity and speed up settling and ensure efficient sediment compaction. This may take 24 hours or longer to settle, but the resulting quality is worth the wait. The aim and importance of the research were benefits of pectolytic enzyme treatment on white grape mashes from Smederevka, such as improve yields of free run juice, reduction volume of gross lees and the more produced wine and on end the more profit.

## **Materials and methods**

### **Commercial pectolytic enzyme preparations**

In this study were used for laboratory trials three commercial macerating pectolytic enzyme preparations with corresponding quantities suggested of producer:

- Vinoxym Process, Novozymes A/S, Bagsvaerd, Denmark; Dose: 4 g/100 kg grapes
- Trenolin Mash DF, Erbslöh Geisenheim AG, Geisenheim, Germany); Dose: 2 mL/100 kg grapes
- Rohavin LX, AB Enzymes GmbH, Darmstadt, Germany; Dose: 3 mL/100 kg grapes

and for industrial trials used one commercial pectolytic enzyme preparation (Trenolin Mash DF, 2 mL/100 kg grapes) along with controls with no added enzyme.

These enzyme preparations are derived from cultures of *Aspergillus niger* which is a species accepted as G.R.A.S. (Generally Recognized As Safe), (Canal-Llauberes, 1993).

### **Grape samples for laboratory trials**

The white grape cultivar Smederevka (*Vitis vinifera*), cultivated in the Ovce pole vineyard, the Povardarie region, Republic of Macedonia, were harvested at optimal maturity (2009 vintage), at 170-190 g L-1 sugar, 6.0-7.0 g L-1 total acids, and pH from 3.0 to 3.2, and transported to the private winery "Imako Vino" Stip, Republic of Macedonia.

### **Grape samples for industrial trials**

The white grape cultivar Smederevka (*Vitis vinifera*), cultivated in the Veles vineyard, the Povardarie region, Republic of Macedonia, were harvested at optimal maturity (2009 vintage), at 180-200 g L-1 sugar, 6.0-7.0 g L-1 total acids, and pH from 3.0 to 3.2, and transported to the private winery "Tristo" Veles, Republic of Macedonia.

### **Vinification. Juice yields and volume of lees**

The grapes were weighed, destemmed, crushed and divided in 5 liters plastic reservoirs for laboratory trials, and for industrial trials were placed in a stainless steel fermentor (4 t.). All laboratory treatments were performed in triplicate and industrial in duplicate. White grape mash made from Smederevka were macerated for 4 hours at 18 to 20°C with addition on one commercial pectolytic enzyme preparation without additions of SO<sub>2</sub> and selected yeast. Control laboratory trials were in all same with experimental trials only whitout added pectolytic enzyme preparation. The enzyme preparations were first diluted to a 10% solution using cool, clean water, and added corresponding quantities (suggested of producer) to the freshly crushed

grapes. At the “no-enzyme addition” (control trials) were added an equal amount of deionized water as a replacement for the enzyme additions. The contents of each reservoir were stirred thoroughly. After maceration the pomace was removed and each must are pour into the funnel and collect musts in 5 liters plastic reservoirs (3 for enzyme treatments musts and 1 for control must (no-treatment)(juice yield). In each reservoir are add 30 ppm SO<sub>2</sub> and are kept musts cool (15-16oC) and allow to stand overnight, so that suspended material will fall to the bottom. After this are measure volume of lees from each reservoir. In each must (reservoir) are add yeast (*Saccharomyces cerevisiae*) NEUTRE SC (Lallemand), (200 mg/kg grapes) at ~25 oC to completion of fermentation.

#### Materials and procedure to measure free run juice yield.

Cheesecloth (two squares to fit funnel); Funnels (2); Glass or plastic reservoirs, 8 to 10 lit., (2); Graduated cylinders, 1000 mL or bigger (1); Spatulas or spoons (2);

The Cheesecloth are place in a funnel and the funnel into glass or plastic reservoir. The grape mash of each plastic reservoir (5 kg) are pour into the funnel and collect filtrate (free run juice) in glass or plastic reservoir. The amount of free run juice (filtrate) collected are measure with graduated cylinders and it is free run juice yield.

#### Materials and procedure to measure volume of lees.

Funnel (1); Glass or plastic reservoirs, 5 liters(4); Graduated cylinders, 1000 ml or bigger (1);

After maceration each must are pour into the funnel and collect musts in 5 liters plastic reservoirs (3 for enzyme treatments musts and 1 for control must (no-treatment). In each reservoir are add 30 ppm SO<sub>2</sub> and are kept musts cool by 15oC to 16oC and allow to stand overnight, so that suspended material will fall to the bottom. After this are measure volume of lees from each reservoir.

### Results and discussion

With enzymes, winemakers can enhance aroma and improve throughput of their white wines, as well as increase profits by increasing yields. Enzymes are very popular in white wine making since extraction and clarification of the must is difficult due to the presence of pectins extracted during winemaking. High viscosity and the cloud particles are kept in suspension. Enzymes also help with reducing viscosity, releasing free-run juice easily, and faster release of juice during pressing. In Table 1 are given results of free run juice yields obtained with pectolytic enzyme treatments on white grape mashes of Smederevka and control trials “no-enzyme addition”. Obtained results are of laboratory trials (5 kg grapes). In Table 1 it can be seen that pectolytic enzyme treatments on white grape mashes of Smederevka gives increased on free run juice yields by 4,62% to 7,12% compared with non-treated mashes of control trials. Pectolytic enzyme preparation Trenolin Mash (7,12%), Rohavin LX (5,52%) and Vinozym Process (4,62%). In Table 2 are given results of free run juice yields obtained with pectolytic enzyme treatment (Trenolin Mash) on white grape mash of Smederevka and control trial “no-enzyme addition”. Obtained results are of industrial trials (1220 kg grapes). In Table 2 it can be seen that pectolytic enzyme treatment on white grape mash of Smederevka gives increased on free run juice yield of up 6,56% compared with non-treated mash of control trial. The results of investigated on the effect of pectolytic enzyme treatments on white grape mash of Smederevka have average been greater yields of free run juice than untreated. The obtained results were in agreement with previously published data but of other winegrapes (Brown R. and Ough S., 1981; Rogerson et al., 2000; Haight G. and Gump H., 1994; Harbord et al, 1990).

**Table 1. Effects of pectolytic enzyme treatments on white grape mashes of Smederevka on free run juice yields. Laboratory trials: 5 kg grapes**

Enzyme preparations	Average L(a)	% of grape weight	Increase yield%
Vinozym Process (4 g/100 kg grapes)	2.430 ± 0.025	48.60	+ 4.62
Trenolin Mash DF (2 mL/100 kg grapes)	2.555 ± 0.022	51.10	+ 7.12
Rohavin LX (3 ml/100 kg grapes)	2.475 ± 0.026	49.50	+ 5.52
Control - no added enzyme	2.199 ± 0.038	43.98	0

aValues represented in the table are averages of results of three separately conducted experiments±SD\*

\*SD- standard deviation



**Effects of pectolytic enzyme treatments on white grape mashes of Smederevka on grape juice yields and volume of lees**

**Table 2. Effects of pectolytic enzyme treatments on white grape mashes of Smederevka on free run juice yields. Industrial trials: 1220 kg grape. Private winery "Tristo" Veles**

Enzyme preparation	Average L (a)	% of grape weight	Increase yield%
Trenolin Mash DF (2 mL/100 kg grapes)	631 ± 9	51.72	+ 6.56
Control-no added enzyme	551 ± 11	45.16	0

aValues represented in the table are averages of results of two separately conducted experiments±SD\*

\*SD - standard deviation

**Table 3. Effects of pectolytic enzyme treatments on white grape mashes of Smederevka on volume of lees. Laboratory trials: 5 liters musts, 30 ppm SO<sub>2</sub>, cool by 15°C to 16°C and allow to stand overnight**

Enzyme preparations	Volume of lees L(a)	Lees volume reduction vs Control%
Vinozym Process (4 g/100 kg grapes)	1.0 ± 0.05	47.3
Trenolin Mash DF (2 mL/100 kg grapes)	1.2 ± 0.05	36.8
Rohavin LX (3 ml/100 kg grapes)	1.3 ± 0.05	31.5
Control - no added enzyme	1.9 ± 0.1	0

aValues represented in the table are averages of results of three separately conducted experiments±SD\*

\*SD - standard deviation

In Table 3 it can be seen that pectolytic enzyme treatments on white grape mashes of Smederevka gives drastic reduction in the volume of gross lees by up 47,3% compared with non-treated mash of control trial. Pectolytic enzyme preparation Vinozym Process (47,3%), Trenolin Mash (36,8%) and Rohavin LX (31,5%). Enzyme treatments on musts speed up settling and ensure efficient sediment compaction (Höhn et al., 2005; Trepo, 2008). The clear must is then racked from the lees without problems.

### Conclusion

Increase free run juice yields by 7.12% and drastic reduction in the volume of gross lees by up 47.3% compared with non-treated mashes of control trials, this makes the application of the pectolytic enzymes in wine industry. By increasing juice yields and reduction volume of gross lees, leading to a higher volume of clear must, and this in the more produced wine and on end the more profit.

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# Utjecaj djelomične defolijacije na koncentraciju polifenola u vinima Graševine, Traminca i Manzonija bijelog (*Vitis vinifera* L.)

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## Sažetak

Poznato je da su grožđe i vino crnih kultivara vinove loze bogati različitim polifenolnim spojevima. U prethodnim je istraživanjima dokazano da ampelotehnički zahvati značajno utječu na polifenolni sastav grožđa i vina kod crnih kultivara vinove loze, međutim, kod bijelih kultivara to je područje još uvijek slabo istraženo. Predmet ovog istraživanja je utjecaj djelomične defolijacije, kao uobičajenog ampelotehničkog zahvata u suvremenom vinogradarstvu, na koncentraciju ukupnih polifenolnih spojeva u vinima kultivara Graševina, Traminac i Manzoni bijeli (*Vitis vinifera* L.) u 2008. godini. Djelomična defolijacija utjecala je na višu koncentraciju ukupnih fenola kod Traminca i Manzonija bijelog, dok na Graševinu nije imala utjecaja.

Ključne riječi: bijeli kultivari, djelomična defolijacija, polifenoli

## Influence of partial defoliation on polyphenol content of Graševina, Traminac and Manzoni bijeli wines (*Vitis vinifera* L.)

### Abstract

It is well known that red grape and wine are an excellent source of various classes of polyphenols. Former investigations approved that canopy manipulation techniques in vineyard strongly affects content of polyphenols in red wine, but effect on white cultivars is still poorly investigated. This investigation reviews the effect of partial defoliation, as usual practice in modern grape-vine production, on polyphenol content of cultivars Graševina, Traminac and Manzoni (*Vitis vinifera* L.) in 2008. Partial defoliation caused higher content of total phenols in Traminac and Manzoni wines, but without influence on Graševina wine.

Key words: partial defoliation, polyphenols, white cultivars

### Uvod

Posljednjih desetak godina polifenolni sastav grožđa i vina te njihova antioksidacijska aktivnost predmet su brojnih istraživanja, ponajviše zbog velikog utjecaja polifenola na organoleptička svojstva vina, posebice na boju, gorčinu i trpkocu (Hernanaz i sur., 2007), te njihovog blagotvornog utjecaja na ljudsko zdravlje (Yang i sur., 2009).

U grožđu i vinu su zastupljene dvije glavne skupine polifenolnih spojeva, a to su neflavonoidi i flavonoidi. Neflavonoidi su jednostavnije građe od flavonoida i imaju jedan fenolni (benzenov) prsten, za razliku od flavonoida koji imaju dva fenolna prstena međusobno povezana lancem od tri ugljikova atoma (Ribéreau-Gayon i sur., 2000). Predstavnici neflavonoida u grožđu i vinu su fenolne kiseline (hidroksibenzojeve i

hidroksicimetne) i stilbeni, a predstavnici flavonoida su flavonoli, flavanonoli, flavan-3-oli i antocijani (Ribéreau-Gayon i sur., 2000).

U suhim bijelim vinima ukupni fenolni spojevi se nalaze u koncentraciji između 50 i 350 mg/L, što je manje od 10% vrijednosti ukupnih fenola u crnim vinima (Ribéreau-Gayon i sur., 2000; Cheynier i sur., 1998). Razlog toga leži u činjenici da je većina polifenolnih spojeva locirana u kožici i sjemenci bobice, koje su zbog tehnologije proizvodnje bijelih vina najčešće vrlo kratko u doticaju sa sokom grožđa, te zbog činjenice da bijeli kultivari uopće ne sadržavaju neke pigmente, npr. antocijane, vrlo značajne u sastavu ukupnih polifenola crnih sorti vinove loze.

Udio polifenolnih spojeva u grožđu i vinu ovisi o velikom broju čimbenika, kao što su kultivar, ekološki uvjeti uzgoja, primijenjeni agrotehnički i ampelotehnički zahvati u vinogradu, te tehnike vinifikacije (Jackson i Lombard, 1993; Downey i sur., 2006; Ribéreau-Gayon i sur., 2000). Osim općeg biološkog potencijala svakog kultivara i klimatskih uvjeta proizvodne godine, na polifenolni sastav grožđa u velikoj mjeri utječu ampelotehnički zahvati u vinogradu (Guidoni i sur., 2008) kojima se modificira mikroklima trsa, a time djeluje i na kemijski sastav grožđa i vina.

Djelomična defolijacija zahvat je zelenog reza uobičajen u suvremenom vinogradarstvu, a predstavlja uklanjanje 3-5 bazalnih listova s mladice u zoni grožđa, čime se postiže bolja osvjetljenost grozdova, što rezultira boljom kakvoćom grožđa na tretiranim trsovima (Hunter i sur., 1991). Osim više koncentracije šećera i niže vrijednosti ukupne kiselosti, djelomična defolijacija utječe i na višu koncentraciju ukupnih polifenola, te antocijana kod crnih kultivara vinove loze. Kad se svemu pridoda i bolje zdravstveno stanje vinograda, proizašlo iz činjenice da se povećanjem temperature i prozračnosti unutar zone grožđa smanjuje pojava i intenzitet zaraze sivom plijesni (*Botrytis cinerea*) (Stapleton i sur., 1990; Zoecklin i sur., 1992), dolazimo do zaključka da je djelomična defolijacija ampelotehnička mjera neizostavna u proizvodnji grožđa visoke kakvoće, posebno u sjevernijim krajevima, kamo spada i vinogradarsko-vinarsko pokušalište Jazbina, gdje je postavljen pokus.

Cilj ovog istraživanja bio je utvrditi da li zahvat djelomične defolijacije utječe na koncentraciju ukupnih fenola u mladim vinima sorti Graševina, Traminac mirisavi i Manzoni bijeli, u uvjetima Zagrebačkog vinogorja, podregije Prigorje-Bilogora.

## Materijali i metode

Pokus je postavljen 2008. godine na vinogradarsko-vinarskom pokušalištu u Jazbini, koje je u sklopu Zavoda za vinogradarstvo i vinarstvo Agronomskog fakulteta Sveučilišta u Zagrebu. Postavljen je po slučajnom bloknom rasporedu, u dva tretiranja po tri repeticije. Svaku repeticiju čine tri susjedna trsa.

Prije provođenja tretmana djelomične defolijacije, na pokusnim je trsovima u ranijem dijelu vegetacije pljevljenjem i prorijeđivanjem grozdova ujednačen vegetativni i generativni potencijal. Prvo tretiranje (D) je djelomična defolijacija, gdje je sa svake mladice tretiranog trsa uklonjeno po pet bazalnih listova. Tretman se provodio uz početak šare grožđa. Kontrolnu varijantu (K) čine trsovi na kojima nije proveden zahvat djelomične defolijacije.

Berba je obavljena ručno, u trenutku tehnološke zrelosti grožđa, na način da se, zasebno za svaku sortu, odvojeno pobralo grožđe iz svakog tretiranja i svake repeticije (ukupno 6 uzoraka), te se kasnije tako odvojeno i prerađivalo.

Uzorci moštava za analizu uzimani su odmah nakon muljanja i runjenja grožđa. Udio šećera u moštu određivao se pomoću refraktometra, a ukupna kiselost titrimetrijskom metodom prema O.I.V.-u (2001).

Nakon prešanja, mošt iz svakog ponavljanja je smješten u staklene posude zapremine pet litara i tretiran sa 5% sumporastom kiselinom u količini 100mL na 100L mošta. Nakon 24 sata mošt je inokuliran kvascima *Saccharomyces cerevisiae* Lallemand EC1118 i ostavljen na fermentaciji na temperaturi od 17°C dok se koncentracija neprovrelog šećera nije spustila ispod 4 g/L. Uzorci vina uzimani su dva dana nakon završetka alkoholne fermentacije i skladišteni na -20°C do provedbe analiza.

Udio ukupnih fenola u vinu određen je spektrofotometrijski uz pomoć Folin-Ciocalteu reagensa (Singleton i Rossi 1965). Kvantifikacija ukupnih fenola je provedena pomoću baždarnog pravca pripremljenog s poznatom količinom galne kiseline.

Ukupni flavan-3-oli određeni su također spektrofotometrijski, metodom s vanilinom uz korištenje (+)-katehina kao standarda.

## Rezultati i rasprava

Iz prikaza u tablici 1 vidljivo je da među istraživanim sortama nema velikih razlika u koncentraciji ispitivanih spojeva. Obzirom da je prorjeđivanjem grozdova u ranijem dijelu vegetacije na pokusnim trsovima smanjena rodnost, koncentracija šećera u moštu je relativno visoka, a ukupne kiselosti niska kod sva tri ispitivana kultivara.

Također su kod sva tri kultivara u moštu defoliranih trsova izmjerene nešto niže vrijednosti šećera, što se podudara s nekim istraživanjima (Hunter i sur., 1991; Reynolds i sur., 1996), no te razlike nisu i statistički značajne. S druge strane, velik broj istraživača navodi da je zahvat djelomične defolijacije pridonio većoj koncentraciji šećera, zbog manjeg sadržaja vode u grozdovima, uslijed intenziviranja procesa transpiracije (Zoecklin i sur., 1992), dok Williams i sur. (1987), te Hunter i sur. (1995) tvrde da djelomična defolijacija ni na koji način ne utječe na koncentraciju šećera u grožđu.

Kod Traminca i Manzonija bijelog zahvat djelomične defolijacije nije uzrokovao nikakve značajne promjene u ukupnoj kiselini, no Graševina pokazuje statistički značajan pad ukupne kiselosti uslijed zahvata djelomične defolijacije, što je potpuno u skladu s brojnim istraživanjima na tu temu (Reynolds i sur., 1996; Zoecklin i sur., 1992). Smanjenje ukupne kiselosti je vjerojatno povezano sa smanjenim pritjecanjem jabučne kiseline iz lišća u grozdove, budući da je dio lisne mase odstranjen prilikom defolijacije, a otkrivanje grozdova zasigurno je utjecalo i na povišenje temperature u zoni grožđa, što je potpomoglo degradaciju organskih kiselina u grožđu, uslijed intenziviranja procesa disanja.

Kako kod bijelih kultivara nema istraživanja o utjecaju ampelotehničkih zahvata na koncentraciju polifenolnih spojeva, ne može se napraviti usporedba ovih podataka s rezultatima istraživanja drugih autora, već eventualno s istraživanjima koja su provedena na crnim kultivarima, pošto svi polifenolni spojevi u bobici nastaju istim biokemijskim putem šikiminske kiseline.

Više istraživanja pokazalo je kako nakupljanje polifenola u grožđu uvelike ovisi o svjetlosti i temperaturi te njihovom međudjelovanju (Crippen i Morrison, 1986; Guidoni i sur., 2008). Naime, veća izloženost bobice svjetlu uvjetuje i više polifenola, dok previsoke temperature mogu smanjiti ukupne polifenole (Crippen i Morrison, 1986). Hunter i sur. (1991.) navode da koncentracija antocijana raste s kasnijom defolijacijom, a najvišu razinu dosegli su kod djelomične defolijacije u vrijeme šare, dok je kvaliteta vina značajno poboljšana, bez obzira na termin i intenzitet defolijacije. Slične rezultate dobili su i 1995., proučavajući utjecaj djelomične defolijacije na Cabernet sauvignon. Guidoni i sur. (2008.) zabilježili su da su koncentracije pojedinačnih antocijana varirale ovisno o klimatskim uvjetima, ali su vrijednosti bile više kod defoliranih nego kod kontrolnih trsova talijanskog kultivara Nebbiolo.

**Tablica 1. Koncentracija šećera i ukupna kiselost mošta, te koncentracija ukupnih fenola i ukupnih flavan-3-ola u vinima Graševine, Traminca i Manzonija bijelog, u Jazbini, 2008. god.**

Kultivar	Tretman	Šećeri (°Oe)	Ukupna kiselost (g/L)	Ukupni fenoli (mg/L)	Ukupni flavan-3-oli (mg/L)
Graševina	K	110,0	5,5	261,55	3,25
	D	109,3	5,1	249,39	3,57
	Signifikantnost	n.s.	**	n.s.	n.s.
Traminac	K	103,3	3,9	228,73	3,70
	D	102,7	4,0	266,60	4,45
	Signifikantnost	n.s.	n.s.	**	n.s.
Manzoni bijeli	K	108,3	5,1	265,43	4,10
	D	108,0	5,1	280,94	4,13
	Signifikantnost	n.s.	n.s.	*	n.s.

K - kontrola; D - djelomična defolijacija

\*\* , \* , n.s. - signifikantno pri  $p \leq 0,01$ ,  $0,05$  ili nesigifikantno prema LSD testu

Tim tvrdnjama pridonose i naša istraživanja na Traminu i Manzoniju bijelom, gdje sa 99%-tnom (Traminac), odnosno 95%-tnom (Manzoni) sigurnošću možemo tvrditi da je zahvat djelomične defolijacije odgovoran za višu koncentraciju ukupnih fenola u vinima tih kultivara. Nasuprot tome, kod Graševine vidljivo je mali smanjenje ukupnih fenola u defoliranoj varijanti, međutim ta razlika nije statistički opravdana.

Flavan-3-oli su jedna od sastavnica polifenolnih spojeva u vinu i pokazuju mali porast kod defoliranih varijanti svih triju sorata, no te razlike nisu statistički značajne. Iz toga možemo zaključiti da zahvat

djelomične defolijacije nije utjecao na nakupljanje ukupnih flavan-3-ola u vinima kultivara Graševina, Traminac i Manzoni bijeli u 2008.godini.

### Zaključak

Iz dobivenih rezultata možemo zaključiti da je djelomična defolijacija, gledajući kroz nakupljanje ukupnih fenola, opravdani zahvat na kultivarima Traminac i Manzoni bijeli, dok na druge analizirane parametre kod navedenih kultivara nije imala nikakav značajniji utjecaj. S druge strane, kod kultivara Graševina potpuno je izostao očekivani učinak na koncentraciju ukupnih fenola, što nam nalaže daljnji nastavak istraživanja na ovoj problematici. Bolje poznavanje utjecaja djelomične defolijacije na polifenolni sastav grožđa i vina bijelih kultivara vinove loze omogućili bi ciljani utjecaj na kvalitetu i nutritivni sastav grožđa i vina, odabirom i primjenom odgovarajućih ampelotehničkih zahvata u vinogradu.

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# Ampelografska analiza i zdravstveno stanje sorti Surina, Pagadebit istarski i Opačevina (*Vitis vinifera* L.) u Istri

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## Sažetak

Znanstvenim istraživanjima na projektu "Genetski i gospodarski resursi *Vitis* sp." (2001.-2006.) i "Valorizacija resursa vinove loze (*Vitis* sp.) i banka gena" (2006.-2011.) sustavno se prate autohtone sorte vinove loze na području Istre. U sklopu istraživanja proučavaju se sorte prisutne u starim vinogradima, te njihova unutarSORTNA varijabilnost. U istraživanjima odabrane su i tri sorte: Surina, Pagadebit istarski i Opačevina. Ampelografski su identificirane i opisane morfološke karakteristike pomoću OIV indikatora te su napravljene kemijske analize mošta (pH, šećeri, kiseline). DAS-ELISA testom utvrđeno je zdravstveno stanje trsova. U svrhu očuvanja bioraznolikosti autohtonih sorti i budućih istraživanja prikupiti će se zdrav biljni materijal za daljnje razmnožavanje, a sadnice će biti posađene u kolekcijskom nasadu autohtonih sorti na Institutu za poljoprivredu i turizam u Poreču.

Ključne riječi: bioraznolikost, autohtone sorte, zdravstveno stanje, morfološke karakteristike

## Ampelographic analysis and sanitary status of cv. Surina, Pagadebit istarski and Opačevina (*Vitis vinifera* L.) in Istria

### Abstract

On the scientific projects "Genetical and economic resources of *Vitis* sp." (2001.-2006.) and "Valorization of viticulture resources (*Vitis* sp.) and gene bank" (2006.-2011.) we gradually examine autochthonous grape varieties in Istria. This research studies the status of varieties and variability within-variety present in old vineyards. There were identified three autochthonous varieties: Surina, Istrian Pagadebit and Opačevina using ampelographic detection. Morphological characteristics of chosen varieties were described using OIV parameters and must was chemically analyzed (pH reaction, sugar content, titratable acidity). Sanitary status of vines was also determined by DAS-ELISA. With purpose of preserving the biodiversity of autochthonous varieties and future research, we will collect propagation material and healthy grafted plants will be planted in collection field of autochthonous varieties on the Institute of Agriculture and Tourism in Poreč.

Key words: biodiversity, autochthonous varieties, sanitary status, morphological characteristics

## Uvod

Vinova loza (*Vitis* sp.) je vrsta koju karakterizira velika sortna i unutarsortna raznolikost, što vrijedi i za sortiment vinove loze u Istri, posebice za autohtone sorte. U sortimentu Istre najzastupljenija sorta je Malvazija istarska, zatim Chardonay, Pinot bijeli i sivi, Sauvignon, Muškat bijeli (momjanski) od bijelih, te Teran, Borgonja, Merlot, Hrvatica, Cabernet sauvignon, Cabernet franc i Pinot crni od crnih sorti (Vitolović, 1960., Maletić i sur., 2008.). Neke od tih sorti kao i autohtone sorte, Malvazija istarska, Teran, Borgonja i dr. među ostalim, istraživane su u sklopu znanstvenih projekata "Genetski i gospodarski resursi *Vitis* sp." (2001.-2006.) te "Valorizacija resursa vinove loze (*Vitis* sp.) i banka gena" (2006.-2011.) (Peršurić i sur., 2004.; Sladonja i sur., 2005.; Ilak Peršurić i sur., 2006.; Pribetić i sur., 2006.; Poljuha i sur., 2010.). Istraživanja i ampelografski opis Pagdebita istarskog, Surine i Opačevine nalazimo u starijim literaturnim izvorima, ampelografiji (Vitolović, 1960. i Bulić, 1949.), a u novije vrijeme u Istrapediji (<http://istrapedija.hr/>). Cilj istraživanja je bilo utvrditi da li ampelografski standardi opisani u literaturi potvrđuju opis trseva nađenih na terenu. Kako se radi o sortama koje se sporadično nalaze u Istri, a nalazi terenskog istraživanja ukazuju na pojedine lokacije i pojedine trseve, nastojali smo potvrditi sortnost i utvrditi njihovo zdravstveno stanje radi eventualnog odabira tih trseva kao potencijalnih klonskih kandidata.

## Materijali i metode

Kriterij za odabir vinograda bila je starost nasada iznad 50 godina i autohtoni sortiment. Kako je ograničenje bio broj trsova in situ, uzeli smo sve pronađene trseve; ukupno 5 Surina, 5 Pagadebita i 3 Opačevine. Ampelografske analize vršene su pomoću OIV deskriptora (Office International de la Vigne et du Vin descriptors, 1983.) modificiranih u projektu Europske unije GENRES 081 (2001.). Korišteni su deskriptori za ampelografski opis grozda u berbi: OIV 202 dužina grozda; OIV 204 zbijenost grozda; OIV 206 dužina peteljke; OIV 208 oblik grozda; OIV 209 broj krila grozda; OIV 220 dužina bobice. Za navedene deskriptore uzimano je deset grozdova po trsu. Za deskriptore OIV 221 širina bobice; OIV 223 oblik bobice; OIV 225 boja kože bobice i OIV 230 boja mesa bobice uzeto je 30 bobica sa odabranih 10 grozdova. Za OIV 235 stupanj čvrstoće mesa bobice; OIV 236 posebnost okusa uzete su pojedine bobice, a za OIV 241 prisustvo sjemenki u bobici; OIV 502 težina jednog grozda; OIV 503 težina jedne bobice, te rezultate kemijske analize mošta: OIV 505 sadržaj šećera u moštu; OIV 506 sadržaj ukupnih kiselina u moštu; OIV 508 pH vrijednost mošta po deset grozdova. Ukupni šećeri u moštu određeni su pomoću digitalnog refraktometra (Artisan TM HR200, Kanada), ukupne kiseline titracijom s 0,1 N NaOH, a pH mošta digitalnim pH metrom (Mettler Toledo MP220, Njemačka). Uzorci grožđa za ampelografsku i kemijsku analizu prikupljeni su u rujnu 2009. godine u redovnom roku berbe.

Uzorci tkiva listova trsova vinove loze analizirani su na tri ekonomski najznačajnija virusa: *Virus lepezastog lista vinove loze* (GFLV), *Virus uvijenosti lista 1* (GLRaV-1) i *Virus uvijenosti lista 3* (GLRaV-3) (Poljuha i sur., 2010.). Analize su izvršene DAS-ELISA testom (double-antibody sandwich enzyme-linked immunosorbent assay). Korišteni su komercijalni identikitovi proizvođača Neogen Europe Ltd, (Škotska), prema uputama proizvođača. Očitavanja su smatrana pozitivnima kada se u jažicama s uzorkom pojavila žuta boja (Poljuha i sur., 2010.). U vrijeme uzimanja uzoraka (lipanj 2010) trsevi Pagadebita osim jednog nisu bili prikladni za uzimanje uzoraka lišća.

## Rezultati i rasprava

Ampelografska analiza 5 trseva Surine pokazala je za OIV kod 202 za 4 trsa ocjenu 5 (duljina grozda: srednja 14-18 cm), za Ptr1 je ocjena 7 (20 cm). Za OIV kod 204 svi grozdovi s odabranih trseva su imali srednje rastresit grozd. Za Ptr1 peteljka grozda je bila srednje dužine (5-7 cm), a ostali su imali kratku peteljku (3-5 cm), (OIV kod 206). Svi grozdovi su imali cilindričan oblik (OIV kod 208) i svi grozdovi osim grozdovi s trsa PTR5 su imali 1-3 krila grozda. Svih 5 trsova je imalo na odabranim grozdovima srednju duljinu bobice 14-20 mm (OIV kod 220) i srednju širinu bobice 14-20 mm (OIV kod 221), oblik bobice okrugli (OIV kod 223), boja pokožice roza (OIV kod 225), neobojena boja mesa bobice (OIV kod 230), stupanj čvrstoće srednje čvrsto meso bobice (OIV kod 235), posebnost okusa bobice: bez posebnosti okusa (OIV kod 236). Kod svih odabranih bobica sjemenke su bile prisutne (OIV kod 241). Težina grozda kretala se od 140 do 160 grama (mala težina), osim za Ptr1 sa 383 g srednje prosječne težine po grozdu (srednja težina, OIV kod 502). Težina svih bobica bila je srednja (oko 3 grama, OIV kod 503).

Ampelografska analiza 5 trseva Pagadebita istarskog pokazala je za OIV kod 202 najučestaliju ocjenu 7 (duljina grozda: dugačak 18-25 cm) osim za PiJ3 i PiJ5 sa srednje dugim grozdom (14-18 cm). Svi trsevi imali su rastresit grozd, osim PiJ1 sa srednje zbijenim grozdom (OIV kod 204), PiJ1 i PiJ4 imali su srednje dugu peteljku (3-5 cm), ostali su imali kratku peteljku do 3 cm (OIV kod 206). PiJ1, PiJ3 i PiJ5 su imali konačan, PiJ2 ljevkast, PiJ4 valjkast oblik grozda (OIV kod 208) sa više od 3 krila kod PiJ2,3,4 i 1-3 krila kod PiJ1 i 5 (OIV kod 209). Duljina bobice bila je srednja (14-20 mm) kod svih grozdova svih trseva (OIV kod 220); širina bobice srednja (14-20 mm), a kod PiJ1 i 2 mala do srednja (do 14 mm) OIV kod 221; sve bobice bile su okrugle (OIV kod 223) sa žuto-zelenom bojom kože bobice (OIV kod 225) i neobojenim mesom bobice (OIV kod 230) i vrlo mekanim mesom bobice (OIV kod 235), bez posebnosti okusa (OIV kod 236) osim za PiJ 1 i 2 koji su imali travnati miris i prisutnim sjemenkama u svim mjerenim bobicama (OIV kod 241). Težina grozda bila je mala 200 g (osim kod PiJ4 400 g - OIV kod 502) i srednjom težinom bobice oko 4 g. (osim za PiJ5 težina je bila oko 2 g - mala) OIV kod 503.

Ampelografska analiza 3 trsa Opačevine pokazala je da OS1\_1 grozd dugačak (18-25 cm), a kod OS2\_2 i OS3\_3 srednji (14-18 cm) OIV kod 202, rastresit za OS3\_3 i OS1\_1, a OS2\_2 srednje zbijen, sa kratkom peteljkom (do 3 cm) OIV kod 206. svi grozdovi su bili koničnog oblika (OIV kod 208) sa 1-3 krila grozda (OIV kod 209) osim za OS2\_2 koji je imao više od 3 krila. Sve bobice s mjerenih grozdova bile su srednje duge (14-20 mm) OIV kod 220, male širine bobice (do 14 mm) OIV kod 221 okruglog oblika (OIV kod 223) žuto-zelene kože bobe (OIV kod 225), neobojanog mesa (OIV kod 230), vrlo čvrstog mesa (OIV kod 235) osim za OS3\_3 koja je imala meku bobicu i bez posebnosti okusa (OIV 236). U svim bobicama sjemenke su bile prisutne (OIV kod 241) sa 1 do 3 sjemenke. Težina grozda bila je 400 g osim za OS3\_3 200 g (OIV kod 502) i srednjom težinom bobice od 2 g (OIV kod 503).

U Tablici 1. prikazane su srednje vrijednosti sadržaja ukupnih šećera (%), ukupnih kiselina (g/l) i pH u moštu ispitanih sorti.

Kod Surine ukupni šećeri kretali su se u rasponu od 16,20% do 19,10%, vrijednost ukupnih kiselina kretala se između 6,8 g/l i 7,0 g/l, a pH vrijednost bila je u rasponu od 3,00 do 3,25. Vrijednosti ukupnih šećera kod Pagadebita istarskog kretale su se u rasponu od 14,59% do 16,03%, ukupne kiseline kretale su se između 7,5 g/l i 14,00 g/l; pH vrijednost bila je u rasponu od 2,76 do 3,10. Vrijednosti ukupnih šećera kod Opačevine kretale su se između 16,59% i 18,39%; ukupne kiseline bile su u rasponu od 9,4 g/l do 11,3 g/l, dok se pH vrijednost kretala od 3,09 do 3,32.

Iz Tablice 2. vidljivo je da je samo tri uzoraka bilo nezaraženo virusom GFLV: dva uzorka Surine i jedan uzorak Opačevine, odnosno zaraza je GFLV-om bila 66,67%, dok je zaraza GLRaV-1 i GLRaV-3 bila 88,87%.

**Tablica 1. Srednje vrijednosti sadržaja ukupnih šećera (%), ukupnih kiselina (g/l) i pH u moštu**

Sorta	Ukupni šećeri (%)	Ukupne kiseline (G/L)	PH
Surina	17,52	6,88	3,10
Pagadebit istarski	15,14	9,24	2,92
Opačevina	17,60	9,23	3,19

**Tablica 2. Zaraženost virusima vinove loze**

Sorta	Uzorak	GFLV	GLRaV 1	GLRaV 3
Surina	PTr1	+	+	+
	PTr2	-	+	+
	PTr3	-	+	+
	PTr4	+	+	+
	PTr5	+	+	+
Pagadebit istarski	PiJ1	+	+	+
Opačevina	OS1_1	+	+	+
	OS1_2	-	+	+
	OS1_3	+	-	-



## Zaključci

Kod sve tri ispitane sorte utvrđena je velika unutarSORTNA varijabilnost vrijednosti OIV parametara. Izuzetak su bili OIV kodovi 220 (duljina bobice), 230 (boja mesa bobice), 241 (prisutnost sjemenki u bobici) i 508 (pH mošta), koji su pokazali ujednačenost kod sve tri sorte. U odnosu na literaturne izvore (Vitolović, 1960) za Surinu su potvrđeni oblik grozda, oblik, duljina i širina bobice te prisutnost sjemenki, za Pagadebit potvrđeni su oblik grozda, broj krila, oblik i boja pokožice bobice te prisutnost sjemenki, a za Opačevinu duljina i širina bobice boja kože i prisutnost sjemenki.

ELISA testom ustanovljen je veliki stupanj zaraženosti virusima GLRaV-1 i GLRaV-3, dok je zaraženost virusom GFLV bila nešto manja. To upućuje na zabrinjavajuće zdravstveno stanje trsova u starim vinogradima u kojima su sačuvane autohtone sorte te potrebu korištenja isključivo nezaraženog biljnog materijala s terena ili postupke otklanjanja virusa.

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sa2011\_0815

# Ampelografska evaluacija klonskih kandidata sorte Graševina (*Vitis vinifera* L.) u 2009. godini

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## Sažetak

Graševina je najvažnija bijela sorta vinove loze u Hrvatskoj koja zauzima oko 30% ukupnih površina pod vinogradima. Zbog visoke razine unutarvarietalne varijabilnosti uočene u proizvodnim nasadima ove sorte, 2004. godine provedena je masovna pozitivna selekcija u Kutjevačkom vinogorju. Izdvojeno je 85 klonskih kandidata koji su bili slobodni od gospodarski štetnih viroza, a isti su razmnoženi te 2006. godine posađeni u pokusni nasad na položaju "Vidim" (Kutjevačko vinogorje). Zajedno s njima u pokusni nasad kao kontrola posađeni su i priznati klonovi ove sorte iz Srbije (SK13), Italije (ISV1) i Slovenije (Mateković - M20/16). 2009. godine započeta je njihova ampelografska evaluacija s posebnim naglaskom na evaluaciju gospodarskih svojstava: prinos po trsu te sadržaj šećera i kiselina u moštu. Rezultati tih istraživanja pokazuju značajne razlike između klonskih kandidata Graševine selekcioniranih u kutjevačkom vinogorju, dok su neki od njih pokazali bolje rezultate od priznatih klonova iz drugih zemalja.

Ključne riječi: vinova loza, Graševina, ampelografska evaluacija, klonska selekcija

## Ampelographic evaluation of cv. Graševina (*V. vinifera* L.) clone candidates in year 2009

### Abstract

Graševina is the most important white cultivar in Croatia, and it covers 30% of all vineyards. Clonal selection started in year 2004, because of high intravarietal variability of this cultivar. 85 clone candidates, free from economically most important viruses were vegetative propagated and they are planted in year 2006. in experimental vineyard located on location "Vidim" placed in Kutjevo vine growing area. 3 clones of cv. Graševina selected and registered in Serbia (SK13), Italy (ISV1) and Slovenia (Mateković - M20/16) were also included in experimental vineyard for comparison. In year 2009 we started with evaluation of their economically important characteristics: yield/vine, sugar and acid content of must. Differences between clone candidates selected in Kutjevo wine growing area are present in experimental vineyard, and some of them showed better results then registered clones from other countries.

Key words: *V. Vinifera* L. Graševina, clonal selection

### Uvod

Graševina je gospodarski najznačajnija i najzastupljenija sorta vinove loze u kontinentalnoj Hrvatskoj pa tako zauzima i vodeće mjesto u ukupnim površinama u Hrvatskoj. Osim u Hrvatskoj ova je sorta značajno zastupljena još samo u Mađarskoj, Sloveniji, Slovačkoj, Austriji, Srbiji i Rumunjskoj. Klonska selekcija prema dosadašnjim saznanjima uspješno je provedena i izdvojeni su klonovi ove sorte u Mađarskoj (Bakonyi -

Bakonyi, 1990.), Slovačkoj (Valentovič, 1972.), Sloveniji (Korošec-Koruza, 1998.) i Srbiji (Cindrić, 1992.). Unatoč činjenici da su najveće površine pod ovom sortom upravo u Hrvatskoj, klonska selekcija Graševine započela je tek 2004. godine, a njome je obuhvaćeno oko 30.000 trsova u proizvodnim nasadima na području Kutjevačkog vinogorja u kojemu je upravo Graševina najznačajnija sorta. 2006. godine podignut je pokusni nasad klonskih kandidata tj. vegetativnog potomstva odabranih matičnih trsova s ciljem provođenja individualne klonske selekcije gdje se u ujednačenim uvjetima pokusnog nasada međusobno uspoređuju njihove gospodarske karakteristike. U ovom radu prikazani su rezultati klonskih kandidata u 2009. godini koji će poslužiti u daljnjem postupku individualne klonske selekcije, tj. smanjivanju broja klonskih kandidata za evaluaciju u narednim godinama.

### Materijali i metode

Testiranje je provedeno kod 250 trsova odabranih u masovnoj pozitivnoj selekciji na prisutnost četiri gospodarski značajna, zakonom propisana, virusa, GFLV (*Grapevine fanleaf virus*), ArMV (*Arabis mosaic virus*), GLRaV-1 i GLRaV-3 (*Grapevine leafroll virus 1 i 3*). Utvrđeno je 140 trsova bez prisustva navedenih virusa. Zbog velikog broja bezvirusnih klonskih kandidata dio njih je odbačen na temelju rezultata *in situ* evaluacije matičnih trsova. Na taj način njihov je broj smanjen na 85, koji su zatim nacijepljeni na bezvirusnu podlogu SO4 i posađeni u pokusni nasad na položaju "Vidim" u proljeće 2006. godine. Njihovim ulaskom u puni rod 2009. godine provedena je evaluacija najvažnijih gospodarskih karakteristika i to: prinos po trsu, sadržaj šećera i kiselina u moštu. Usporedno sa klonskim kandidatima u pokusnom nasadu su na istoj podlozi posađeni i priznati klonovi ove sorte iz Srbije (SK13), Italije (ISV1) i Slovenije (Mateković - M20/16).. Razmak sadnje u nasadu je 2x1m, a uzgojni oblik je jednostruki Guyot sa opterećenjem od 12 rodnih pupova po trsu. Svaki klonski kandidat zastupljen je s najmanje 10 trsova. Sa svakog klonskog kandidata uzet je prosječan uzorak grožđa koji je korišten za određivanje sadržaja šećera refraktometrijski te sadržaja kiselina titracijskom metodom. Uzorkovanje je obavljeno 1. listopada 2009. godine. Stavljanjem u odnos prinosa i sadržaja šećera u moštu, te sadržaja kiselina u moštu dobiva se dobar pokazatelj za daljnju selekciju klonskih kandidata, pri čemu se boljima smatraju klonski kandidati koji istovremeno imaju viši prinos i sadržaj šećera u moštu od prosjeka svih klonskih kandidata (Preiner, 2008.). Povoljan sadržaj kiselina kod tih istih dodatni je kriterij za njihovu selekciju.

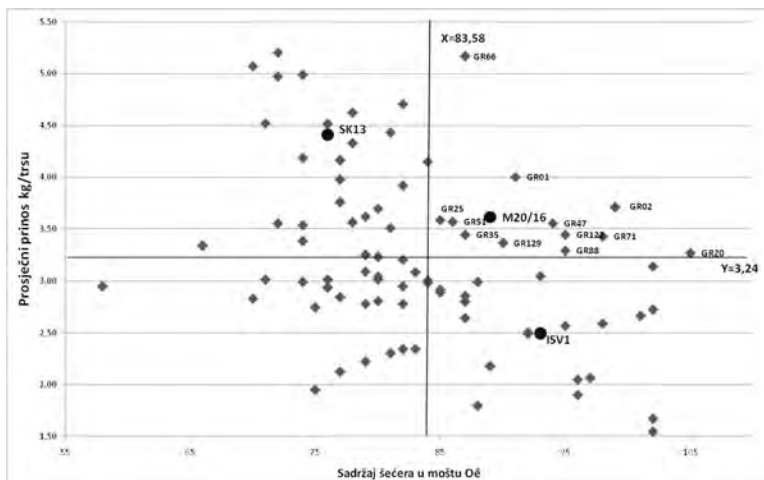
### Rezultati i rasprava

Rezultati mjerenja prinosa po trsu tj. prosječni prinos po trsu i rezultati mjerenja sadržaja šećera u moštu kod klonskih kandidata Graševine stavljeni su u međusobni odnos u grafu 1. Prosječne vrijednosti za jedno i drugo svojstvo korištene su kako bi se graf podijelio u četiri kvadranta. Klonski kandidati koji su iznad prosjeka po sadržaju šećera u moštu i uz to imaju prosječni prinos po trsu iznad prosjeka svih klonskih kandidata nalaze se u gornjem desnom kvadrantu. Na grafu su posebno istaknute kontrole (priznati klonovi), pa je tako SK13 u uvjetima pokusnog nasada pokazao iznadprosječni prinos, uz sadržaj šećera ispod prosjeka, ISV1 je iznad prosjeka po sadržaju šećera, ali sa relativno niskim prinosom od samo 2,5 kg po trsu ispod je prosjeka svih klonskih kandidata.

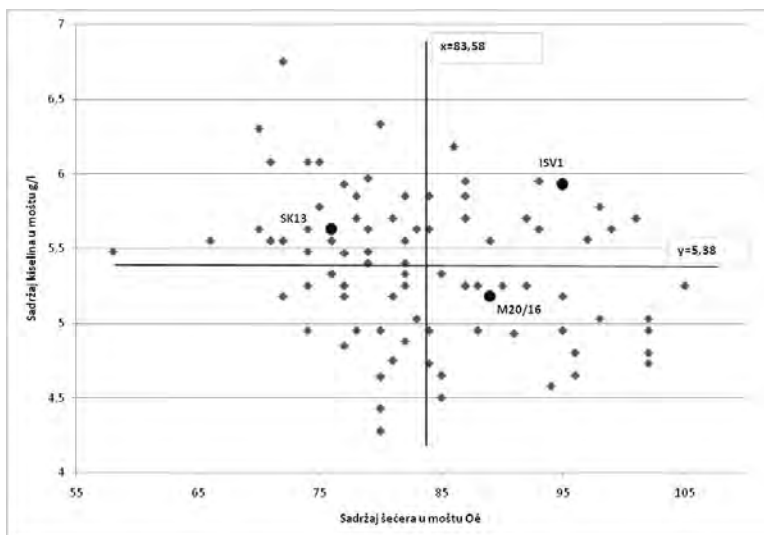
Klon B12/16 pokazao je iznadprosječne rezultate za prinos i za sadržaj šećera u moštu i kao takvog možemo ga smatrati prikladnim za ovo uzgojno područje. Dio klonskih kandidata u ovom istraživanju koji se nalaze u gornjem desnom kvadrantu grafa 1 pokazao je bolje rezultate od klona B12/16 po prosječnom prinosu, uz nešto niži sadržaj šećera u moštu (GR66), a klonski kandidati GR20, GR47, GR71, GR88, GR122 i GR129 bolji od klona B12/16 po sadržaju šećera uz nešto manji prosječni prinos po trsu. Klonski kandidati GR01 i GR02 bolji su od klona M20/16 i po sadržaju šećera i po prosječnom prinosu po trsu. Klonski kandidati GR25, GR51 i GR35 unatoč iznadprosječnim rezultatima u sadržaju šećera u moštu i prosječnog prinosa po trsu, nalaze se ispod klona 20/16.

Sadržaj kiselina kod klonskih kandidata koji su pokazali iznadprosječne vrijednosti za prinos i sadržaj šećera prikazani su u tablici 1. Sadržaj ukupnih kiselina kod sorte Graševina u Kutjevačkom vinogorju u punoj zrelosti često je prenizak, te temeljem toga možemo zaključiti kako klonskim kandidatima koji su u našem pokusnom nasadu pokazali viši sadržaj kiselina (uz iznadprosječan prinos i sadržaj šećera) možemo dati prednost u daljnjem selekcijskom postupku. Glavnina klonskih kandidata prikazanih u tablici 1 ima sadržaj ukupnih kiselina iznad 5g/l što možemo smatrati donjom granicom za dobivanje uravnoteženih vina ove sorte.

Slovenski klon M20/16 pokazao je najbolje rezultate od priznatih klonova koji su kao kontrola uključeni u ovaj pokusni nasad po sadržaju šećera i prosječnog prinosa po trsu, sa sadržajem ukupnih kiselina u moštu od 5,18g/l također se pokazao prikladnim za ovo uzgojno područje. Klonski kandidat GR02 koji je pokazao bolje rezultate prinosa i sadržaja šećera u moštu, ima također i viši sadržaj kiselina u moštu (5,63g/l), dok GR01 ima nešto niži sadržaj ukupnih kiselina (4,93g/l) od kontrolnog klona M20/16.



Graf 1 Odnos sadržaja šećera u moštu i prosječnog prinosa po trsu kod klonskih kandidata Graševine u 2009. godini sa položaja "Vidim" Kutjevačkog vinogorja.



Graf 2 Odnos sadržaja kiselina i šećera u moštu kod klonskih kandidata Graševine u 2009. godini sa položaja "Vidim" Kutjevačkog vinogorja.

Tablica 1: Sadržaj ukupne kiselosti kod klonskih kandidata s prinosom po trsu i sadržajem šećera u moštu višim od prosjeka svih klonskih kandidata

Šifra klonskog kandidata	Sadržaj šećera u moštu Oe°	Sadržaj ukupnih kiselina u moštu g/l	Prosječan prinos kg/trsu
GR001	91	4,93	4,00
GR002	99	5,63	3,71
GR020	105	5,25	3,27
GR025	85	4,5	3,59
GR035	87	5,85	3,44
GR047	94	4,58	3,55
GR051	86	6,18	3,57
GR066	87	5,7	5,17
GR071	98	5,78	3,43
GR088	95	4,95	3,29
GR122	95	5,93	3,44
GR129	90	5,25	3,36
M20/16	89	5,18	3,61

### Zaključak

Klonska selekcija kod vinove loze važna je mjera popravljanja kvalitete kod sorata su dobro prilagođenih uzgojnom području i prihvaćenih od potrošača. Graševina kao najvažnija hrvatska sorta vinove loze je zasigurno je jedna od takvih sorata, a klonskom selekcijom može se uvelike doprinijeti isplativosti uzgoja ove sorte. Iz rezultata ovog istraživanja vidljivo je kako između klonskih kandidata selekcioniranih na području kutjevačkog vinogorja nalazimo značajnu varijabilnost u pogledu najvažnijih gospodarskih svojstava, a neki od klonskih kandidata nadmašuju priznate klonove iz susjednih vinogradarskih zemalja što potvrđuje opravdanost klonske selekcije Graševine u Hrvatskoj.

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# Controlling microbial infection by managing grapevine canopy

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## Abstract

Pinots (*Vitis vinifera* L.) are known as tight-clustered grape varieties, where the mechanical pressure of adjacent berries may disrupt cuticle waxes, thus predisposing these sites to greater incidences of infection. One of the main causes of crop quality degradation is grape rot due to the development of various microorganisms (bacteria, yeasts or other fungi). Among them *Botrytis cinerea* is one of the most frequent problems. Because mold spores are ubiquitous, the control of germination and growth in the vineyard by use of fungicides may only be part of the solution. Therefore, carefully selected cultural practices may play a significant role toward encouraging or discouraging mold and other microbial infections.

A field trial was established in Pinot Noir vineyard of Vipava Valley for two consecutive years. Preliminary results based on visual examination of microbial compromised grapes indicated that earlier leaf removal treatments reduced the extent of microbe damage on grape. Therefore in the following harvest three different treatments of leaf removal (at pre-flowering, berry-set and veraison phase of grape development) were performed, using untreated vines as a control. Temperature and humidity data were collected in the grape area of all treatments. Microbial population on grapes was followed using standard cultivation methods during ripening and at harvest time as well as visual inspection of damaged / sound grapes was performed at both times. At harvest time compactness of grapes was also evaluated. Parallel trial with excluding last Switch® application was done to evaluate the effect in different treatments.

In general we observed the change in species composition on the surface of grapes with early predominance by the basidiomycetous yeasts and species *Aureobasidium pullulans*, and at harvest time with the prevalence of the ascomycetous yeasts, lactic / acetic acid bacteria and molds. Leaf removal was much more effective against *Botrytis Cinerea* compared to additional Switch® application, especially at leaf removals at earlier stages. Pre-flowering leaf removal also showed significant reduction of grape compactness. The results suggesting early leaf removals as successful tool for reducing the risk of microbial infections.

Key words: Pinot Noir, grape quality, grapevine canopy, leaf removal, grape soundness

## Introduction

In general grapevine pathogens can be sub-divided into main pathogens of high economical importance which are pre-dominant, like downy mildew (*Plasmopora viticola*), powdery mildew (*Erysiphe necator*) and bunch rot (*Botrytis cinerea*) and those which occur only locally or temporary (Ribéreau-Gayon et al. 2005). *B. cinerea* development, alone or associated with other microorganisms, lowers potential grape quality. The enological consequences are serious in wines made from altered grapes: oxidations, degradation of color and aromas, and fermentation and clarification difficulties. The objective measurement of the sanitary state of the harvest therefore presents an obvious interest (Kassemeyer and Berkelmann-Lohnertz 2009).

Nowadays, summer canopy management is frequently applied in order to improve cluster microclimate, and

leaf removal is one of the more studied, whether manual or mechanical (Percival et al. 1994, Reynolds et al. 1996). Although this practice may have different goals, it is usually employed from fruit set to veraison on high-density canopies to improve light exposure and air circulation around the clusters, with substantial benefits in terms of tolerance to rot. The functional relationship between source availability around bloom and yield (Caspari and Lang 1996, Poni et al. 2006) inherently implies that defoliation carried out around flowering can reduce fruit set, leading to looser clusters. This approach could potentially be very useful in excessively tight clusters in order to reduce berry-to-berry compression and thereafter rot sensitivity.

### Materials and Methods

The experiment was carried out during vintage 2010 in the vineyard of Pinot Noir located in Vipava Valley (Slovenia). The vineyard was planted in 2004, Guyot trained with a plant density of 5682 plants/he (0.8 m x 2.2 m) and a E-W row orientation (altitude 95 m a.s.l.).

A 2-ways-completely-randomized experimental design was set up with 16 plots of 5 vines, comparing leaf removal (4 treatments) and Switch® / no Switch® application (Syngenta, ciprodinil + fludioxonil) at veraison. Leaf removal (LR) was performed at pre-flowering (BBCH 57), berry-set (BBCH 71) and veraison (BBCH 83) phenological stage, manually removing the basal 5-6 leaves of all shoots, thus allowing grapes to be better exposed to the sunlight. Untreated vines with no leaf removal performed at all were used as control treatments.

Week before harvest and at harvest time all the clusters were visually examined for grey mold and sour rot occurrence and 50 clusters for each treatment were weighted and sized at harvest in order to calculate compactness rate (cluster weight/length rate). Grey mold diffusion and incidence averages were calculated, transformed and ANOVA analyses were performed.

During ripening and at harvest time the microbial enumeration was also performed by plating 100 µL of a dilution series of juice, in duplicate, on selective culture media as follows: WL (Walerstein Laboratory) nutrient agar (Fluka) supplemented with 0.03% chloramphenicol for yeasts enumeration; Potato dextrose agar (PDA) (Biolife) for molds enumeration; Glucose-yeast extract-carbonate medium (GYCM) (50 g L<sup>-1</sup> glucose, 10 g L<sup>-1</sup> yeast extract, 30 g L<sup>-1</sup> CaCO<sub>3</sub>, 25 g L<sup>-1</sup> agar) for acetic acid bacteria and MRS medium (Biolife) supplemented with 2% tomato juice and 0.1 mg mL<sup>-1</sup> cycloheximide for lactic acid bacteria enumeration. Plates were incubated at 25 °C for up to 10 days. Colonies were counted and expressed as colony forming units (CFU) per mL.

### Results and Discussion

Leaf removal reduced the amount of leaf area compared with the untreated vines, and also triggered a strong lateral shoot re-growth (data not shown). As related with treatment timing, the relative amount of laterals was thereafter modified, causing a different microclimate conditions (temperature, relative humidity) around clusters (figure 1) that significantly affected the occurrence of grey mold. Veraison treatment showed the highest values of temperature and the lowest of relative humidity in the south part of the canopy, most probably due to lowest amount of leaves in the cluster area as leaf removal was performed later with less time for lateral re-growth.

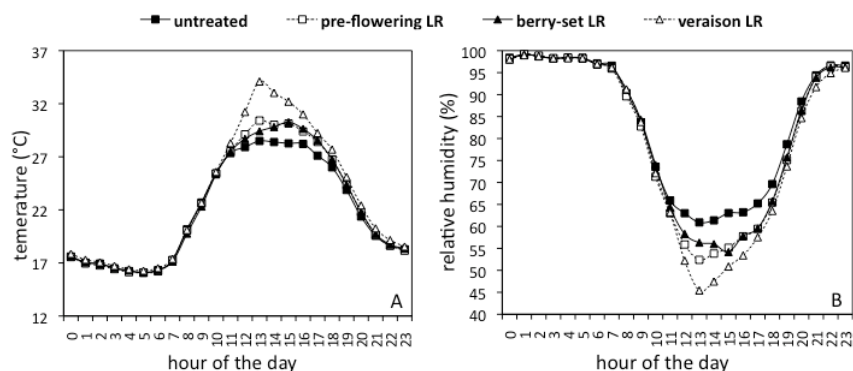


Figure 1 - Daily trends of temperature (A) and relative humidity (B) as affected by leaf removal (average 06-26 Aug) in the south part of the canopy

Among yield parameters, cluster weight dropped down significantly in the pre-flowering treatment providing evidence that yield reduction is one of the effects of this early practice (table 1). However also compactness ratio was reduced by the earlier defoliation thereby supporting both a diminished fruit-set and / or reduced berry size as reported by Poni et al. (2006), while on the other side none of post-flowering treatments resulted in a reduction of cluster weight and compactness ratio as compared with untreated grapevines.

**Table 1 - Cluster weight and compactness rate as affected by leaf removal treatments**

	Cluster weight (g)	Compactness ratio (g/cm)
Untreated /NLR/	127 a	10,9 a
Leaf removal pre-flowering /PFLR/	111 b	8,90 b
Leaf removal at berry-set /BSLR/	123 a	10,7 a
Leaf removal at veraison /VLR/	136 a	11,1 a
<i>Sign. F</i>	0,000 ***	0,000 ***

Grey mold occurrence did showed several differences among treatments, mainly for leaf removal that appeared to be more effective than fungicide application. The timing of defoliation conversely resulted in a shift of canopy development with an increase of lateral shoots positively related with the treatment earliness. It is well known that the first application of a specific fungicide against grey mold (BBCH 77: berries beginning to touch) is the most effective in controlling this pathology. The earlier the leaves are eliminated from the cluster area, the better the fungicide will reach clusters thus significantly reducing grey mold diffusion. Grey mold incidence was significantly higher only in the untreated vines. The relatively higher values of diffusion in the veraison treatment could be related with a reduced effectiveness of the first specific fungicide (at BBCH 77), probably because leaves did not allowed fungicide to reach clusters perfectly.

Fungicide application did not show significant reduction of grey mold (incidence) even if at the last collection time an enhanced diffusion was highlighted.

The interaction between leaf removal and fungicide application, revealed that the application of Switch® significantly reduced grey mold only when the pathogen incidence was higher (leaf removal at veraison and control treatment).

**Table 2 - Grey mold diffusion (%) and incidence (%) as affected by leaf removal and fungicide application on 13th Sep and 21st Sep 2010.**

	13 Sep 2010		21 Sep 2010	
	Diffusion	Incidence	Diffusion	Incidence
Leaf removal (LR)				
Untreated	30,4 a <sup>1</sup>	4,75 a	41,1 a	9,09 a
Leaf removal pre-flowering	4,10 bc	0,73 b	4,84 bc	0,75 b
Leaf removal at berry-set	1,78 c	0,48 b	2,89 c	0,50 b
Leaf removal at veraison	8,45 b	0,89 b	9,19 b	1,86 b
<i>Sign. F</i>	0,000 ***	0,000 ***	0,000 ***	0,000 ***
Fungicide application (FA)				
Switch®	8,96	1,73	10,6 b	2,44
no Switch®	13,4	1,70	18,4 a	3,66
<i>Sign. F</i>	0,173 n.s.	0,490 n.s.	0,000 ***	0,311 n.s.
Interaction LR x FA				
<i>Sign. F</i>	0,000 ***	0,000 ***	0,000 ***	0,000 ***

<sup>1</sup> mean were separated using Student Newman Keuls test.

As expected we observed in all treatments and at control the change in the composition of microbial population on the surface of grapes. During ripening mostly species *Aureobasidium pullulans* and basidiomycetous yeasts from genera *Rhodotorula* and *Cryptococcus* prevailed, while at harvest time ascomycetous yeasts (data not shown), lactic / acetic acid bacteria, *B. cinerea* and other molds dominated. The shift in species composition, accompanied also with higher count, was the most prominent in untreated vines as observed also by visual inspection. Even more, grape samples originated from leaf removal treatment at veraison and from untreated vines showed not only the highest counts for *B. cinerea* but also for acetic and lactic acid bacteria (figure 2).



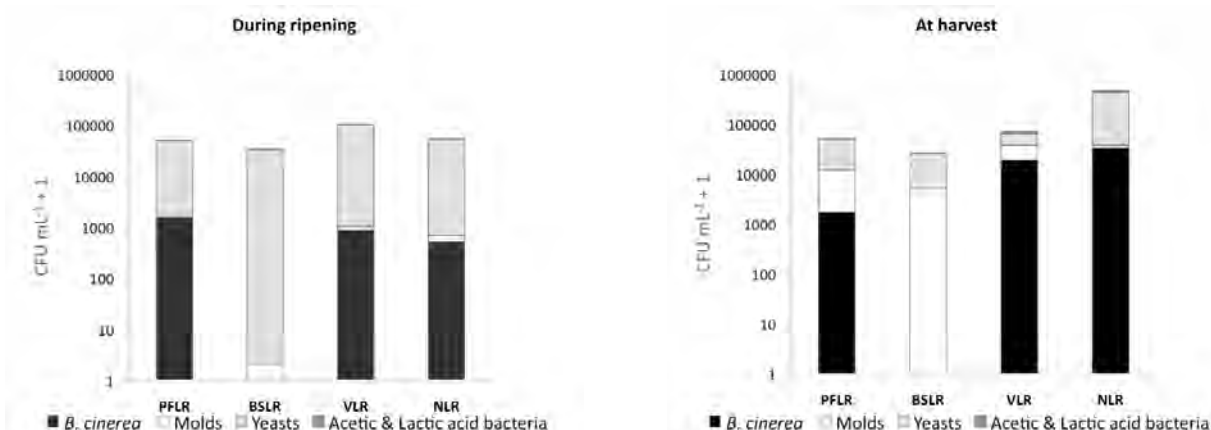


Figure 2 - Mean values for microbial population for grape samples originated from leaf removal treatments (leaf removal pre-flowering - PFLR, leaf removal at berry-set - BSLR, leaf removal at veraison - VLR and untreated vines - NRL) during ripening (left) and at harvest time (right).

## Conclusions

Higher counts of microbial population were observed in veraison (late) leaf removal and in treatments without leaf removal, most probably due to minimized air circulation / canopy microclimate conditions and also due to lower spray penetration. Earlier leaf removal treatments were therefore found to be more effective tool to control potential microbial affections, however the performance of veraison leaf removal was better comparing to control / untreated ones. Additional promising results were obtained in cluster compactness data by observing significant reduction at pre-flowering leaf removal treatment, accompanied also with yield reduction, that can reduce the need for later cluster thinning and therefore reduce the production costs. Further field experiments of more seasons, sites and of other compact-grape variety vineyards are to be performed aiming to assure successful application of very early leaf removal performances to viticultural practice. In our future studies quantification of microbial indicator metabolites will also be included in order to evaluate the correlation between the presence and actual activity of microbes.

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# Soil fertility affect on chemical leaf composition on two types of viticulture's in Gevgelija vineyard conditions

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## Abstract

Soil fertility was examined on two types of viticulture's: Muscat Italia and Ribier breaded in Gevgelija vineyard conditions.

The chemical leaf composition was analyzed at the same types of viticulture's. Soil fertility and the representation of the macro-elements have great influence on the chemical leaf composition.

It is determined that soil samples taken from soil around the viticulture Ribier had greater content of nitrogen, phosphorus, potassium and hummus in comparison with soil samples taken from soil around the type Muscat Italia.

Higher nitrogen, phosphorus, potassium, calcium and magnesium content were determined in leafs in the viticulture Ribier in comparison with the leaf samples on the viticulture Muscat Italia.

Key words: Soil fertility, chemical composition, viticulture

## Introduction

For normal development of the grapevine, getting high and stable yields quality grapes, certain necessary conditions of the environment are necessary. Soil environmental factors have direct or indirect impact on life functions of grapevine. Soil is key factor for development, represents support for strengthening, and is mineral food source and regulator of water, air and heat mode. Loose, deep, weakly acidic and weakly alkaline soils that easily heated, with good aeration, supplied with enough water and nutrients suitable for growing grapevine. Soil fertility or the presence of nutrients in soil, as well as their availability and dynamics are of great importance for the overall development of the grapevine. Nitrogen is an essential macro element. It is a constitutive element. The soil found in the form of organic and inorganic compounds. Grapevine this element used throughout the vegetation, but needs of this element is different in the separate pheno phases. The grapevine has most intensive using before blooming and before the start of maturation.

According to the study of Popovski [2] in R. Macedonia 77.05% of the vineyards are uploaded to diluvia soils srozems, rendzines and cinnamon soil.

The fertility of the soil largely in depends from the chemical composition of leaves from the nutritional grapevine. The content of nutrients with basic macro and micro elements depends from the presence of these elements in soil.

In the soils with higher fertility there is greater intensity of use of basic nutrients and their concentration and distribution in the organs of the grapevine.

## Soil fertility affect on chemical leaf composition on two types of viticulture's in Gevgelija vineyard conditions

The aim of our investigation was to determine the chemical composition of leaves depending on the fertility of the soil. In two vine varieties Muscat Italia and Ribier grown in conditions of Gevgelija wine region.

### Materials and methods

The tests were performed on grape in Gevgelija region. Two vine cultivars were included Muscat Italia and Ribier.

For fertility determination of soil samples, soil samples were taken on the end of vegetation. Soil samples were taken with auger on depth of 0-20 cm 20-40 cm, 40-60 cm and 60-80 cm. In laboratory conditions the samples are driven to air dry condition and ready for agrochemical analysis.

In soil samples the following parameters were analyzed:

- pH reaction - potentiometer response determined with pH meter (Bogdanovic M\_et\_al 1996)
- Available nitrogen content - determined by a method of Tjurin and Kononova
- Available phosphorus content - determined by AL method and spectrophotometer reading - Available content of potassium - determined by AL method and reading on flame photometer
- Content of humus determined by method of Kotzman (Bogdanovic M et.al 1996)

After harvesting leaf samples were taken separately for the two vine cultivars. For analysis lower leaves were used as opposed to the first cluster taken from all sides of the grapevine.

In laboratory conditions the lives samples were washed with 0.05% solution of HCL, than washed with distilled water and dried at room temperature. With grinding in mill the samples were brought into powder and prepared for analysis.

In the leaves samples following parameters were determined:

- Nitrogen content determined by wet incineration air-dried plant material with H<sub>2</sub>SO<sub>4</sub>, and then distillation by Kjeldal
- Phosphorus content determined by wet incineration air-dried plant material with a mixture of H<sub>2</sub>SO<sub>4</sub> and H<sub>2</sub>SO<sub>4</sub> and HClO<sub>4</sub> (1:1) and reading spectrophotometer
- Potassium content determined by wet incineration air-dried plant material with a mixture of H<sub>2</sub>SO<sub>4</sub> and H<sub>2</sub>SO<sub>4</sub> and HClO<sub>4</sub> compared to 1:1 and reading flamephotometer
- Content of calcium and magnesium determined by wet incineration air-dried plant material with HNO<sub>3</sub> and HClO<sub>4</sub> and reading absorpation atomic spectrophotometer PU 9100 X (Official Methods of analysis of international 1995).

### Results and discussion

The basic content of the soil depends on the macro elements and their concentration in the leaves. Tab. 1 shows the results of soil fertility are given under the vineyards of Muscat Italy, and variety Ribier.

From the results presented in Tab.1 conclusion can be made that soil samples under the variety Muscat Italy are available with high fertile nitrogen.

Tab. 1 Soil fertility

Cultivar	Depth cm	pH		Available forms, mg/100g soil			Humus %
		H <sub>2</sub> O	KCl	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	
Muscat Italy	0 -20	8.30	7.20	6.40	14.60	22.00	1.60
	20 -40	8.48	7.18	6.80	15.10	21.00	1.58
	40 -60	8.46	7.17	6.60	15.80	22.60	1.50
	60 - 80	8.44	7.18	6.50	15.30	21.80	1.56
	Average	8.42	7.18	6.57	15.2	21.85	1.56
Ribier	0 -20	8.47	7.23	7.10	16.20	23.00	1.68
	20 -40	8.40	7.28	7.30	16.50	23.40	1.70
	40 - 60	8.42	7.20	7.20	16.80	23.60	1.66
	60 - 80	8.41	7.22	6.90	16.70	22.80	1.64
	Average	8.42	7.23	7.12	16.55	23.20	1.67

Average content of available nitrogen on depth of 0-80 cm is 6.57 mg/100g soil in Italy Muscat variety, and 7.12 mg/100g soil in variety Ribier.

In both varieties the highest available nitrogen content is in soil layer 20-40 cm. The soil samples taken under the variety Muscat Italy have average content of this element on depth of 0-80 cm (15;20 mg/100 g soil). In soil samples under the variety Ribier the results showed the following content 16.55 mg/100g soil.

In both varieties the highest content of available phosphorus was determined in soil layer 40-60cm. Average fertility was determined according to the content of available phosphorus in soil samples from both varieties. Like the previous two elements, potassium plays an important role in many processes in grapevine organs. The grapevine belongs to group of plants that adopt a large amount of potassium. That's why is very important to know the content of the examined elements in soil, because the soil is the main source for supplying organs of grapevine with potassium. The conclusion from the data in Tab. 1 is that there is good fertility of the soil with potassium available in two varieties.

Soil samples under the variety Muscat Italy have average content of available potassium at depth of 0-80 cm (21.85 mg/100g soil) and 23.20 mg/100 g in soil samples under the variety Ribier. According to the content of humus, which is an important mineral organic matter, the soil in the two varieties is poorly fertile. Its average content at depth of 0-80 cm is 1.56% in the soil sample under variety Muscat Italy to the 1.67% in the soil under Ribier variety. pH response was favourable in both varieties.

The soil fertility had a profound impact on the chemical composition of leaves of the tested varieties.

The conclusion from the results from tab. 2 is that content of nitrogen is ranged from 1.78% in the leaves of cultivar Muscat Italy to 1.84% in the leaves of the variety Ribier.

**Tab. 2 Chemical content of leaves in% of dry matter**

Cultivar	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Ca	Mg
Muscat Italy	1.78	0.84	1.18	4.70	0.58
Ribier	1.84	0.53	1.27	4.78	0.67

The content of phosphorus in the leaves is analogous to the fixed lower soil fertility. It ranged from 0.84% in the leaves of cultivar Muscat Italy to 0.23% K<sub>2</sub>O in the leaves of the variety Ribier. Good fertility of the soil with potassium is correlated with the presence of this element in the leaves of both varieties.

The leaves of the variety Muscat Italy have 1.18% content of potassium. The leaves of the variety Ribier have 1.27% content of potassium.

The leaves of both varieties are well supplied with calcium and magnesium.

The contents of all tested macro elements are higher in the leaves of the variety Ribier regarding leaves of cultivar Muscat Italy.

### Conclusion

After following the soil fertility and making this study the following conclusions can be made:

- In soil samples under the variety Ribier we found higher fertility of nitrogen, phosphorus, potassium and content of humus then in the soil under the variety Muscat Italy.
- Soil fertility has a major impact on the chemical composition of leaves.
- In the leaves of the variety Ribier determined a higher percentage of nitrogen, phosphorus, potassium, calcium and magnesium compared with the leaves of cultivar Muscat Italy.

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# The effect of mineral fertilizing on cluster content of N, P, K at cultivar Chardonnay and Italia Riesling in Skopje vineyard area

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## Abstract

During the period of three years an experiment was carried out with mineral fertilizers on cluster content of nitrogen, phosphorus and potassium on two cultivars of wine chardonnay and Italia Riesling. The experiment was done in block system with seven treatments and three repetitions. The following treatments of fertilizers were determined:

1. Control (unfertilized)
2. N<sub>80</sub>P<sub>80</sub>K<sub>80</sub>
3. N<sub>80</sub>P<sub>165</sub>K<sub>122</sub>
4. N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (in the autumn 1/2 of active substance N was applied with urea)
5. N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (in the spring 1/2 of active substance N was applied with urea)
6. N<sub>80</sub>P<sub>165</sub>K<sub>122</sub> + urea foliar
7. N<sub>80</sub>P<sub>165</sub>K<sub>122</sub> + magnifert foliar

Mineral fertilizing positive effects on cluster content of nitrogen phosphorus and potassium at all treatments to both cultivars. In all treatments with different doses of mineral fertilizers higher content of nitrogen phosphorus and potassium was obtained than the control treatment. At both cultivars highest increasing index of cluster content of nitrogen phosphorus and potassium was obtained with the treatment of N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (1/2 of active substance of nitrogen made in spring).

Key words: mineral fertilizing, cluster, nitrogen phosphorus and potassium.

## Introduction

The nutrition of the grapevine is specific agro technical measure that affects the quantity and quality of production of grapes and its products. Proper nutrition has a major influence on numerous physiological - biochemical processes taking place in different organs of grapevine. With good nutrition, the conditions for development of strong lineages can maintain a high native vegetation and potential of cluster. Among other positive affects is the timely payment of cluster that the grapevine provides, increased resistance to berry low winter temperatures. Among cluster and maturation of their degree of resistance to low winter temperatures there is a positive correlation. Hence it is very important in pheno phase maturing elements of nutrition, especially phosphorus, calcium, zinc and boron to be present in optimum quantities. The timely payment of cluster is conditioned by the presence of micro elements affecting oxide-reduction and many other processes taking place in the grapevine.

Among macro elements, potassium has very important role in the conduct of life processes of the grapevine. This element has the most significant influence on the processes of maturation, and has increased the

resistance of cluster on low winter temperatures.

Mineral composition of year-long cluster, or their total content as well as their relationship is very important criterion for assessing the degree of nutrition the grapevine, and thus the need for mineral nutrition.

The aim of our study was to determine the influence of the soil and foliar fertilization on the cluster content of nitrogen, phosphorus and potassium in two vine varieties chardonnay and Italia Riesling growing in Skopje vineyard area.

### Materials and Methods

The experiment was done in commercial vineyard of the Institute of Agriculture, Department for viticulture and enology, located in the Skopje area. The examined material was vine cv. chardonnay and the cv. Italia Riesling. The experiment was established in seven treatments and three repetitions:

Control (unfertilized)

$N_{80}P_{80}K_{80}$

$N_{80}P_{165}K_{122}$

$N_{80}P_{101}K_{80}$  (in the autumn 1/2 of active substance N was applied with urea)

$N_{80}P_{101}K_{80}$  (in the spring 1/2 of active substance N was applied with urea)

$N_{80}P_{165}K_{122}$  + urea foliar

$N_{80}P_{165}K_{122}$  + magnifert foliar

Following mineral fertilizers were applied:

NPK 15:15:15

NPK 10:30:20

Urea 46% N

Magnifert (NPKB 8:4:8:1 + microelements Mg, Mn, Co, Fe, Zn and Cu in helat form).

For basic fertilization in autumn all the variants NPK 15:15:15 and NPK 10:30:20 fertilizers were applied. The fertilization was done during the first half of November, 2006/2008, in previous opened rows with 40 cm depth and 60 cm distance from the vines.

At variant 4  $N_{80}P_{101}K_{80}$  in autumn half of active substance N was applied with urea. At variant 5  $N_{80}P_{101}K_{80}$  in spring half of active substance N was applied with urea. The foliar treatments were applied 3 times: 10-15 days before flowering, 10-15 after flowering and during the verasion. The concentration of urea was 0. 3% at variant 6 and 0. 3, 0. 4 and 0. 5% at variant 7.

In the end of vegetation average samples were taken of clusters for chemical analysis. The average samples were first dried at room temperature to air dry condition. Then the samples were chopped into fine material and grinded in an electric mill were they were brought into powder. The data is statistically processed with LSD test. Dry floral material with damp cremation and concentrated H<sub>2</sub>SO<sub>4</sub> is processed and then Kjeldal destination is made (for N). The content of P and K is determined with the same method with adding HClO<sub>4</sub>:H<sub>2</sub>SO<sub>4</sub> (1:1).

### Results and discussion

The results obtained on the influence of mineral fertilization on the content of nitrogen in cluster in vine varieties, chardonnay and Italia Riesling are given in tab. 1. The data concludes that soil and foliar fertilization have given positive effects on the content of N, P, K in cluster by both varieties. The positive effect of mineral nutrition was noted in all three experimental years. Among the cultivar chardonnay content of nitrogen in the cluster was higher than the variety Italia Riesling as a result of variety specificity.

The average nitrogen content in cluster in variety chardonnay ranged from 0. 70% in control variant to 0. 77% at the variant 5. The average index increased for nitrogen content in variants with different fertilizer doses ranged from 4% for variant 7, and 10% for variant 5. The same dynamics of content of this element was concluded in the cultivar Italia Riesling. The lowest average of nitrogen content 0. 62% contained cluster of control variant, and the highest content of 0. 71% nitrogen was determined in cluster in variant 5 and 6. The average index increase ranged from 8% in cluster of variant 2 and 14% for cluster of variants 5 and 6.

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Highest nitrogen content in cluster of variant 5 was determined in both varieties due to the spring period and because of part of active nitrogen in soil. This method of fertilization was made in the period of intense growth and advancement; and during this period the grapevine can be sufficiently supplied with nitrogen. NO<sub>3</sub><sup>-</sup> is easily movable in soil. This damned if is introduced only in fall and cannot entirely be used by the plant. According to results from studies of numerous authors, mature and well-qualified one-year branch of grapevine usually contain from 0.4 to 0.9% nitrogen [10, 11, 12].

The results for the content of phosphorus in cluster by both varieties are shown in tab. 2. In cluster in variety chardonnay is established higher phosphorus content in relation to the contents of cluster of the variety Italia Riesling. The average phosphorus content in cluster in variety chardonnay is ranged from 0.3% in the control variant and variant 2 to 0.39% in clusters from variants 6 and 7. The average index in increased content of phosphorus was highest among the clusters of variant 6 and 7 and was 30%. The lowest average content of phosphorus in the clusters of variety Italia Riesling was 0.2%.

The highest average index of phosphorus content is 33% at the cultivar Italia Riesling determined in the clusters of the variant 5. In the literature, depending on the conditions of the test different information are given about content of phosphorus in the cluster of grapevine. Buric [12] noted that average content of phosphorus in cluster during the vegetation is 0.28%. According to tests on Damic and Nikolic [10] the content of phosphorus in cluster is 0.31% and according to Licina[11] the content of phosphorus is 0.64%.

The content of potassium in cluster grapevine ranges from 0.3% to 1.2% [10, 13]

Tab 1. Content of NO<sub>3</sub><sup>-</sup> in cluster in% dry matter

Var.	Chardonnay					Italia Riesling				
	1 year	2 year	3 year	M	Index	1 year	2 year	3 year	M	Index
1	0.68	0.70	0.73	0.70	100	0.63	0.60	0.63	0.62	100
2	0.70	0.72	0.84	0.75	107	0.63	0.65	0.72	0.67	108
3	0.74	0.75	0.79	0.76	108	0.64	0.66	0.79	0.70	112
4	0.72	0.73	0.80	0.75	107	0.66	0.65	0.77	0.69	111
5	0.74	0.76	0.81	0.77	110	0.66	0.69	0.77	0.71	114
6	0.70	0.74	0.83	0.76	108	0.67	0.68	0.78	0.71	114
7	0.71	0.71	0.78	0.73	104	0.63	0.65	0.79	0.69	111

LSD (0.05) = 0.08 LSD (0.05) = 0.11

LSD (0.01) = 0.11 LSD (0.01) = 0.15

Tab 2. Content of P<sub>2</sub>O<sub>5</sub> in cluster in% dry matter

Var.	Chardonnay					Italia Riesling				
	1 year	2 year	3 year	M	Index	1 year	2 year	3 year	M	Index
1	0.30	0.31	0.29	0.30	100	0.21	0.22	0.20	0.21	100
2	0.29	0.31	0.30	0.30	100	0.23	0.26	0.25	0.25	119
3	0.30	0.35	0.34	0.33	110	0.22	0.24	0.29	0.25	119
4	0.32	0.36	0.40	0.36	112	0.23	0.25	0.30	0.26	123
5	0.32	0.35	0.45	0.37	123	0.26	0.26	0.33	0.28	133
6	0.34	0.38	0.45	0.39	130	0.23	0.23	0.28	0.25	119
7	0.34	0.36	0.46	0.39	130	0.22	0.22	0.28	0.25	119

LSD (0.05) = 0.08 LSD (0.05) = 0.05

LSD (0.01) = 0.11 LSD (0.01) = 0.07

Tab 3. Content of K<sub>2</sub>O in cluster in% dry matter

Var.	Chardonnay					Italia Riesling				
	1 year	2 year	3 year	M	Index	1 year	2 year	3 year	M	Index
1	0.64	0.63	0.63	0.63	100	0.52	0.53	0.51	0.52	100
2	0.66	0.68	0.66	0.67	106	0.58	0.60	0.60	0.59	113
3	0.64	0.66	0.68	0.66	104	0.54	0.59	0.57	0.57	109
4	0.66	0.70	0.76	0.71	112	0.54	0.60	0.64	0.59	113
5	0.68	0.72	0.87	0.76	120	0.57	0.64	0.69	0.63	121
6	0.66	0.70	0.77	0.71	112	0.56	0.62	0.68	0.62	119
7	0.68	0.71	0.71	0.70	111	0.58	0.62	0.69	0.63	121

LSD (0.05) = 0.09 LSD (0.05) = 0.08

LSD (0.01) = 0.12 LSD (0.01) = 0.11

Tab. 3 shows the results obtained for content of potassium in cluster from the cultivars chardonnay and Italia Riesling. Soil and foliar fertilization had positive effect over the content of potassium in cluster in both varieties. In both varieties, including different variations, similar results have been achieved for the content of potassium in cluster. Significant difference in the content of potassium in cluster exists in the control variant.

The average potassium content in cluster for variety chardonnay ranges from 0.63% in the control variant to 0.71% in variants 4 and 6. The average index increases for potassium content, and is ranged from 4% for variant 3 to 20% variant 6.

The average potassium content in cluster of variety Italia Riesling ranges from 0.51% in control variant to 0.63% in variants 5 and 7. Increased index content of potassium in cluster of this variety ranges from 9% in variant 3 to 21% in variant 5 and 7.

### Conclusion

Based on three years research for determination on effect of mineral fertilizing on cluster content of nitrogen, phosphorus and potassium at cultivars chardonnay and Italia Riesling grown in Skopje vineyard area, following conclusions can be made:

Mineral fertilization had positive effects on the content of nitrogen, phosphorus and potassium in the cluster of all varieties by both cultivars.

In all tested variants of the cultivars higher content of nitrogen was found.

In both cultivars the highest nitrogen content was determined in cluster from variant N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (in the spring 1/2 of active substance N was applied with urea). The index was 10% increased in the variety chardonnay, 14% in Italia Riesling.

Highest index of increased content of phosphorus in the variety chardonnay was determined in cluster from variant N<sub>80</sub>P<sub>165</sub>K<sub>122</sub> + urea foliar and variant N<sub>80</sub>P<sub>165</sub>K<sub>122</sub> + magnifert foliar which was 30%. In the variety Italia Riesling highest index increase of phosphorus content of 33% was determined in the variant N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (in the spring 1/2 of active substance N was applied with urea).

Highest index of increased content of potassium in both varieties was determined in cluster from variant N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (half of the active substance was released by nitrogen urea in the spring). The index of increased content of potassium was with 20% increase in the variety chardonnay and 21% in the variety Italia Riesling.

From all the tested varieties as best allocate variant N<sub>80</sub>P<sub>101</sub>K<sub>80</sub> (half of the active substance was released by nitrogen urea in the spring).

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# Učinkovitost ekološki prihvatljivih pripravaka u suzbijanju patogene gljive *Botrytis cinerea* Pers. ex Fr. na vinovoj lozi

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## Sažetak

Cilj istraživanja je bio utvrditi učinkovitost pripravaka, čija je primjena dozvoljena u ekološkom vinogradarstvu u suzbijanju patogene gljive *Botrytis cinerea* na različitim kultivarima vinove loze. Za suzbijanje sive plijesni u istraživanju su korištene kombinacije pripravaka: Oikomb+Propolis, Neoram WG+Propolis i Vodeno staklo+Propolis. Djelotvornost primijenjenih pripravaka izražena je na osnovu procjene jačine zaraze s *Botrytis cinerea* te broja zaraženih grozdova u kontroli i broja zaraženih grozdova u tretmanu. Najveći koeficijent učinkovitosti (KE) kod svih kultivara postignut je uporabom pripravka Oikomb+Propolis (46,65-78,69%). Slabiju učinkovitost pokazala je varijanta Neoram WG + Propolis (44,53-71,56), a najslabiju varijanta Vodeno staklo + Propolis (42,22-68,95).

Ključne riječi: učinkovitost, *Botrytis cinerea*, jačina zaraze, pripravci

## The efficiency of ecological allowed preparations in control *Botrytis cinerea* Pers. ex Fr. on the grapevine

### Abstract

The aim of this study was to determine the effectiveness of selected preparations, application of which is permitted in organic vineyards in the control of *Botrytis cinerea* on different cultivars of grapevine. To block gray mold, the researchers used a combination of preparations: Oikomb + Propolis, Neoram WG + Propolis and Watery glass + Propolis. The effectiveness of the applied preparations were expressed on the basis of assessment of the strength intensity of infection with *Botrytis cinerea* (number of infected clusters in control and the number of infected clusters in treatment). The highest efficiency coefficient (KE) in all cultivars was achieved using a mixture Oikomb + Propolis (46.65 to 78.69%). Poor performance showed the Neoram WG + Propolis (44.53 to 71.56), and the poorest variant was the variant Watery glass + Propolis (42.22 to 68.95).

Key words: efficiency, *Botrytis cinerea*, the intensity of infection, preparations

### Uvod

Ekološki prihvatljive metode suzbijanja biljnih bolesti u nasadima vinove loze imaju sve veću tendenciju primjene, obzirom na prekomjernu uporabu različitih kemijskih sredstava. Primjenom ekološki prihvatljivih pripravaka uz provedbu primjerenih agrotehničkih zahvata moguće je ostvariti značajne prinose zdravog grožđa. Siva plijesan vinove loze koju uzrokuje gljivica *Botrytis cinerea* predstavlja jednu od ekonomski

najznačajnijih bolesti vinove loze, osobito intenzivnog uzgoja (Kišpatić, 1976). Izravne štete od napada gljive *Botrytis cinerea* u smanjenju uroda u Hrvatskoj kreću se od 3 do 15%, ovisno o godini, a prosječne godišnje štete iznose oko 4,1%. (Maceljki i sur., 2006).

Kod obrambenih mehanizama i otpornosti vinove loze na *Botrytis cinerea*, postoji bitna razlika u osjetljivosti vegetativnih i generativnih organa loze (Topolovec - Pintarić, 2000).

U ekološkoj proizvodnji vinova loza se može tretirati i sredstvima koja jačaju nespecifičnu otpornost biljaka, a nisu izravno usmjerena protiv bolesti (biljni preparati, preparati od algi, propolis, te homeopatski i biodinamički preparati). Prednost ovih sredstava je u tome da se ne smanjuje njihovo djelovanje ni kod dugotrajnih i učestalih primjena.

U odnosu na dosadašnja iskustva u suzbijanju gljive *Botrytis cinerea* još uvijek se nastoji proučiti povezanost između ove patogene gljive i aktiviranja obrambenih mehanizama vinove loze, koji po mišljenju autora Pezet, R. i Pont V., (1984) mogu biti aktivni i pasivni. Zbog potrebe reduciranja uporabe kemijskih fungicida, današnja istraživanja usmjerena su ne samo na registraciju biofungicida poput pripravka Trichodex WP (Topolovec-Pintarić i sur., 2004), nego i na primjenu različitih biodinamičkih pripravaka kojima se jača imunitet vinove loze te smanjuje opasnost od povećanja broja rezistentnih jedinki.

### Materijal i metode

Istraživanja su obavljena tijekom 2009. godine u ekološkim vinogradima OPG-a "Čegec", smještenim na lokalitetu Štuk, površine 2 ha. U pokus je uključeno sedam kultivara vinove loze: Chardonnay bijeli, Traminac, Graševina, Zweigelt, Štajerska bjelina, Pinot sivi i Rajnski rizling. Za postavljanje pokusa izabran je potpuno slučajni blok sustav. Pokusne parcele predstavljene su sa 2 tretirane i 2 kontrolne repeticije/sortimentu, od kojih svaku repeticiju čini po 10 trsova. Za suzbijanje sive plijesni u istraživanju su korištene kombinacije pripravaka: Oikomb + Propolis, Neoram WG + Propolis i Vodeno staklo + Propolis. Oikomb je preparat sačinjen od dviju komponenta (vodenog stakla i biljnih ekstrakta) i predstavlja kombinirani proizvod HF-Pilzvorsorge i Kaliwasserglas-a. Vodeno staklo sačinjavaju natrijeve ili kalijeve soli silicijeve kiseline. Silicijeva kiselina mehanički učvršćuje epidermu i kutikulu, čime sprječava prodor hifa gljiva. Propolis je ljepljiva smolasta tvar koja nastaje preradom biljnih sokova koje pčele sakupljaju sa različitih biljaka, a na biljke djeluje protuobakterijski, proturivirusno i protugljivično. Neoram WG je kontaktni preventivni fungicid, formuliran u obliku močivih samodispergirajućih granula, proizvedenih FLUID BED tehnologijom, koja osigurava bolju topivost u vodi, veću iskoristivost, te bolju učinkovitost i pokrovnost. Na bazi je aktivne tvari bakar  $Cu^{2+}$  iz bakarnog oksiklorida.

Raspored tretiranja obavljen je prema fenološkoj metodi - fenofazama (A, B, C i D), četiri puta tijekom vegetacije, gdje je: Fenofaza A - tretiranje po završetku cvatnje, Fenofaza B - tretiranje u vrijeme zatvaranja grozdica, Fenofaza C - tretiranje u vrijeme promjene boje grozda (šara) i Fenofaza D - tretiranje pred berbu.

Prilikom berbe grožđa obavljeno je ocjenjivanje jačine zaraze s *Botrytis cinerea* prema EPPO-skali (EPPO, 1982), ocjenama od 0-5, izraženo u postotku, te na osnovu broja grozdova svake kategorije (ocjene) dobivene vrijednosti razvrstane su u šest kategorija i obrađene prema Townsend-Heuberger formuli (Townsend, G. R, Heuberger, J. W., 1943):

$P = S_n \times k / N \times K$ , gdje je:

P = srednja vrijednost stupnja bolesti svih procjenjenih objekata

$S_n$  = broj ponovljenih slučajeva u svakoj kategoriji

k = kategorija (ocjena)

N = ukupan broj objekata uzet u procjeni

K = ukupan broj kategorija uzet u procjeni

Učinkovitost ispitivanih ekološki prihvatljivih pripravaka određena je usporedbom broja jedinki između tretmana i kontrole po formuli Abbot (1925):

$KE = (K - T / K) \times 100$ , gdje je:

KE - koeficijent učinkovitosti (%)

K - broj zaraženih grozdova u kontroli (stupanj zaraze)

T - broj zaraženih grozdova u tretmanu

Kod analize dobivenih rezultata i statističke obrade istih, primijenjena je analiza varijance (ANOVA).

## Rezultati i rasprava

Na osnovu prosječnih vrijednosti jačine zaraze (%), analizom varijance (ANOVA) utvrđene su razlike između tretmana i kontrolnih površina. Najaču zaraza s *Botrytis cinerea* očekivano su pokazale kontrolne varijante, a najslabiju zarazu pokazala je varijanta Oikomb+Propolis. Varijante sredstva na bazi bakra (Neoram WG + Propolis) i (Vodeno staklo + Propolis) pokazale su nešto veću zarazu s gljivom *Botrytis cinerea*, ali značajno manju u odnosu na kontrolu (Tablica 1). Usporedbom jačine zaraze grozdova ispitivanih kultivara nisu nađene razlike koje se mogu pripisati različitoj osjetljivosti kultivara. Kod kontrolnih varijanti svih ispitivanih kultivara utvrđena je značajno visoka jačina zaraze u odnosu na varijantu Oikomb+Propolis.

Tablica 1. Ocjena jačine zaraze s *B. cinerea* u 2009. godini; lokalitet Štuk

Kultivar	Varijante (jačina zaraze) Koncentracija (%)				LSD 0,05
	- Kontrola	0,5+0,5 Oikomb +Propolis	0,25+0,5 Neoram WG + Propolis	0,5+0,5 Vodeno staklo + Propolis	
Chardonnay	44,81 /b	9,26 /a	16,25 /a	38,46 /b	13,39
Traminac	40,60 /b	7,95 /a	9,56 /a	17,01 /a	9,31
Graševina	44,57 /d	4,70 /a	17,83 /b	29,00 /c	6,73
Zweigelt	40,49 /c	11,58 /a	18,91 /a	23,03 /a, b	9,72
Pinot sivi	43,65 /c	14,89 /a	26,95 /b	28,71 /b	10,77
Štajerska bjelina	42,02 /c	11,58 /a	23,81 /a	26,36 /a, b	12,35
Rajnski rizling	43,35 /c	7,74 /a	23,61 /b	36,55 /c	11,14

Vrijednosti označene istim slovom ne pokazuju signifikantne razlike uz vjerojatnost pogreške P=0,05

Na osnovu intenziteta zaraze utvrđena je učinkovitost primijenjenih pripravaka čija je djelotvornost izražena kroz koeficijent učinkovitosti. Učinkovitost pripravaka u pokusu određena je na osnovi broja zaraženih grozdova u kontroli i broja zaraženih grozdova u tretmanu sa ciljem utvrđivanja najučinkovitijeg pripravka za suzbijanje *Botrytis cinerea* na ispitivanim kultivarima vinove loze.

Tablica 2. Učinkovitost pripravaka u suzbijanju *B. cinerea* u 2009. godini; lokalitet Štuk

Kultivar	Varijante (jačina zaraze) Koncentracija (%)			LSD
	0,5+0,5 Oikomb + Propolis	0,25+0,5 Neoram WG + Propolis	0,5+0,5 Vodeno staklo +Propolis	
Chardonnay	68,96 /a	52,50 /b	49,20 /b	13,18
Traminac	70,22 /n.s	68,32 /n.s	56,23 /n.s	19,87
Graševina	75,33 /a	50,11 /b	48,46 /b	22,27
Zweigelt	46,65 /n.s	44,53 /n.s	42,22 /n.s	8,36
Pinot sivi	58,74 / n.s	55,69 / n.s	49,32 / n.s	21,69
Štajerska bjelina	61,90 / n.s	51,27 / n.s	48,85 / n.s	31,20
Rajnski rizling	78,69 / n.s	71,56 / n.s	68,95 / n.s	20,92

Vrijednosti označene istim slovom ne pokazuju signifikantne razlike uz vjerojatnost pogreške P=0,05

Na osnovu koeficijenta učinkovitosti ispitivanih pripravaka (Tablica 2), visok koeficijent učinkovitosti gotovo kod svih kultivara postignut je uporabom pripravka Oikomb+Propolis (46,65-78,69%). slabiju učinkovitost pokazala je varijanta Neoram WG + Propolis (44,53-71,56), a najslabiju varijanta Vodeno staklo + Propolis (42,22-68,95). Učinkovitost primjenjenih pripravaka kod 5 od 7 istraživanih kultivara ne pokazuje signifikantne razlike.

Uzmemo li u obzir da se ispitivanim pripravcima suzbijala siva plijesan u ekološkom vinogradu, niski koeficijenti učinkovitosti ispitivanih pripravaka u odnosu na jačinu zaraze osobito u kontrolnim varijantama pokazuju zadovoljavajuće rezultate.

## Zaključci

Učinkovitost primjenjenih sredstava (Oikomb+ Propolis, Neoram WG+ Propolis i Vodeno staklo+propolis), prema uzročniku sive truleži grožđa na različitim kultivarima vinove loze u ekološkom vinogradu bila je zadovoljavajuća. Uzmemo li u obzir da je jačina zaraze u kontrolnim varijantama iznosila od 40,49 do 44,81%, što ukazuje na godinu s visokom prisutnošću sive truleži grožđa, slabija učinkovitost ispitivanih pripravaka bila je opravdana. Usporedbom između pripravaka najučinkovitiji pripravak predstavlja kombinacija Oikomb+Propolis, kod svih ispitivanih kultivara.

Ova istraživanja potvrđuju da se primjenom biodinamičkih pripravaka u ekološkoj zaštiti vinove loze mogu polučiti zadovoljavajući rezultati u suzbijanju najznačajnijih biljnih bolesti u koje pripada i *Botrytis cinerea* Pers. ex Fr.

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# Inventarizacija i morfološka karakterizacija genotipova badema *Prunus amygdalus* na području Hercegovine

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## Sažetak

Cilj ovog istraživanja je da se iz populacije badema u Hercegovini, izdvoje genotipovi dobrih morfološko-fenoloških osobina. Evidentirano je i istraženo 27 autohtonih genotipova badema od kojih su metodom pozitivne individualne selekcije odabrana i analizirana tri genotipa. Istraživanja su obuhvatila praćenje fenofaza cvjetanja i zrenja, kao i njihove morfološke i pomološke karakteristike. Genotip II se ističe polumekom ljuskom i visokim stupnjem randmana jezgre (54,41%), a ima i kasno cvjetanje. Genotip III ima povoljno vrijeme cvjetanja.

Ključne riječi: badem, selekcija, genotip, morfološko - fenološke karakteristike

## Inventarisation and morphological characterization of genotypes of almond *Prunus amygdalus* in the area of Herzegovina

### Abstract

Aim of this study was to select the genotypes with good morphological-phenological characteristics from the population of almonds in Herzegovina. The recording and studying of 27 autochthonous almond genotypes was carried out, and three genotypes were selected and analysed using method of positive individual selection. The study comprised observation of blossom and ripening phenophases, as well as its morphological and pomological characteristics. Genotype II was highlighted with its semi-soft shell and high degree of yield of kernel (54,41%), and it has late blossom. Genotype III has convenient blossom period.

Key words: almond, selection, genotype, morphological-phenological characteristics

### Uvod

U Bosni i Hercegovini badem (*Prunus amygdalus L.*) raste u dijelu gdje preovladava mediteranska klima, a to je šire područje Hercegovine. Po dosadašnjim saznanjima badem je vrlo rijetko bio predmet istraživanja u BiH. Ova kultura se širila iz centralne Azije preko cijelog Mediterana zahvaljujući starim Grcima i Feničanima (Godini, 2005.). Danas je proizvodnja badema ograničena na tri regiona u svijetu. To su Azija, mediteranske zemlje i Kalifornija, a u manjim količinama se proizvodi u Australiji, Južnoj Africi, Čileu i Argentini (Aslanta i Gülerüz, 2001). U širem mediteranskom pojasu uzgaja se u Španjolskoj, Portugalu,

Italiji, Francuskoj i Turskoj. Na prostoru južne Evrope, Male Azije, jugozapadne i srednje Azije raste više od 30 vrsta badema. Oni su prema genetičkoj srodnosti i geografskoj rasprostranjenosti podijeljene na pet sekcija. Među njima je 20 vrsta od većeg značaja za evoluciju badema (Mišić, 2002.). Badem (*Prunus amygdalus L.*) je porijeklom iz Azije, odakle se uzgojem preselio na zapad i udomaćio u zemljama Sredozemnog mora. Raste kao poludivlje drvo, ali je najpoznatiji kao kultivirana biljka (Gizdić, 1997.). Postojeći sortiment badema ne zadovoljava, naročito u pogledu otpornosti prema zimskim i kasnim mrazovima, prouzrokovateljima bolesti i štetočinama, pa se ulažu znatni naponi da se proširi genetska osnova oplemenjivanja ove važne lupinaste voćke (Mišić, 2002.). Selekcijom badema nastoje se stvoriti nove sorte s kasnijom cvatnjom, izraženom samooplodnjom, visokom rodnošću, jezgrom što veće kakvoće, lakom i učinkovitom berbom plodova, dobrim spajanjem šavova, otpornošću prema bolestima i štetnicima, smanjenjem osipanja cvjetnih pupoljaka, mekoćom kore, količinom ulja i randmanom (Gizdić, 1997.).

Cilj ovog istraživanja je da se iz postojeće populacije badema u Hercegovini pozitivnom individualnom selekcijom izdvoje genotipovi dobre kakvoće ploda, dobrih gospodarskih svojstava osobina i kasnog cvjetanja kako bi se obezbijedila genetska osnova za stvaranje novih i popravak postojećih genotipova badema. Istraživanja su obuhvatila morfološke i fenološke karakteristike navedene voćne vrste.

### Materijal i metode

Ispitivanja su obavljena u dvije godine, u razdoblju od veljače do listopada, na širem području Hercegovine. U prvoj godini je izvršena inventarizacija pri čemu je prikupljeno i proučavano 27 genotipova. Na osnovu utvrđenih morfološko-fenoloških svojstava izdvojena su tri za koje se smatralo da imaju vrijedna svojstva pa je njihova detaljnija karakterizacija nastavljena u sljedećoj godini. Odabir je vršen metodom pozitivne individualne selekcije (Kurtović i Jarebica, 1999.; Beljo, 2006.).

Istraživanja su obuhvatila analizu slijedećih parametara: visina i starost stabla, visina i obim debla, prosječna dužina i širina listova, prosječna dužina i širina plodova, prosječna masa plodova s ljuskom i prosječna masa jezgre. Dobiveni rezultati su obrađeni standardnim statističkim metodama. Tijekom vegetacije praćene su slijedeće fenofaze: početak vegetacije, početak i kraj cvjetanja, početak i kraj listanja, početak i kraj sazrijevanja i početak opadanja listova (kraj vegetacije). Odabrana stabla se nalaze na lokalitetu Dubravske visoravni, općina Stolac, na privatnim posjedima poljoprivrednih proizvođača u selu Borojevići, te su na istim izvršene prethodno opisane analize. Za uzorak je uzeto po 30 listova i plodova sa svakog stabla, koji su mjereni u laboratoriju Agromediteranskog fakulteta u Mostaru.

Tablica 1. Prikaz rasprostranjenosti ispitivanih genotipova na području Hercegovine

Redni broj	Lokacija	Broj genotipova
1.	Mostar- Šarića harem	2
2.	Mostar- Balinovac	1
3.	Mostar-Hodbina	1
4.	Mostar- Bijelo Polje -Lišani	3
5.	Mostar- Bijelo Polje-Salakovac	4
6.	Mostar- Bijelo Polje-Podgorani	1
7.	Mostar-Humi	1
8.	Mostar-Sjeverni Logor	1
9.	Mostar-Dračevica	1
10.	Čapljina -Opličići	8
11.	Stolac- Borojevići	3
12.	Čitluk -Biletići	1
	Ukupno	27

U toku istraživanja, na području Hercegovine, prikupljeno je 27 genotipova, od toga u općini Mostar 15, u Čapljini 8, Stocu 3 i Čitluku 1 genotip. Od svih prikupljenih genotipova izdvojena su tri sa lokaliteta Stoca (Borojevići) koji su dalje analizirani.



## Rezultati i rasprava

U tablici 2. su prikazane osnovne morfološke karakteristike i starost stabla odabranih genotipova badema.

**Tablica 2. Osnovni morfološki parametri i starost odabranih genotipova badema**

	Genotip I	Genotip II	Genotip III
Visina stabla (m)	6,0	6,0	7,0
Starost (god)	11	19	24
Visina debla (cm)	110	100	110
Obim debla (cm)	89	92	115

Na temelju podataka iz tablice 2 može se konstatirati da visina stabla, te visina i opseg debla imaju približnu vrijednost, iako se radi o stablima različite starosti. Starost stabla se kretala od 11 do 24 godine, dok su istraživanja Karadeniz i sur. (2003.) obavljena na stablima prosječne starosti od 30 do 50 godina.

Podaci o prosječnoj dužini i širini listova odabranih genotipova badema su evidentirani u tablici 3.

**Tablica 3. Prosječna dužina i širina listova odabranih genotipova badema**

	Dužina listova (mm)		Širina listova (mm)	
	X±Sx	Cv (%)	X±Sx	Cv (%)
Genotip I	54,8±0,68	8,44	11,4±0,85	23,59
Genotip II	70,1±2,05	9,15	13,1±1,57	38,09
Genotip III	87,9±1,74	6,27	12,9±1,00	24,49

Na temelju podataka prikazanih u tablici 3 u istraživanom periodu, može se zaključiti da prosječno najduže listove ima genotip III (87,9 mm), slijedi genotip II (70,1 mm), te genotip I sa prosječno najmanjom dužinom listova od 54,8 mm. Najveću prosječnu širinu listova ima genotip II (13,1 mm), zatim genotip III (12,9 mm), dok genotip I ima najmanju prosječnu širinu lista od 11,4 mm. Dobiveni podaci odgovaraju literaturnim podacima. Bulatović (1985.) i Gizdić (1997.) navode da je list kod badema dug 4-7 cm, a širok 1,5-2 cm. Kod sva tri genotipa je primijećeno da imaju visok koeficijent varijabilnosti za širinu lista (od 23,59% do 38,09%), za razliku od svojstva dužina lista (od 6,27% do 9,15%).

Rezultati mjerenja prosječne dužine i širine zrelih plodova s ljuskom odabranih genotipova badema su prikazani u tablici 4.

**Tablica 4. Prosječna dužina i širina zrelih plodova s ljuskom odabranih genotipova badema**

	Dužina zrelih plodova (mm)		Širina zrelih plodova (mm)	
	X±Sx	Cv (%)	X±Sx	Cv (%)
Genotip I	29,46±0,39	7,36	22,10±0,28	6,92
Genotip II	38,06±0,35	5,07	25,76±0,29	6,13
Genotip III	35,46±0,54	5,55	25,38±0,35	5,00

Najveću prosječnu dužinu ploda (38,06 mm), kao i širinu (25,76 mm) ima genotip II, potom genotip III (dužina 35,46 mm i širina 25,38), dok prosječno najmanju dužinu (29,46 mm) i širinu plodova s ljuskom (22,10 mm) ima genotip I. Koeficijent varijabilnosti je nizak za oba svojstva kod sva tri odabrana genotipa. Karadeniz i sur. (2003.) navode dužinu ploda između 18 i 48 mm, a širina ploda je iznosila 12 do 28 mm, dok Cordeiro i sur. (2001) mjere dužinu ploda od 30,40 do 43,10 mm i širinu ploda od 18,35 do 30,80 mm. Polat i sur. (2001) su evidentirali dužinu ploda od 27,99 do 40,20 mm i širinu ploda od 19,57 do 24,92 mm.

U tablici 5 evidentirani su pokazatelji prosječne dužine i širine jezgre, kao i mase ploda i jezgre.

**Tablica 5. Prosječna dužina i širina jezgre odabranih genotipova badema**

	Dužina jezgre (mm)		Širina jezgre (mm)		Masa ploda (g)		Masa jezgre (g)	
	X±Sx	Cv (%)	X±Sx	Cv (%)	X±Sx	Cv (%)	X±Sx	Cv (%)
Genotip I	23,14±0,29	6,87	13,72±0,18	7,43	5,09±0,62	5,34	1,16±0,07	3,21
Genotip II	27,45±0,32	6,41	16,21±0,20	6,97	2,83±0,31	4,22	1,54±0,12	2,78
Genotip III	25,63±0,24	5,15	14,54±0,24	9,14	7,69±0,94	7,21	1,53±0,08	2,89

Na temelju podataka prikazanih u tablici 5, uočljivo je da je najveća prosječna dužina i širina jezgre evidentirana kod genotipa II, a najmanja kod genotipa I. Dobiveni podaci ne odstupaju znatno od rezultata drugih autora. Cordeiro i sur. (2001.) su u svojim istraživanjima evidentirali prosječnu dužinu jezgre ploda od 20,05 do 31,05 mm, dok je prosječna širina jezgre ploda iznosila 11,60 do 17 mm.

Najveću prosječnu masu plodova s ljuskom imao je genotip III i iznosi 7,69 g, kao i najveću prosječnu masu jezgre (1,53 g). Prosječna masa ploda genotipa I je 5,09 g, a najmanja kod genotipa II 2,83 g. Prosječna masa jezgre kod genotipa II iznosila je 1,54 g, dok je najmanja prosječna masa jezgre izmjerena kod genotipa I (1,16 g). Na osnovu ovih podataka može se konstatirati da se genotip II ističe visokim randmanom jezgre (54,41%), što je znatno veća vrijednost u odnosu na podatke do kojih su došli Strikić i sur. (2010.) (13,6 do 48%), Aslanta i Güleriyüz 2001 (14,66 do 26,81%), te Karadeniz i sur. 2003 (11,17 do 50,91%). Kod izdvojenih 7 genotipova badema iz Hrvatske (Strikić i sur. 2010) masa ploda se kreće od 2,2 do 3,8 g. Prema istraživanju Aslanta i Güleriyüz (2001) utvrđena je masa ploda od 3,02 do 6,14 g, dok je masa jezgre iznosila od 0,72 do 1,15 g, što je manje u odnosu na sva tri genotipa koji su izdvojeni u okviru ovog istraživanja. Karadeniz i sur. 2003 su kod izdvojenih osamnaest genotipova badema ustanovili masu ploda od 2,73 do 10,74 g, a masa jezgre je iznosila od 0,71 do 1,40 g. Cordeiro i sur. 2001. su ispitivali pomološke karakteristike trinaest genotipova badema u Portugalu i ustanovili da je masa ploda iznosila od 4,207 do 10,530 g, a masa jezgre između 1,018 i 1,674 g.

**Tablica 6. Prikaz fenofaza odabranih genotipova badema u oglednom periodu**

	Početak vegetacije	Početak cvjetanja	Kraj cvjetanja	Početak listanja	Kraj listanja	Početak zrenja	Kraj zrenja	Opadanje lista
Genotip I	20.2	28.2.	20.3.	14.3.	26.4.	15.8.	20.9.	20.8.
Genotip II	26.2	04.3.	23.3.	15.3.	22.4.	07.8.	12.9.	11.8.
Genotip III	17.2	25.2.	16.3.	10.3.	23.4.	10.8.	19.9.	05.8.

Kasna cvatnja badema je najčešće cilj oplemenjivačkih programa ove vrste jer je tako manja mogućnost stradanja od mraza i temperature su pogodnije za oprašivanje i oplodnju (Monastra i Reparella, 1997.). Najkasniji početak i kraj cvjetanja imao je genotip II (tablica 6). Dobiveni podaci se mogu porediti sa istraživanjima iz Hrvatske (Strikić i sur. 2010.) gdje je period punog cvjetanja kod 7 izdvojenih genotipova zabilježen od 13.02. do 24.03.

### Zaključci

Šire područje Hercegovine ima značajan prirodni resurs koji se očituje u mogućnosti proizvodnje badema. Trenutno stanje proizvodnje nije zadovoljavajuće. U ovom istraživanju pronađeni su i izdvojeni genotipovi koji nose vrlo vrijedne karakteristike koje treba iskoristiti u voćarskoj proizvodnji širih razmjera i u oplemenjivačkim programima kojima bi se stvorile nove, domaće kreacije badema ili poboljšale već postojeće. Genotip II se ističe plodovima polumeke ljuske i visokim randmanom jezgre (čak 54,41%) a ima i kasnu cvatnju što se posebno cijeni zbog opasnosti od proljetnog mraza. Genotip III također ima povoljno vrijeme cvatnje. Kako se danas u voćarstvu traga za genotipovima badema otpornim prema zimskim i kasnim mrazevima, suši, uzročnicima bolesti i štetočinama, koji kasno cvjetaju, imaju meku ljusku (mekiši) i slatku jestivu jezgru, može se zaključiti da je ovaj rad dao značajan doprinos u pronalaženju ovakvih genotipova na domaćim lokalitetima, a time i doprinos u proširenju genetske osnove oplemenjivanja ove važne lupinaste voćke. Daljnji rad treba biti usmjeren prema usavršavanju konvencionalnih i novih, biotehnoških metoda u cilju poboljšanja svih navedenih svojstava badema.

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# Dinamika rasta sadnica jabuke u zavisnosti od ekspozicije plemke i položaja pupa na njoj

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## Sažetak

Mnoga istraživanja interakcije podloga-plemka pokazuju da podloga kontrolira ukupan porast, dok plemka utječe na distribuciju rasta, kao što su dugi ili kratki prirasti isto kao i broj pupova koji će postati cvatni.

Dosadašnjim istraživanjem međusobnih odnosa podloge i plemke, utvrđen je utjecaj srednjih pupova (sa plemke) na porast i kakvoću voćnih sadnica i dat je niz odgovora vezan za ovu problematiku. Ovim eksperimentom se nastojalo istražiti i odgovoriti na još neka pitanja koja su ostala nedovoljno objašnjena, kao što je utjecaj ostale dvije kategorije pupova (bazalni i vršni) na porast i kakvoću voćnih sadnica.

Rezultati pokazuju da najveći rast jednogodišnjih izbojaka imaju sadnice porijeklom iz pupova koji po mikrolokaciji pripadaju srednjim i vršnim pupovima.

Ekspozicija na kojoj se nalazi pup statistički značajno ne utječe na visinu sadnice.

Ključne riječi: sadnica, jabuka, kakvoća, pup, ekspozicija

## Dynamics of growth apple saplings, depending on the topographical location of scion and bud on it

### Abstract

Many studies on the interaction of rootstock-scion show that the foundation controlled by the total increase, while the scion affects the distribution of growth, such as long or short gains, as well as the number of buds that will become a flower.

Previous investigations of the relations between the rootstock and the scion determined the effect of medium-sized buds (the scion) on growth and quality of fruit saplings and given the number of responses related to this issue. This experiment aimed to investigate and respond to further questions that are not yet fully explained, such as the impact of the other two categories of buds (base and peak) on the growth and quality of fruit saplings.

Statistical-mathematical method has been proved that the greatest strength of growth have a one-year increments saplings originating from buds at the micro-location, which are medium and apical buds.

When testing the impact of topographic locations scion at the height of saplings, we can not conclude that the north-south orientation significantly affect the height of saplings.

Key words: saplings, apples, quality, bud, topographic location

## Uvod

Za suvremenu visoku proizvodnju svake voćne vrste, jedan od najvažnijih čimbenika je kvalitetna sadnica, a za proizvodnju takvih sadnica potrebno je puno truda i znanja. Za proizvodnju voćnih sadnica najviše se koristi tehnika okuliranja na spavajući pup.

Pri uspješnom kalemljenju podloga i plemka sačinjavaju jedno živo biće - simbiot, koji se sastoji iz sjedinjenih komponenti različitog porijekla i sa različitim funkcijama.

Mnoga istraživanja interakcije podloga-plemka pokazuju da podloga kontrolira ukupan rast, dok plemka utječe na broj i vrstu izbojaka (Ferree et al., 2001.a,b) isto kao i broj pupova koji će postati cvjetni (Hirst i Ferree, 1995.). Plemka ima veći utjecaj od podloge na mjesečnu brzinu rasta stabla (Tworkoski and Miler, 2007.). Slabo bujna podloga M9 u kombinaciji sa različitim plemkama konstantno ima najniži, dok podloga sjemenjaka ima najveći vegetativni rast stabla i promjer debla (Tworkoski i Miller, 2007.).

Premda se podloga koristi za kontroliranje veličine stabla jabuke, mehanizam koji je odgovoran i koji je usko vezan za to djelovanje na rast stabla je još uvijek nejasan (Atkinson i Else, 2001). Glavne poteškoće u utvrđivanju utjecaja podloge su povezane s činjenicom da su ti utjecaji kumulativni i varijacije u razvoju sadnica se preklapaju iz godine u godinu (Barritt et al., 1995; Ferree et al., 1995.).

Osnovni cilj ovog istraživanja je utvrđivanje optimalne ekspozicije plemke i pupa na njoj, za postizanje dobre kakvoće sadnica jabuke. Rasadnička proizvodnja mora tržištu ponuditi kvalitetan sadni materijal sa dobrom razvijenošću nadzemnog sustava.

## Materijal i metode

Istraživanja su provedena u razdoblju od 2006. Do 2008. godine u voćnom rasadniku "Dobrinjsko polje" - Visoko. Rasadnik se nalazi na 9 km od Visokog prema Kaknju, sa nadmorskom visinom od 400m, na 43° 59' 24" sjeverne zemljopisne dužine i na 18° 10' 47" istočne zemljopisne širine.

Istraživanja su obavljena u uvjetima standardnog komercijalnog rasadnika uz primjenu standardnih agrotehničkih mjera i zaštite od bolesti i štetočina.

Eksperiment je postavljen po slučajnom blok rasporedu, sa 30 sadnica u ponavljanju.

U istraživanju su bile uključene dvije sorte jabuke Idared i Jonagold cijepljene na jednogodišnjoj vegetativnoj podlozi M9, proizvedenoj u matičnjaku nagrtanjem u rasadniku Visoko.

Plemke su uzimane sa dvije ekspozicije: južne i sjeverne. Dužina internodija je bila ujednačena sa po 30 pupova na svakoj plemci.

Cijepljenje na podlogu je obavljeno u toku jednog dana, i to cijepljenje na spavajući pup - okuliranjem (u kolovozu). Uporabljene su svi pupovi koji se nalaze na kalem grančici (bazalni, srednji i vršni). Cijepljenje je izvedeno na sjevernoj strani podloge na stalnoj visini od 10cm iznad zemlje. Vezivanje pupova je obavljeno gumicom.

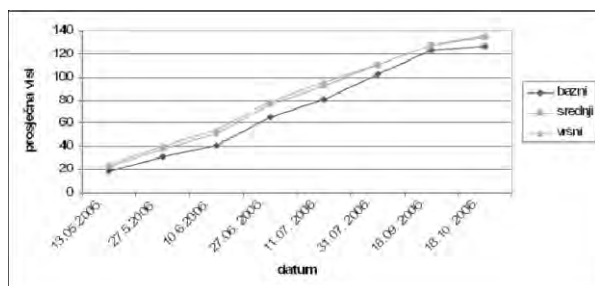
Dinamika rasta sadnica je praćena kroz osam mjerenja u svakoj godini istraživanja.

Dobiveni podaci obrađeni su statističkim programom SPSS for Windows 10.0 primjenom Kruskal-Wallisov one way i Mann-Whitney U testa ( $P < 0,05$ ).

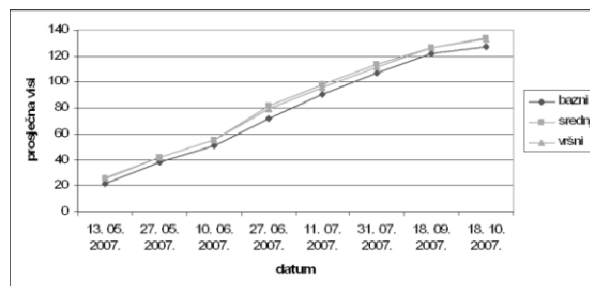
## Rezultati i rasprava

### Utjecaj pozicije pupa

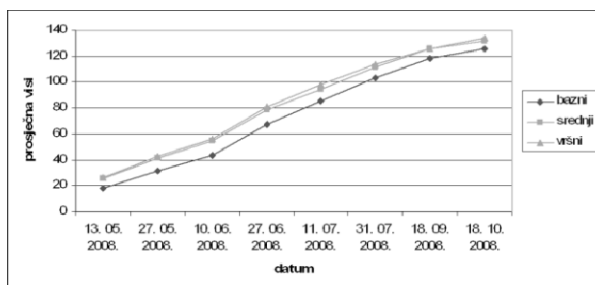
Iz grafikona 1, 2 i 3 primjećujemo da je kod sadnica proizvedenih iz bazalnih pupova, visina sadnica bila značajno manja kod svakog mjerenja u sve tri godine istraživanja.



Grafikon 1. Prosječna visina sadnica jabuke Idared i Jonagold proizvedenih iz bazalnih, srednjih i vršnih pupova za 2006.godinu



Grafikon 2. Prosječna visina sadnica jabuke Idared i Jonagold proizvedenih iz bazalnih, srednjih i vršnih pupova za 2007.godinu



Grafikon 3. Prosječna visina sadnica jabuke Idared i Jonagold proizvedenih iz bazalnih, srednjih i vršnih pupova za 2008.godinu

Tablica 1. Rezultati Kruskal-Wallis testa- razlika između visina sadnica jabuke sorti Idared i Jonagold u razdoblju 2006.-2007.godine

Datum	2006.		2007.		2008.	
	Hi-kvadrat	Razina značajnosti	Hi-kvadrat	Razina značajnosti	Hi kvadrat	Razina značajnosti
13. 05.	14,95	0,001***	14,88	0,001***	43,81	0****
27. 05.	17,89	0****	14,58	0,001***	40,29	0****
10. 06.	20,38	0****	10,62	0,005***	37,58	0****
27. 06.	12,09	0,002***	19,13	0****	26,61	0****
11. 07.	14,34	0,001***	10,50	0,005***	22,99	0****
31. 07.	8,30	0,016*	5,33	0,07 n.s.	11,03	0,004***
18. 09.	3,37	0,19 n.s.	2,43	0,30 n.s.	6,16	0,046***
18. 10.	2,53	0,28 n.s.	5,68	0,06 n.s.	6	0,05*

Napomena: n.s., \*, \*\*, \*\*\*, \*\*\*\*- nije statistički značajno i statistički značajno uz  $P < 0,05, 0,01, 0,001$  i  $0,0001$

Kod najvećeg broja mjerenja (19 od 24, odnosno 79,17% mjerenja) razlika između grupa prema varijabli visina je statistički signifikantna u sve tri posmatrane godine. Smjer razlike je uvijek isti u kontekstu najnižih prosječnih vrijednosti za varijablu visina kod grupe baznih pupoljaka. Stoga zaključujemo da pozicija pupoljka statistički značajno utječe na varijablu visina i da se bazni pupoljci statistički značajno prema visini razlikuju od druge dvije grupe, jer im je prosječna visina signifikantno niža.

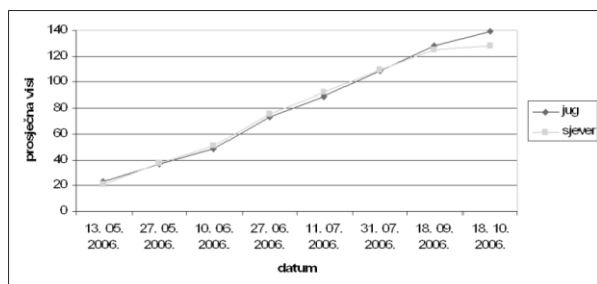
#### Utjecaj ekspozicije

U 2006. godini (Grafikon 4) primjećuje se da je visina sadnica proizvedenih iz plemki sa sjeverne ekspozicije bila manja samo kod posljednjeg mjerenja u odnosu na sadnice proizvedene iz plemki sa južne ekspozicije.

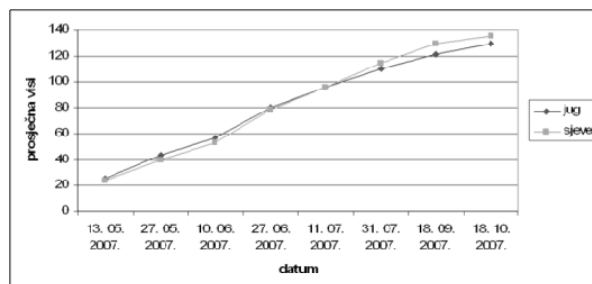
U 2007. godini (Grafikon 5) primjećuje se da je visina sadnica proizvedenih iz plemki sa sjeverne ekspozicije bila manja samo u posljednja tri mjerenja u odnosu na sadnice proizvedene iz plemki sa južne ekspozicije.

U 2008. godini (Grafikon 6) primjećuje se da je visina sadnica proizvedenih iz plemki sa sjeverne ekspozicije bila veća kod sadnica proizvedenih iz plemki sa južne ekspozicije.

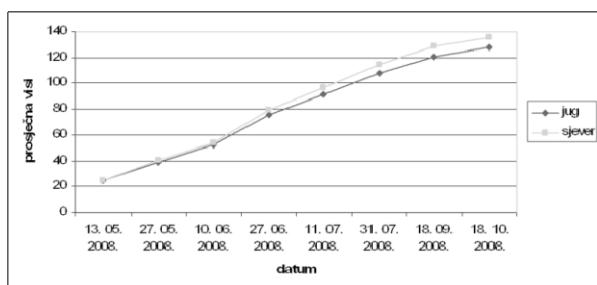
## Dinamika rasta sadnica jabuke u zavisnosti od ekspozicije plemke i položaja pupa na njoj



Grafikon 4. Prosječna visina kod dvije grupe pupoljaka (sjeverni i južni) za 2006.godinu



Grafikon 5. Prosječna visina kod dvije grupe pupoljaka (sjeverni i južni) za 2007.godinu



Grafikon 6. Prosječna visina kod dvije grupe pupoljaka (sjeverni i južni) za 2008.godinu

Tablica 2. Rezultati Mann Whitney U testa- razlika između visina za sadnica jabuke u razdoblju 2006.-2007.godine

Datum	2006.		2007.		2008.	
	z	Razina značajnosti	z	Razina značajnosti	z	Razina značajnosti
13. 05.	-7,043	0,008*	-1,82176	0,0681n.s.	0,037	0,97n.s
27. 05.	0,079	0,778n.s.	-2,22523	0,026*	1,391	0,164n.s
10. 06.	0,005	0,942n.s.	-3,92017	8,85****	1,948	0,051n.s
27. 06.	0,006	0,941n.s.	-1,99897	0,046*	3,257	0,001***
11. 07.	0,354	0,552n.s.	0,63127	0,53n.s.	4,842	0****
31. 07.	0,072	0,788n.s.	2,40295	0,016*	5,38	0****
18. 09.	-4,5	0,034*	4,4751	7,64****	5,316	0****
18. 10.	-21,615	0****	3,15326	0,0016*	4,476	0****

Napomena: n.s., \*, \*\*, \*\*\*, \*\*\*\*- nije statistički značajno i statistički značajno uz  $P < 0,05, 0,01, 0,001$  i  $0,0001$

Kod 58,33% mjerenja (Tablica 2) razlika između visina sadnica ovisno o ekspoziciji plemki je statistički značajna u sve tri godine istraživanja ali je taj utjecaj ekspozicije neujednačen, pa se ne može donijeti zaključak o njenom utjecaju.

### Zaključci

Isi dobivenih rezultata rada na istraživanju kakvoće vegetativnih pupoljaka na plemci i njihovog razmještaja u krošnji matičnih stabala mogu se donijeti sljedeći zaključci:

- Utvrđeno je da je kavoća pupova na jednogodišnjem izbojku jabuke ovisna o mikrolokaciji pupoljka (bazalni, srednji, vršni) i ta kavoća se odražava na snagu rasta i kakvoću sadnica.
- Najveću snagu rasta jednogodišnjeg prirasta imaju sadnice porjeklom iz srednjih ivršnih pupova.
- Na temelju dobijenih rezultata ne može se zaključiti da ekspozicija plemke utječe na varijablu visina i pokazane statistički značajne razlike ne mogu se povezati s utjecajem strane svijeta obzirom da razlike ne idu uvijek u istom smjeru.

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# Usporedba parametara kakvoće hrvatskih i uvoznog kivija

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## Sažetak

Cilj ovoga rada bio je istražiti razliku u fizikalnim i kemijskim svojstvima plodova kivija uzgojenih na dvama klimatskim područjima: kontinentalnom (Požega, Hrvatska), i mediteranskom (Metković, Hrvatska te nepoznata lokacija u Italiji). Fizikalna i kemijska svojstva kivija određena su prema AOAC metodama. Rezultati istraživanja su pokazali da se uzorci kivija razlikuju po svojim fizikalnim i kemijskim svojstvima. Kivi koji je uvezen iz Italije bio je najlošije kakvoće uzimajući u obzir sve analizirane parametre. Kivi uzgojen u Požegi u neujednačenim uvjetima proizvodnje imao je lošije rezultate analize od kivija uzgojenog u području Metkovića u ujednačenim uvjetima proizvodnje. Kivi iz područja Metkovića je imao najveću duljinu i obujam ploda, najviše topljive suhe tvari te šećera, dok je kivi iz Požege imao najmanju ukupnu kiselost.

Ključne riječi: kivi, kakvoća, svojstva

## Comparison of quality parameters among Croatian and imported kiwi

### Abstract

The primary object of this research was to establish a difference in physical and chemical properties of kiwi fruit grown in three different climates: continental climate (Požega, Croatia), Mediterranean climate (Metković, Croatia) and Mediterranean climate (Italy). Differences among physical and chemical properties of kiwifruit samples. Length of fruits, volume, dry matter and total acidity were analyzed. Kiwifruit from Metković region had highest length and volume of fruit, and the highest amount of dry matter, while kiwifruit from Požega had lowest total acidity. Kiwifruit imported from Italy had the worst quality of analyzed parameters.

Key words: kiwifruit, quality, properties

### Uvod

Kivi (*Actinidia chinensis/deliciosa*) je subtropsko voće podrijetlom iz Kine odakle se širi ostalim djelovima svijeta ovisno o klimatskim uvjetima (Abedini, 2004). Trenutno je Italija najveći proizvođač kivija za Europu sa 80% izvoza (FAO, 2008.). Plod kivija je bogat izvor vitamina (C, A, B1, B2, B6 i E) i mineralnih tvari (Ca, Fe, Na, Mn, Zn i Cu). Jestivi dio ploda iznosi 90 - 95% od čega 80 - 88% vode (Mohammadian i Teimouri, 1999). Kemijski sastav i fizikalne karakteristike su glavni pokazatelji kakvoće kivija. Jestivi dio ploda sadrži 1,0 - 1,6% kiselina, 0,7 - 0,9% ulja, 0,11 - 1,2% proteina, 0,45 - 0,74% mineralnih tvari, 1,1 do 3,3% vlakana, 17,5% ugljikohidrata i 12 - 18% topljive suhe tvari (Rashidi i Seyfi, 2007). Kivi se zbog svojih nutritivnih vrijednosti, osim konzumacije u svježem obliku, prerađuje u različite voćne prerađevine. Prerađuje se u

džem, voćni sok, vino te zamrznuto, sušeno, konzervirano ili kandirano voće (Kotecha i Madhavi, 1995). Uzgoju kivija najviše pogoduje klima sa vlažnim i toplim ljetima, te blagim zimama. Međutim, pokazalo se da se kivi izrazito dobro prilagođava različitim klimatskim uvjetima. U Republici Hrvatskoj uzgoj kivija je najviše zastupljen u jadranskom području, te na posebnim lokacijama u kontinentalnom području gdje se uspješno može uzgajati vinova loza, marelica i breskva (Brzica, 2002).

Cilj ovoga rada je istražiti razliku u parametrima kakvoće između kivija koji je uzgojen na tri različite lokacije: Požega (Hrvatska), Metković (Hrvatska) i Italija (uvozni kivi).

### Materijal i metode

Istraživanja fizikalnih i kemijskih karakteristika su provedena na uzorcima kivija uzgojenim na različitim klimatskim područjima: Požega (Hrvatska), Metković (Hrvatska) i Italija (uvozni kivi). Kivi uzgojen na području Metkovića, kao i onaj uvozni iz Italije su uzgojeni u ujednačenim uvjetima proizvodnje dok se kod kivija iz Požege radi o uzgoju iz hobija te uvjeti uzgoja nisu ujednačeni. Iz svih uzoraka kivija je metodom slučajnog odabira uzeto 10 plodova kivija za određivanje veličine ploda po duljini i obujma ploda. Za kemijske analize je priređen ispitni uzorak na način da su kiviju odvojene sjemenke radi lakšeg uzorkovanja, te je uzorak usitnjen pomoću štapnog miksera. Udio vlage u priređenom uzorku je određivan sušenjem na 105° C do konstantne mase (AOAC, 1995). Suha tvar određena je refraktometrijskom metodom gdje je mjereno indeks refrakcije ispitivane otopine na 20° C, refraktometrom, na temelju kojeg se pomoću tablice izračunava količina suhe tvari (AOAC, 1995). Šećeri su određivani Luffovom metodom izraženi kao prirodni i ukupni invert (AOAC, 1995). Ukupna kiselost je određena potencijometrijskom metodom koja se temelji na titraciji otopinom natrijeva hidroksida uz prisutnost indikatora fenolftaleina (AOAC, 1995). pH vrijednost mjerena je pri 20° C na pH - metru MetlerToledo, vrijednost pH je očitana izravno na ljestvici instrumenta (AOAC, 1995). Sve analize su rađene na ispitnom uzorku sa dva ponavljanja kojima je udovoljeno zahtjevima u pogledu ponovljivosti, te je za rezultat uzeta aritmetička sredina.

### Rezultati i rasprava

Mnogi autori kao što su Chichester (1984.), Li i She (1999.), Hasey (1994.), i dr. radili su istraživanja fizikalnih i kemijskih svojstava kivija uzgojenih u SAD-u. U ovom radu su prikazani rezultati analize fizikalnih i kemijskih svojstava kivija uzgojenih na različitim klimatskim područjima. Također je razlika između kivija i ta da su uzorci kivija uzgojeni u Italiji i Metkoviću iz ujednačenih uvjeta proizvodnje, dok je uzorak uzgojen u Požegi proizveden u neujednačenim uvjetima proizvodnje, tj. uzgojen je iz hobija. U tablici 1. prikazani su rezultati analize kemijskih i fizikalnih svojstava triju uzoraka kivija.

Tablica 1. Fizikalna i kemijska svojstva kivija

	Kivi uzgojen u Požegi	Kivi uvezen iz Italije	Kivi uzgojen na području Metkovića
Voda, (%)	82,31	84,96	81,24
Suha tvar, (%)	17,18	14,40	18,33
Duljina ploda, (mm)	55,00	53,00	65,00
Obujam ploda, (mm)	142,00	140,00	153,00
Ukupna kiselost, mmol/100g	22,64	23,48	22,92
pH	5,70	4,42	5,48
Prirodni invert, (%)	9,36	6,56	9,94
Ukupni invert, (%)	10,60	7,20	11,21

Prema Hasey-u (1994.) duljina ploda kivija iznosi od 51 mm do 70 mm što potvrđuju i rezultati istraživanja prikazani u tablici 1. U navedenoj tablici duljina kivija se kreće od 53 mm (uzorak 2.) do 65 mm (uzorak 3.). Proporcionalno duljini i obujam ploda je najveći kod 3. uzorka (153 mm), a najmanji kod 2. uzorka (140 mm). Veličina i izgled ploda su najznačajnije osobine kako za uzgajivače tako i za tržište. Minimalni uvjeti koje plod kivija mora zadovoljiti kako bi se mogao plasirati na tržište propisani su Pravilnikom o kakvoći voća (2007.). Kivi uzgojen na području Metkovića (uzorak 3.) sadrži najmanju količinu vode (81,24%), a samim time i najveću količinu suhe tvari (18,33%) što ga izdvaja kao najbolji uzorak među ispitivanim uzorcima. Minimalna količina suhe tvari propisana Pravilnikom o kakvoći voća (2007.) iznosi 15% kako bi se

mogli ostvariti minimalni zahtjevi zrelosti za plod kivija. Od svih analiziranih uzoraka jedino uzorak 2. ne zadovoljava minimalne zahtjeve budući da ima koncentraciju suhe tvari 14,4%. Navedeni uzorak ima najveću koncentraciju ukupne kiseline (23,48 mmol/100g), najmanju pH vrijednost (4,42), te najmanju koncentraciju prirodnog (6,56%) i ukupnog inverta (7,2%) što ga svrstava među uzorak najlošije kakvoće. Rezultati kemijske analize uzorka 1. i uzorka 3. (Tablica 1.) pokazuju da su razlike vrijednosti ispitivanih parametara minimalne. Međutim, veća razlika između ta dva uzorka postoji u fizikalnim svojstvima analiziranih plodova kivija. Duljina ploda kivija uzgojenog na području Metkovića (uzorak 3.) je veća za 10 mm od ploda kivija uzgojenog u Požezi (uzorak 1). Obujam ploda također se povećava proporcionalno sa duljinom tako da uzorak 3. ima za 11 mm veći obujam od uzorka 1.

### Zaključak

Prema rezultatima analize fizikalnih i kemijskih svojstava istraživanih uzoraka kivija najlošiju kakvoću je imao kivi uvezen iz Italije. Navedeni kivi ima koncentraciju suhe tvari 14,40% što ne udovoljava propisu navedenom u Pravilniku o kakvoći voća o minimalnoj količini suhe tvari od 15,00% da bi se proizvod mogao plasirati na tržište. Plodovi kivija uzgojeni u području Metkovića dali su najbolje rezultate kako za fizikalna, tako i za kemijska svojstva. Plodovi prethodno navedenog kivija imaju najveću količinu suhe tvari, najviše šećera te najveću duljinu i obujam ploda. Plodovi kivija uzgojeni u Požezi nešto su lošije kakvoće od onih uzgojenih na području Metkovića, osim u sadržaju kiseline koja je kod ovoga uzorka najmanja. Neophodno je naglasiti da je kivi iz Požege uzgojen iz hobija, te je unatoč tome proizvođač postigao izrazito dobru kakvoću.

Hrvatski kivi je izrazito dobre kakvoće i udovoljava Pravilniku o kakvoći voća, dok kivi uvezen iz Italije ne udovoljava navedenom pravilniku, ali se unatoč tome i dalje uvozi u Hrvatsku.

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# Seasonal variability of olive fruit (*Olea europaea*) cv. Oblica phenols

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## Abstract

The seasonal variability of olive fruit cv. Oblica phenols was assessed using HPLC-DAD-FLD and LC-MS/MS analysis, aiming to evaluate the impact of harvest season (2007/2008) on fruits quali- and quantitative phenolic profile within the same olive orchard located in Croatian island, Hvar. As seen from results, no qualitative differences in fruits phenol composition was observed between the seasons, however, a significant impact of seasonal variation was reflected at the quantitative level, confirmed by both individual (HPLC-DAD) and total phenol (Folin-Ciocalteu) analysis. The chromatograms of extracts revealed the presence of 12 phenolic compounds with oleuropein and demethyleuropein presenting more than 85% of all the phenols quantified. Interestingly, the fruits total phenol content has decreased significantly (40%) in season 2008 from a previous 45.79 mg GAE g<sup>-1</sup> DW (in 2007) to a 27.82 mg GAE g<sup>-1</sup> DW (in 2008), respectively. Similarly, the same trend was observed in the case of individual phenols level, with much higher concentrations found in fruits 2007 for most of phenols analysed, except for oleuropein and verbascoside present in more than 2-times higher concentrations in fruits of 2008.

Key words: *Olea europaea*, cv. Oblica phenols, seasonal variation

## Introduction

Plant phenolic compounds have attracted increased attention over recent years for diverse reasons including their wide range of bioactivities (Obied et al., 2007). They have been considered as the key product among the food constituents responsible for beneficial effects of Mediterranean diet (Tomas-Barberan, 2001) associated with lower incidence of coronary heart disease and certain types of cancer. Olive fruits are important food components of this popular diet consumed as table olives or olive oil used as primary source of fat in Mediterranean area (Boskou et al., 2006). However, they have both been recognized as an important and valuable source of different phenols varying from simple phenols, phenolic acids and alcohols to more complex like flavonoids, secoiridoids, lignans and others. The type and quantity of olive fruit phenols depend on several factors including the cultivar and genetics, degree of maturation, climatic conditions during growth and agriculture practices (Ryan and Robards, 1998).

As being a part of Mediterranean area, olive fruits production present an important part for both Slovenian and Croatian economy as well as of their landscape inheritance/tradition. While cv. Istrska Belica is the most widely spread olive variety of Slovenian orchards (60%), the autochthonous cv. Oblica is the predominant in Croatia, accounting 75% of a total olive production. The cultivar is suitable for both - olive oil and table olives production, which is also the reason for its spread cultivation. In fact, beside to Croatia, cv. Oblica is also grown in Slovenia (0.1%), Serbia and Montenegro or even further in the continents of Australia, America (California) and Africa (South Africa). The fruits are of medium size with medium oil content, showing high morphological variability within one or between different growing areas (Bartolini et al., 2005).

In our previous research (Jerman et al., 2010) the phenolic profile of cv. Oblica olive fruits grown in season 2007 (Hvar, Croatia) was characterized by HPLC-DAD-FLD-MS/MS method developed, however, best to our knowledge there is no data available concerning its phenols interseasonal variability. Thus, the present study was carried out with aim to evaluate the variability of cv. Oblica quali- and quantitative phenolic profiles in respect to a growing season 2007 and 2008, respectively.

## Materials and methods

### Olive fruits

Cv. *Oblica* samples (cca 5 kg) of green-reddish skin coloration were harvested on November 2007 and 2008 at the end of their maturation period in Croatian island, Hvar. The fruits were selected randomly from different parts of ten olive trees of similar yields, size and age, immediately frozen with liquid nitrogen and freeze-dried in a Kambič LIO-5P lyophilisator (Semič, Slovenia). The olive pulp was separated from the kernel, grounded into homogeneous powder with the aid of liquid nitrogen and stored at  $-25\text{ }^{\circ}\text{C}$  until the analysis.

### Phenols extraction

Extracts were prepared according to Jerman et al. (2010), where the phenols from a freeze-dried olive sample (1.5 g) were extracted (3 x 20 min) with 25 mL of methanol using high intensity probe ultrasonication (100 W, 30 kHz, 100% amplitude) with LABSONIC<sup>®</sup>M ultrasonic homogenizer SARTORIUS (Goettingen, Germany). Combined methanolic extracts were quantitatively transferred into 100 mL volumetric flask, diluted with methanol and stored in a screw-capped dark glass containers in freezer ( $-25\text{ }^{\circ}\text{C}$ ) until further HPLC-DAD-MS analysis.

### HPLC-DAD and LC-MS/MS analysis

Prior to chromatographic analysis, the aliquot of methanolic extract (15 mL) was evaporated to dryness using rotary evaporation ( $35\text{ }^{\circ}\text{C}$ , LABOROTA 4000; Heidolph, Schwabach, Germany) and re-dissolved in 1 mL of acidic HPLC eluent ( $\text{H}_2\text{O}/\text{CH}_3\text{COOH}$ , 95:5, v/v), further filtered through  $0.45\text{ }\mu\text{m}$  PTFE filters (Macherey-Nagel, Düren, Germany). Phenols were separated on Waters Spherisorb ODS-2 ( $5\mu\text{m}$ , 250 mm x 4.6 mm) attached to Supelco security guard (10 mm x 4.1 mm) at flow rate of  $1\text{ mL min}^{-1}$  using gradient elution consisted of solvent A ( $\text{H}_2\text{O}/\text{CH}_3\text{COOH}$ , 95:5, v/v) and B (methanol) under analysis program as follows: 5% B (0 min), 10% B (3 min), 25% B (18 min), 29% B (19 min), 30% B (24 min), 31% B (30 min), 35% B (31 min), 45% B (41 min), 55% B (51 min), 65% B (61 min), 100% B (67 min) and 5% B (70 min).

### Total phenol analysis

The fruits total phenol content was determined calorimetrically at 765 nm using Folin-Ciocalteu reagent according to Amerine and Ough (1988) and results were expressed in mg of gallic acid equivalents (GAE) per g of olive fruits dry weight.

### Statistical analysis

All experiments were performed at least in triplicate ( $n \geq 3$ ) and the data are expressed as means  $\pm$  SD. The statistical significances were evaluated by analysis of variance (ANOVA) and MRT test ( $\alpha = 5\%$ ) using STATGRAPHICS Plus 4.0.

## Results and discussion

The HPLC-DAD and LC-MS/MS analysis revealed the presence of 12 phenolic compounds in cv. *Oblica* extracts (Figure 1), belonging to several classes of phenolic alcohols (hydroxytyrosol glucoside, tyrosol), secoiridoids (demethyloleuropein, oleuropein, ligstroside, caffeoyl-6-secologanoside, comselogside), cinnamic acids (verbascoside) and flavonoids (luteolin-7-O-glucoside, rutin, quercitrin, apigenin-7-O-glucoside).

Table 1 summarizes the screening data of cv. *Oblica* major phenols, including UV-VIS and ESI-MS spectral characteristics needed for an accurate phenols identification, while their further quantification was carried out at 280, 320 in 365 nm based on external six-point calibrations in the range close to phenol concentrations found in olive fruits;  $5\text{-}500\text{ }\mu\text{g mL}^{-1}$  (hydroxytyrosol, tyrosol, quercitrin, apigenin-7-O-glucoside, caffeic and *p*-coumaric acid),  $25\text{-}1000\text{ }\mu\text{g mL}^{-1}$  (verbascoside, rutin, luteolin-7-O-glucoside) and  $75\text{-}6000\text{ }\mu\text{g mL}^{-1}$  (oleuropein). Phenols were expressed with authentic standards when available, while hydroxytyrosol glucoside, caffeoyl-6'-secologanoside, comselogside, demethyloleuropein and ligstroside were expressed as

hydroxytyrosol, caffeic acid, *p*-coumaric acid and oleuropein equivalents in mg g<sup>-1</sup> of olive fruits dry weight (DW).

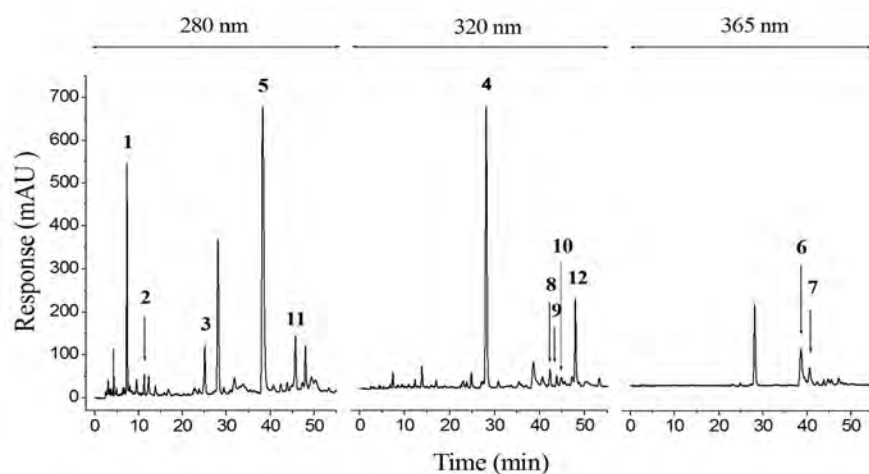


Figure 1: HPLC-DAD chromatogram of olive fruit extract cv. Oblica monitored at 280, 320 and 365 nm. Peak numbers are referring to Table 1.

Table 1: Screening data of major phenols present in cv. Oblica extracts

Peak no	Phenolic compounds	HPLC-DAD		ESI-LC-MS		Standard
		$\lambda_{\max}$ (nm) <sup>a</sup>	Calibration curve <sup>b</sup>	M (g/mol)	Main ESI fragments	
1	Hydroxytyrosol glucoside	236, 278	$y = 17,104x - 10,419$ $R^2 = 0,9998$	316	315, 153, 121	No
2	Tyrosol	236, 276	$y = 11,515x - 5,5101$ $R^2 = 0,9998$	138	137	Yes
3	Demethyloleuropein	242, 280	$y = 4,3503x + 41,59$ $R^2 = 1,0000$	526	525, 389, 319, 183	No
4	Verbascoside	240, 284, 332	$y' = 29,297x - 96,444$ $R^2 = 0,9999$	624	623, 461, 161	Yes
5	Oleuropein	242, 280	$y = 4,3503x + 41,59$ $R^2 = 1,0000$	540	539, 377, 307, 275, 223	Yes
6	Luteolin-7-O-glucoside	255, 348	$y'' = 35,177x - 328,66$ $R^2 = 0,9997$	448	447, 285	Yes
7	Rutin	256, 356	$y'' = 28,594x + 721,45$ $R^2 = 0,9919$	610	609, 301	Yes
8	Caffeoyl-6'-secologanoside	232, 298, 328	$y' = 90,109x - 94,524$ $R^2 = 1,0000$	552	551, 507, 389, 281, 251, 179, 161	No
9	Quercitrin	256, 350	$y'' = 31,201x - 38,051$ $R^2 = 0,9998$	448	447, 301	Yes
10	Apigenin-7-O-glucoside	237, 268, 338	$y' = 54,596x - 113,23$ $R^2 = 0,9996$	432	431, 269	Yes
11	Ligstroside	242, 275	$y = 4,3503x + 41,59$ $R^2 = 1,0000$	524	361, 291, 259, 101	No
12	Comselogoside	238, 314	$y' = 159,75x - 66,176$ $R^2 = 0,9997$	536	535, 491, 389, 345, 265, 163, 145	No

a max UV absorption wavelength is denoted bold,

b y - quantification at 280 nm, y' - quantification at 320 nm, y'' - quantification at 365 nm

As expected, the HPLC-DAD quantitative analysis confirmed high phenolic content in the fruits of cv. Oblica, however, in accordance to literature, the majority of phenols present belonged to the class of secoiridoids, especially oleuropein and demethyloleuropein accounting of more than 85% of all the phenols quantified, followed by ligstroside, verbascoside, rutin, hydroxytyrosol glucoside, luteolin-7-O-glucoside, comselogoside, caffeoyl-6'-secologanoside, quercitrin and apigenin-7-O-glucoside (Figure 2). The levels of cv. Oblica individual phenols (mg g<sup>-1</sup> DW) were in the range as previously reported for Portuguese and

Italian olives (Ryan et al., 2002; Vinha et al., 2005) varying in respect to the cultivar, its origin and other factors typically influencing phenols content.

Highly significant ( $P < 0.01$ ) differences in fruits phenol content were observed between the growing seasons of 2007 and 2008, as confirmed by both HPLC as well as Folin-Ciocalteu analysis. The fruits total phenol content has decreased significantly (40%) in season 2008 from a previous 45.79 mg GAE g<sup>-1</sup> DW (in 2007) to a 27.82 mg g<sup>-1</sup> DW (in 2008), respectively. Similarly, the same trend was observed at individual level (Figure 2), with much higher concentrations found in fruits 2007 for most of the phenols analysed. In fact, only three out of 12 phenols quantified, namely oleuropein, ligstroside and verbascoside were present in significantly higher concentrations in fruits 2008, as their content was more than doubled (96/280/263%) according to a previous season (oleuropein; 32.09 vs. 16.35 mg g<sup>-1</sup> DW; ligstroside 5.59 vs. 1.47 mg g<sup>-1</sup> DW; verbascoside; 4.87 vs. 1.34 mg g<sup>-1</sup> DW).

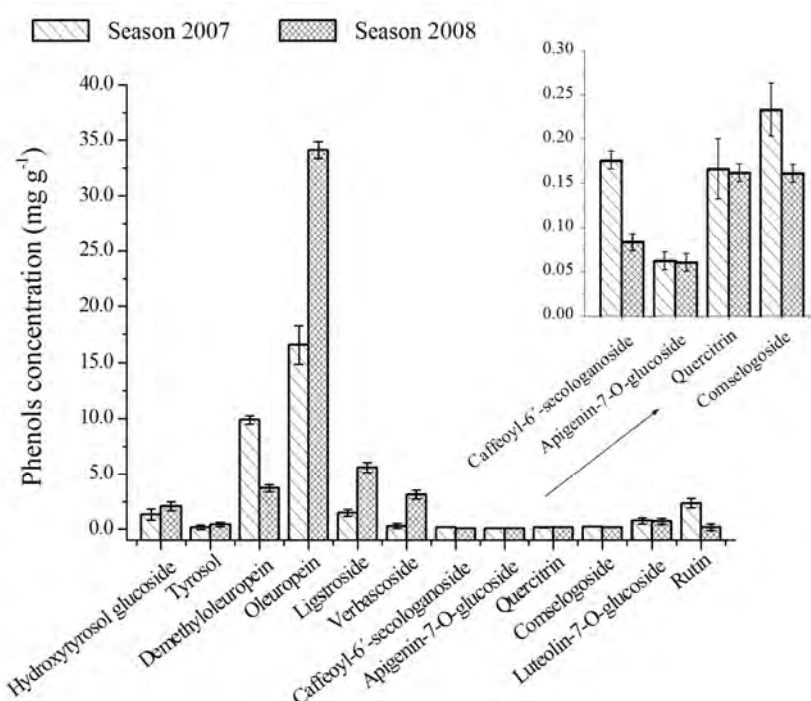


Figure 2: Olive fruit phenols content of cv. *Oblica* with regards to harvest seasons 2007 and 2008.

This difference could be attributed to a variety of factors influencing the fruits phenol content such as maturity stage, agricultural practice, pathological conditions, geo-climatical factors and/or even the olive tree fruit alteration. In our opinion the first three factors have not very likely contributed to these changes observed, as (1) agricultural techniques have not been changed between the growing seasons 2007/2008, (2) pathological conditions were not observed in the olive fruits sampled and (3) all fruits were of comparable maturity stage. Thus, we can only speculate that the seasonal variations could be result of (if) any climatical variation between 2007 and 2008 such as the temperature and precipitation pattern change, which unfortunately was not monitored within the study conducted. Nevertheless, the fruits phenol interseasonal variation can be also explained by the olive trees alternate bearing, *i.e.* providing high fruit loads every second year. This is also supported by previous study of Ryan et al. (2003), demonstrating that any changes in *O. europaea* physiology and metabolism can be reflected in phenols content of various plant tissues, including olive fruits.

### Conclusions

The results of our study confirmed the presence of 12 phenol compounds found in olive fruits *Olea europaea* cv. *Oblica*, which is in line with previous reports for other olive varieties. The interseasonal 2007/2008 comparison of fruits phenolic profiles has pointed to a great impact of harvest season on both individual and total phenol levels, demonstrating their different and important accumulation response. This is however of

great support for the future interseasonal phenols variation monitoring, providing important information of the quality and quantity of natural antioxidants expected in our food. However, at the present moment we can not provide more clear conclusions, since a more detailed analysis with more samples of various geographical origins is needed during future years, in order to better understand the fruits phenolic profile variation and potentially (if) establish any link between the seasonal variables and olive fruits phenolic content.

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# Water uptake of cherry trees related to weather conditions

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## Abstract

Our research aim is to measure water-demand of different rootstock/scion composite trees by sapflow equipment and to study the meteorological factors affecting water use. The investigations are carried out in Soroksár in Hungary at 'Rita' sweet cherry orchard. The pattern of sapflow was analyzed in relation of solar radiation and vapour pressure deficit. Between solar radiation and sap flow was found a parabolic relation, daily pattern of sapflow is in close relation (cubic) also to vapour pressure deficit. The sapflow performance of sweet cherry trees on different rootstocks showed typical daily characters.

Key words: meteorological factors, water consumption, sap flow, *Prunus Mahaleb*

## Introduction

Sap flow (SF) measurement system is well known tool to estimate the water consumption of the trees, apart from it following the sap flow parallel the current weather circumstances the soil-plant-air interaction can be understood. We do not have any exact information on water use of high density sweet cherry orchards on different rootstocks. SF of 'Rita' sweet cherry trees on sandy soil in Soroksár was monitored by the heat balance Dynamax packaged SF measuring system in the vegetation period of 2009. Furthermore global radiation, air temperature, relative humidity and soil moisture were measured synchronously. The SF measurements are carried out using Dynamax Flow 32 equipment with Dynagage SF gauges (Dynamax Inc., Houston, TX, USA) developed from the designs published by Sakuratani (1981,1984), Baker and Van Bavel (1987) and Steinberg et al. (1989,1990b). In our study we analyzed the water consumption of the trees on four different rootstocks as a function with meteorological parameters.

## Material and method

The investigations were carried out in Soroksár (47°22'N,19°09'E, 103 m above sea level) at the Experimental Farm of Corvinus University of Budapest on four selected trees in sixth leaf. The cultivar is 'Rita', ripening early, between 22 -28 May. The selected trees were budded onto *Prunus mahaleb* 'Érdi V' seedlings, on 'Korponay' seedlings, on *Prunus canescens* x *Prunus cerasus* GiSeLA 6, and on Mazzard (*Prunus Avium*). As the growth vigor of rootstocks concerns, based on the tree size in average of 9 trees the 'Érdi V' is considered as vigorous, while 'Korponay' as moderate vigorous, according to investigations of Gyeviki et al. (2009).

The experimental orchard is planted to 4 x 2 m spacing with 1250 treesha<sup>-1</sup> density in spring 2004. Trees are trained to Hungarian spindle (Hrotkó et al., 2007). The applied heat balance method for measuring SF rates is practical and capable of great precision. In general, installation of the gauges followed procedures recommended by the manufacturer (Dynamax, 1990). Measurements were made by gauges SGA50-ws (trunk diameter: 45-65 mm), SGA70-ws (trunk diameter: 65-90 mm). The measurements were carried out by sensors set on the trunk at 40-50 cm height from the soil surface under the leaf canopy.

Sap flow was measured between May and August of 2009, on 45 sample days. Air temperature, precipitation,

air humidity, soil moisture at two different depth were also measured parallel with sap flow direct in the canopy (Fig. 1). The daily observation was round the clock, outputs from the gauges were monitored every 15 sec and signals were recorded as 15 min averages apart from some error. Global radiation was registered by the Hungarian Meteorological Service, in Pestszentlőrinc 10 km far from our field.

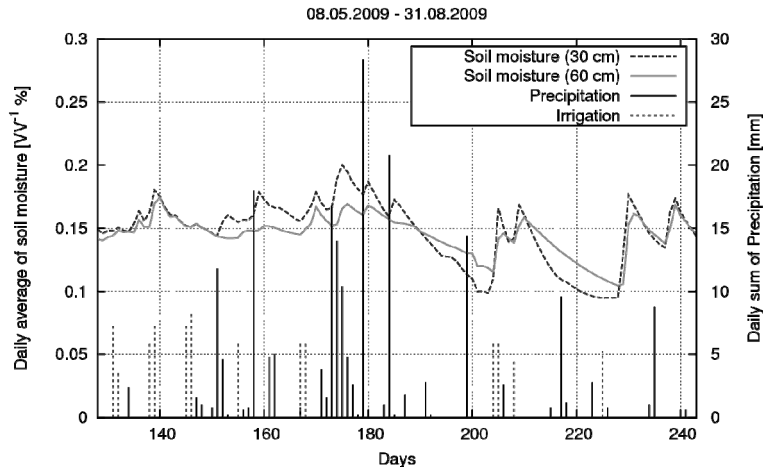


Fig. 1 Meteorological conditions on the research field

Results and Discussion

We have made dimensionless profiles for the 45 measured day for each rootstocks to show the correlation between the sap flow and the meteorological elements. First we searched for the highest global radiation value. At the time of the highest radiation rate, we checked the sap flow, vapour pressure deficit, and temperature data, and have done with that values the dimensionless profiles. As the figures show there is positive nonlinear correlation between daily SF and vapour pressure deficit (VPD), with the increasing VPD sap flow rises cubic (Fig 2). SF of trees is very intensive by the decreasing air humidity. Between SF and global radiation there is parabolic relation (Fig. 3). High level of global radiation might limit water use. In this case stomas are going to close to avoid more water loss by the transpiration. The relation between the SF and temperature is not so obvious.

Typical diurnal sap flow (SF) course are shown in Figs. 4 and 5 In the morning around 7:00 a.m. started the increasing sap flow which became quite quick and intensive followed a depression between 10:00 and midday. Comparing to the very intensive morning sap-flow after 18:00 p.m. the water flow slowly reached the minimal level. The first daily maximum is shown up around 8:00. Second highest level is shown between 14:00-16:00. Daily SF curves of trees with different rootstocks run near to each other and SF reach the peaks almost at the same period.

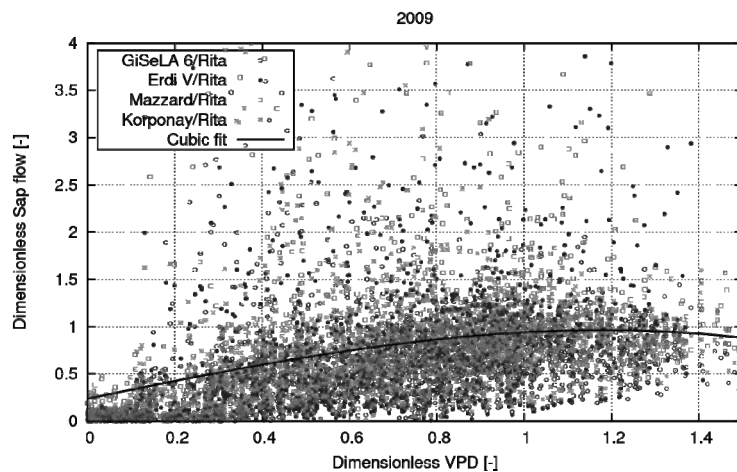


Fig. 2 Non-linear regression between the sap flow related to the vapour pressure deficit  $f(x)=ax^3+bx^2+cx+d$

## Water uptake of cherry trees related to weather conditions

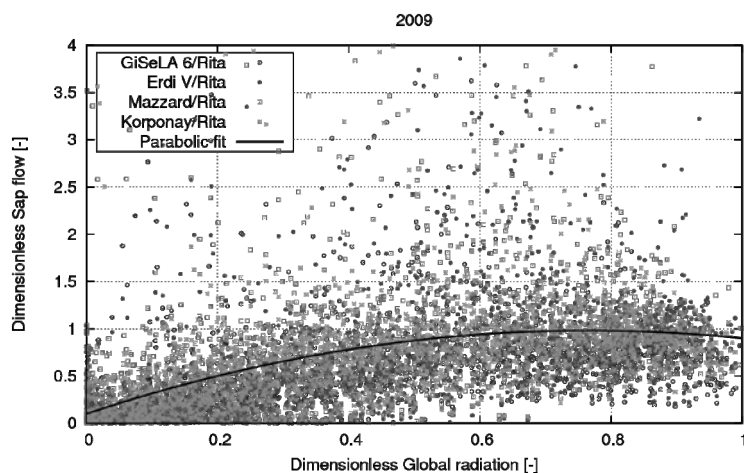


Fig. 3 Non-linear regression between the sap flow related to the global radiation  
 $f(x)=a(x-b)^2+c$

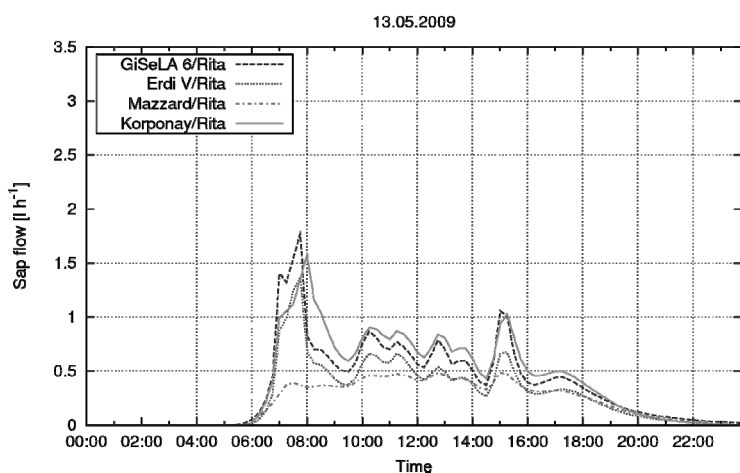


Fig. 4 The daily sap flow trend on the selected day

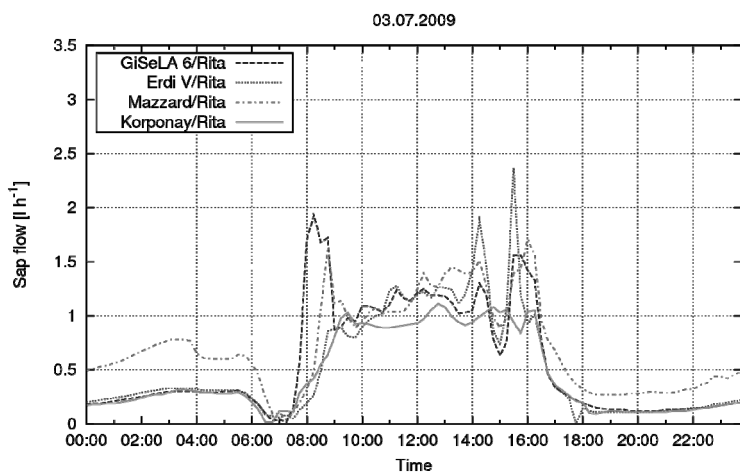


Fig. 5 The daily sap flow trend on the selected day

## Conclusion

The sap flow course is determined by the current weather conditions. The most important factor which has an effect for the water uptake is the global radiation and vapour pressure deficit. It can be written by parabolic and cubic functions. Considerable differences are found between trees on different rootstocks in the daily sap flow course. On the selected days the sap flow of the tree budded on dwarfing rootstock starts the most intensive.

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sa2011\_0905

# Antioxidant activity of selected plum cultivars

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## Abstract

The fruits of four different plum cultivars 'Čačanska lepotica', 'Valor', 'Stanley', and 'Tophit' were analysed for antioxidant activity, which was evaluated in plum extracts using ABTS assay. The results obtained showed that the antioxidant activity depended on the cultivar. The highest antioxidant activity was estimated in 'Valor' plums (18.6  $\mu\text{mol}$  of Trolox equivalent (TE)/g of fresh weight (FW)), followed by cultivars 'Čačanska lepotica' (12.8  $\mu\text{mol}$  TE/g FW) and 'Stanley' (11.4  $\mu\text{mol}$  TE/g FW), whilst cultivar 'Tophit' showed the lowest value (10.8  $\mu\text{mol}$  TE/g FW).

Key words: plums (*Prunus domestica* L.), antioxidant activity, ABTS

## Introduction

Epidemiological studies have shown that high daily consumption of fruits and vegetables may have favourable health benefits which are considered to be related to the various substances with antioxidant capacity present in foods. A positive association has been suggested between the consumption of foods with antioxidant properties and their possible role in preventing degenerative diseases (Feskanich et al., 2000, Haegele et al., 2000). Antioxidants prevent or retard degenerative reactions produced by reactive oxygen and nitrogen species *in vivo* and lipid peroxidation in foods (Cevallos-Casals and Cisneros-Zevallos, 2003).

Fruits provide a wide-variety of antioxidants, including vitamin C, vitamin E ( $\alpha$ -tocopherol), carotenoids, flavonoids and other phenolic compounds which contribute to the antioxidant capacity. Vinson et al. (1995) have shown that many phenols and polyphenols are stronger antioxidants than vitamin antioxidants. Among various fruits, however, their contents and profile differ greatly. Many factors, such as genetics, growing conditions, diseases, pests, ripeness during harvest, post-harvest manipulations etc. may affect the antioxidant activity of foods.

Plums contain high amounts of bioactive compounds such as carotenoids, anthocyanins, flavonoids, and polyphenolic acids (Vinson et al., 2001). Despite reports that they are an important source of compounds with benefits for human health, their consumption remains low and this is probably due to the lack of maturity index. Consumption may increase if the fruit is ripe, tasty, and has intensive aroma (Crisosto et al., 2004). The antioxidant activity in plums depends on the cultivar (Cevallos-Casals et al., 2006, Kim et al., 2003).

Numerous methods have been developed to determine the antioxidant capacities of food extracts (ORAC, TRAP, ABTS, DPPH and FRAP), but there has not been a consensus as to the preferred method. ABTS assay is one of the most-widely used, it is simple, reproducible, requires simple laboratory equipment, and has a good fit with other methods used for measuring antioxidant activity.

The purpose of this study was to evaluate the antioxidant activity of four different plum cultivars. The antioxidant activity of plum fruit extracts were tested using ABTS free radical decolourisation assay.

## Materials and methods

### Chemicals

2,2'-azino-bis-(3-ethylbenzothiazolin-6-sulfonate) diammonium salt (ABTS) and Trolox (6-hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid) were obtained from Sigma-Aldrich (St. Louis, Missouri). All other chemicals used were of analytical grade.

### Fruit samples

In 2007, fruits of four different plum cultivars (*Prunus domestica* L.) were collected from the five year experimental orchard of the Fruit Growing Centre, Maribor. Plum cultivars, 'Čačanska lepotica' and 'Tophit' were grafted on Jaspny rootstock and plum cultivars 'Valor' and 'Stanley' on Mirabolana 29C rootstock. The experiment consisted of ten trees for each cultivar. When the plums reached eating quality, fifty similar fruits were picked from each cultivar. They were randomly-divided into five replicates of 10 fruits. The plums were pitted by hand, dipped into liquid nitrogen, and homogenized using a blender (Grindomix GM 200, Retsch). A portion was used for the determination of total soluble solids (TSS) and titratable acidity (TA). Three grams of sample was weighed into a centrifuge tube, frozen in liquid nitrogen, and stored at - 80 °C until extraction.

### Total soluble solids (TSS) content and titratable acidity (TA)

TSS content was determined in the juice obtained for each sample using a refractometer (Atago N1). TA, as a malic acid, was determined by titration with 0.1 mol/L NaOH solution up to pH 8.1.

### Extraction

To estimate the antioxidant activity of plums, 20 mL of acidified aqueous methanol (50:50, v/v, 2.4 mol/L HCl) was added to the sample within a centrifuge tube, and extraction was then performed according to the procedure described by Pérez-Jimenez and Saura-Calixto (2005). The extraction was done in duplicate for each sample.

### ABTS assay

Antioxidant activity was evaluated according to the ABTS modified assay (Stratil et al., 2006). The ABTS $\cdot^{\circ+}$  solution was prepared by reacting aqueous ABTS solution (7 mmol/L) with 2.45 mmol/L potassium persulphate solution for 20 h at room temperature in the dark. The ABTS $\cdot^{\circ+}$  solution was then diluted with phosphate buffer solution (pH 7.4) to an absorbance of 0.70 ( $\pm 0.02$ ) at 734 nm. The plum extracts (50  $\mu$ L) were reacted with 1 mL of diluted ABTS $\cdot^{\circ+}$  solution in the dark for 30 min. Experiments were performed in duplicate and the absorbance was monitoring at 734 nm using a Cary 1E Varian UV/Vis spectrophotometer (Varian Inc., Palo Alto, CA). The vitamin E analogue Trolox was used as standard. Results were expressed as  $\mu$ mol of Trolox equivalent (TE) per gram of fresh weight (FW).

### Statistical analysis

The results obtained were analysed using the SPSS program version 17.0 for Windows (SPSS. Inc., Chicago, IL). The data of antioxidant activities were subjected to a one-way analysis of variance (ANOVA) and Duncan's test was performed to determine the significance at  $p < 0.05$ .

## Results and discussion

The plums were harvested at consume ripeness. This was determined according to our experiences based on the colour of the skin, size, TSS content, TA and TSS/TA ratio. 'Valor' had the highest TSS content (18.3%), followed by 'Tophit' (15.7%), whilst 'Stanley' and 'Čačanska lepotica' had similar contents of soluble solids 14.7% and 14.4%, respectively. From the literature data, TSS content in plums is very important for consumer acceptance, since TSS is significantly correlated with the perception of sweetness, aroma intensity and plum flavour and the ratio TSS/TA with sweetness and flavour intensity (Crisosto et al., 2004). TA (expressed as% of malic acid) varied from 0.97% in 'Čačanska lepotica' to 1.13% in 'Tophit'.

## Antioxidant activity of selected plum cultivars

Antioxidant activities were evaluated in plum extracts by scavenging ABTS radical cations. The ABTS method is one of the more often used methods for the determination of antioxidant capacity (Rice-Evans et al., 1996). It is based on the reaction of  $ABTS\cdot\dot{O}^+$  with electron/hydrogen donors to form colourless ABTS. A decrease in  $ABTS\cdot\dot{O}^+$  concentration was linearly dependent on the Trolox concentration (Figure 1) with a correlation coefficient ( $R^2$ ) higher than 0.99. The results are expressed as Trolox equivalents, that is, the  $\mu\text{mol}$  of Trolox necessary to provide the same antioxidant capacity as a gram of sample (Re et al., 1999).

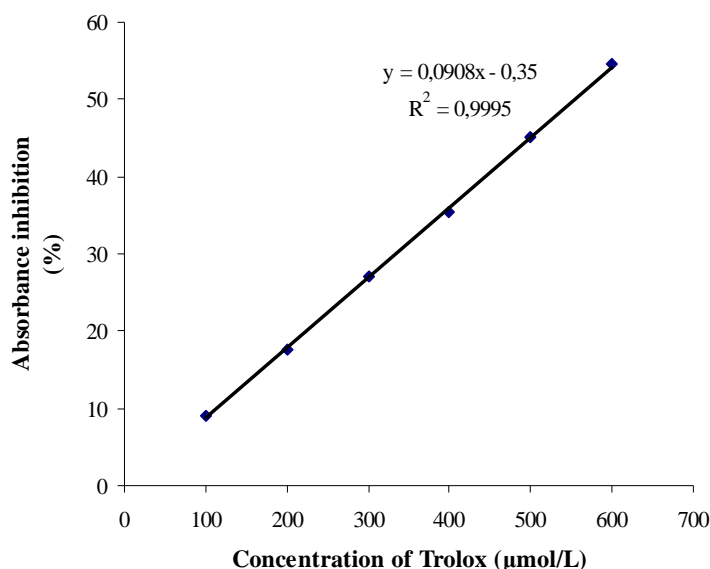


Figure 1. Effects of Trolox concentration on the inhibition of  $ABTS\cdot\dot{O}^+$  at 734 nm.

The antioxidant activities of various plum cultivars were within the range from 10.8  $\mu\text{mol TE/g FW}$  to 18.6  $\mu\text{mol TE/g FW}$  (Table 1). There was a significant difference at a level of  $p < 0.05$  in average antioxidant activity among the plum cultivars. 'Valor' was found to have the highest antioxidant activity, whereas 'Tophit' had the lowest. In general, the antioxidant activity found in 'Valor' was similar to the previously reported value for greengage plums, *var. Claudia* 18  $\mu\text{mol TE/g FW}$  obtained using the same methodology and standard (García-Alonso et al., 2004). A comparison of our study's results with other results in the literature was impossible due to different calibration standards, the different methods used to evaluate antioxidant activity, and the different ways of expressing concentrations (dry weight, fresh weight, mass or molar units).

The antioxidant activity of plums is relatively high compared with other fruit species (Stacewicz-Sapuntzakis et al., 2001). Wang et al. (1996) reported the antioxidant activity for commonly consumed fruits rated in the order of strawberry > plum > orange > red grape > kiwi > pink grapefruit > white grape > banana > apple > tomato > pear > melon. However, our data demonstrated that the antioxidant capacity of plum fruits is strongly influenced by the cultivar. The plum cultivars used in this study were grown at the same location under the same horticultural practices, so the differences in antioxidant activities confirmed that the cultivar has an important role in the biosynthesis of phenolic compounds, which is quite typical for plums (Díaz-Mula et al., 2009, Kim et al., 2003).

Table 1: Antioxidant activities ( $\mu\text{mol TE/g sample, FW basis}$ ) of plum cultivars obtained by the ABTS method.

Cultivar	Antioxidant activity
'Stanley'	11.4c
'Valor'	18.6a
'Čačanska lepotica'	12.8b
'Tophit'	10.8d

Values with a different letters indicate statistically significant differences in the mean (Duncan's test,  $p < 0.05$ ).

## Conclusion

The antioxidant activity of four plum cultivars was estimated using ABTS assay. Various plum cultivars showed statistically significant differences in antioxidant activity. Regarding the fact that plum cultivars were grown at the same location under the same horticultural practices and that fruits with no pest or mechanical injuries were harvested at a very similar ripening stage, the differences in antioxidant activity found could be ascribed to genetic variability. The results may suggest that plums in our diet could be a good source of antioxidants, which may provide health-promoting effects for humans.

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# A new method for protecting tree from winter injury

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## Abstract

When woody plants are subjected to a sudden large drop in temperature, injury or even death of plants can occur. An electrical heater unit designed for cold protection tree in winter. It made up from three layers. Material of middle layer was from glass wool and two outer layers were from waterproof rubber covering. Thermal wires were placed inside the layers. Electrical heater of tree could be used for trees with trunk diameter between 15 cm to 45 cm. The electrical heater around the trunk was wrapped, and then in a cooler chamber was placed. Tests carried out in five different temperatures (-8, -12, -15, -18 and -20°C) with five replications on the same trunk. Essential power and voltage for this electrical heater was 54.6 W and 24 V. Tests results indicated that the tree heater kept trunk in temperature 20, 19, 18, 15 and 14°C while cooler chamber temperature was -8, -12, -15, -18 and -20°C, respectively.

Key words: tree heater, tree injury, protecting tree, electrical heater, cold climate.

## Introduction

The effects of temperature vary with plant species, stage of growth, age, general health and water content. Winter damage, however, does not always show up as direct injury. Freezing temperatures that are not sufficient to kill can cause a plant to be predisposed to other problems such as bacterial blight, phytophthora root rot, and several other pest problems (Anonym, 1997). Young, actively growing, flowering, and/or dehydrated plants tend to be most vulnerable (Bradley and Horticulture, 1998). It was found that development and growth of fruits and leaves were limited by low temperature, which would cause damage symptoms such as fruit abscission, chilling injury and leaves injury (Huang *et al.*, 2005). Frost injures plants by causing ice crystals to form in plant cells, making water unavailable to plant tissues and disrupting the movement of fluids (Anonym, 2003). Symptoms of freeze injury could include desiccation or burning of foliage, water-soaked areas that progress to necrotic spots on leaves stems or fruit and death of sections of the plant or the entire plant (cold 20% protection).

Protecting trees from cold damage is a difficult task. The problems of tree care, a shortage of trees and increasingly frequent freezes have generated a new interest in protecting trees from possible damage by cold (cold 20% protection). The best way to prevent winter injury is to ensure maximum acclimation by optimizing growing conditions during the growing season and minimizing stressful conditions. Supplying adequate moisture and balanced nutrition are essential (Anonym, 1997).

Several methods used for cold protection. One method is using tree canopy covers. These can reduce cold injury. Tree canopies elevate minimum night temperature under them by reducing radiant heat loss from the ground to the atmosphere (Ingram and Yeager, 2003). Another way is using soil banks. Soil banks must be put up before danger of cold and removed as soon as possible after the threat of cold has passed. Although, expensive labor, maintain difficulty and problems of disease are disadvantage of using this method.

Heaters are devices for cold protection. Orchard heaters provide heat by direct radiation and convection. Stack heaters give out 25-30 percent radiant heat, which moves along a straight line from the heater to the trees. Air around the immediate area of the heater is heated by convection. Because of the need for fuel-burning efficiency and pollution reduction, orchard heaters have evolved to the upright stack design. The greatly increased cost of fuel has practically eliminated heaters from the growers cold protection strategy.

Tree wraps were most useful protecting young trees. Tree wraps protect only the trunk and leaf loss. Most tree wraps, unlike soil banks, can be attached anytime during the year and left on the tree throughout the year or even for several years. Types of tree wraps are Fiberglass wrap, Polyurethane foam, Rigid Polystyrene Foam (Thick-Walled) and Closed Cell Polyethylene Foam (Jackson and Parsons, 1994). Completely drape the plant from top all the way to the ground. Do not allow any openings for warmth to escape. This procedure will trap the heat radiating from the soil and maintain a more humid atmosphere around the plant foliage (Bradley and Horticulture, 1998).

This paper describes the development and testing of an electrical heater for protecting fruits trees from cold temperatures.

### Materials and Methods

An electrical heater unit (Fig. 1) designed for cold protection tree in winter. As shown in Fig. 2 it made up from three layers. The materials of inside layer was glass wool with thickness 3cm and outer layers were waterproof rubber covering. The layers have an overall dimension of 150cm in length, 77cm in width. For high absorption of sunray, one of the outer layers had a dark color. Thermal wires were placed inside the layers which were connected by some rope.

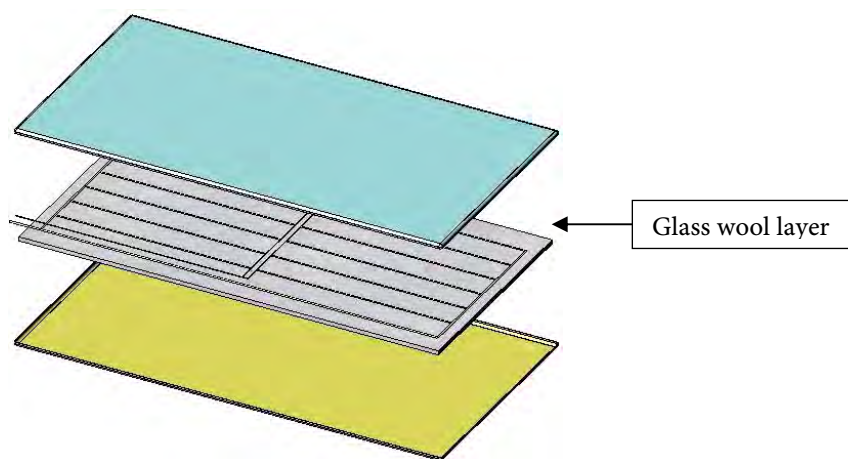


Fig. 1. The electrical heater unit of tree. Fig. 2. The three layers of electrical heater of tree.

As shown in Fig. 3 this electrical heater had two groups of thermal wires that were parallel connected. Each series had six thermal wires with length of 70 cm, diameter of 0.01cm and resistance of  $126.6 \Omega$ . Intervals between wires were 10cm and placed parallel on the glass wool layers. Essential power required 54.6 W by 24 V DC supply e.g. Tractor battery.

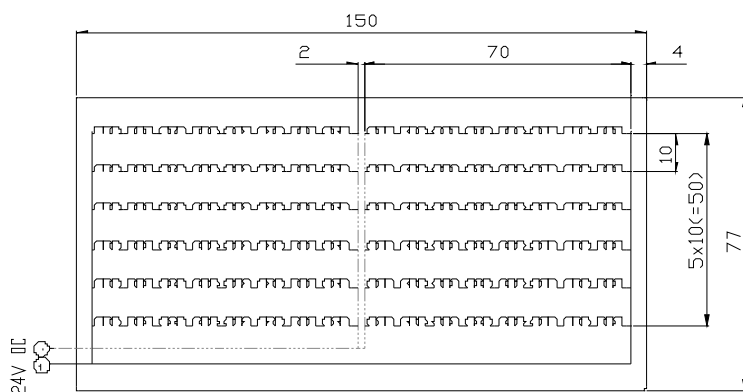


Fig. 3. The arrangement thermal wires on the inside layer (Dimensions in cm).

With respect to the facts that in Iran temperature of some cities at winter times does fall to  $-20^{\circ}\text{C}$ , therefore, in this study the maximum temperature range for experiments  $-20^{\circ}\text{C}$  was chosen. For conducting the experiments on these electrical heater, a cooler (Model CA12-2232, Baradaran, Iran) was applied (Fig 4). The cooler chamber had the ability of changing temperature inside its chamber from  $-25^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$  to  $5^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$ . Electrical heater of tree could be used for trees with trunk diameter between 15cm to 45cm. Tests carried out by a trunk with diameter of 21cm. The electrical heater was wrapped around the trunk and was placed in the cooler chamber. Temperature between electrical heater and trunk was measured by thermometer (PT100). Tests were executed in five different chamber temperatures range ( $-8$ ,  $-12$ ,  $-15$ ,  $-18$  and  $-20^{\circ}\text{C}$ ) on the same trunk. For each temperature range, experiments were conducted in five replications.

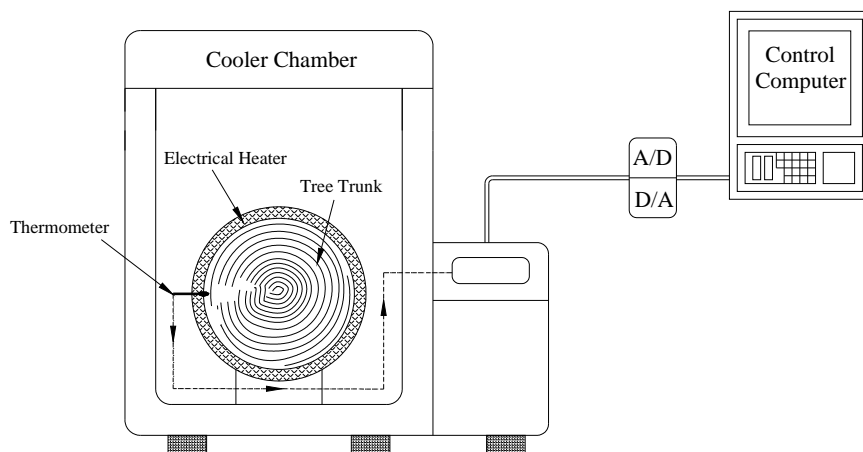


Fig. 4. The cooler chamber.

### Results and discussion

The results of tests for trunk placing in five different temperature ( $-8$ ,  $-12$ ,  $-15$ ,  $-18$  and  $-20^{\circ}\text{C}$ ) are shown in Fig.5. Tests results indicated that the tree heater kept trunk in temperature 20, 19, 18, 15 and  $14^{\circ}\text{C}$  while cooler chamber temperature was  $-8$ ,  $-12$ ,  $-15$ ,  $-18$  and  $-20^{\circ}\text{C}$ , respectively. Voltage and electric flux of thermometer for all tests were constant. As shown in Fig.5 an initial high rate of thermal sorption followed by slower absorption in the latter times. In all of the tests after 4 h trunk temperature reaches steady temperature.

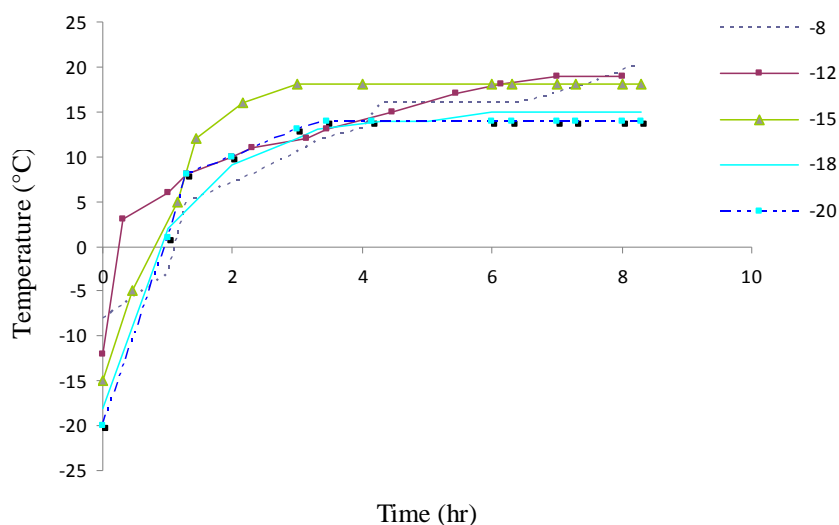


Fig. 5. The temperature between electrical heater and trunk in five different chamber temperatures range versus experiment time.

## Conclusions

This paper presents the design modification and evaluation of an electrical heater unit of tree. The results indicated that the tree heater kept trunk in temperature 14°C while cooler chamber temperature was -20°C. Therefore, the electrical heater unit could protect trees in winter times at -20°C against freezing.

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# Study of electrical resistance on apples

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## Abstract

Non destructive physical tests are recent trends for quality evaluation of fruits. Information on post harvest variation in electrical resistance and moisture content needs to develop new instruments for this purpose. Electrical resistance and weight of apple stored for 50 days at  $22\pm 2^{\circ}\text{C}$ . Temperature was measured using LCR Meter and precision electronic balance, respectively. In this experiment, special plate electrodes were developed and used. Constant forces were applied to apple sets located between two plate electrodes. The relationship between the electrical resistance and the weight loss, during the storage period, was also investigated. The results indicated that, the electrical resistance decreases by third degree equation and the weight of apple decreases linearly with increase in storage period.

Key words: apple, electrical resistance, electrical properties, storage, plate electrode

## Introduction

The developments of science, technology, and especially of information technology, have made many non-destructive methods available for analysis of materials, which can also be applied to fruits. Fruit industries need non-destructive techniques for on-line sorting and certifying high quality fruits. Numerous studies have been performed to devise accurate food quality measuring techniques. Electrical resistance measurement is a relatively new method applied to food quality assessment.

Electrical methods can detect quality factors and are sensitive to variations in the concentration and state of water. Therefore, it can be associated with maturity, damage, overripe condition, decay or other quality factors (Puchalski, 1994).

There is an increasing need for methods to sort agricultural products according to various standards of quality. The techniques and apparatus used by different authors vary considerably. However, the techniques for solid samples are often costly, sophisticated and bigger in size, thus undesirable to be used by researchers (Jha and Matsuoka, 2000). Development of a new instrument requires a lot of information on engineering properties and their relationships (Jha, 1999). The analytical relationships between electrical resistance properties and quality criteria have not yet been fully developed. Thus, further exploration is needed to acquire more data on electrical resistance, characteristics of fruits, and also employing new approaches for determination of their quality. Electrical properties of fruits are considered as accepted indicators for detecting fruit quality. For example; electrical resistance was used to determine the extent of tissue damage that occurred as a result of bruising of apple fruit (Puchalski, 1994; Jackson et al., 2000; Puchalski and Brusewitz, 2000).

Rotz and Mohsenin (1978) measured electrical resistance of bruised and unbruised tissues in apples. They used two needles inserted into the apple skin and a General Radio Impedance Bridge at 1 kHz; they found the electrical resistance of bruised tissue is lower than unbruised tissue. Puchalski (1994) measured electrical resistance of apple. He used an electrical sensor consisted of two electrodes of 10-4mm dimension (width-length) which were set at a constant distance on a Teflon probe. The sensor pushed into the fruit to measure electrical resistance of the sample between two electrodes. Harker and Forbes (1997) measured tissue resistance and reactance on persimmon fruit at frequencies between 50Hz and 1MHz. Puchalski and Brusewitz (2000) measured electrical resistance of the bruised and unbruised tissue of apple at the frequency of 1 kHz, using a universal impedance bridge and showed that the electrical resistance of unbruised tissue

was more than bruised tissue and larger bruise volume had lower electrical resistance. Jha and Matsuoka (2004) measured changes in electrical resistance of eggplant with gloss, weight and storage period. The results of these investigations have shown the electrical resistance increased with increase in storage period and with decrease in both weight and gloss index of eggplant during storage.

The purpose of this study is to evaluate effects of storage time and weight loss on electrical resistance of apple. In most of the previous research, the electrodes were pushed into the fruit so injured it and thus in each individual test, samples should be changed. In this experiment, especial electrodes for measuring electrical resistance were developed and used without damaging the fruit.

### Material and Methods

In this research, apple fruit (red delicious) with an average weight 198g is selected. The apples were picked up and stored in  $22 \pm 2$  °C. During storing time, the experiments carried out in every 12 hours. Weight loss of apples was determined by precision electronic balance with 0.1% accuracy.

To obtain the electrical resistance relationship of apple, an apparatus, originally built at the University of Tehran, was used. Fig. 1 shows the complete system of the apparatus used in this research. The complete unit has overall dimensions of 410 mm in length, 350 mm in width and 330 mm in height. The overall construction of the apparatus was made up of the following main components.

Base, (1): All of the parts are assembled on the base.

Square flange bearing, (2): The rotation of the frame is available by square flange bearing (UCF204).

Frame, (3): Probes and load cell have been set on the frame. The frame can change its angle through the provided pivot. For small fruits, it is recommended to perform the experiment in horizontal property, because the weight of the fruit is not suitable for the existing probe. However, for heavier fruits such as watermelon, if the frame could not hold the fruit in horizontal position, it could be rotated or moved down.

Probes, (4): Probes were constructed from four parts; regulating screw, Circular nut, chamber, and copper plate. These components are connected to the frame by a regulating screw.

- Regulating screw: This is adjustable on the frame. The Probes are adjustable to appropriate distance to match the size of apple, by the regulating screw.
- Circular nut: Circular nut was placed on frame and it was made of polyethylene. It was fixed to the copper plate on the chamber.
- Chamber: The plate electrodes, as insulator parts, were placed between circular nut and chamber. Also the circular nut and the chamber provide a cavity so that the copper plate electrodes can ignore the fruit curvature. The chambers push the electrodes on fruit.
- Copper plate electrodes: Two copper plate electrodes with 0.03 mm thickness and 140 mm in diameter were used for electrical resistance measurement in this experiment. The thickness of plate electrodes provided a suitable solidity and flexibility for applying force. The diameter of the copper plate is bigger than internal diameter of the circular nut (about 4mm) thus, it has enough flexibility following the fruit curvature.

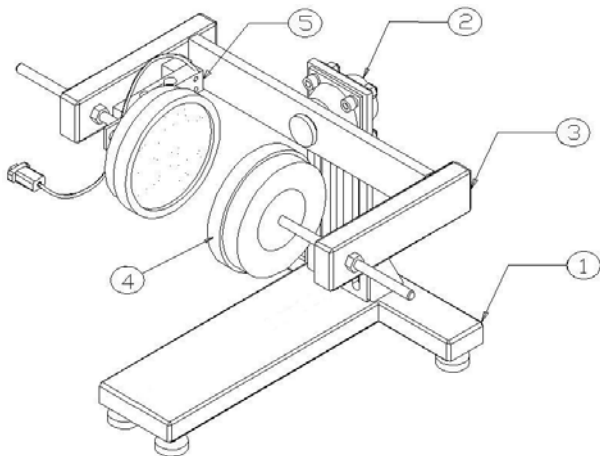


Fig. 1 The schematic of the apparatus

Load cell (5): The force was measured with a beam type load cell (DBBP, Bongshin, Korea, 100N capacity) equipped with a digital weighing indicator. The force was adjusted about  $1\pm 0.2$  N. The load cell connected to the indicator. Therefore, in every experiment, the applied force on the fruit was adjusted manually. In this experiment, constant forces were applied and thus, there was a similar connection between fruit and copper plate.

As mentioned above, the applied forces on the apples were constant through this experiment. Initially, the tissue impedance components were measured by using a function generator and an oscilloscope (Zhang and Willison (1991), Harker and Dunlop (1994)). Alternating current at frequencies between 50 Hz and 1 MHz was passed through the tissue samples. Impedance characteristics were determined from the dimensions of an ellipse traced on the oscilloscope. In later work, impedance characteristics were determined using LCR meter. In this experiment, electrical resistance of apples was measured with LCR Meter (41R, Lutron, Taiwan). The LCR Meter was operated at two frequencies, 120 Hz and 1 kHz. This method is simple and accurate. The basic accuracy of LCR Meter is due to the lower resistance and capacitance 0.5% and 0.7%, respectively. Electrical resistance measurements were performed at two frequencies; 120 Hz and 1 kHz.

### Results and Discussion

The variations in electrical resistance, during 50 days of storing period, are shown in Figure 2. The mean of volumetric moisture content at the beginning of the experiment appeared to be 0.81 and at the end of the experiment (after 50 days) was 0.77. The weight loss was caused by decreasing moisture content, during the storing period.

Figure 2 shows the relationship between electrical resistance of tissue and passed time by apple. At frequency 1 kHz, the mean values for the samples during storage time of 50 days at  $22\pm 2^\circ\text{C}$  varied from 72.58 k $\Omega$  to 138.88 k $\Omega$ . The electrical resistance  $E_r$  decreased with storage period  $S_p$ . At frequency 120 Hz, the mean values of electrical resistance for the samples varied from 442.81 k $\Omega$  to 1002.71 k $\Omega$ . The electrical resistance  $E_r$  decreased with storage period  $S_p$  (Fig. 3).

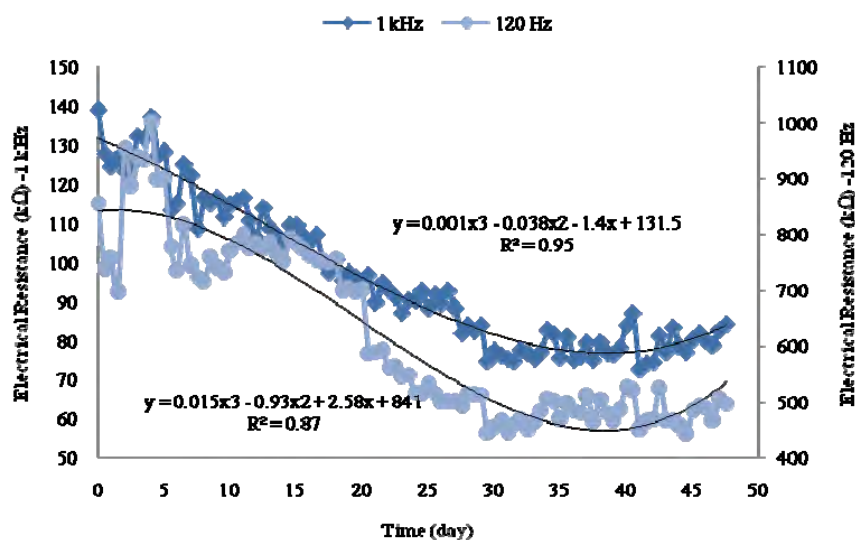


Fig. 2 Electrical resistance in relation to versus time, measured in 1 kHz and 120 Hz.

As Figure 2 indicate, the rate of decrease diminished slowly with the storage period and tended to be flat after 25 days of storage. The major reason for the increase of resistance may be a decrease in the moisture content of fruits in a similar pattern during storage due to continual transpiration (Jha and Matsuoka, 2004).

The sharp decline of electric resistance of the apple, during the early storage time, and the following moderate decrease, can be attributed to the fruit moisture content effect in a similar pattern. As the storing

time increases, due to the continual transpiration (Jha and Matsuoka, 2004) the fruit weight and accordingly, the moisture content decreases.

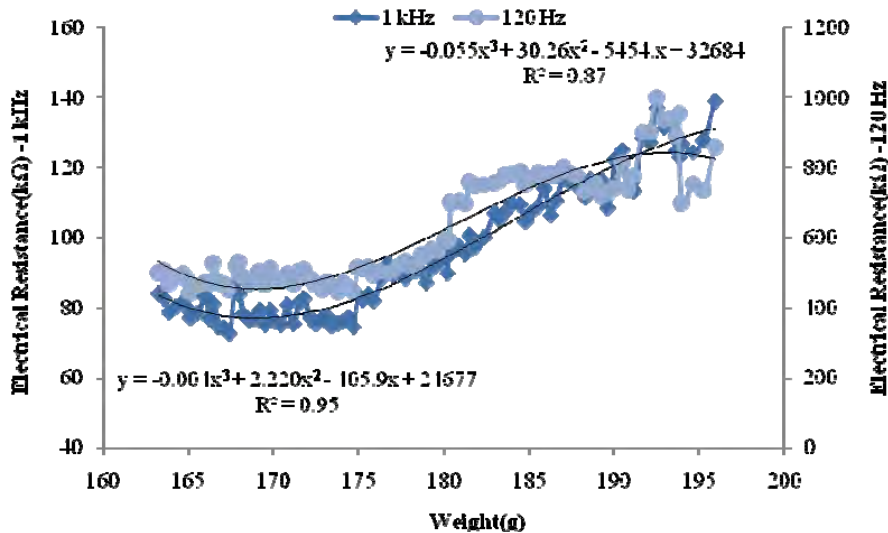


Fig. 3 Electrical resistance in relation to weight, measured in 1 kHz and 120 Hz

The electrical resistance varied inversely with change in weight of apple during storage for 50 days at  $22 \pm 2^\circ\text{C}$  (Fig. 3). Loss of water during storage increased the electrical resistance of apple because of the percentage increase in the mass of dry matter, a bad conductor of electricity, during the storage period. The best form of equation fitted to the data of electrical resistance  $E_r$  and the weight,  $W$ , in g during storage, was found to be quadratic (correlation coefficient of 0.95 at frequency 1 kHz and correlation coefficient of 0.87 at frequency 120 Hz).

The third degree equation relationship between electrical resistance and storage time was observed for apple. The results indicated that, the weight of the apples in this experiment, decreased linearly with increase in storage period. Water loss of the whole fruit also contributes to mobile ions concentration increasing when ripening. In general, the increasing of ions concentration in the electrolyte of the fruit leads to the decreasing of resistance (Liu, 2006). However, highly concentrated solutions do not follow this pattern; they reveal the opposite trend instead. Therefore, based on these experiments, it is believed that the concentration of ions in fruit becomes very high during ripening.

This investigation indicates that the electrical resistance measurement has a great potential in assessing fruit ripening and forecasting the length of fruit storage.

By combining the apple's humidity changes with the resistance changes, it is suggested that the storage time consists of three stages, unripe, eating-ripe stage, and overripe stage respectively. In unripe stage, physiological development and electrical resistance increase. In eating-ripe stage, the moisture content and the electrical resistance decrease during the storage time. In overripe stage, moisture content would be very low at the end of the period of storage, thus electrical resistance increases.

### Conclusion

The electrical resistance of apple fruit was measured by developing and employing special electrodes. This was performed without any physical damage to the fruit. The electrical resistance decreased during the storage time by third degree equation. The results also indicated that, the weight of apple decreased linearly with increase in storage period.



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# Does harvest time influence fruit quality traits in primocane fruiting raspberry cultivars?

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## Abstract

In the present study, physical and chemical fruit traits of five primocane fruiting raspberry cultivars ('Himbo Top', 'Lyulin', 'Rossana', 'Heritage' and 'Golden Bliss') affected by the harvest time were analysed. Results from this study showed that the earliest ripening time was observed in cv. 'Himbo Top' (3rd July), whereas cv. 'Rossana' was the latest (12th August). 'Himbo Top' exhibited the highest values of fruit weight in both harvest dates (summer - 3.97 g and autumn - 1.98 g), followed by yellow fruited cv. 'Golden Bliss' which is characterized by the lowest amounts of total soluble solid (TSS) and the highest levels of titratable acidity (TA) in both harvesting dates. An increase of TSS and total phenolic contents (TPH) from summer to autumn harvest can also be observed and explained by the influence of environmental factors. Very high contents of TPH were found in cv. 'Rossana' ranging from 3.62 mg GA g<sup>-1</sup> FW (summer harvest) to 4.71 mg GA g<sup>-1</sup> FW (autumn harvest). Total antioxidant capacity (TAC) also tended to increase in fruit harvested in autumn achieving the highest value in cv. 'Rossana' (3.58 mg asc g<sup>-1</sup> FW).

Key words: raspberry, primocane fruiting cultivars, harvest time, fruit quality.

## Introduction

Primocane fruiting raspberry cultivars have received much attention since there is an increasing demand for fresh raspberries out-of-season. These cultivars provide extended market supply with fresh raspberry fruit after the florican raspberry season is finished (Milivojević et al., 2010). Quality attributes of raspberry fruit have been widely studied (Scalzo et al., 2005; Agaoglu and Eyduran, 2006; Kafkas et al., 2008; Ochmian and Skupień, 2008; Milivojević, 2008; Milutinović et al., 2008) and are demanded by consumers, particularly nutritional value of raspberry fruit that is important for general health benefits. These benefits can also be ascribed to the total antioxidant capacity and specific related compounds, such as phenolics, contained in raspberry fruit (Benvenuti et al., 2004; Pantelidis et al., 2007). A greater consumption of fresh raspberries, by spreading primocane fruiting raspberry cultivars in the production, is considered as one of the ways of increasing the intake of natural antioxidants. If nutritional components are combined with high sensorial fruit quality, these cultivars are considered to be good quality crops with a high market value.

Since primocane fruiting raspberry cultivars provides the season extension by producing berries late in the season, the aim of this study was to get information on seasonal stability/variability of fruit quality traits in five primocane fruiting raspberry cultivars.

## Material and methods

The five primocane fruiting raspberry cultivars ('Himbo Top', 'Lyulin', 'Rossana', 'Heritage' and 'Golden Bliss') were used for detailed analysis. Studies were conducted at the Experimental station "Radmilovac", a collective raspberry orchard on open field of the Faculty of Agriculture, Belgrade University in 2009. Fruit samples of each cultivar were collected separately for summer and autumn harvest in triplicate to investigate physical fruit properties as follows: fruit weight, number of drupelets per fruit and index of fruit shape which

was calculated as the ratio of the maximum height and width. Each sample consisted of 30 fruits pooled to obtain a composite sample and analysed for soluble solids content (SSC) using a digital refractometer (Pocket PAL-1, Atago, Japan). Titratable acidity (TA) was measured using a digital buret and 0.1 M NaOH, to titrate samples to an endpoint of 8.1, and acidity based as percent of malic acid equivalent. The amount of total phenolics (TPH) was determined in the fruit of red raspberry cultivars according to the Folin-Ciocalteu's spectrophotometric (2501 PC Shimadzu, Kyoto, Japan) procedure (Singleton and Rossi 1965) using gallic acid (GA) as a standard for the calibration curve. Results were read at 724 nm and expressed as milligrams of GA equivalent per gram of fresh weight (mg GAE g<sup>-1</sup> FW). Determination of total antioxidant capacity (TAC) was done in the same cultivars following the ABTS method of Arnao et al. (1999). Results were expressed as milligrams of ascorbic acid equivalent per a gram of fresh weight (mg asc g<sup>-1</sup> FW). A statistical analysis was performed using software Statistica 6.0 for Windows (StatSoft Inc., Tulsa, OK, USA). Significant differences among the means were determined by LSD test at a level of P ≤ 0.05.

## Results and discussion

One of the most important features determining cultivar suitability for growing is its ripening season. Data of ripening season of five primocane fruiting raspberry cultivars are presented in Table 1. The earliest ripening time and the longest harvest season were observed in cv. 'Himbo Top' (3rd July and 100 days, respectively), whereas cv. 'Rossana' was the latest with the shortest period of harvesting (12th August and 50 days, respectively).

Tab. 1 - Ripening season of primocane fruiting raspberry cultivars

Cultivar	Beginning	The end	Duration (days)
Himbo Top	03.07.	10.10.	100
Lyulin	05.08.	28.09.	55
Rossana	12.08.	30.09.	50
Heritage	04.08.	30.09.	58
Golden Bliss	04.07.	10.10.	99

Large differences were found among cultivars tested in terms of physical fruit characteristics in both harvest time (Table 2). 'Himbo Top' exhibited the highest average values of fruit weight and number of drupelets per fruit (2.97 g and 93.4, respectively). Conversely, the smallest fruit size was observed in cv. 'Lyulin' (2.03 g), whereas cv. 'Rossana' expressed the lowest number of drupelets per fruit (68.4). Great variability existed in obtained results affected by the harvest date, i.e. higher values were recorded in fruits of summer harvest in each of cultivars tested. Index of fruit shape ranged from 0.94 ('Lyulin' and 'Heritage') to 1.00 ('Rossana' and 'Golden Bliss') which indicates that studied raspberry cultivars mostly had flatted round fruit shape.

The obtained results of chemical fruit composition in table 3 indicated that cv. 'Golden Bliss' was characterized by the lowest amounts of SSC in both harvest dates (9.5% and 11.8%, respectively). However, other cultivars differed for their SSC between summer and autumn harvest achieving the highest value during the summer harvest in cv. 'Heritage' (13.2%), i.e. during the autumn harvest in cv. 'Rossana' (15.5%). Moreover, an increase of SSC in fruits of autumn harvest in comparison to those obtained in summer harvest can also be observed and explained by the influence of environmental factors. As opposed to our results, Pantelidis et al. (2007) found lower amount of SSC in fruit of cv. 'Heritage' harvested in autumn than in those harvested in June (8.0% and 10.0%, respectively). Titratable acidity values in raspberry cultivars were also different between two harvesting dates and most studied cultivars are characterized by lower values in fruits harvested in summer. In general, the highest levels of TA in both harvesting dates were recorded in cv. 'Golden Bliss'.

The total content of phenolics is known to influence their antioxidant and other health-related bioactivities, therefore this study aims to quantify TPH content and its changes during the harvest season (Table 4). Very high contents of TPH were found in cv. 'Rossana' ranging from 3.62 mg GA g<sup>-1</sup>FW (summer harvest) to 4.71 mg GA g<sup>-1</sup>FW (autumn harvest). The second highest TPH content was recorded in cv. 'Himbo Top', but no significant differences were observed between summer and autumn harvest.

Tab. 2 - Physical fruit traits of primocane fruiting raspberry cultivars

		Fruit weight (g)	Index of fruit shape	Numbers of drupelets	
Cultivar (C)	Himbo Top	2.97 a	0.95 b	93.4 a	
	Lyulin	2.03 d	0.94 b	80.4 b	
	Rossana	2.22 c	1.00 a	68.4 d	
	Heritage	2.44 b	0.94 b	91.4 a	
	Golden Bliss	2.46 b	1.00 a	74.3 c	
Harvest (H)	Summer harvest	3.15	0.96	91.2	
	Autumn harvest	1.69	0.98	72.0	
C x H	Himbo Top	SH	3.97 a	0.87 f	99.1 b
		AH	1.98 d	1.04 a	87.8 c
	Lyulin	SH	2.92 bc	0.98 bc	110.4 a
		AH	1.14 e	0.89 ef	50.5 g
	Rossana	SH	2.70 c	1.02 ab	71.2 ef
		AH	1.74 d	0.98 bc	65.7 f
	Heritage	SH	3.10 b	0.92 de	102.1 b
		AH	1.77 d	0.95 cd	80.7 cd
	Golden Bliss	SH	3.08 b	0.98 bc	73.1 e
		AH	1.83 d	1.02 ab	75.4 de
ANOVA (F test)	Cultivar	37.01*	9.44*	37.4*	
	Harvest	794.72*	5.25*	148.43*	
	Cultivar x Harvest	12.94*	20.97*	47.92*	

\* Data are the means of three replications. Values within column followed by the same letter are not significantly different at  $P \leq 0.05$  (LSD test). \*, significant at  $P \leq 0.05$ . SH, summer harvest. AH, autumn harvest.

Tab. 3 - Chemical fruit traits of primocane fruiting raspberry cultivars

		TSS (%)	TA (%)	TPH (mg GA g <sup>-1</sup> FW)	TAC (mg asc g <sup>-1</sup> FW)	
Cultivar	Himbo Top	11.3 c	1.03 ab	2.92 a	2.42 b	
	Lyulin	12.3 b	0.94 bc	2.04 d	1.86 c	
	Rossana	12.7 b	0.95 bc	4.17 a	2.87 a	
	Heritage	13.7 a	0.87 c	2.57 c	2.27 b	
	Golden Bliss	10.6 d	1.10 a	ND	ND	
Harvest	Summer harvest	10.6	0.93	2.61	1.78	
	Autumn harvest	13.6	1.03	3.24	2.94	
C x H	Himbo Top	SH	10.0 f	0.96 cd	2.79 c	1.99 de
		AH	12.6 c	1.09 ab	3.06 c	2.85 b
	Lyulin	SH	10.7 e	0.94 d	1.81 e	1.12 f
		AH	13.9 b	0.94 d	2.27 d	2.60 c
	Rossana	SH	9.8 f	0.91 d	3.62 b	2.17 d
		AH	15.5 a	0.99 bcd	4.71 a	3.58 a
	Heritage	SH	13.2 c	0.75 e	2.22 d	1.83 e
		AH	14.2 b	0.99 bcd	2.92 c	2.71 bc
	Golden Bliss	SH	9.5 f	1.07 abc	ND	ND
		AH	11.8 d	1.13 a	ND	ND
ANOVA (F test)	Cultivar	54.08*	8.57*	187.74*	68.82*	
	Harvest	424.04*	13.98*	91.07*	526.77*	
	Cultivar x Harvest	28.34*	2.487 <sup>ns</sup>	7.022*	10.84*	

\* Data are the means of three replications. Values within column followed by the same letter are not significantly different at  $P \leq 0.05$  (LSD test). ns, non significant. \*, significant at  $P \leq 0.05$ . ND, not detectable. SH, summer harvest. AH, autumn harvest. FW is fresh weight.

The TAC results presented here showed similar levels for cultivars tested, probably reflecting similar TPH content. Cv. 'Rossana' exhibited the greatest TAC levels ranging from 2.17 mg asc g<sup>-1</sup> FW (summer harvest) to 3.58 mg asc g<sup>-1</sup> FW (autumn harvest). Taking into account the influence of harvest time on expressed TAC, it becomes apparent that antioxidant properties of primocane fruiting raspberry cultivars increase in the later period of harvesting season. These data also underline the importance of appropriate and well-balanced growing conditions for sustaining the highest fruit quality and nutritional value.

## Conclusions

The evaluation of physical and nutritional fruit quality traits represent an important task to better identify the commercial exploitation of primocane fruiting raspberry cultivars. This study pointed out that the nutritional value of raspberry fruit is strongly influenced not only by cultivar, but also by harvesting time. All cultivars tested were expressed larger fruit size in summer harvest, whereas the obtained results of chemical fruit composition indicated that higher levels of SSC, TA, TPH and TAC were found during the autumn harvest. This also confirms that quality of the fruit is often associated with negative agronomic traits and, in this study smaller fruit size showed the highest nutritional value.

Overall, cvs. 'Himbo Top', 'Rossana' and 'Heritage' demonstrated the best fruit quality traits and clearly hold high position among the studied primocane fruiting raspberries. Furthermore, these cultivars could be considered as a good source of natural antioxidants.

## Acknowledgements

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# Utjecaj MAP na tvrdoću plodova jabuka tijekom skladištenja na niskim temperaturama

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## Sažetak

U cilju produženja trajnosti plodova jabuka ispitan je utjecaj konzerviranja u modificiranoj atmosferi (MA), koja se razvija pakiranjem u polimerne filmove tijekom skladištenja. Za ispitivanja upotrijebljene su tri sorte jabuka ("Idared", "Granny Smith" i "Gloster"). Plodovi su pakirani u polimerne filmove niske gustoće različitog sastava i debljine (polietilen (PE), polipropilen (PP) i polietilentereftalat (PET)). Kao referentni uzorak korištene su jabuke skladištene u istim uvjetima bez pakiranja u polimerne filmove. Uspješnost metode praćena je na osnovi analiza određivanja tvrdoće plodova sirovine tijekom 30 dana skladištenja. Ispitivanjima je utvrđeno da se pakiranjem u polimerne filmove koji uključuju debljinu filma od 12 µm (PET), 20 µm (PP) i 45 µm (PE) može dodatno povećati trajnost jabuka čuvanjem na temperaturi od + 4 °C. Rezultati su pokazali da se sve tri folije, bez obzira na vrstu polimera i debljinu filma, mogu jednako uspješno upotrijebiti za očuvanje kakvoće jabuka.

Ključne riječi: jabuka, pakiranje, modificirana atmosfera, polimerni filmovi, tvrdoća

## Effects of MAP on the apple fruits firmness during refrigerated storage

### Abstract

Experiments were carried out to determine whether storage of apples in modified atmosphere (MA) which develops by packaging in semipermeable plastic film may influence the fruit firmness.

For these experiments the three different cultivars of apples (Idared, Granny Smith and Gloster) have been used. Fruits are packed in low density polymere films (polyethylene (PE), polypropilene (PP) and polyethylene therephalate (PET)) with different characteristics and film thickness. As the reference sample were used apples stored in the normal atmosphere at the same conditions of temperature and humidity. The influence of packaging in MA is monitored on the bases of physical analyses of firmness of the commodities during 30 day storage at low temperature. Testing has determinate that packaging in polyethylene films with more permeability, which include 12 µm (PET), 20 µm (PP) and 45 µm (PE) film thickness can additionally extend the shelf-life of apples by storage at temperatures of 4 °C. The results showed that all three used foils, in spite of marked differences in polymer characteristics and film thickness, could successfully be used for keeping quality of fresh apple fruits 30 days.

Key words: apples, packaging, modified atmosphere, polymer films, firmness

### Uvod

Proizvodnja jabuka u Hrvatskoj posljednjih godina je u stalnom porastu. Podaci za 2008. govore da je te godine proizvedeno 80.201 t jabuka od čega je za tržište bilo namijenjeno 57.341 t a 22.860 t pretežno za vlastite potrebe. Jabuka je također i voće koja se najviše konzumira (2006. godine - 15,17 kg godišnje po stanovniku u RH, 2007. godine - 17,73 kg te 2008. godine - 14,06 kg) (SLJH, 2009). Zbog toga što jabuka zauzima visoko mjesto u pogledu proizvodnje i konzumacije vrlo je važno pronaći kvalitetan način skladištenja da bi se proizvod mogao što duže sačuvati u što izvornijem obliku ili u potpuno svježem stanju. MAP u kombinaciji s hlađenjem, predstavlja tehnologiju koja se danas sve više primjenjuje, kako zbog prednosti takvog pakiranja tako i zbog sve većih zahtjeva potrošača za svježom i kvalitetnom hranom. MAP se uspješno primjenjuje pri skladištenju različitih vrsta voća, a posebno onih visoke komercijalne vrijednosti. Cilj ove tehnologije je promjena koncentracije CO<sub>2</sub> i O<sub>2</sub> u atmosferi koja okružuje proizvod čime se omogućava usporavanje rasta mikroorganizama, usporava disanje proizvoda, smanjuje aktivnost enzima, te sprječavaju oksidacijski procesi što za posljedicu ima povećanje trajnosti, očuvanje nutritivne vrijednosti lako pokvarljive hrane i istovremeno osiguravanje njene sanitarne ispravnosti (Brecht, 1995).

Tekstura i tvrdoća vrlo su važni čimbenici ocjenjivanja kvalitete voća koje se nudi na tržištu. Parametri kvalitete, u što se ubraja i tekstura, općenito se mijenjaju tijekom vremena, kao dio normalnog metabolizma proizvoda. Ove promjene koji su izravno pod utjecajem O<sub>2</sub> ili CO<sub>2</sub>, ili su posljedica biokemijskih procesa, mogu biti usporene primjenom MA. Ranija istraživanja o utjecaju MA pokazala su da u jabukama skladištenim u MA sporije dolazi do promjena teksture nego u jabukama skladištenim u normalnoj atmosferi (Rocha, i sur. 2004; Konopacka i Plocharski, 2002; Konopacka i Plocharski, 2004). Mekšanje plodova jabuke tijekom skladištenja je vjerojatno rezultat razgradnje kemijskih veza između molekula hemiceluloze i pektinskih tvari uz pomoć prisutnih enzima (Siddiqui i sur., 1996).

Osim samih osobina sirovine, na stvaranje modificiranoga sastava atmosfere utječu i čimbenici koji ovise o svojstvima polimernog materijala (propusnost za plinove i vodenu paru, propusnost u funkciji relativne vlažnosti i temperature, površina filma i otpornost na vanjske utjecaje) i uvjetima atmosfere izvan pakovanja (brzina strujanja, temperatura i relativna vlažnost zraka). Vrlo bitan čimbenik koji utječe na sastav MA predstavlja i slobodan volumen unutar pakovanja. O utjecaju pakiranja voća i povrća u polimernu ambalažu koja omogućava modifikaciju inicijalne atmosfera pakovanja i/ili njenu kontrolu, na očuvanje kvalitete sirovine, napisan je veliki broj radova (Zagory i sur., 1988; Kader i sur., 1989; Rocha i sur., 2004). Autori tih radova potvrđuju već poznatu činjenicu da smanjena koncentracija O<sub>2</sub> i/ili povišena koncentracija CO<sub>2</sub> reduciraju brzinu respiracije i proizvodnju etilena, što odgađa dozrijevanje voća i povrća. Nasuprot tome, previsoke koncentracije CO<sub>2</sub> i preniske koncentracije O<sub>2</sub> mogu izazvati anaerobnu respiraciju sirovine koja dovodi do razgradnje tkiva, nakupljanja etanola i acetaldehida, razvoja neugodna mirisa i mikroorganizama štetnih za zdravlje potrošača. Zbog toga minimalni udjel O<sub>2</sub> u polimernoj ambalaži s voćem i povrćem ne bi smio biti manji od 2 do 3%. Pakiranje, osim navedenog, predstavlja prepreku gubitku vodene pare i pomaže održavanju visoke relativne vlažnosti zraka i turgora voća i povrća. Ako je relativna vlažnost zraka previsoka može pospješiti kondenzaciju vlage na sirovini i stvoriti uvjete za rast patogenih mikroorganizama. Međutim, ako je voće i povrće pakirano pojedinačno, tada u slučaju razvoja patogenih mikroorganizama kod jednog ploda neće doći do kontaminacije druge pakirne jedinice. To sprečavanje širenja bolesti je jedna od glavnih prednosti pojedinačno pakirane sirovine (Ben-Yehoshua, 1985).

Polazeći od toga, cilj ovog rada bio je utvrditi utjecaj skladištenja u MA koja se razvija pakiranjem u ambalažu od polimernih materijala različitog sastava i debljine filma (PE, PP i PET) na tvrdoću plodova jabuke. U radu su prikazani rezultati istraživanja promjene tvrdoće plodova jabuka tijekom 30 dana skladištenja u MA. Odabrane su tri različite sorte; "Idared" kao isključivo industrijska sorta te višenamjenske sorte "Granny Smith" i "Gloster".

### Materijali i metode

U pokusu su korišteni plodovi jabuka sorti "Idared", "Gloster" i "Granny Smith". Pokusi su provedeni u laboratoriju Zavoda za poljoprivrednu tehnologiju, skladištenje i transport. Nakon dopremanja u laboratorij plodovi su probрани te su za skladištenje odabrani oni bez vidljivih znakova oštećenja. Prije skladištenja ispitana je tvrdoća i za svaku pojedinu sortu (Tablica 1), a analize su ponovljene nakon 7, 15 i 30 dana skladištenja. Za pakiranje su korišteni polimerni filmovi niske gustoće različitog sastava i debljine filma (polietilen (PE), polipropilen (PP) i polietilentereftalat (PET)). Debljina filmova kretala se od 12 μm (PET),

20 µm (PP) do 45 µm (PE). Navedeni polimerni filmovi su nabavljeni od proizvođača "Aluflexpack d.o.o." Zadar. Plodovi su pojedinačno pakirani zamatanjem u navedene filmove izrezane na komade dimenzija 30 x 30 cm. Ovakav način pakiranja je odabran u cilju dobivanja što manjeg slobodnog prostora unutar pakovine. Nakon pakiranja u polimerne folije, jabuke su skladištene u hladnjači na temperaturi od + 4 °C. Tijekom vremena uslijed pasivne modifikacije u pakovanjima se ostvarila modificirana atmosfera. Osim zapakiranih jabuka, kao referentni uzorak skladišteni su i nezapakirani plodovi koji su bili izloženi normalnom sastavu atmosfere.

Tvrdoća plodova mjerena je ručnim penetrometrom Effegi, tip FT 327 sa skalom izraženom u kg (pri čemu 1 kg odgovara vrijednosti od 10 N) i cilindričnom sondom promjera 8 mm. U četiri točke na najvećem promjeru ploda mjerena je snaga potrebna sonde da probije meso ploda do 8 mm dubine pri konstantnoj brzini penetriranja. Penetrometrom je vršen pritisak na meso ploda gdje je odstranjena kožica debljine ≈2mm. Maksimalna vrijednost potrebna za penetraciju sonde u tkivo ploda očitana je na skali penetrometra (AOAC, 1995). Mjerenja tvrdoće su provedena u četiri repetitije na svakom plodu (jedan uzorak sadržavao je 3 ploda), a rezultati su prikazani kao srednja vrijednost dobivenih mjerenja (n=12).

### Rezultati i rasprava

Dobiveni rezultati ispitivanja tvrdoće plodova jabuka sorti "Idared", "Gloster" i "Granny Smith" skladištenih u MA, te u normalnoj atmosferi statistički su obrađeni i prikazani u tablici 1. Statističkom obradom podataka pokazalo se da postoje razlike između skladištenja u MA te skladištenja u normalnoj atmosferi. Za sve tri sorte jabuka skladištenih pri temperaturi od + 4°C primijećeno je smanjenje tvrdoće ploda bilo da su skladištene bez folije ili pakirane u polimerne folije. Tvrdoća plodova prije skladištenja bila je najveća za sortu "Granny Smith" i iznosila je prosječno  $83,67 \pm 3,31$ N, nešto manju tvrdoću plodova imali su plodovi sorti "Gloster" ( $63,00 \pm 7,36$  N) i "Idared" ( $43,67 \pm 9,02$  N).

Najveće promjene uočene su na sorti "Gloster" skladištenoj u normalnoj atmosferi gdje se tvrdoća s početne vrijednosti od 63,00 N s vremenom smanjila do konačnih 28,83 N. Iz podataka vidljivo je da je smanjenje tvrdoće plodova kroz 30 dana skladištenja iznosilo 54,3% što nam ukazuje da skladištenje u normalnoj atmosferi negativno utječe na održivost plodova ove sorte. Na plodovima skladištenim u polimernim filmovima najmanji pad tvrdoće zabilježen je na jabukama pakiranim u PP filmove (23,3%). Nešto veći pad zabilježen na jabukama pakiranim u PE (43,8%), i PET (51,6%) filmove.

Za sortu "Idared" tvrdoća ploda nakon 30 dana čuvanja u normalnoj atmosferi se smanjuje za 18,8% u odnosu na početnu vrijednost. Od uzoraka skladištenih u MA tvrdoća ploda se najmanje smanjila na jabukama pakiranim u PET filmove (8,5%) dok je nešto veće smanjenje tvrdoće u odnosu na početnu vrijednost zabilježeno na jabukama pakiranim u PP (8,9%), i PE (11,7%) filmove. Iz dobivenih rezultata vidljivo je da skladištenje industrijske sorte "Idared" u MA može pridonijeti očuvanju kvalitete plodova.

Rezultati ispitivanja tvrdoće dobiveni za sorte "Idared" i "Gloster" u skladu su sa istraživanjima drugih autora (Konopacka i Plocharski, 2004; Kader, 1989) koji su utvrdili da se u jabukama skladištenim u CA i MA odgađa njihovo dozrijevanje a samim time i mekšanje ploda.

Za sortu "Granny Smith" tvrdoća ploda nakon 30 dana čuvanja u PE filmovima se smanjuje za 16,8% u odnosu na početnu vrijednost. Nešto manje smanjenje tvrdoće u odnosu na početnu vrijednost zabilježeno je na jabukama pakiranim u PET filmove (14,5%) i skladištenih u normalnoj atmosferi (13,2%). Najmanje smanjenje tvrdoće ploda zabilježeno je na jabukama pakiranim u PP filmove (9,3%).

Tablica 1. Tvrdoća plodova tijekom skladištenja (N)

Kultivar	Gloster				Granny Smith				Idared			
	Bez folije	PE	PP	PET	Bez folije	PE	PP	PET	Bez folije	PE	PP	PET
Način skladištenja												
Svježi uzorak	63,00 ± 7,36	63,00 ± 7,36	63,00 ± 7,36	63,00 ± 7,36	83,67 ± 3,31	83,67 ± 3,31	83,67 ± 3,31	83,67 ± 3,31	43,67 ± 9,02	43,67 ± 9,02	43,67 ± 9,02	43,67 ± 9,02
Nakon 7 dana	34,25 ± 1,66	34,17 ± 1,95	35,50 ± 3,48	38,00 ± 3,10	81,33 ± 3,52	84,25 ± 3,19	84,75 ± 2,26	81,25 ± 1,76	35,00 ± 1,21	38,17 ± 1,64	39,83 ± 1,64	40,58 ± 2,27
Nakon 15 dana	35,00 ± 1,76	33,67 ± 1,83	40,92 ± 2,68	31,67 ± 1,72	76,33 ± 3,82	84,92 ± 2,64	86,08 ± 2,87	79,33 ± 3,87	34,75 ± 1,76	38,00 ± 1,18	40,92 ± 2,43	39,50 ± 1,73
Nakon 30 dana	28,83 ± 2,59	35,42 ± 2,27	48,25 ± 3,02	30,50 ± 2,07	75,75 ± 3,11	72,58 ± 3,70	79,17 ± 4,55	74,58 ± 3,34	35,50 ± 1,24	38,58 ± 1,56	39,83 ± 3,01	40,00 ± 2,66

\* Rezultati su prikazani kao srednja vrijednost 12 mjerenja ± standardna devijacija



## Zaključak

Pakiranjem jabuka sorti "Idared" i "Gloster" u odabrane polimerne filmove (PE, PP i PET) može se, zbog modifikacije sastava atmosfere unutar pakovanja, povećati njihova trajnost, tj. usporiti njihovo propadanje i smanjenje tvrdoće. Za sortu "Granny Smith" nisu primijećene veće razlike u smanjenju tvrdoće između plodova skladištenih u MA i normalnoj atmosferi. Do najvećih promjena tvrdoće ploda došlo je u plodovima sorti "Idared" i "Gloster" koji su skladišteni u normalnoj atmosferi. Dobiveni rezultati ukazuju da održivost ploda jabuke pri skladištenju na + 4 °C ovisi ne samo o karakteristikama sorte već uvelike i o uvjetima pakiranja i skladištenja.

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# Effect of chemical and hand thinning young apple tree on yield and fruit quality

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## Abstract

The aim of this study was to evaluate the effectiveness of two thinning agents in relation to hand thinning in reducing fruit set in 'Gala' and 'Granny Smith' young apple trees. The agents tested were NAA (two concentrations) and carbaryl. Chemical and hand thinning showed greater influence on reduction fruit set in cv. 'Granny Smith' than in cv. 'Gala'. Fruit thinning significantly increased the average fruit size, especially in cv. 'Granny Smith'. In cv. 'Gala', similar effect was only observed in treatment with higher concentration of NAA. Fruit thinning did not influence on other fruit quality parameters for both cultivars. A high return bloom was recorded in treatments with thinning fruit in comparison to unsprayed treatment. It was higher in cv. 'Granny Smith' than cv. 'Gala'

Key words: chemical thinning, hand thinning, 'Gala', 'Granny Smith'

## Introduction

Apple trees often form too many blossoms and set too many fruits to bear marketable crops year after year (Stopar, 2006). In fruit trees, the competition among fruits reduces their size if there is excessive fruit set (Dusi et al., 2006). Fruit thinning of apples (*Malus domestica* Borkh.) is an important cultural practice (Fallahi and Fallahi, 2004; Bound, 2006) that is used to prevent excessive fruit set, improve fruit quality and minimize biennial bearing (Janoudi and Flore, 2005). When apple orchard has been established by using feathered nursery tree excessive crop load can be obtained in first years. In young apple orchards thinning apple fruitlets can be done by hand, however that work is often impossible, especially in large areas, because of labor costs and the limited supply of available labor. Therefore, chemical thinning has to be carried out to ensure profitable apple production (Stopar, 2006). For a successful high density planting, cropping should not be too high in the first years. This is important in order to avoid biennial cropping, insufficient growth and having the allotted space filled in a timely manner (Wertheim et al., 2000). It is particular important for 'Gala' apples, that is difficult to thin properly because of its high fertility and extended bloom period (Costa et al., 2004).

The objective of this work was to evaluate possibility of reducing fruit set with two chemical thinners for the young apple tree cvs. 'Gala' and 'Granny Smith'. Secondly, this work aimed does different concentration of NAA offer alternatives in view of changing of Carbaryl as a thinning agent.

## Material and methods

This trial was conducted in the 2009 season on 3-year-old apple trees of cv. 'Brookfield Gala' and 4-year-old apple trees of cv. Granny Smith, both on M9 rootstock. The experimental plot was located in a commercial orchard in Bela Crkva ("Južni Banat" company) located in northeastern Serbia. Planting spacing was 3.3 m x 0.8 m (3.787 trees/ha). For each treatment, five replicates (with two different trees of homogenous size and fruit load per replicate) were selected in a completely randomized design. The treatments applied were the following:

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1. NAA: 7 mg L<sup>-1</sup> for both cultivars when the mean fruit diameter was 12 mm
2. NAA: 10 mg L<sup>-1</sup> for cultivar 'Granny Smith' when the mean fruit diameter was 12 mm
3. NAA: 14 mg L<sup>-1</sup> for cultivar 'Gala' when the mean fruit diameter was 12 mm
4. Carbaryl 500 mg L<sup>-1</sup> for both cultivars when the mean fruit diameter was 12 mm
5. Hand thinning after June drop for both cultivars
6. Control: Unsprayed

The spray volume applied was 800 L ha<sup>-1</sup>. Fruit was harvested in August for cultivar 'Gala' and in September for cultivar 'Granny Smith'. Number and weight of fruit recorded for each tree. Fruit was graded by size into four groups. Samples of 10 randomly selected fruit from each replicate were examined for diameter of fruit, fruit firmness, soluble solids content and total acidity. Fruit diameters were measured using callipers. Fruit flesh firmness was measured with a penetrometer using a tip with a diameter of 11 mm. Juice expressed from the apples during the firmness measurements was collected and soluble solids concentration assessed with an Atago PR-1 digital refractometer. The return bloom was estimated next year at full bloom with the scale 1 - 10 (1 = no flowers, 10 = abundant flowering). Data were analyzed using analysis of variance. Mean separation was done by Tukey's HSD test at 1% and 5% level of significance.

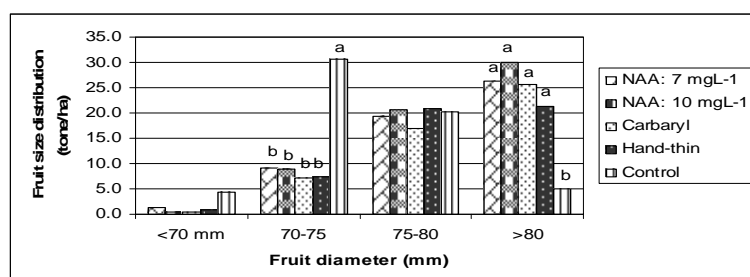
### Results and discussion

Chemical and hand thinning expressed significant influence on decreasing of total fruit number per tree in cv. 'Granny Smith' (table 1). However, lower number of fruit per tree did not affect lower total yield per tree, i.e. per hectare. Both chemical and hand thinning were significantly increased the share of fruits with diameter above 75 mm in total yield. On unsprayed apple trees, the largest amounts of fruits were observed in the class with diameters ranged from 70 to 75 mm, whereas all other treatments had the largest amounts of fruits in class above 80 mm (fig.1). There were not significant differences among the treatments in two other fruit classes. Our results are in agreement with finding of Fallahi and Fallahi (2004).

**Table 1. The effect of chemical and hand thinning on productivity of apple cv. 'Granny Smith'**

Treatment	Fruit (no. tree <sup>-1</sup> )	Yield (kg tree <sup>-1</sup> )	Yield (t hectare <sup>-1</sup> )	Fruit > 75mm diameter (%)	Bloom index <sup>a</sup>
NAA: 7 mg L <sup>-1</sup>	76.8ab	14.9	56.3	79.7a	9.4a
NAA: 10 mg L <sup>-1</sup>	79.4ab	15.9	60.4	84.5a	9.3a
Carbaryl	66.6b	13.3	50.3	85.4a	9.0a
Hand-thin	71.0b	13.3	50.3	83.5a	7.3b
Control	99.1a	15.9	60.4	42.4b	4.2c
	**	ns	ns	**	**

\* =  $P < 0.05$ ; \*\* =  $P < 0.01$  according to Tukey's test. <sup>a</sup> Scale: 0 = no flowers to 10 = abundant flowering.



**Fig. 1. Effect of chemical and hand thinning on fruit size distribution in 'Granny Smith'**

Size classes represent fruit diameters of: < 70, 70-75, 75-80 and > 80 mm. Different letters above column represent statistically significance at 5% level by Tukey's HSD test.

In general, fruit thinning expressed a positive influence on both fruit weight and fruit diameter (table 2). Obtained values were significantly lower in control treatment in comparison to other treatments. The highest fruit firmness was recorded on trees which were subjected to Carbaryl treatment, whereas the lowest one was obtained under NAA (7 mg L<sup>-1</sup>) treatment. Fruit thinning did not influence other fruit quality parameters of 'Granny Smith'.

**Table 2. The effect of chemical and hand thinning on apple fruit quality of cv. ‘Granny Smith’**

Treatment	Fruit quality parameters					
	Weight (g)	Diameter (mm)	Firmness (kg cm <sup>-2</sup> )	Iodine starch index (1-5)	Soluble solids (Brix°)	Total acid (%)
NAA: 7 mg L <sup>-1</sup>	190.4a	77.8a	8.4b	2.2	11.1	0.51
NAA: 10 mg L <sup>-1</sup>	201.5a	78.8a	8.8ab	1.9	10.5	0.53
Carbaryl	202.6a	78.9a	9.5a	2.1	11.0	0.49
Hand-thin	193.9a	78.3a	9.0ab	2.2	10.3	0.51
Control	166.7b	74.2b	9.3ab	2.1	10.6	0.47
	**	**	**	ns	ns	ns

\* =  $P < 0.05$ ; \*\* =  $P < 0.01$  according to Tukey’s test

Apple trees of cv. ‘Gala’, which were subjected to both chemical and hand fruit thinning, showed lower fruit number per tree compare to the control trees, but no significant differences were observed (table 3). Consequently, significant differences between yield per tree as well as yield per hectare were not recorded. It has to be taken into account that ‘Gala’ is considered as a hard to thin cultivar, which is probably the reason for such insignificant thinning (Stopar et al., 2010).

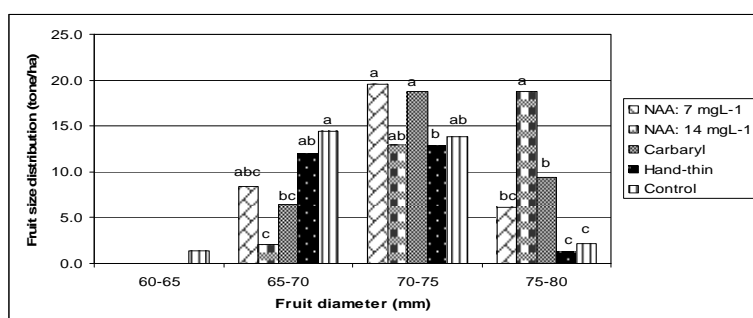
Return bloom index showed higher values in all thinning treatments than those obtained in control treatment.

The very high amount of fruit with diameter above 75 mm was obtained under treatment with 14 mg L<sup>-1</sup> NAA (94.1%) (Fig. 2).

**Table 3. The effect of chemical and hand thinning on productivity of apple cv. ‘Gala’**

Treatment	Fruit (no. tree <sup>-1</sup> )	Yield (kg tree <sup>-1</sup> )	Yield (t hectare <sup>-1</sup> )	Fruit > 70mm diameter (%)	Bloom index <sup>a</sup>
NAA: 7 mg L <sup>-1</sup>	56.6	8.7	33.1	75.7ab	4.7a
NAA: 14 mg L <sup>-1</sup>	49.2	8.6	32.7	94.1a	5.2a
Carbaryl	55.8	8.9	33.6	82.5a	4.9a
Hand-thin	46.6	6.7	25.3	54.8b	4.9a
Control	59.9	8.1	30.8	50.6b	1.7b
	ns	ns	ns	**	*

\* =  $P < 0.05$ ; \*\* =  $P < 0.01$  according to Tukey’s test. <sup>a</sup> Scale: 0 = no flowers to 10 = abundant flowering.



**Fig. 2. Effect of chemical and hand thinning on fruit size distribution in ‘Gala’**

Size classes represent fruit diameters of: < 65, 65-70, 70-75, and >75 mm. Different letters above column represent statistically significance at 5% level by Tukey’s HSD test

Concerning the fruit weight values obtained for cv. ‘Gala’, unsprayed treatment showed lower value (137 g) in comparison to chemical treatments with NAA (14 mgL<sup>-1</sup>) and Carbaryl (177 g and 161 g, respectively). Stopar (1999) reported that NAA applied in cv. ‘Gala’ with concentration of 15 ppm increased mean fruit size. However, other fruit quality parameters studied in this work was not differed depending on the thinning treatment.

Table 4. The effect of chemical and hand thinning on apple fruit quality of cv. 'Gala'

Treatment	Fruit quality parameters					
	Weight (g)	Diameter (mm)	Firmness (kg cm <sup>-2</sup> )	Iodine starch index (1-5)	Soluble solids (Brix°)	Total acid (%)
NAA: 7 mg L <sup>-1</sup>	156abc	73.0ab	8.0	3.6	12.3	0.15
NAA: 14 mg L <sup>-1</sup>	177a	74.7a	7.7	3.7	12.4	0.17
Carbaryl	161ab	72.7ab	8.0	3.6	12.5	0.17
Hand-thin	145bc	72.6ab	8.1	3.6	12.3	0.16
Control	137c	70.4b	8.3	3.4	11.7	0.15
	**	*	ns	ns	ns	ns

\* =  $P < 0.05$ ; \*\* =  $P < 0.01$  according to Tukey's test

### Conclusions

Chemical and hand thinning showed greater influence on reduction fruit set in cv. 'Granny Smith' than in cv. 'Gala'. Fruit thinning significantly increased the average fruit size, especially in cv. 'Granny Smith'. In cv. 'Gala', similar effect was only observed in treatment with higher concentration of NAA. A high return bloom was recorded in treatments with thinning fruit in comparison to unsprayed treatment. It was higher in cv. 'Granny Smith' than cv. 'Gala'. Taking into account the achieved results, with chemical thinning should start as soon as possible because of that early application does not harm precocity. NAA completely can replace carbaryl as chemical thinning agent in young apple orchard, due to its utilization is prohibited in many EU countries.

### Acknowledgements

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# Pomological and chemical characteristics of pomegranate cultivars (*Punica granatum* L.) in the valley of the river Neretva

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## Abstract

Pomegranate (*Punica granatum* L.) in Croatia is grown on its southern coastal area. Main production is concentrated in the area of the river Neretva. In this study pomological and chemical characterization of nine cultivars of pomegranate grown in Metkovic (Bokežan, Barski slatki, Ciparski rani, Crveni rani, Dividiš, Kristal, Konjski zub, Sladun and Šerbetaš) was done. The following characteristics of the fruit were determined: fruit weight, length, width and shape, color of the skin, arils and juice, aril weight, aril and juice yield, dry matter content, total titratable acids (citric acid eq.) and pH value. The results showed significant differences between cultivars in all analysed parameters.

Key words: arils, fruit color, fruit weight, soluble solids, total acidity

## Introduction

Pomegranate (*Punica granatum* L.) belongs to the family Punicaceae. With olive and fig, it is one of the oldest cultivated sub-tropical fruit species in our region. In Croatia, pomegranate has been traditionally grown in central and southern Dalmatia, mainly in small orchards and gardens. The potential for growing is not sufficiently exploited, and plantation establishment and production is unplanned.

Pomegranate is fruit tree of a moderate request, and it provides regular and high income. For centuries, all parts of the tree (leaves, flowers, and roots) are used for medical purposes (Godwa et al., 2009). Consumption of pomegranate fruit in the world is increasing very fast, because of its health benefits. The fruit is consumed as juice or as raw arils. The arils are, rich in sugar, vitamins, minerals, and polyphenols. Recent studies suggest that pomegranate juice contains anticancer, antimicrobial, and antiviral components (Schwartz et al., 2009; Reddy et al., 2007; Kotwal, 2007). About 52% of the total fruit weight is comprised of arils, while the arils themselves. They are composed of 80% of juice and 20% seed. Studies have demonstrated that the arils have significant antioxidant activity (Kulkarni et al, 2004).

Fruit maturity is estimated by the outer skin color, juice color, and juice acidity (Al -Said et al., 2009), all of which vary by cultivar. Pomegranate fruits can be harvested when they reach a suitable size and color of skin achieves the desired pigment. The main parameters of maturity are TSS (total soluble solids), TA (total acids) and TSS/TA ratio (Pekmezci and Erkan <http://www.ba.ars.usda.gov/hb66/113pomegranate.pdf>).

The aim of this study was to collect and characterize the pomegranate cultivars grown in the valley of river Neretva (Metković) and to determine similarities and differences between them.

## Material and methods

The study was conducted in the river Neretva (Metković) valley. A survey of the growing area was made in the fall of the 2009 and fruit samples of cultivars Bokežan, Barski slatki, Ciparski rani, Crveni rani, Dividiš, Kristal, Konjski zub, Sladun and Šerbetaš were collected. Experiment was conducted in three replicates for each cultivar, while each replicate presented three pomegranate fruits. For each of the studied cultivars, fruit weight (g) using a laboratory scale, width and height of the fruit (mm) and skin thickness (mm) were determined using digital calipers. The shape of the fruit was determined by the ratio of fruit width and height. Aril yield (%) was determined as the ratio between fruit weight and aril weight, and juice yield (%) was determined as the ratio of 50 g of arils and milliliters of juice obtained from those arils after pressing. The fruit basic skin color, percentage of red color, and the presence of other colors was determined by subjective evaluation. Color of arils and color of juice was determined based on the coloration scale from the cream color to the red black color. Dry matter content (%) was determined by refractometer, and total acid content (expressed as% citric acid) was acquired by the titration method using 0.1M NaOH (AOAC, 2000). The data obtained were analyzed using analysis of variance using the STATVIEW software package (SAS Institute Version 5.0). Differences between mean values were tested with LSD test at a significance level of  $P \leq 0.05$ .

## Results and discussion

Significant differences in the pomological characteristics of studied cultivars were found (Table 1). Cultivars Bokežan (594 g) and Dividiš (585 g) had the highest fruit weight and cv. Konjski zub (288 g) and Ciparski rani (321 g) had the smallest fruit weight compared to other cultivars. All were found to be round in shape (Table 1). According to Barone et al., (2001) cv. Denti di cavalli (Konjski zub) on Sicilia achieved a weight of 392 g and aril yield of 61%. Cultivar Kristal had the thinnest skin (2.9 mm) compared to all others studied, with the exception of Šerbetaš (3.6mm). Pekmezci and Erkan cit. Küpper,(1995) state that pomegranate fruit skin thickness varies from 1.5mm to 4.25mm.

According to Turkish standards for pomegranate fruit packaging and marketing, fruits are classified into 4 groups: small (150-200 g), medium (201-300 g), large (301-400 g) and very large (401-500g) (Pekmenzci and Erkan, 2004).

The number of arils per fruit ranged from 273 in cv. Konjski zub to 693 in cv. Crveni rani. Weight of 100 arils was significantly higher in cv. Kristal (80.9 g) compared to other studied cultivars, while the cv. Šerbetaš (31.9 g) had lowest determined 100-count aril weight (Table 1). Cultivars Barski slatki, Ciparski rani, Crveni rani, Konjski zub, Sladun and Šerbetaš had higher aril yield compared to Bokežan and Dividiš (Table 1). Juice yield in the cv. Konjski zub (76.2%) was higher than in cvs. Bokežan, Ciparski rani, Crveni rani, Kristal and Sladun.

The basic skin color of studied cultivars was yellow to green (Table 2).

All cultivars except cv. Kristal have a certain percentage of red skin color, which overflows through the primary color (Table 2). The most apparent red color of all cultivars was determined on the sunlight side of the fruit while the side which is located in the shade was mainly green or yellow. Cultivars Barski slatki, Ciparski rani and Šerbetaš belong to a group of cultivars with dark red arils and dark red to red juice. Lightest color of arils and juice (cream to light pink) was observed in cv. Dividiš.

The quality of the cultivar is defined by different parameters that give an overall picture of cultivar. Pomegranate fruit can be harvested when they reach the typical size and skin color specific for that cultivar. The main parameters for the determination of harvest maturity are TSS (total soluble solids), TA (total acids) and the TSS/TA ratio.

Cultivar Bokežan (16%) had the highest determined content of TSS and cvs. Dividiš (13.1%) and Konjski zub (12.5%) had lowest content (Table 3). Total soluble solids at harvest ranged from 8.3-20% (Küpper, 1995). The cultivar Wonderful, under Israeli conditions, obtained TSS from 11% - 16% (Barone cit. Ben-Arie et al., 1984). The content of total acids (citric acid equivalents) was the highest in cv. Bokežan (1.52%) and the lowest in cv. Kristal (0.72%). According to Küpper (1995) TA ranges from 0.13% to 4.98%. Cultivars with TA < 1% belong to the group of sweet, 1-2% are sweet-sour and > 2% are in the group of acid cultivars (Onur and Kaska, 1985). The TSS/TA ratio depended on the cultivar. Cultivars Ciparski rani, Crveni rani, Kristal, Konjski zub, and Sladun had higher TSS/TA ratio than cultivar Bokežan, resulting in a sweeter fruit to taste.

The highest pH value was determined in cv. Kristal (4.03) and lowest in cv. Bokežan (3.10) and Dividiš (3.16).

**Table 1. Pomological characteristics of nine pomegranate cultivars grown in the valley of the river Neretva**

Cultivar	Fruit weight (g)	Fruit width (mm)	Fruit height (mm)	Fruit width/height ratio	Fruit shape	Skin thickness (mm)	Number of aril per fruit	Weight of 100 arils (g)	Aril yield (%)	Juice yield (%)
Bokežan	594a	99.5a	87.9a	1.13	rounded	4.7c	692a	44.2e	50.3b	64.7d
Barski slatki	419c	86.3bc	78.8c	1.10	rounded	4.3bc	621ab	41.3e	59.8a	74.6ab
Ciparski rani	321e	80.3cd	73.8d	1.10	rounded	4.6bc	532bc	38.6e	61.1a	68.7cd
Crveni rani	506b	90.8b	87.7a	1.00	rounded	4.5bc	693a	41.4e	58.3a	70.0cd
Dividiš	585a	96.7a	87.7a	1.11	rounded	4.7c	430cd	72.3b	52.1b	74.7ab
Kristal	422c	91.0b	80.2b	1.14	rounded	2.9a	369d	80.9a	54.0ab	67.3cd
Konjski zub	288e	76.1e	71.4d	1.10	rounded	4.4bc	273d	63.3c	57.9a	76.2a
Sladun	328d	79.9d	70.8d	1.13	rounded	3.8b	351d	54.4d	58.4a	70.4bcd
Šerbetaš	343d	80.4cd	75.0cd	1.10	rounded	3.6ab	669a	31.9f	60.4a	71.6abc

<sup>1</sup> Different letters within column indicate significant differences among cultivars according to LSD test ( $P \leq 0.05$ )

**Table 2. Skin, aril and juice color of nine pomegranate cultivars grown in the valley of the river Neretva**

Cultivar	Skin color		Aril color	Juice color
	Basic	% red		
Bokežan	yellow	80	bright red	pink
Barski slatki	yellow-green	40	dark red	dark red
Ciparski rani	yellow	70-80	dark red	red
Crveni rani	yellow	80-90	red	red
Dividiš	yellow	30	creamy-bright pink	creamy-bright pink
Kristal	green	0	pink	pink
Konjski zub	green	20	pink	pink
Sladun	bright yellow	70	red	pink
Šerbetaš	green	20	dark red	dark red

<sup>1</sup> Different letters within column indicate significant differences among cultivars according to LSD test ( $P \leq 0.05$ )

**Table 3. Total soluble solids (TSS), total acids (TA), TSS/TA ratio and pH of juice of nine pomegranate cultivars grown in the valley of river Neretva**

Cultivar	TSS (%)	TA (%)	TSS/ TA ratio	pH
Bokežan	16.0a1	1.52a	10.6b	3.10f
Barski slatki	15.0b	0.59c	25.6ab	3.50e
Ciparski rani	13.9d	0.29de	34.3a	3.59d
Crveni rani	14.2cd	0.23de	33.1a	3.72c
Dividiš	13.1e	1.14b	23.7ab	3.16f
Kristal	14.8bc	0.72f	40.0a	4.03a
Konjski zub	12.5e	0.37d	33.9a	3.81b
Sladun	13.9d	0.20e	32.3a	3.75bc
Šerbetaš	14.5bcd	0.46cd	31.8ab	3.80bc

<sup>1</sup> Different letters within column indicate significant differences among cultivars according to LSD test ( $P \leq 0.05$ )

## Conclusion

Significant differences in pomological and chemical characteristics were found among pomegranate cultivars grown in the valley of the river Neretva. The pomegranate fruits were medium to very large in size. Cultivar Konjski zub had medium fruit, cultivars Ciparski rani, Sladun, and Šerbetaš had large fruit, while cultivars Bokežan, Barski slatki, Crveni rani, Dividiš and Kristal had very large fruit. Cultivars Bokežan and Dividiš belong to the group of sweet-sour and other studied cultivars to the group of the sweet cultivars.



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# The effect of altitude and latitude on the phenology of the plum cv. Požegača in Serbia

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## Abstract

Several phenological stages of the plum cv. Požegača at 60 locations in Serbia in a 35- year period were examined: leaf unfolding, beginning of flowering, full flowering, harvest and general leaf colouring. All examined phenophases, except general leaf colouring, are strongly influenced by altitude, while the latitude has a significant influence on flowering phenophases and harvest. These climatic controls also affect an interrelation of phenophases onset. A difference between the mean dates of general leaf colouring and harvest gets smaller with increased altitude and latitude. Požegača generally flowers before leafing at lower elevation, while at higher locations the beginning of flowering could be more than 15 days after leaf unfolding.

Key words: plum, Požegača, phenology, altitude, latitude

## Introduction

Many phenological studies of larger regions confirm that the latitude, altitude and the degree of oceanity - continentality are important to the timing of plant phenophases (Menzel, 1997; Roetzer and Chmielewski, 2001). The responses of species to existing climate gradients along altitudinal and latitudinal gradients can be used to predict the likely effects of future climate change.

The altitude in Serbia is the most influential control of thermal conditions which regulate phenological dynamics to a great extent. According to Mišić (1994), temperature decreases by 0.5-0.6°C for every 100 m increase in altitude. Vulić (1998) reported that decrease of temperature with altitude in Serbia is not the same at all latitudes. Between 44 and 45°N is 0.5°C/100m, while between 42 and 43°N varies from 0.3 to 0.4°C/100m.

This work has aimed at determining the effect of altitude and latitude on the phenology of the plum cv. Požegača in Serbia. Plum (*Prunus domestica* L.) is still, according to its participation in total fruit production, among most important fruits in Serbia, despite the decline of total tree number in last few decades, aggravation of age tree structure, unfavourable assortment, poor health condition caused by virus Sharka (Plum Pox) and smaller price competitiveness comparing to other fruit species. Požegača has been chosen for analysis, because it is the only plum cultivar which has a representative data set (long enough for sufficient number of stations). Since, there is no data for other varieties of this fruit, spatial distribution of cv. Požegača may serve as indicator of regional influence on phenology of other varieties as well.

## Materials and methods

The phenological data were collected within phenological network organized by Republic Hydrometeorological Service of Serbia. Records were taken at 60 locations throughout the state representing an altitude range from 39 m to 1030 m and a latitude range from 42° 14' to 46° 06' N. Data were available for the 35 years from 1961 to 1995.

Following phenological events were considered: leaf unfolding, beginning of flowering, full flowering, harvest and general leaf colouring. Growing period is defined in a narrower sense as active period of photosynthesis, as it was done, for example, by Menzel (2003) in her studies. This period begins with leaf unfolding and ends with general leaf colouring.

Since in Serbia the higher mountains are mostly in the southern part of the country and there is a correlation between the altitude and latitude of the examined locations ( $r=-0.64$ ,  $p<0.001$ ), we used partial correlations to examine the relationship between the phenological events and geographical location of observation sites. The partial correlation is a measure of the linear dependency between two variables, where the influence of a third variable is eliminated. Multiple regression equations for all examined phenophases were determined to enable estimation of joint importance of the latitude and altitude on plum phenological dynamics.

## Results and discussion

Partial correlation of different phenological phases with altitude and latitude is given in Table 1. The values of Pearson correlation coefficient are given in parenthesis in order to illustrate how the correlation results of two variables could be clouded because they are both related to a third variable in cases when simple correlation is used.

**Table 1. Partial and simple correlation coefficients (in parenthesis) between the onset time of different phenophases of the plum cv. Požegača and altitude and latitude**

	Leaf unfolding	Beginning of flowering	Full flowering	Harvest	Leaf colouring	Development period	Diff
Altitude	0.68*** (0.71***)	0.88*** (0.86***)	0.89*** (0.87***)	0.79*** (0.79***)	-0.11 n.s. (-0.02 n.s)	-0.47*** (-0.41***)	-0.60*** (-0.56***)
Latitude	0.20 n.s. (-0.34**)	0.51*** (-0.35**)	0.48*** (-0.38**)	0.34** (-0.35**)	-0.19 n.s. (-0.16 n.s)	0.26* (0.08 n.s)	-0.31** (0.16 n.s)

Diff - difference between the mean date of general leaf colouring and harvest

\*  $P<0.05$

\*\*  $P<0.01$

\*\*\*  $P<0.001$

n.s. Non significant

Altitude is better correlated with phenological timing than latitude. The effect of intercorrelations among selected variables is more pronounced in case of latitude. The partial and simple correlation coefficients even have an opposite signs as a consequence of the stronger influence of altitude than latitude and negative correlation between them. Compared to spring phenophases and harvesting, correlation between the mean date of general leaf colouring and geographical location was much weaker. The same findings about influence of thermal conditions on the spring and autumn phenological events were reported by other authors (Walther et al., 2002; Chmielewski et al., 2004.). Also, result that flowering appears to be more sensitive to geographical location than leaf unfolding agrees with results of other studies dealing with influence of air temperature on these spring phenophases (Chmielewski and Rotzer, 2001; Črepinšek et al, 2006).

Regression equations with day of the year (for phenological stage onset) or number of days (for growing period length) as the dependent variables ( $y$ ) and altitude ( $x_1$ ) and latitude ( $x_2$ ) as the independent variables are as follows:

- $y = 0.0185 x_1 + 1.002 x_2 + 55.99$  ( $R^2 = 0.52$ ) for leaf unfolding;
  - $y = 0.0270 x_1 + 2.038 x_2 + 8.29$  ( $R^2 = 0.81$ ) for beginning of flowering;
  - $y = 0.0292 x_1 + 1.995 x_2 + 13.91$  ( $R^2 = 0.82$ ) for full flowering;
  - $y = 0.0348 x_1 + 2.345 x_2 + 134.99$  ( $R^2 = 0.67$ ) for harvest;
  - $y = -0.0224 x_1 - 2.723 x_2 + 308.96$  ( $R^2 = 0.22$ ) for length of the growing period;
- where  $R^2$  is the coefficient of determination.

The regression equation for general leaf colouring is not presented, because the correlation analysis showed weak correlation with altitude and latitude. According to given regression equations, leaf unfolding is delayed by 1 day per degree of latitude and by nearly 2 days per 100 m of altitude, flowering by 2 days per degree of latitude and by nearly 3 days per 100 m of altitude. These results are close to those obtained by Menzel (1997), who analyzing European phenological data found that early phenophases were delayed by

2.5-3 days per degree of latitude and 2-4 days per 100 m of increased elevation. When harvest is considered, our data show 2.3-day delay per degree of latitude and 4.5-day delay per 100 m of altitude. Length of the growing period is shortened by 2.7 days for each degree of latitude and 2.2 for each 100 m of increased elevation.

As it can be seen from Table 1, the number of days between general leaf colouring and harvest decreases with altitude. Using the relationship between the difference in the mean dates of these phenophases and altitude (Fig.1), theoretical elevation, where these two phenological events overlap, could be estimated. According to our data, this elevation line lies around 1200 m for the plum cv. Požegača in climatic condition of Serbia.

Another interesting result that we came up with was that Požegača generally flowers before leafing at lower elevation, while at higher locations the beginning of flowering could be more than 15 days after leaf unfolding. According to regression equations for these two phenological stages (Fig. 2), estimated elevation at which the alternation occurs is 500 m.

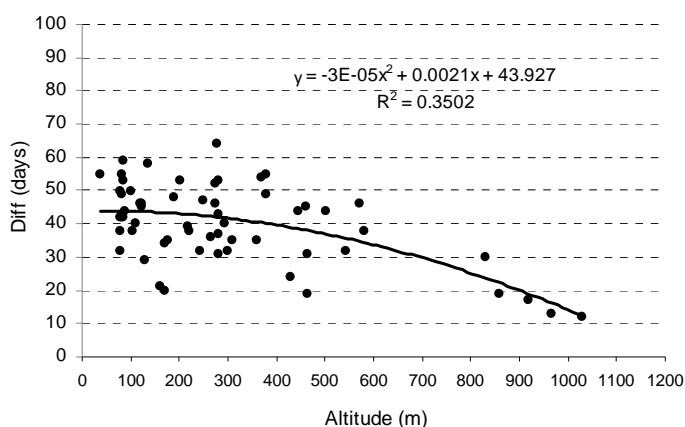


Figure 1. Difference between the mean date of general leaf colouring and harvest (Diff) of the plum cv. Požegača as a function of altitude

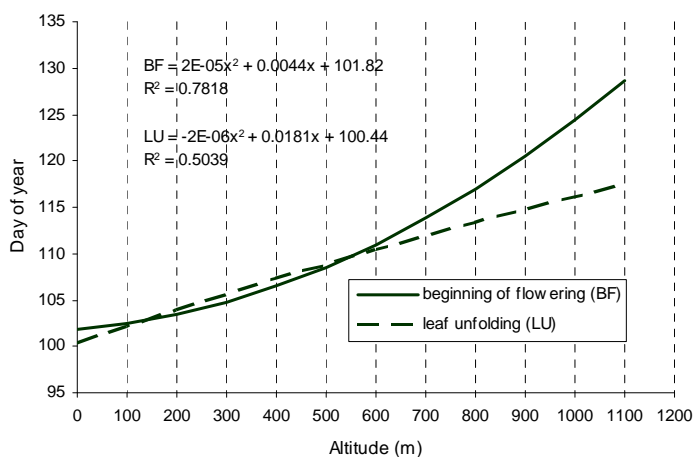


Figure 2. Relationships between the beginning of flowering and leaf unfolding of the plum cv. Požegača and altitude

### Conclusion

Our analysis of 60 sites in Serbia demonstrates that phenology of Požegača is strongly influenced by altitude and to a lesser extent by latitude. The only phenological stage that does not show significant correlation with altitude is general leaf colouring. A delay in the developmental rate and shortening of development period was found in partial correlations with altitude and latitude. The synchronization of phenological events is also affected by geographical location. The mean dates of harvesting and leaf colouring get closer with increased altitude and latitude. In the case of leaf unfolding and beginning of flowering even inversion of phenological timing occurs with increased altitude.

The results obtained from this work should provide better understanding of plum phenology, which could be very useful for improving plum cultivation in the studied region. Also, they can be helpful in estimation of possible global warming impact on plum growing in climate change studies.

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# Utjecaj sorte i primjene sredstava za zaštitu bilja na kakvoću ploda kupine (*Rubus spp.*)

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## Sažetak

Istraživana je kakvoća plodova kupina Dirksen Thornless i Thornfree iz nasada u kojima se primjenjivala i u kojima se nisu primjenjivala zaštitna sredstva. Veća je masa i topljiva suha tvar ploda kupina zabilježena u nasadima u kojima su se primjenjivala zaštitna sredstva. Plodovi sorte Dirksen Thornless imali su veću masu. Plodovi sorte Thornfree imali su veći sadržaj topljive suhe tvari u nasadu u kojima se primjenjivala zaštitna sredstva.

Ključne riječi: sorta kupina, primjena zaštitnih sredstava

## Influence of cultivars and application of pesticides on quality of blackberry fruits (*Rubus spp.*)

### Abstract

The primary objective of this research was to determine the effects of application of pesticide on blackberry fruit characteristics. The well known blackberry cultivars, Dirksen Thornless and Thornfree were used as materials. Fruit weight and soluble solid contents of fruits were higher when they picked from pesticide treated orchards. Fruits of cultivar Dirksen Thornless had higher fruit weight value while Thornfree had higher amount of soluble solid content, in particular in treated with pesticides.

Key words: blackberry, *Rubus*, total soluble solid

### Uvod

Kupina (*Rubus spp.*) je biljka iz porodice *Rosaceae*. Ljudi konzumiraju plod kupine u svježem stanju, iako se plod kupine može prerađivati u različite prerađevine kao što su sokovi, vina, džemovi, pekmezi i slično.

U svijetu je potražnja za ovom voćnom vrstom u velikom porastu, posebno zbog toga što je izuzetno bogato prirodnim antioksidativnim spojevima. Ekstrakti plodova ovog voća su poznati inhibitori slobodnih radikala (Heinonen, i sur., 1998; Wang i Lin, 2000).

U zadnje vrijeme javlja se trend uzgoja kupine u uvjetima ekološke proizvodnje, tj. bez primjene zaštitnih sredstava od bolesti, štetnika i korova (Toldam-Andersen, 2009).

Istraživanja su pokazala da genotip ima veliki utjecaj na sadržaj bioaktivnih komponenti u jagodastom voću (Anttonen i Karjalainen, 2005).

U ovom istraživanju korištene su sorte koje se uzgajaju u Republici Hrvatskoj, s ciljem da se ustanovi utjecaj sorte i primjene zaštitnih sredstava na morfološka i kemijska svojstva ploda kupine.

### Materijal i metode

Plodovi kupine su brani u nasadima koji se nalaze na području Požege. Istraživane su dvije sorte: Dirksen Thornless i Thornfree. Berba plodova kupina obavljena je u dva nasada kupina, koji nisu navodnjavani. U jednom nasadu su se primjenjivala zaštitna sredstva, a drugom nasadu se nisu primjenjivala zaštitna sredstva. Plodovi su ubrani u tehnološkoj zrelosti u tri navrata, a u svakoj repeticiji bilo je 100 plodova. Pokus je obavljen 2008. godine.

Svakom plodu kupine je izmjerena masa i količina topljive suhe tvari. Masa je mjerena digitalnom vagom s osjetljivošću 0,001 g, a topljiva suha tvar ručnim refraktometrom (% topljive suhe tvari). Od dobivenog soka plodova kupine po svakom uzorku određena je ukupna kiselost titracijom sa 0,75 M NaOH. Plodovima je određena specifična težina soka piknometrijski.

Dobiveni podaci mase i količina topljive suhe tvari su analizirani analizom varijance (ANOVA) i t testom.

### Rezultati i rasprava

Iz tablice 1 može se uočiti da postoji signifikantna razlika u masi (g) između plodova kupine nasada u kojem su primjenjena i u kojem nisu primjenjena zaštitna sredstva, neovisno o sorti. Veća masa plodova kupine zabilježena je u nasadu u kojem su primjenjena zaštitna sredstva. Signifikantna razlika je u količini topljive suhe tvari koja je bila veća u plodovima ubranim u nasadu s primjenom zaštitnih sredstava. Specifična težina bila je veća kod plodova ubranim u nasadu gdje su primjenjena sredstva zaštite. Također i kiselina je veća u nasadu u kojem su primjenjivana zaštitna sredstva.

Tablica 1. Razlike plodova kupine ovisno o uporabi kemijske zaštite od bolesti i štetnika

	Masa ploda (g)	Topljiva suha tvar (%)	Ukupna kiselina (g/l)	Specifična težina
Primjenjena zaštitna sredstva	4,50 a	9,311 a	13,25 ns	1,04765 ns
Bez primjene zaštitna sredstva	3,63 b	7,692 b	11,8 ns	1,03818 ns

Tablica 2. Razlika ploda kupine ovisno o sorti i primjeni zaštitnih sredstava

	Masa ploda (g)	Topljiva suha tvar (%)	Ukupna kiselina (g/l)	Specifična težina
Dirksen Thornless, primijenjena zaštitna sredstva	5,39 a	7,65 b	12,4 ns	1,0389 b
Dirksen Thornless, bez primijene zaštitnih sredstava	4,77 b	7,52 b	12,6 ns	1,0352 b
Thornfree, primijenjena zaštitna sredstva	3,61 c	10,97 a	14,1 ns	1,0564 a
Thornfree, bez primijene zaštitnih sredstava	2,48 d	7,86 b	11,0 ns	1,0412 b
LSD 5%	0,19	0,22	5,8	0,0114
LSD 1%	0,25	0,29	13,7	0,0263

Iz tablice 2 može se vidjeti signifikantna razlika u masi ploda kupine između sorti, ali i nasada u kojima se nisu primjenjivala zaštitna sredstva.

Plodovi sorti Dirksen Thornless i Thornfree imali su veću masu u nasadu gdje su se primjenjivala zaštitna sredstva. Također plodovi sorte Dirksen Thornless imali su veću masu ploda od sorte Thornfree što je u skladu sa literaturnim izvorima (Eyduran i sur, 2008).

Signifikantna razlika u topljivoj suhoj tvari zabilježena je kod sorte Thornfree, veća vrijednost bila je kod plodova iz nasada u kojem su primjenjivana zaštitna sredstva. Plodovi sorte Dirksen Thornless iz nasada u kojem se i nije primjenjivala zaštitna sredstva i sorte Thornfree iz nasada u kojem se nije primjenjivala zaštitna sredstva imaju manju topljivu suhu tvar.

Nema signifikantne razlike kod određivanja kiselina (g/l).

Signifikantna razlika je kod specifična težina bila je veća kod plodova sorte Thornfree koji su ubrani u nasadu u kojem se primjenjivala zaštitna sredstva.

Prema podacima iz Srbije prema Miletić i sur, 2006 masa sorte Thornfree je 5,0 g, a topljiva suha tvar 10,15% i kiselina 2,82%. Prema literaturnim izvorima u Estoniji je masa ploda kupine 1,0 do 3,6 g, a titracijska kiselina 8,4 do 18% (Kadri, 2009). Prema podacima iz Turske masa ploda kupine se kretala 1,2 do 5,4 g, a topljiva suha tvar od 8,6 do 14,1 (Toldam-Andersen, 2009).

## Zaključak

Plodovi kupine iz nasada u kojima je provedena primjena zaštitnih sredstava imali su veću masu i topljivu suhu tvar. Sorta Dirksen Thornless imala je plodove veće mase, ali manje topljive suhe tvari od sorte Thornfree. Plodovi kupine sorte Dirksen Thornless imali su veću masu iz nasada u kojima je provedena zaštitna, a kod sorte Thornfree veću količinu topljive suhe tvari iz nasada u kojima su primjenjena zaštitna sredstva.

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# The possibility of autonomous detection of tree position with GPS for the need of early apple yield forecast

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## Abstract

The accuracy of different GPS devices for precise sampling of trees needed for early yield forecast was studied in two years campaign. The precise positioning is fundamental for the comparison of yields between different years. In our experiment we used GPS devices MarchII, ASUS P565 and Nokia 5800 XpressMusic, which represented different precision and price ranges. To determine the positions and their accuracy, 245 randomly trees were selected from 245 orchards. We found out that the measurements made with MARCH II deviated to a diagonal for 16,72 m (X for 11,41 m and Y for 10,56m). Measurements made with ASUS P565 deviated in diagonal for 15,41m (X for 3,48 m, Y for 13,85 m). Nokia 5800 XpressMusic showed the highest deviation of 46,14 m in diagonal (X for 11,36 m, Y for 39,6 m). From the comparison of individual devices we have found out, that ASUS P565 as the best deviated in diagonal only for 1,31 m from MARCH II, but there was no significant difference. Despite the fact that discrepancies in individual trees is in particular measurement minimal (0,33 m), these devices are not yet precise sufficiently to be unequivocally identified with the position of sample trees.

Key words: GPS, positioning, orchard, sampling

## Mogućnost automatskog lociranja stabala pomoću GPS sustava za potrebe rane prognoze uroda jabuka

### Sažetak

U dvije godine kampanje proučavana je točnost različitih GPS uređaja za precizno uzimanje uzoraka stabala potrebno za ranu prognozu uroda jabuka. Precizno pozicioniranje od temeljne je važnosti za usporedbu prinosa između različitih godina. U našem pokusu koristili smo GPS uređaje March II, ASUS P565 i Nokia 5800 XpressMusic, koje se razlikuju u preciznosti i cijeni. Za određivanje položaja i njihove točnosti, slučajnim izborom odabrano je 245 stabala iz 245 voćnjaka. Ustanovili smo da se rezultati mjerenja sa aparatom MARCH II razlikuju po dijagonali za 16,72 m (što znači 11,41 m po X osi te za 10,56 m po Y osi). Mjerenja sa ASUS P565 odstupila su po dijagonali u prosjeku za 15,41 m (3,48 m po X-u te za 13,85 m po Y-u). Nokia 5800 XpressMusic pokazao je najviše odstupanja, u prosjeku za 46,14 m, odnosno 11,36 m po X-u te 39,6 m po Y-u). Iz usporedbe pojedinih uređaja saznali smo, da je Asus P565 kao najbolji odstupio u dijagonali od MARCH II samo za 1,31 m, međutim nije bilo značajne razlike. Unatoč činjenici da je odstupanje u poziciji pojedinih stabala posebno malo (0,33 m), ovi uređaji još nisu precizni dovoljno da bi njima nedvojbeno mogli identificirati pozicije uzorka stabala.

Ključne riječi: GPS, pozicioniranje, voćnjak, uzorkovanje

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## Introduction

In the European Union (EU-25), about 10 million tons of apples are harvested every year, but with great fluctuations from year to year and from orchard to orchard. Yield prediction is hence a pre-requisite for all partners in the food chain, orchard owners, trade, shippers and retailers. Thus, modelling fruit growth with an emphasis on tree variability is a crucial step in the management of fruit quantity and quality through horticultural practices (Lescourret et al., 1998) with a great impact on yield prediction per hectare in every growing region. Oriade and Dillon (1997) investigated the variability of fruit growth by using a stochastic approach of fruit growth rates and considering the sink strength of the fruit. However, all these models simulate the environmental conditions in the orchard, which can significantly vary from the real values. Due to time-consuming counting and the lack of experts a lot of inaccurate forecasts appeared in Slovenia from 1998-2004, when the yield was forecasted by the Bavendorf model (Winter, 1986). From these reasons the Bavendorf method was changed by the method of image analysis introduced by Stajnko et al. 2004. However, even though the method itself was very accurate for forecasting the yield on particular parcel, the small number of sample orchard made it rather vague for entire country, so in the individual years the estimated yield differ from the actual production between 5 to 25%. Therefore it was decided to increase the sample population to 245 orchards selected from the register of orchards. However, for accurate forecasting, where the samples are used for predictions, it is essential that they are always taken at the same location so we can talk about the current state of real data and data with which we can design the organization in advance.

The main advantage of image analysis method represents its possibility to capture a lot of images in a variety of orchards in a short time in order to improve forecast accuracy. However, it is desirable very much that each year the images are captured from the same trees. Everyone who was already sampling the trees from the orchards it is crystal clear that it is very difficult to locate the positions without any additional marks, as it requires a lot of walking.

The solution of these problems should represent a global positioning system (GPS), which enables the user to access to selected trees for the taking of samples quickly and easily. Since in the sampling method of image analysis we already have camera with, we were interested in researching smart phone with built-in GPS receiver as a substitute for professional GPS equipment.

The objective of our research was to determine whether our three different GPS devices (March II, ASUS P565 and Nokia 5800 XpressMusic) lead us to the same position of sample tree, even one year after the first measurement was taken. Another aim was also to determine whether the black hail net (Wiesel double-weft 2.9 mm x 8.9 mm, 0.3mm PEHD), which is installed 1.5 m over the trees affect the signal reception and accuracy of measurements.

## Material and methods

From the register of intensive crops 245 locations of the orchards were selected according to the different apple varieties, planting year and growing form. From July 4<sup>th</sup> to July 14<sup>th</sup> 2009, on days with mediate whether conditions, the samples of tree images were taken from the orchards. Additionally four trees from each plantation were georeferenced with three GPS devices and marked by the plastic label. One year later, from July 2<sup>nd</sup> to July 12<sup>th</sup> 2010 we captured tree images again from the same trees and checked the position of each marked tree by GPS devices. Since all measurements were performed in different parts of Slovenia on altering days it was not possible to compare the positions at the same number of functioned satellites.

For our research three different GPS devices were used according to the price and accuracy reference i.e. March II, ASUS P565 and Nokia 5800 XpressMusic. March II is a professional hand-held GPS receiver for field data capture. It is using a Motorola integrated 8-channel GPS receiver with referencing provides a horizontal accuracy of less than 3 m. ASUS P565 PDA is so called 'smart phone' driven by an 800 MHz processor and operates on Windows Mobile 6.1 environment and built-in digital camera with a resolution of 3.0 mega pixels. Built-in GPS receiver for the autonomous positioning signal may be caught in the canyons and under canopy. For this handheld in 2008 a software Garmin Mobile XT was uploaded and a program FK mobile was developed by Šinjur et al. (2008), which enables autonomous guiding to the marked trees by integrated compass function. Nokia 5800 XpressMusic is a GSM phone, which supports GPS for car navigation and pedestrian navigation and Nokia Maps 2.0 Touch. The device also supports Assisted GPS (A-GPS), which is used to provide packet data connection, which assists in the calculation of the coordinates of the current location when your device is receiving signals from satellites.

### Procedure for calculating the differences

All used devices operate in a coordinate system WGS84, which refer the position in the usual geographical coordinate format (Lat. 13 ° 39'48.7", Lon. 45 ° 57' 41.1"), however a direct subtract for calculating differences in position is not possible. Therefore we applied the Excel forms, which first record the geographical coordinates of degrees, minutes, and seconds in the decimal representation and then in the geographical coordinates. Finally, the difference in meters was calculated from geographical units so that the  $\varphi$  (latitude) was multiplied by 31 m and  $\lambda$  (longitude) by 22 m.

### Statistical analysis

Statistical analysis was performed with a SPSS Statistics 17.0 for Windows ® as the most familiar and widespread statistical programs in Slovenian education and research field. For analysis the difference between three GPS devices a 'paired samples analysis' at  $\alpha < 0.05$  was used.

### Results

Figure 1 shows the average differences between the first and second measurements as well a standard deviation for the measuring instrument ASUS P565, which shows that the average difference for X coordinate was 3.48 m and for Y coordinate 13.85 m, with standard deviations of 3.35 m for X and 17.87 m for Y. So in the diagonal the average difference was 15.41 m with standard deviation of 17.21 m.

Figure 2 shows the average differences between the first and second measurements as well a standard deviation for the measuring instrument MARCH II, which shows that the average difference for X coordinate was 11.41 m and for Y coordinate 10.56 m, with standard deviations of 9.48 m for X and 10.68 m for Y. So in the diagonal the average difference was 16.72 m with standard deviation of 12.84 m, which is not significant different from the ASUS P565.

In the Figure 3 the average differences between the first and second measurements as well a standard deviation for the measuring instrument Nokia 5800 XpressMusic, which shows that the average difference for X coordinate was 11.37 m and for Y coordinate 39.60 m, with standard deviations of 15.19 m for X and 49.83 m for Y. So in the diagonal the average difference was 46.14 m with standard deviation of 47.61 m, which was significant different from both ASUS P565 and MARCH II.

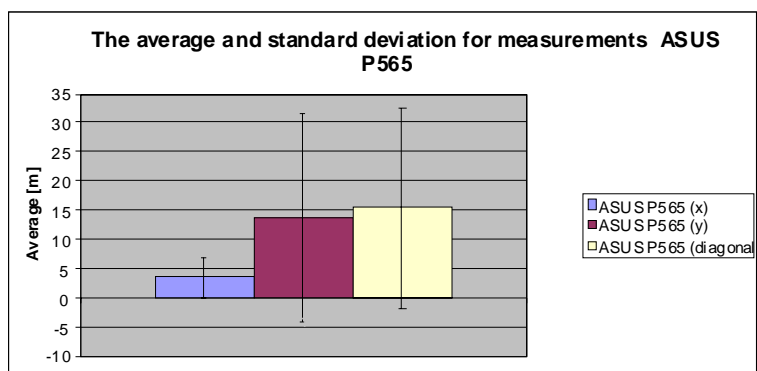


Figure 1: The average and standard deviation between two measurements of ASUS P565

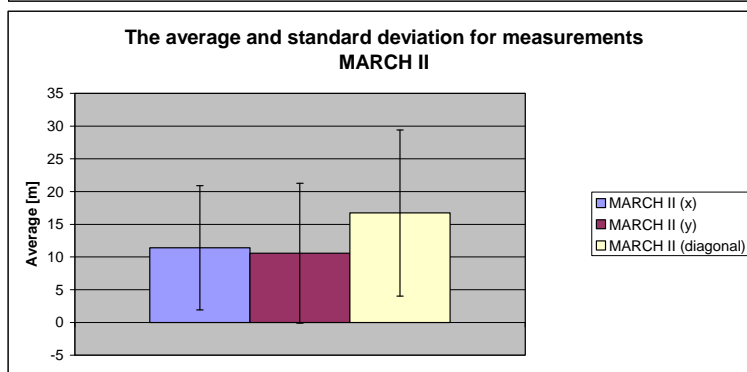


Figure 2: The average and standard deviation between two measurements of MARCH II

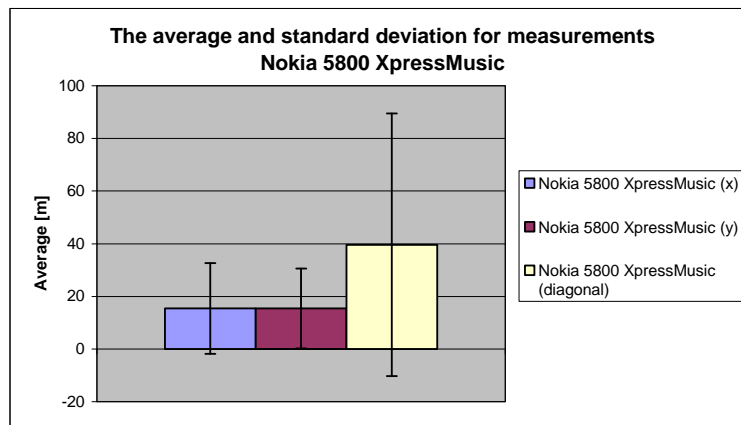


Figure 3: The average and standard deviation between two measurements of Nokia 5800 XpressMusic

### Conclusions

Absolute accuracy of the declared facilities for MARCH II and ASUS P565, which has been used in the experiment would be up to  $\pm 10$  m, except Nokia 5800, where the producer recalls that it should not be used for very precise measurements. The manufacturer contends, moreover, that the accuracy of the MARCH II and ASUS P565 even below 2.5 m, however in practice we achieve such results only in a few cases.

The main reason for not reaching declared the 2.5 m accuracy was due to a number of satellites, which hardly ever reached 12. Anyway on the average we achieve a relative accuracy of approximately  $\pm 10$  m. It turns out that the error in measurements was most affected by the number of satellites, given in our situation. For example, when we performed measurements on July 12<sup>th</sup> 2009, we receive a signal from an average of eight satellites, while on July 1<sup>st</sup> 2010 we accept the signal from just 6 satellites, which was otherwise satisfactory to take measurements but obviously not enough to improve accuracy.

In Nokia 5800 XpressMusic, we found that, although we were in an orchard, this device would still indicate the position coordinates outside the plantation. Very important findings could also be the fact that a hail network did not affect the signal quantity, since the same number of satellites was detected under and outer of network. We can make a general conclusion that in spite of some very precise measurements, these devices are not sufficiently reliable to indicate the position of sample trees with less than 0.7 m, which is usual space between trees in the lines. It can only be applied for determining a particular row from which the samples were taken one year before. This fact can help us or another person in easily finding the sampling zone, which is without a doubt very useful tool for saving time in locating the correct part of orchards

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# Pomološke i kemijske karakteristike jagode Clery na području Vrgorca

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## Sažetak

Jagoda je voće, ugodne jedinstvene arome i okusa. U Hrvatskoj je posebno cijenjena s područja Vrgorca, tzv. "Vrgoračka jagoda" koja na tržište dolazi desetak dana ranije od jagode proizvedene u kontinentalnom dijelu Hrvatske. Uzorci su sakupljeni iz različitih sustava uzgoja (plastenik i uzgoj na otvorenom). Cilj ovog istraživanja bio je odrediti pomološke (visina, širina, tvrdoća i masa ploda) i kemijske parametre (kiselina, topljiva suha tvar, pH) kvalitete u svrhu karakterizacije kvalitativnih svojstava sorte Clery. Razlike između analiziranih uzoraka nisu bile uvjetovane različitim načinom uzgoja.

Ključne riječi: jagoda, intenzitet boje, masa ploda, ukupne kiseline, topljiva suha tvar

## Pomological and chemical traits of strawberry Clery on Vrgorac fields

### Abstract

Strawberry is a fruit of kind, unique taste and aroma. In Croatia Vrgorac fields strawberry, so-called "Vrgoračka jagoda", which has up to ten days earlier market appearance than the strawberry produced in mainland, is especially appreciated. Samples were collected from different ways of farming (greenhouse and growing in open area). The aim of our study was to determine pomological (height, width, firmness and fruit weight) and chemical parameters (total acid, total soluble solid, pH) in order to characterize qualitative properties of cultivar Clery grown on Vrgorac fields. Differences between analyzed samples were not determined by different methods of cultivation.

Key words: Strawberry, fruit colour density, fruit weight, total acid, total soluble solid

### Uvod

Jagoda (*Fragaria x ananassa* Duch.) ima jedinstvenu, izrazito poželjnu aromu i okus i jedna je od najpopularnijih ljetnih voćnih vrsta (Sturm i sur., 2003). Također, bogata je spojevima različitog bioaktivnog djelovanja. Naime, pozitivan utjecaj jagode na snižavanje rizika od nastanka tumora i srčanih oboljenja, kao i njeno pozitivno djelovanje na imunološki sustav u cjelini dokazano je u mnogobrojnim studijama (Hannum, 2004). Zahvaljujući spoznajama o zdravstvenoj korisnosti plodova jagode ona postaje sve traženije voće na tržištu (Schopplein i sur., 2002).

Kemijska i senzorska svojstva ploda jagode uvjetovana su sortom, uzgojnim područjem i tehnologijom proizvodnje. Harmoničan okus ploda potječe od sadržaja ukupnih kiselina, ukupne topljive suhe tvari i njihovog međusobnog odnosa. Odnos ukupnih kiselina i ukupne topljive suhe tvari je u direktnoj vezi sa stupnjem zrelosti ploda (Sturm i sur., 2003).

U Hrvatskoj posebno je cijenjena jagoda s područja Vrgorca čiju visoku kvalitetu osigurava plodno tlo polja Jezero (2.914 ha) i Rastok (1.675 ha), blaga mediteranska klima s obiljem sunca, kao i visoka tehnologija proizvodnje. Za razliku od ostalih jagoda prisutnih na našem tržištu tzv. "Vrgoračka jagoda" dolazi na tržnice deset do petnaest dana ranije, što joj osigurava visoku cijenu u odnosu na jagodu proizvedenu u kontinentalnom dijelu Hrvatske.

Cilj našeg istraživanja bio je utvrditi pomološke (visina, širina, tvrdoća i masa ploda) i kemijske parametre (kiselina, suha tvar, pH) kvalitete u svrhu karakterizacije kvalitativnih svojstava sorte Clery uzgojene na području Vrgorca, a koja se na tržištu naziva "Vrgoračka jagoda".

### Materijal i metode

Uzorci sorte Clery (2 kg/uzorak) prikupljeni su na osam lokacija na cijelom uzgojnom području Vrgorca iz različitih sustava uzgoja (plastenik i uzgoj na polju). Uzorak 1, 2, 3 i 4 prikupljeni su iz uzgoja u plasteniku, dok su uzorci 5, 6, 7 i 8 prikupljeni iz uzgoja na otvorenom. Izmjerena je masa ploda, dužina, širina i visina ploda, tvrdoća, sadržaj suhe tvari, ukupnih kiselina (izražene kao limunska), pH te boja ploda.

Masa ploda (g) izmjerena je pomoću analitičke laboratorijske vage (Metler Toledo), a dimenzije ploda (dužine, širine i visine ploda), izražene u mm, pomoću digitalne pomične mjerke. Tvrdoća ploda ( $\text{kg/cm}^2$ ) izmjerena je digitalnim stolnim penetrometrom promjera cilindra 8 mm (Turoni, Italia). Topljiva suha tvar (TSS) izražena u postocima utvrđena je refraktometrijski (A'Cruss optronic, Njemačka), a sadržaj ukupnih kiselina (TA) metodom titracije s 0.1 M NaOH (AOAC, 2000). Iz odnosa TSS/TA utvrđen je indeks zrelosti. Intenzitet boje određen je metodom kolorimetrije (ColorTec-PCM) po CIE LAB sistemu boja, a prikazan je vrijednostima L, a, b, C i H.

Dobiveni podatci obrađeni su analizom varijance koristeći programski paket STATVIEW (SAS Institute Version 5.0). Razlike između srednjih vrijednosti testirane su LSD testom za  $p \leq 0.05$ .

### Rezultati i rasprava

Pomološke karakteristike plodova jagode Clery značajno su se razlikovale između istraživanih uzoraka (tablica 1).

Tablica 1. Pomološke karakteristike jagode sorte Clery uzgajane na području Vrgorca

Uzorak	Masa ploda (g)	Dužina ploda (mm)	Širina ploda (mm)	Visina ploda (mm)	Tvrdoća ( $\text{kg/cm}^2$ )
1	12.4d	28.8c	26.2d	38.7cd	0.8a
2	14.6c	30.2b	27.5bc	38.9cd	0.7a
3	16.3abc	31.1b	28.4ab	39.8bc	0.7a
4	12.6d	28.3c	26.0d	39.8bc	0.6b
5	15.6bc	30.6b	28.2ab	39.6c	0.7a
6	15.7abc	31.3ab	28.0ab	39.1cd	0.6b
7	17.7a	32.5a	29.1a	42.7a	0.7a
8	12.8d	28.6c	26.7cd	38.0d	0.7a

<sup>1</sup> Različita slova unutar stupaca pokazuju značajne razlike između sorata temeljem LSD testa ( $P \leq 0.05$ )

U tablici 1 vidljivo je da su se uzorci značajno razlikovali u masi ploda. Uzorak 7 imao je veću masu ploda u odnosu na uzorak 1, 2, 4, 5 i 8. Najmanja masa ploda utvrđena je u uzorku 1, 4 i 8. Dužina ploda uzorka 7 bila je veća od dužine ploda uzoraka 1, 2, 3, 4, 5 i 8. Širina ploda uzorka 7 bila je veća od širine ploda uzoraka 1, 2, 4 i 8. Visina ploda uzorka 7 bila je najveća u odnosu na ostale istraživane uzorke.

Tvrdoća ploda varirala je od 0,6 do 0,8  $\text{kg/cm}^2$ . Između uzoraka 1, 2, 3 (plastenik) i uzoraka 5,6,7,8 (polje) nije utvrđena statistički opavdana razlika (tablica 1). Slične rezultate dobili su Voća i sur. (2006) proučavajući tvrdoću plodova različitih sustava uzgoja sorte Elsanta pri čemu je također utvrđeno da između tvrdoće plodova uzgajanih u polju i visokim tunelima ne postoje signifikantne razlike.

Tablica 2. Vrijednosti kemijskog sastava jagode sorte Clery uzgajane na području Vrgorca

Uzorak	TSS (°Brix)	TA (g/L)	Odnos TSS/ TA	pH
1	6.7d	7.2b	0.93d	3.38d
2	7.5b	7.4b	1.02b	3.44cd
3	5.7e	7.2b	0.79e	3.31e
4	8.3a	7.5b	1.10a	3.45c
5	6.1e	8.7a	0.70f	3.33de
6	6.2e	7.0c	0.88d	3.50bc
7	6.8bcd	7.3b	0.94c	3.67a
8	7.5bc	7.4b	1.02b	3.52b

<sup>1</sup> Različita slova unutar stupaca pokazuju značajne razlike između sorata temeljem LSD testa ( $P \leq 0.05$ )

Iz tablice 2 vidljivo je da se sadržaj topljive suhe tvari (TSS) značajno razlikovao između uzoraka i varirao je od 5.7 do 8.3° Brix. Najveći sadržaj suhe tvari imao je uzorak 4, dok je najmanji sadržaj suhe tvari imali uzorci 3, 5 i 6. Sadržaj TA (%), izraženih kao limunska kiselina, varirao je od 7.0 g/L do 8.7 g/L. Najveći sadržaj TA utvrđen je u uzorku 5 a najmanji u uzorku 6. Vrijednosti pH varirale su od 3.31 do 3.67. Najveću pH vrijednost imao je uzorak 7 dok je najmanju pH vrijednost imao uzorak 3 u odnosu na sve ostale istraživane uzorke osim uzorka 5. Sorta Clery uzgajana na otvorenom u okolici Zagreba imala je TSS 8.1 Brix, TA 6.4 g/L, te pH vrijednost 3.66 (Voća i sur., 2008). Rutkovski i sur. (2006) utvrdili su sadržaj TSS od 5.2 do 10.4%, a Laugale and Bite (2006) od 8.4 do 11.6%. Sadržaj TSS ovisi o sorti, sustavu uzgoja te klimatskim uvjetima uzgojnog područja. Odnos TSS i TA daje informacije o odnosu šećera i kiselina i zajedno sa bojom vrlo je značajan u determiniranju kakvoće ploda. Tako Voća i sur. (2008) navode za sortu Clery vrijednost odnosa TSS/TA od 1,27 dok su se na području Vrgorca vrijednosti TSS/TA kretale od 0,70 do 1,10.

U tablici 3 rezultati prikazuju značajne razlike između uzoraka u obojenosti plodova. Najtamnije obojeni plodovi i najmanji intenzitet boje utvrđen je kod uzoraka 3 i 5. Uzorak 1 imao je svjetliju boju u odnosu na sve istraživane uzorke kao i najjače izražen intenzitet boje. Vizualni doživljaj boje uzorka 6 bio je bolji u odnosu na sve istraživane uzorke osim uzorka 3. Prosječne vrijednosti parametara obojenosti plodova za sortu Clery kod Voća i sur. (2008) bile su: L=36.04, C=30.60 i h=49,75.

Tablica 3. Boja ploda jagode sorte Clery uzgajane na području Vrgorca

Uzorak	L	C	h
1	35.43a	27.97a	45.69de
2	33.99b	24.48c	48.99bc
3	32.26d	22.71d	50.20ab
4	34.46b	24.66bc	47.02cde
5	32.78cd	22.67d	49.01bc
6	33.17c	24.98bc	52.36a
7	34.32b	24.45c	48.21bcd
8	34.52b	25.28bc	44.59e

<sup>1</sup> Različita slova unutar stupaca pokazuju značajne razlike između sorata temeljem LSD testa ( $P \leq 0.05$ )

### Zaključak

Pomološki (visina, širina i masa ploda) i kemijski parametri (kiselina, suha tvar, pH), kao i parametri boje ploda, jagode sorte Clery uzgajane na području Vrgorca pokazali su značajne razlike između različitih proizvođača, dok razlike nisu bile uvjetovane različitim načinom uzgoja. Jagoda u agroekološkim uvjetima Vrgorca dozrijeva 10-ak dana ranije u odnosu na ostala uzgojna područja u Republici Hrvatskoj te kao prvo svježe voće na tržištu osigurava visoku cijenu i rentabilnost. Temeljem navedenog potrebno je izvršiti daljnja istraživanja sa ciljem unapređenja proizvodnje i definiranja kakvoće proizvoda.

### Zahvala

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# Sorbitol and sugar composition of plum fruit during ripening

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## Abstract

Sorbitol and sugar composition in fruits were investigated in 6 different plum cultivars during ripening. The fruits were harvested at different maturity stage in the experimental orchard of the Agricultural Institute Osijek. Sugars (glucose, fructose and sucrose) and sorbitol in fruits were identified and quantified by high performance liquid chromatography (HPLC). Significant differences were found between sucrose, glucose, fructose and sorbitol depending on harvest date and on cultivar. The amount of sorbitol and sugars in fruits significantly increased during maturation. The individual sugars, glucose and sucrose were the highest in all harvest stages. Glucose was the predominant sugar in one cultivar. Fructose content remained relatively low. Plums with high total sugar content had higher content of sorbitol. The discriminant analysis (LDA) showed that plum cultivars were clearly separated according to sorbitol and sugars composition in fruit.

Key words: plum, cultivar, ripening, sorbitol, sugars

## Sorbitol i sastav šećera plodova šljiva tijekom dozrijevanja

### Sažetak

Sorbitol i sastav šećera u plodovima šljiva su istraživani u 6 različitih kultivara tijekom dozrijevanja. Plodovi su ubrani u različitim fazama dozrijevanja u pokusnom voćnjaku Poljoprivrednog Instituta Osijek. Šećeri (glukoza, fruktoza i saharoza) i sorbitol su identificirani i kvantificirani tekućinskom kromatografijom visoke djelotvornosti (HPLC). Značajne razlike su uočene između saharoze, glukoze, fruktoze i sorbitola u ovisnosti o datumu berbe i kultivaru. Tijekom dozrijevanja količina sorbitola i šećera u plodovima se značajno povećala. Pojedinačni šećeri, glukoza i fruktoza su bili najviši u svim fazama dozrijevanja. Glukoza je bila prevladavajući šećer u jednom kultivaru. Količina fruktoze je ostala relativno niska. Šljive sa visokim udjelom ukupnih šećera su imale i viši udio sorbitola. Diskriminantna analiza (LDA) je pokazala da se kultivari šljiva mogu razdvojiti prema količini sorbitola te sastavu i količini šećera u plodu.

Ključne riječi: šljiva, kultivar, dozrijevanje, sorbitol, šećeri

### Introduction

Plums are the most extensively distributed of the stone fruits, the most varied in native and cultivated variety and the most adapted to a wide range of soils and climatic conditions. The fruits show a wide range of size, flavour, colour, and texture. Plums are primarily used for fresh consumption as well for processing. Varietal differences can also contribute to variations in the consumption of raw and finished product. Maturity at

harvest is the most important factor that determines final fruit quality and storage-life (Siddiq, 2006). Fruit ripening is a highly coordinated, genetically programmed, and an irreversible phenomenon involving a series of physiological, biochemical, and organoleptic changes that lead to the development of a soft and edible ripe fruit with desirable quality attributes. A wide spectrum of biochemical changes such as increased respiration, chlorophyll degradation, biosynthesis of carotenoids, anthocyanins, flavor and aroma components, increased activity of cell wall-degrading enzymes, and a transient increase in ethylene production are some of the major changes involved during fruit ripening (Prasanna et al, 2007).

In plums, traditional indices that have been commonly used to establish the best harvest time, are characteristics related to colour of the skin and flesh, fruit firmness, soluble solids content, and titratable acidity (Blažek and Pištekova, 2009; Guerra and Casquero, 2009; Nunes et al., 2009). Sugar content is the most relevant to consumer perception of maturity and it is factor closely related to the stage of maturity in plum fruits. Plum contain three predominant sugars: glucose, fructose, sucrose and sugar alcohol sorbitol and their content varied with cultivar (Wilford, Sabarez and Price, 1997; Usenik et al., 2008). The sorbitol content, peculiar in fruits of the Rosaceae family, is one of the criteria used when choosing the variety for drying. In fact, sorbitol, in addition to possessing a good laxative effect at low doses (70g/day), is not easily caramelized and is not a reactant molecule in the Maillard reaction, thereby preventing excessive browning in prunes (Cinquanta, Di Matteo and Esti, 2002).

The objective of this work was to investigate the influence of the harvest date on the level of sugars and sorbitol in different plum cultivars during ripening.

### Material and methods

Six plum cultivars (*Prunus domestica* L.): “Cacanska ljepotica”, “Topstar”, “Toptaste”, “Jojo”, “Haganta”, “Tophit”, were harvested in 2009 from experimental four year old orchard of the Agricultural Institute Osijek. Plum trees were planted in a randomized block design with three replications per four trees in each. The fruit were harvested at three or four different times at six- to eight-day intervals during ripening (t1-t4). “Cacanska ljepotica” was harvested on date: 10th, 16th and 24th of July; “Topstar” on 16th, 24th, 30th of July and 6th of August; “Toptaste” on 24th, 30th, of July and 6th, 13th of August; “Jojo” and “Haganta” on 13th, 20th, 27th of August and 3th of September; 2nd, 9th, 17th and “Tophit” on 26th of August and 2nd, 9th, 17th of September. In each harvest, 10 fruits were selected from each tree and these combined within each replication to yield 40 fruit per replication per harvest date. The samples were brought to the laboratory immediately after harvesting. Ten fruits from each replication were used to determine sorbitol, sucrose, glucose, fructose and total sugars.

Seedless plum fruits were thoroughly crushed in an electric mixer. Sugars and sorbitol from pulp were extracted with water at 50°C for 15 min. After filtration, extracts were passed through 0,45µm syringe filter, just before analyses. Sorbitol and sugars were analyzed by using a Perkin-Elmer High Performance Liquid Chromatography system series 200 equipped with degasser, isocratic pump, refractive index detector and TotalChrom Navigator (HPLC software). The separation was performed on MetaCharb Ca Plus column (300 x 7,8), thermostated at 90°C. 20 µL aliquots were injected into the column and eluted with deionized water at flow rate of 0,5 mL/min. Standard solution was composed of sucrose, glucose, galactose (internal standard), fructose and sorbitol at concentration of 5, 10 and 15 mg/ml. Sugars from aqueous sample extract were identified by their retention time and quantified by peak area using internal standard procedure. Total sugars were represented as the sum of sucrose, glucose and fructose. All measurements were conducted in four replications. Sorbitol and sugar content were expressed as a percentage of fresh weight of plum.

One-way analysis of variance (ANOVA) and multiple comparisons (Duncan’s post hoc test) were used to evaluate the significant difference of the data at  $P < 0,05$ . Comparative analyses of plum cultivars were performed using linear discriminant analysis. All statistical analyses were performed using statistical-graphic system "Statistica" version 7.0 (Stat Soft software Inc., Tulsa, OK, USA).

### Results and discussion

Changes in sorbitol and sugars content during ripening of plum cultivars are shown in Fig.1. The sorbitol, individual and total sugars content in ‘Cacanska ljepotica’ plums were the lowest at the first sampling date and then increased during the fruit ripening, for sucrose to 4,13%, for glucose 3,76%, for total sugar 10,19%

## Sorbitol and sugar composition of plum fruit during ripening

and sorbitol to 2,02% at the last sampling date. A one-way ANOVA showed significant difference ( $p < 0,05$ ) between all harvests for sucrose, fructose and total sugars content. Significant difference was not found between first and second sampling date for glucose and sorbitol. The predominant sugar in this plum cultivar at last sampling date was sucrose.

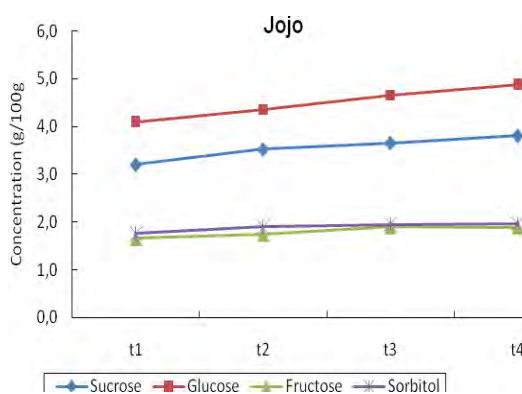
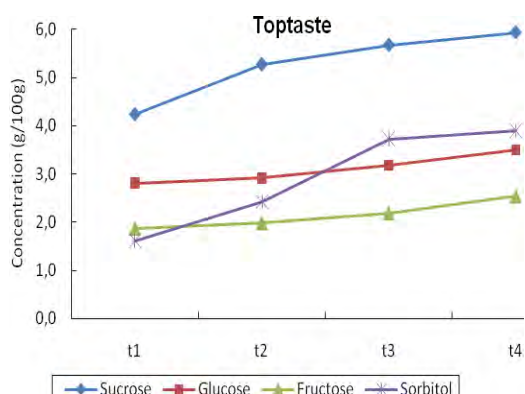
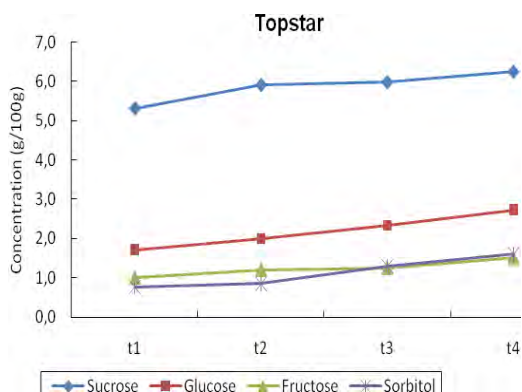
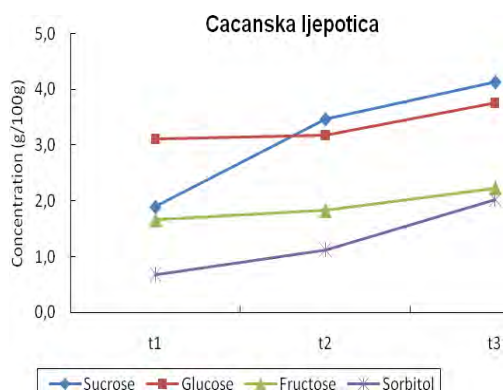
A one-way ANOVA showed significant difference ( $p < 0,05$ ) between sampling date for glucose and total sugar in cultivar “Topstar” and their levels at the last sampling date were 2,73% and 10,47%, respectively. The sorbitol detected at the second sampling date (0,85%) was not significantly different to the value determined on the first sampling date, while a level of sucrose and fructose was not significantly different on the second and third sampling date. In the last ripening stage contents of sorbitol, sucrose and fructose were 1,60%, 6,24% and 1,50%, respectively. Sucrose was the predominant sugar in this plum cultivar.

Sorbitol, sucrose and total sugars were changed significantly during ripening in “Toptaste” plum cultivar and their level at the last sampling date increased to 3,9%, 5,93% and 11,89%. Glucose and fructose were not significantly changed in first and second ripening stage and their values increased in last sampling date to 5,93% and to 2,55%.

Glucose and total sugars were changed significantly during ripening until the last harvest date in “Jojo” plum cultivar. Glucose was predominant sugar in this cultivar and its level increased to 4,88% at the last sampling date. Sorbitol, sucrose and fructose were not significantly changed in penultimate and last sampling data. At last sampling date sorbitol level was 1,96%, sucrose 3,81% and fructose 1,89%.

Glucose and fructose in cultivar “Haganta” were in increase during all sampling dates with no significant difference between third and last sampling date. The highest percentage for glucose and fructose was 4,69% and 2,32%. Sorbitol and sucrose were not significantly changed in second and third sampling date, but significant increase was noticed in the last stage of ripening (5,09% and 3,61%).

Sucrose, glucose and total sugar content in “Tophit” plums were the lowest at the first sampling date and then significantly increased during the fruit ripening for sucrose to 4,90%, for glucose 3,74%, for total sugar 10,99% at the last sampling date. Significant difference was not found between third and last sampling date for fructose and second, third and last date for sorbitol. In the last ripening stage contents of sorbitol and fructose were 3,79 and 2,49%. The predominant sugar in this plum cultivar at last sampling date was sucrose.



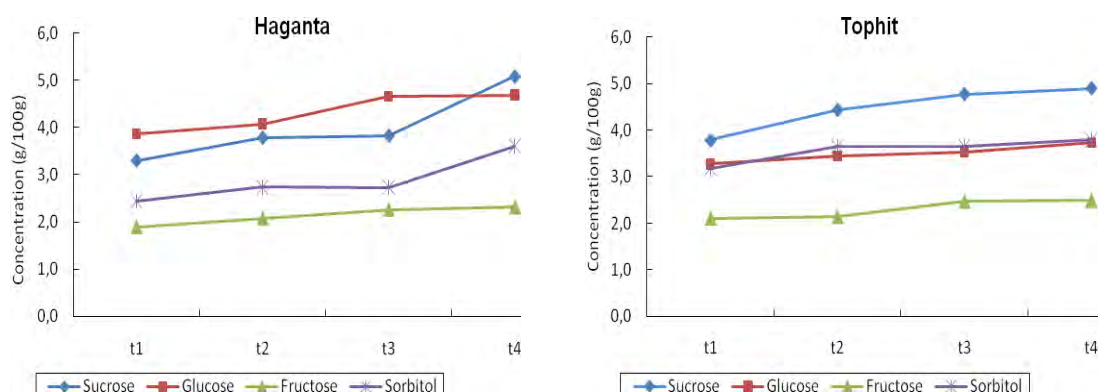


Figure 1. Changes in sorbitol and sugars during ripening of plum cultivars

According to the concentration of total sugars in the last sampling date, the highest level was found in “Haganta”, followed by “Toptaste”, “Tophit”, “Jojo”, “Topstar” and the lowest in “Cacanska ljepotica”. High level of sorbitol was found in “Toptaste”, “Tophit” and “Haganta”. Obtained results showed significant influence of cultivar on concentration of sorbitol, sucrose, glucose, fructose and total sugars in investigated plum cultivars. Discriminant analysis using sorbitol and individual sugar content as the variables showed that plum cultivars were grouped according to their sorbitol and sugar composition (Fig.2).

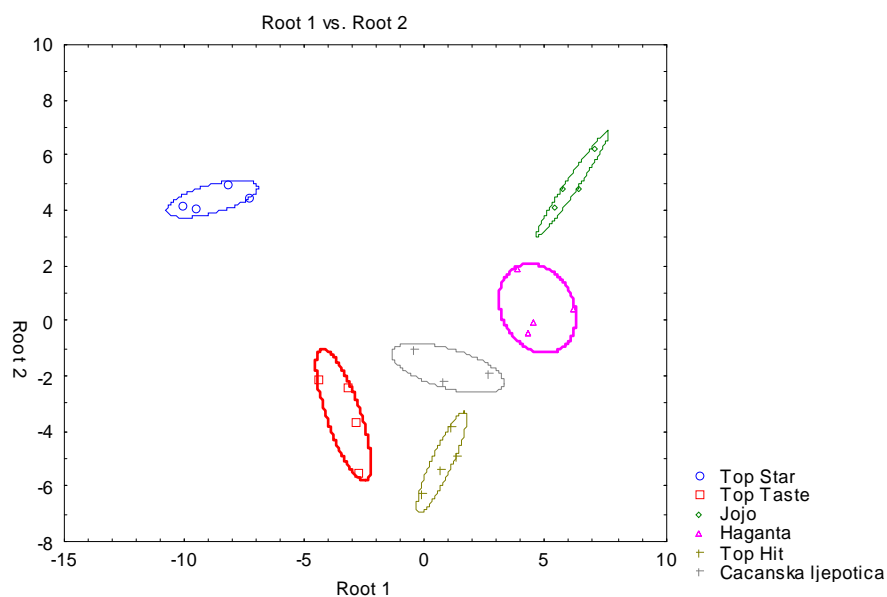


Figure 2. Result of discriminant analysis

### Conclusion

The results showed significant influence of maturation and harvest date on sorbitol and sugars concentrations in investigated plum cultivars. The amount of sorbitol, individual and total sugars in plums significantly increased during maturation. The individual sugars, glucose and sucrose were the highest in all harvest stages. Glucose was the predominant sugar in one cultivar. Fructose content remained relatively low. Plums with high total sugar content had higher content of sorbitol. The discriminant analysis (LDA) showed that plum cultivars were clearly separated according to sorbitol and individual sugars content in fruit.

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# The most significant pests of apple in the area of East Sarajevo

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## Abstract

Insect pests on apples in the region of East Sarajevo have been studied during 2007. and 2008. year in three locations. In two locations, Kasindo and Pale, examination has been done in extensive plantations over 40 years old, in location Kula, in intensive plantation. Total number of determined species is 36, in extensive plantations were affirmed 33 species, accordingly 25 species and in intensive plantation 18 species were affirmed .

According to the size, intensity and finding frequency, the most important insect pests on apples in East Sarajevo are: *Cydia pomonella* Linne, *Anthonomus pomorum* Linne, *Aphis pomi* De Geer, *Dysaphis plantaginea*, *Callisto denticulella* Thunberg, *Lithocolletis blancardella* Fabricius, *Lithocolletis corylifoliella*, *Stigmella malella* Stainton, *Leucoptera malifoliella* Costa (1836) and *Lyonetia clerkella* Linne.

Key words: insect pests, apple, East Sarajevo

## Introduction

During a growing season, an apple is exposed to many pests attacks, where important place belongs to insects. Some insect species are present on apples during whole year, where hibernate in all different stages, while some occur only in a certain period of vegetation, depending on developmental stages of a plant and insect species bionomics. Feeding by different plant parts, insects cause physiological weakening of a plant, deformation of plant organs, reduced fruiting or defoliation, while species that damage crops often can cause their early decline, reducing the market value, and sometimes even complete destruction of the plant.

In countries around the world, some species have special economic importance, among which stands *C. pomonella*, which is the most dangerous pest in the whole area of distribution with harmfulness up to 100% but only in plantations where they do not implement appropriate measures.

In area of Sarajevo and BiH, there is no enough literature about harmful fauna in apple. The most important pests during mid 60's were studied in detail such as leaf miners (Dimić, 1964) and some kind of the moth (Batinica, 1966).

The area which East Sarajevo includes is part of Sarajevo region, and there is no any research about harmful insect pests on an apple on that area.

Since a satisfactory yield can be achieved only by conducting the appropriate protection measures, including chemical control of harmful species, it is necessary to identify and know the composition of the harmful insect pests on apples in this area and define the most common and economically important species, which was the aim of this study.

## Materials and methods

Insect pests of apple in East Sarajevo, are studied in orchards near the location Kasindo, Pale and Kula. Extensive planting characters are present in sites of Kasindo and Pale, while in the area of Kula intensive way of apple growing is present where chemical control measures are escorted to combat insect pests, and disease causes.

During the growing season, since the swelling and opening of the buds to the harvesting and leaf falling, in intervals of 10-15 days, orchard patrolling has been done, apple tree examination because of presence of harmful insects and their collection in a different development stages. By visual examination method of randomly selected trees, was accompanied presence of harmful insects, infestation degree, the intensity of attacks and damage simtoms.

By method of sampling of 100 different plant organs (leaf buds, flower buds, leaves, fruits) with a randomly selected trees in each orchard, was carried out exmination of insect pests to determine developmental stage, the intensity of the attacks of certain harmful species and analyzed the symptoms of damage.

In laboratory conditions, was carried out cultivation of materials that included detailed examination of insects collected by hits and by sampling infested plant parts, growing larvae stages of insect collecting, preserving in 70% alcohol.

### Results and disscusion

The region of East Sarajevo is determined and total number of species of insect pests is 36, in extensive plantations were affirmed 33, accordingly 25 species and in intensive orchards 18 species.

According to the size, intensity of attacks and finding frequency, are defined ten the most important species of insects in this area. Their origin is different by insect orders. In the order of Hemiptera were found two species that belong to the suborder Sternorrhyncha and fam. Aphididae. These are *Aphis pomi* de Geer and *Dysaphis plantaginea* Linne, which in the literature cited as important pests of apple (Petrović-Obradović, 2003; Lazarev, 1972). In the order Coleoptera, the most harmful species was *Anthonomus pomorum* Linne and the order Lepidoptera has the largest number of harmful insects. It was determined 7 species among which are dominated leaf miners of the family Lithocolletidae (*Callisto denticulella* Thunberg, *Lithocolletis blancardella* Fabricius and *Lithocolletis corylifoliella* Haworth), fam. Lyonetidae (*Leucoptera malifoliella* (Costa (1836)), *Lyonetia clerkella* Linne) and fam. Nepticulidae with the type of *Stigmella malella* Stainton. From fam. Tortricidae, was particularly harmful *C. pomonella*.

Visual inspection of randomly selected trees, as well as leaf examination, in all orchards during both years, there is an *A. pomi* moving there from May to August (Kasindo, Kula) moving there from May to August (Kasindo, Kula) and the month of July (Pale). It was particularly present in June and July and then it formed numerous colonies of winged and wingless individuals in all cultures.

Less time presented during the growing season was a *D. plantaginea*, whose colonies were observed in early April, and there it was by mid-June, when she left an apple, and crossed to the *Plantago* sp. as a secondary host.

With emergence of flower buds, there was a large number of unopened flowers which where gradually got brown. By their opening at the bottom of flower boxes, larvae of *A. pomorum* were found, which, according to the literature are considered to be one of the most important pests of flower buds.

Overview of flower buds was performed two times during the growing season, and the total number of examined buds is 200 in each year (Table 1).

Table 1. Number of mined leaves in sites

	Localities					
	Kasindo		Pale		Kula	
	2007.	2008.	2007.	2008.	2007.	2008.
The number of damaged position from A.pomorum	85	51	28	35	26	22
% of damaged fruit from A. pomorum	42,5	25,5	14,0	17,5	13	11

Throughout the growing season, from May to October, were found blown leaves and mines with caterpillars, but also empty, already abandoded mines.

Leaf review is performed nine times during the growing season in two years of research. Every time 100 leaves were sampled, and total number of examined leaves was 900 in each year. Total number of upbringinged species is 6, which are determined by the appearance of damage, ie. types of mines and morphological characteristics of adults. These are: *C. denticulella*, *L. blancardella*, *L. corylifoliella*, *L. malifoliella*, *L. clerkella* and *S. malella* (Tab.2).

Table 2. Number of mined leaves in localities

Species of leaf miner	Number of mined leaves					
	Kasindo		Pale		Kula	
	2007.	2008.	2007.	2008.	2007.	2008.
<i>Callisto denticulla</i>	235	336	152	204	0	0
<i>Lithocolletis blancardella</i>	87	61	84	57	9	4
<i>Lyonetia clerkella</i>	42	50	55	51	41	62
<i>Stigmella malella</i>	21	26	25	15	10	40
<i>Lithocolletis corylifoliella</i>	13	11	20	25	2	6
<i>Leucoptera malifoliella</i>	13	8	3	4	47	10
The total number of mined leaves	411	49	339	356	109	122
Expression of the%	45,66	54,66	37,66	39,55	12,11	13,55

The highest percentage of mined, from total number of pages viewed during both years was the site of Kasindo (45 in 2007. and 54.66 in 2008.), slightly lower in the locality of Pale (37.66 in 2007. and 39.55 in 2008.), while the lowest leaf was mined in the locality Kula (12.11 in 2007. and 13.55 in 2008.) which can be explained by using chemical protection measures against pests and disease causing (Table 2).

According to the literature, the species of leafminers are important pests of apple whose larvae, feeding by the parenchyma tissue causes mines of various forms of assimilation and thus reduce transpiration leaf area (Stamenković, 2000; Dimić, 1964; Almaši et al., 2004).

When it comes to pests of apple fruit, in all localities, the greatest damage caused *C. pomonella*, who according to the literature is considered one of the most important pests of apple in the world (Chapman & Lienka, 1971; Chapman, 1973; Barnes, 1991, cit. Mansour, 2007).

Overview of fruit was performed six times during the growing in all localities, and in each year was examined 600 products of the tree, and 600 fallen products.

A much higher percentage of damaged fruits of *C. pomonella* is present in extensive plantations which is consistent with published data, according to which the percentage of damaged fruit is up to 82.3% in plantations where there is no chemical control measures to combat, or 42.3% of the plantations with the use of chemical control (Stamenković et al., 1995; Graora and Jerinić-Prodanović, 2005; Nikolić, 2006).

Table 3. The percentage of damaged fruits of *C. pomonella*

	Localities					
	Kasindo		Pale		Kula	
	2007.	2008.	2007.	2008.	2007.	2008.
% of damaged fruit from <i>C. pomonella</i>	45,25	50,75	39,69	42,33	28,87	30,93

According to the data of foreign authors, *C. pomonella* can damage or destroy and up to 100% of embryos in the absence of any control measure, or up to 10% in plantations where there is no population control and chemical control measures of protection (Talhok, 1954; Chapman, 1973; Barnes, 1991, cit. Mansour, 2007).

## Conclusion

Total number of determined harmful insect species in East Sarajevo is 36, in extensive plantations 33 and 25 and in intensive plantations 18 species. According to their number, attack intensity and finding frequency, the most important types are: *Cydia pomonella* Linne, *Anthonomus pomorum* Linne, *Aphis pomi* De Geer, *Dysaphis plantaginea*, *Callisto denticulella* Thunberg, *Lithocolletis blancardella* Fabricius, *Lithocolletis corylifoliella*, *Stigmella malella* Stainton, *Leucoptera malifoliella* Costa (1836) and *Lyonetia clerkella* Linne.

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# Proizvodnja jabuke bez ostataka sredstava za zaštitu bilja

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## Sažetak

Cilj istraživanja bio je utvrditi da li je u Sloveniji, uz ograničenu uporabu sredstava za zaštitu bilja mogu proizvoditi voće bez ostataka pesticida. U pokusnom voćnjaku smo imali dvije vrste proizvodnje: ona u kojoj smo provodili mjere sukladno standardu postojeće integrirane proizvodnje i druga, gdje smo izveli modificirani sustav (IPM"0.0"RL) na način da su voćke prskanje do početka srpnja prema sustavu integrirane proizvodnje, a nakon toga prema propozicijama organske proizvodnje. Rezultati naših pokusa su pokazali da sustav IPM"0.0"RL daje dobre rezultate u godinama s prosječnim napadom bolesti i štetnika.

Ključne riječi: voće, pesticidi, zaštita voćaka, bolesti, štetnici

## Production of apples free of pesticides

### Abstract

The aim of the study was to determine whether the limited use of pesticides allows production of fruits without pesticide residues in Slovenian orchards. In orchards we had two types of production: those where we have implemented standard measures of the existing integrated production (IPM) and plots, where we implemented the modified protection, and in a way that they have been spraying for all variants to the beginning of July the same, then we at IPM"0.0"RL only use products for biological control. With this we want to reduce the concentration of the pesticide residues at harvest. At harvest, fruit samples were taken for analysis of pesticide residues. The results of our experiments showed that the IPM"0.0"RL system is quite useful in the years with average pressure of diseases and pests.

Key words: fruits, pesticides, plant protection, diseases, pests

### Uvod

Spoznaja o štetnim učincima ostataka pesticida u plodovima voća motivirala je znanstvenike i stručnjake da pokušaju riješiti ovaj problem, te je kao rezultat definiran sustav integrirane proizvodnje. Sustav integrirane proizvodnje (IPM - Integrated Production Management) se već duži niz godina provodi i unapređuje u voćarski naprednim zemljama. Današnji zahtjevi idu i dalje jer se smatra da su ostaci pesticida i u sustavu IPM preveliki. Kao primjer možemo navesti podatke iz 15 država EU, Norveške i Lihtenštajna za 2002. godinu, koji su pokazali da je 56% svih pregledanih uzoraka svježeg voća, povrća i žitarica sadržavalo ostatke pesticida. Pri tom je 38,5% svježih uzoraka sadržavalo manje ili jednake koncentracije od maksimalno dozvoljenih (MRL - Minimal Risk Levels), a 5,5% više od MRL (Monitoring of pesticide residues in products of plant origin in the European union, Norway, Iceland and Liechtenstein, 2004). Slična situacija bila je i u Sloveniji. Kontrola ostataka pesticida u voću u EU u posljednjih nekoliko godina je pokazala da se na tržištu

nudi oko 45-50% voća bez prisutnosti mjerljivih ostataka pesticida, oko 40-45% voća kod kojeg se koncentracija kreće unutar granica MRL, te oko 2,5 do 5,5% voća s ostacima pesticida iznad MRL (ECHO dokument, 2004). S ciljem da se potrošačima nudi voće bez ostataka zaštitnih sredstava razvijen je sustav organske proizvodnje voća kao najviši standard, te modificirani sustav IPM u kojem će ostaci pesticida biti minimalni, odnosno jednaki nuli (IPM"0.0"RL). Na svjetskom tržištu već se pojavljuje voće s oznakom sustava uzgoja IPM"0.0"RL. Prije četiri godine smo i mi u Sloveniji započeli s pokusima, kojima želimo odgovoriti na sljedeća pitanja:

1. Da li sustav IPM"0.0"RL omogućava proizvodnju plodova jabuke u kojima će ostaci zaštitnih sredstava biti ispod 5% maksimalno dozvoljenih koncentracija (MRL)?
2. Da li je sustav IPM"0.0"RL prihvatljiv sa stajališta smanjene količine i kakvoće priroda?
3. Da li je sustav IPM"0.0"RL ekonomski održiv?

### Razvoj sustava IPM"0.0"RL

Postizanje cilja IPM"0.0"RL zahtjeva veće promjene u tehnologiji proizvodnje voća. Ovaj sustav je trenutno vrlo aktualan u Engleskoj, gdje se već 6 godina intenzivno proučavaju modificirane tehnologije proizvodnje voća (Pennel, 2006). Pokusi izvedeni u razdoblju 2000-2006. god. u pokusnoj postaji East Malling su pokazali da je sustav IPM"0.0"RL izvodljiv (Cross i sur., 2003; Cross i Berrie, 2007). Rezultati pokusa, koji se sastojao od varijante u kojoj je tehnologija bila prema propozicijama IPM, te varijante "zero rezidues", pokazuju manje razlike u stupnju oštećenja od čađave krastavosti i nekih štetnika (savijač, lisne uši). Nadalje, isti istraživači ukazuju da će sustav IPM"0.0"RL biti ekonomski opravdan za srednje i manje osjetljive sorte.

Udruga proizvođača voća Pipfruit New Zealand Inc. planira da će u sljedećih 5 godina oko 90% plodova jabuke i kruške proizvesti po tehnologiji naziva Apple Futures, a koja omogućuje proizvodnju plodova bez ostataka zaštitnih sredstava (Pipfruit New Zealand, 2007). Kada se na tržištu pojave veće količine takvog voća, vjerojatno će se i našim proizvođačima od strane trgovaca postavljati zahtjevi za proizvodima slične kakvoće. Postavlja se pitanje da li ćemo biti spremni za takve izazove?

Naše nevladine organizacije nedovoljno realno reklamiraju naše voćarstvo kada šalju podatke o proizvodnji u druge zemlje. Postavlja se pitanje da li je uzorkovanje koje obavljaju dovoljno objektivno za objektivnu procjenu stanja na našem tržištu? Tako na stranicama PAN izvještaja ECHO Slovenija nalazimo podatke o većim ostacima pesticida od graničnih vrijednosti MRL (ECHO dokument, 2004). Treba imati na umu da se u zemljama okruženja prati naša proizvodnja voća, te da podaci o ostacima pesticida u voću daju ukupnu sliku o našoj proizvodnji. U izvještaju organizacije PAN Europe o sadržaju ostataka sredstava za zaštitu bilja, gledano u odnosu na prosjek Europe, navodi se nadprosječni sadržaj u plodovima jabuke proizvedenim u Sloveniji (Smolka, 2006).

Stav potrošača, koji se sve bolje formulira pod okriljem nevladinih organizacija (u EU više od 800), ukazuje da proizvođači i državne administracije premalo čine u cilju proizvodnje plodova visoke kakvoće bez ostataka pesticida i da političari u Briselu odugovlače s donošenjem direktiva za takvu proizvodnju jer im je ustvari važniji ekonomski učinak od bilo čega drugog (Butler Ellis, 2006).

Ukoliko europski političari u strategiji održive uporabe pesticida (EU directive - The strategy on sustainable use of pesticides) "misle ozbiljno" kada planiraju smanjenje uporabe sredstava za zaštitu bilja za 50% u narednih deset godina, onda je sada pravo vrijeme za pripremu za sustav proizvodnje IPM"0.0"RL. Vrlo su zanimljive ocjene nekih analitičara tržišta koji procjenjuju da bi ponuda voća uzgojenog po sustavu IPM"0.0"RL vjerojatno dovela do povećanja potrošnje voća. Naime, potrošači se sve više osvrću na ostatke pesticida, pa ukoliko u tom pogledu imaju nedoumice, troše manje voća pa i ukoliko voće sadrži izrazito male, praktično neškodljive količine zaostalih sredstava za zaštitu bilja. Proizvođači diljem Europe očekuju razumijevanje potrošača da je nije moguće proizvesti visokokvalitetno voće bez značajnih ulaganja i da, prema tomu, takvi proizvodi moraju imati veću cijenu (Wise i Findlay, 2003).

U susjednoj Austriji su trgovački lanci (npr. Billa) u kojima se prodaje oko 40% voća, uveli stroge kriterije glede sadržaja ostataka zaštitnih sredstava, pa se primjerice traži smanjenje za 80% u odnosu na sadržaj ostataka pesticida koji propisuje državna administracija. "Biti na polju i u dogovoru s proizvođačima rješavati njihove probleme je značajan dio našeg posla. Želimo uspostaviti tijesnu povezanost između supermarketa i proizvođača, tako da proizvođači kroz povećanu prodaju i bolje cijene mogu nadoknaditi potencijalni gubitak prihoda zbog smanjenja upotrebe pesticida." (Beurtscher, 2006).

S ciljem da utvrdimo da li je u našim proizvodnim uvjetima moguće proizvesti voće bez mjerljivih ostataka pesticida postavili smo pokus u 2007. godini na površinama Fakultete za kmetijstvo in biosistemske vede u Mariboru. U pokusnom nasadu smo imali dva tretmana: a) standardna primjena zaštitnih sredstava sukladno propozicijama IPM i b) modificirani IPM sustav, odnosno sustav IPM“0.0“RL u kojem su voćke do početka srpnja tretirane sukladno sustavu IPM, a nakon toga sukladno sustavu biološke proizvodnje. Početni rezultati su ohrabrujući jer ukazuju da je i u našim uvjetima implementacija sustava IPM“0.0“RL moguća. Ipak, za širu primjenu ovog sustava potrebno je riješiti još čitav niz problema koji zadiru u tehnologiju proizvodnje i izbor sorti, čuvanje plodova, marketing i dr.

### Zaključna razmatranja

Na osnovi pokusa i uvida u postignuća drugih u Europi i svijetu, može se zaključiti da se uz suvremene promjene tehnologije proizvodnje voća može i u Sloveniji implementirati ekonomski održiv sustav IPM“0.0“RL. Za postupan prelazak na ovaj sustav potrebno je uraditi sljedeće:

- u proizvodnju uvesti sorte veće otpornosti na bolesti i štetnike uz odgovarajuću promociju tih sorata kako bi ih potrošači prepoznali i prihvatili,
- pripremiti podatke i upute za izvođenje modificiranih programa zaštite od bolesti i štetnika,
- pripremiti upute za promjenu tehnologije skladištenja i skladišnog procesiranja,
- uvesti standarde volumena voćaka prilagođene za izmjeru uporabljenih količina zaštitnih sredstava zbog smanjenja unosa zaštitnih sredstava u okoliš i optimiziranja nanosa zaštitnih sredstava na ciljne površine,
- uvesti metode kvalitetnog prikupljanja klimatskih podataka i brze računalne prognoze pojave bolesti na razini voćnjaka.

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# Problematika određivanja roka berbe šljive

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## Sažetak

U voćarskom centru Maribor - Gačnik u 2010. godini smo proučavali razvoj pojedinih parametara zrelosti i kvalitete ploda šljive *Prunus domestica* L. U pokusu su bile sorte šljive Valor i Stanley. Cilj istraživanja bio je utvrditi optimalno vrijeme berbe za pojedine sorte šljive i odnose između pojedinih parametara zrelosti i kvalitete. Eksperimentalni rezultati su pokazali da boja kao parametar kvalitete i zrelosti kod različitih sorti šljiva nije dobar pokazatelj optimalnog vremena berbe, jer se u godini istraživanja boja kože ploda kod sorte Valor razvila 17, a kod sorte Stanley 10 dana prije konzumnog dospijeca plodova utvrđenog drugim parametrima kakvoće.

Ključne riječi: šljiva, zrelost, boja kože

## Plum - the issue of harvest date

### Abstract

At Fruit growing Centre Maribor - Gačnik in 2010 we investigated the development of certain parameters of maturity and quality of plum (*Prunus domestica* L.). In the experiment were included plum cultivar 'Valor' and 'Stanley'. The aim of this study was to determine the optimal harvest time for each variety of plums, and relationships between the parameters of maturity and quality. The results showed that for different varieties of plum the skin colour as a quality and a ripeness parameter is not a good indicator of optimal harvest time, because in 2010 varieties 'Valor' developed skin colour 17 days and 'Stanley' 10 days before its eating maturity.

Key words: plum, ripeness, skin colour

### Uvod

Parametri unutarnje i vanjske kvalitete ploda šljive su izravno vezani na procese koji se odvijaju tijekom sazrijevanja. Unutarnja kvaliteta određuje se prema kriterijima koji su ujedno i kriteriji zrelosti. To su čvrstoća mesa ploda, sadržaj topljive suhe tvari i organskih kiselina, te okus. Glavni vanjski parametar zrelosti je boja kože ploda. Dozrijevanje ploda je složen proces, u koji su uključeni hormoni odgovorni za dozrijevanje, biosinteza pigmenta, metabolizam kiselina, šećera i hlapljivih sastojaka koji uvjetuju okus (Kristla et al. 2009). Tijekom sazrijevanja dolazi do brojnih fizioloških, biokemijskih i strukturnih promjena koje se mogu identificirati mjerenjem određenih fizioloških-kemijskih parametara (Nunes et al. 2009). Određivanje optimalnog vremena berbe nije lako jer za šljive, za razliku od jezgričavih voćaka, nisu razvijeni indeksi zrelosti. Optimalan rok berbe plodova šljive vrlo je važan i iz razloga što dugotrajna pohrana plodova nije moguća (Steinbauer et al. 2005).

Cilj našeg istraživanja bio je utvrditi povezanost između razvoja pojedinih parametara zrelosti i kvalitete šljiva i neizravno ispitati vezu između obojenosti kožice i zrelosti ploda sorti šljiva Valor i Stanley.

### Materijal i metode

Pokus je izveden u voćarskom centru Maribor - Gačnik. Sadnice sorata Valor i Stanley cijepljene na podlozi Myrobalana 29C, bile su posađene 2003. godine. Razmak sadnje je iznosio 4,5 x 2,5 m, a uzgojni oblik je bio vitko vreteno. Sustav održavanja bio je u skladu s propisima za integriranu proizvodnju voća. Međuredni prostor je bio zatravljen i po potrebi malčiran. Voćke su navodnjavane sustavom kap po kap.

Izmjere su obavljene tijekom srpnja, kolovoza i rujna na po pet po rastu ujednačenih stabala za svaku sortu. Za svaku sortu je označeno 200 plodova za praćenje dinamike parametara vanjske i unutarnje kakvoće. Prva mjerenja su obavljena 27. srpnja, a zatim u razmaku 3-4 dana. Izmjere boje kožice obavljene su *in situ*, a kod svakog mjerenja boje uzet je uzorak od 15 plodova za izmjere parametara dozrelosti (sadržaj topive suhe tvari, tvrdoća mesa ploda, masa ploda). Posljednje izmjere su obavljene u momentu optimalne dozrelosti utvrđene organoleptički. Za mjerenje boje kožice ploda (L, a, b) korišten je kolorimetar Minolta CR-400 (sustav CIE - Commission Internationale l'Eclairage, Brücker.1984). Tvrdoća mesa ploda (TMP - g/cm<sup>2</sup>) je utvrđivana elektroničnim penetrometrom (promjer 6 mm), masa ploda je utvrđivana vaganjem pomoću digitalne vage, a sadržaj topive suhe tvari (TSS - °Brix) refraktometrom Atago.

Dobiveni podaci su statistički obrađeni pomoću programskog paketa Microsoft Excel 2003 i SPSS for Windows 10.0. Urađena je jednosmjerna analiza varijance ANOVA i Duncan test (0,05).

### Rezultati i rasprava

#### Sorta Valor

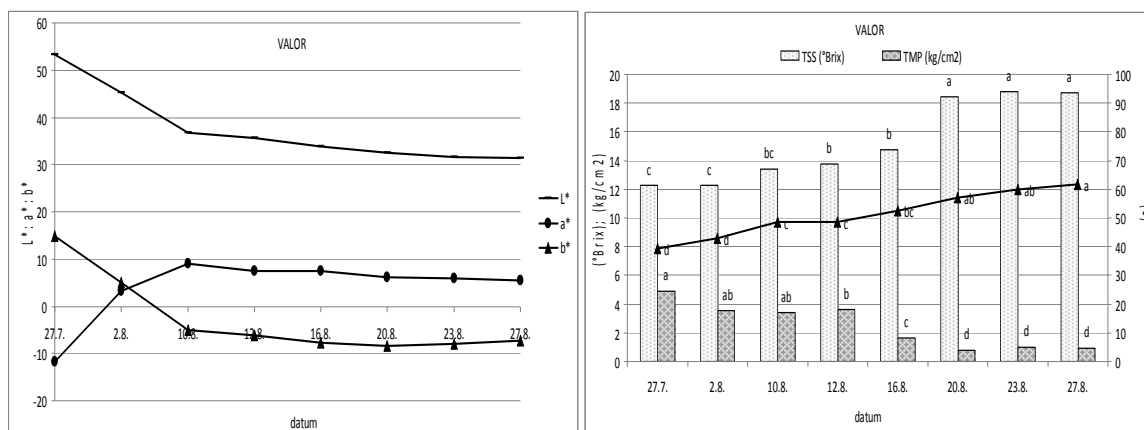
U grafikonu 1b prikazane su promjene parametara zrelosti. U prvom mjerenju (27. srpnja) 31 dan prije berbe, izmjerili smo tvrdoću mesa ploda (TMP) 4,88 kg / cm<sup>2</sup>. Nakon toga TPM se smanjuje do posljednjeg mjerenja (27. kolovoza) kada iznosi 0,93 kg / cm<sup>2</sup>. Međutim, značajno smanjenje TMP uslijedilo je već 25 dana prije berbe (s 4,88 kg / cm<sup>2</sup> na 2,57 kg / cm<sup>2</sup>), te 10 dana prije berbe nakon čega se TMP neznatno smanjila.

Valor je sorta koja ima relativno visoku topivu suhu tvar (TSS). U prvom mjerenju vrijednost TSS je bila 12,25 ° Brix, a u posljednjem mjerenju za 31 dan je porasla na 18,72 ° Brix. Značajno povećanje sadržaja TSS je utvrđeno tjedan dana prije berbe, kada se TSS povećala s 14,75 na 18,45 ° Brix. Povećanje TSS se podudara s značajnim promjenama u TMP.

Prosječna masa ploda se povećavala tijekom mjerenja. U prvom mjerenju (27. srpnja) masa ploda je bila 39,2 g, a u zadnjem mjerenju (27. kolovoza) i 61,53 g. Značajan porast mase dogodio se 17 dana prije berbe (porast s 42,95 na 48,52g).

Podaci u grafikonu 1a pokazuju promjene parametara boje kožice ploda. Značajna promjena boje dogodila se oko 17 dana prije optimalne zrelosti (27. kolovoza). U tom razdoblju smanjila se vrijednost parametra L od 53,35 na 36,78, što znači da su plodovi postali tamniji. Istovremeno se povećala vrijednost parametra a\* od -11,83 do 8,94 što potkrepljuje nakupljanje crvenih pigmenta. U isto vrijeme smanjuju se vrijednost parametra b\* od 14,91 do 4,94 što potvrđuje intenziviranje plave boje. Nakon toga nisu zabilježene veće promjene boje, a plodovi su do berbe postali za nijansu tamniji.

## Problematika određivanja roka berbe šljive



Graf. 1. Promjena parametara boje (a) i parametara kakvoće (b) ploda sorte Valor

Usporedba podataka prikazanih u grafikonu 1a i b pokazuju da tijekom razvijanja boje također dolazi do velikih promjena u tvrdoći mesa (02. kolovoza) i prosječne mase ploda (10. kolovoza). Nakon toga slijede promjene parametara unutarnje kakvoće (dozrelosti), a boja se bitno ne mijenja, pa bi, ukoliko bismo plodove brali samo prema boji kože, vjerojatno plodove obrali prerano (u slučaju sorte Valor 17 dana prerano).

### Sorta Stanley

U grafikonu 2b prikazane su promjene parametara zrelosti. U prvom mjerenju (02. kolovoza) 32 dana prije berbe, izmjerili smo tvrdoću mesa ploda (TMP) 4,60 kg / cm<sup>2</sup>. Nakon toga TPM se smanjuje do posljednjeg mjerenja (03. rujna) kada iznosi 0,99 kg / cm<sup>2</sup>. Međutim, značajno smanjenje TMP uslijedilo je već 18 dana prije berbe (s 4,60 kg / cm<sup>2</sup> na 2,27 kg / cm<sup>2</sup>), te 10 dana prije berbe nakon čega se TMP neznatno smanjila.

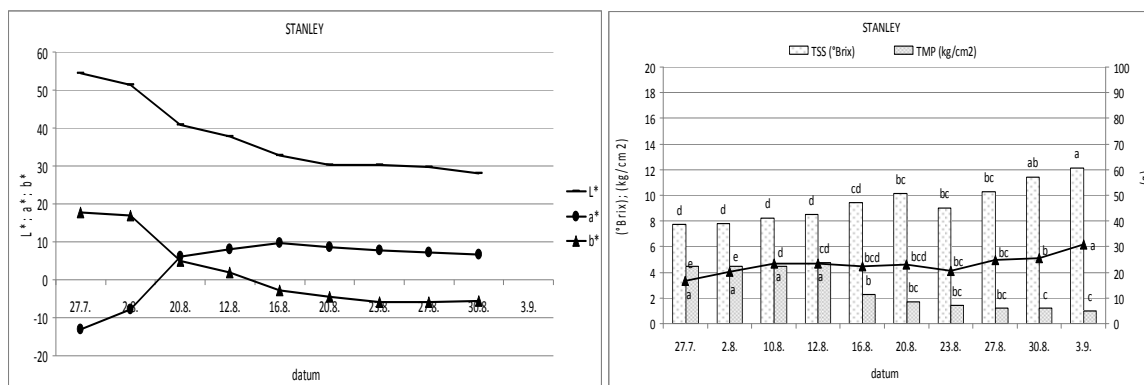
Sorta Stanley postigla je relativno nisku TSS. U prvom mjerenju je iznosila 7,71 ° Brix, a u posljednjem 12,11° Brix. Tijekom istraživanog razdoblja nisu utvrđene značajnije nagle promjene sadržaja topive suhe tvari.

Prosječna masa ploda u istraživanom razdoblju permanentno se povećavala. U prvom mjerenju (02. kolovoza) iznosila je 16,7 g i do posljednjeg mjerenja (03. rujna) porasla je na 30,93 grama. Značajno povećanje prosječne mase ploda zabilježeno je 24 dana prije berbe.

Podaci u grafikonu 2a pokazuju promjene parametara boje kože ploda. Značajna promjena boje dogodila se oko 22 dana prije optimalne zrelosti. Iz grafikona je vidljivo da se vrijednost parametra L smanjila s 54,33 na 32,77, što znači da su plodovi postali tamniji. Uz tu promjenu, promijenila se i vrijednost parametara a\* i b\*. Vrijednost parametra a\* se povećala od -12,92 na 8,17 što ukazuje na nakupljanje crvenih pigmenta. Vrijednost parametra b\* se smanjila s 17,76 na 1,93, što pokazuje nakupljanje plavih pigmenta. Značajne promjene boje kože ploda prestale su 10 dana prije optimalnog roka berbe (23. kolovoza), a zatim se boja nije bitno mijenjala.

Za vrijeme intenzivne promjene boje zabilježene su i značajne promjene TMP i prosječne mase ploda. Međutim, desetak dana prije optimalnog roka pa do berbe boja kože ploda se nije bitno mijenjala, dok su se ostali parametri dozrelosti bitno mijenjali. Ovo ukazuje na rizičnost prognoziranja roka berbe na osnovi boje ploda.

Dobiveni rezultati za sorte Valor i Stanley suglasni su navodima Walkowiak-Tomczak et al. (2008), koji su utvrdili da boja kože ploda nije siguran indikator dozrelosti, odnosno nije pouzdan parameter za određivanje roka berbe.



Graf. 2. Promjena parametara boje (a) i parametara kakvoće (b) ploda sorte Stanley

### Zaključak

Na temelju obavljenih istraživanja može se zaključiti da promjena boje kože ploda nije pouzdan parametar dozrelosti i ne može poslužiti za utvrđivanje optimalnog roka berbe. U obavljenom istraživanju plodovi sorte Valor su postigli boju zrelih plodova 17, a sorte Stanley 10 dana prije optimalne dozrelosti. Dobiveni podaci ukazuju na potrebu praćenja ostalih parametara dozrelosti za svaku sortu posebno, kako bi se mogao prognozirati optimalan rok berbe.

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# Višegodišnji rezultati istraživanja senzoričkih osobina plodova trinaest sorata jabuka uzgajanih na pokusnom dobru Gačnik-Maribor

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## Sažetak

Na Fakulteti za kmetijstvo in biosistemske vede Univerze u Mariboru svake godine organiziramo senzoričko ocjenjivanje različnih sorti jabuke. Tako smo u razdoblju od 1998. do 2009. godine sa studentima starim 20-25 godina obavili ocjenjivanje plodova 13 sorata jabuke. Ocjenjivali smo vanjski izgled plodova: oblik, veličinu i boju. Od unutarnjih svojstava ocjenjivali smo: čvrstoću, teksturu i sočnost, te okus mesa ploda, odnos šećera i kiselina, aromu i punoću. Prema vanjskim parametrima najbolje ocjene dobili su krupni plodovi crvene boje kožice, a najslabije sitni slabo obojeni plodovi. Prema unutrašnjim svojstvima najbolje su bili ocjenjeni čvrsti i sočni plodovi s izraženom aromom i kiselo slatkog okusa. Najlošije su bili ocijenjeni plodovi slabije konzistencije i bez izražene arome.

Ključne riječi: jabuka, senzoričko ocjenjivanje, vanjski i unutarnji parametri kakvoće ploda

## Longterm research results of fruit sensory properties of thirteen apple varieties grown on the experimental site Gačnik-Maribor

### Abstract

At Faculty of Kmetijstvo in biosistemske vede, University of Maribor, each year we organize sensory evaluation of different varieties of apples. Thus in the years 1998-2009 we conducted 13 evaluations of apple fruits with students aged between 20 and 25 years. We evaluated the external appearance of the fruit: shape, size and colour. We also evaluated the internal properties of fruits, which includes assessment of the physical properties of the fruit: firmness, texture and juiciness and flavour; relationship between sugar and acid, aroma and fullness. In the evaluation, we include different varieties that have evolved over the years. Evaluators in the external appearance of the fruit is best evaluated large fruit with a nice red color expressed. The lowest rated were small fruit with poor colour expressed. In the internal properties of fruits have received top ratings firm and juicy fruit with flavour and expressed sour sweet taste. The worst estimates were given soft fruit without flavour.

Key words: apple, sensory evaluation, external and internal fruit characteristics

## Uvod

Sortiment jabuke se s godinama mijenja. Tako se sortama koje se već više od 20 godina uspješno uzgajaju pridružuju nove sorte. Starije sorte u pravilu imaju izraženu crvenu boju s izuzetkom sorte Golden Delicious. U ovom razdoblju su se pojavile sorte sa slabije izraženom bojom kožice kao što su Fuji i Braeburn, što je donekle otežalo njihovo prihvaćanje od strane potrošača. Nasuprot njima, posljednjih godina pojavljuju se sorte vrlo atraktivnog izgleda. Ipak, treba imati u vidu da se iza relativno neprivlačnog vanjskog izgleda može skrivati odlična unutrašnja kakvoća, a iza atraktivnog vanjskog izgleda slabija unutrašnja kakvoća. Iz tog je razloga potrebno senzorički ocjenjivati nove sorte. Cilj naših istraživanja svodi se na odgovor na pitanje kako mlađa generacija potrošača prihvaća nove sorte jabuke.

## Materijal i metode

U razdoblju od 1998. do 2009. godine obavili smo 13 senzoričkih ocjenjivanja plodova jabuke. Ocjenjivači su bili studenti stari 20-25 godina. Ocjenjivani su parametri vanjske kakvoće (oblik, veličina i boja) i unutrašnje kakvoće ploda (čvrstoća, tekstura, sočnost, okus, odnos šećera i kiselina, aroma). Svake godine su ocjenjivani plodovi 6-10 sorata, proizvedenih u Sadjarskom centru Maribor u Gačniku. Plodovi su čuvani u hladnjači, a ocjenjivanje smo izveli u razdoblju studeni-siječanj, kada su plodovi u optimalnom stanju užitnosti. Za senzoričko ocjenjivanje su odabrani karakteristični plodovi za pojedinu sortu, po pet za svako ponavljanje (2-4). Najprije su ocjenjivani vanjski parametri kakvoće, a zatim unutrašnji pri čemu je oguljena kožica i za ocjenu su korištene kriške plodova. Svako svojstvo je ocjenjivano ocjenama od 1 do 10, pri čemu je 10 bila najviša ocjena. Prilikom ocjenjivanja korištene su upute i objavljeni standardi za senzoričke ocjene (Silbereisen,1996; Werth,1997; Egger,2010). Iz dobivenih ocjena izračunate su srednje vrijednosti. Tijekom 13 godina neke sorte su bile ocjenjivane svake godine, a druge manje puta. U radu se iznose rezultati za sorte koje su ocjenjivane najmanje kroz 3 godine.

## Rezultati i rasprava

### Vanjski parametri kakvoće

Ocjenjivači su najbolje ocijenili plodove veličine 80+, a slabije one čiji je ekvatorijalni promjer bio manji od 70 mm. U svim ocjenjivanjima je najbolju ocjenu dobila krupnoplodna sorta Cameo, dok su slabije ocjene dobile sorte sitnijeg ploda, pri čemu se ističe sorta Topaz koja je zbog sitnih plodova bila najslabije ocijenjena.

Ocjenjivači su visoke ocjene dali sortama okruglastih plodova. Ocjenjivači su loše ocijenili sorte spljoštenog oblika kao i sorte čiji plodovi imaju izražena rebra (Crveni delišes).

U početnim godinama ocjenjivanja sorte Zlatni delišes i Jonagold su bile dobro ocjenjivane za svojstvo boje kožice ploda. Kasnije su visoke ocjene dobivale sorte Gala i Pinova, da bi s pojavom sorata Mairac, Kanzi i Diwa one dobivale najviše ocjene. Nasuprot njima, slabije obojene sorte Braeburn i Fuji, sve do pojave bolje obojenih klonova nisu bile prema boji ploda visoko ocijenjene.

Za vanjski izgled su najveće prosječne ocjene dobile nove sorte Diwa, Mairac, Kanzi i Cameo. Višu prosječnu ocjenu dobile su i sorte Zlatni delišes i Jonagold, dok su sorte Braeburn i Fuji, koje su zbog kakvoće ploda prepoznali potrošači, dobile nešto nižu ocjenu.

### Unutrašnji parametri kakvoće

Tvrdoća ploda je tijekom 13-godišnjeg razdoblja različito ocjenjivana. Kada su u ocjenjivanje uključene sorte Fuji i Braeburn one ostvaruju najviše ocjene, dok Zlatni delišes, koji je ranije bio bolje ocijenjen, biva slabije ocijenjen. Podaci ukazuju da mlađa generacija daje prednost sortama tvrdih plodova. U prilog tomu govore i visoke ocjene za sorte Mairac, Kanzi i Cameo. Sorta Diwa je dobila sličnu ocjenu kao i sorta Pinova i Gala, dok su sorte manje čvrstih plodova kao što su Topaz, Crveni delišes i Idared dobile značajno nižu ocjenu.

Prema ukupnoj prosječnoj ocjeni za tvrdoću, teksturu i sočnost vode nešto starije sorte Fuji i Braeburn i sorte novije generacije (Mairac, Kanzi i Cameo). Lošije su bili ocijenjeni plodovi sorata Idared, Jonagold i Zlatni delišes.

**Višegodišnji rezultati istraživanja senzoričkih osobina plodova trinaest sorata jabuka uzgajanih na pokusnom dobru Gačnik-Maribor**

Prema svojstvima: odnos šećera i kiselina, aroma i punoća okusa, najbolje je bila ocijenjena sorta Cameo, zatim Kanzi, Mairac i Diwa. Nešto slabije ocjene dobile su sorte Fuji i Gala, a značajno slabije sorte Zlatni delišes, Idared i Crveni delišes, te Topaz.

Iz Tab. 1. je vidljivo da je prema prosječnoj ukupnoj ocjeni najviše rangirana sorta Cameo. Ona je praktično prema svim parametrima kakvoće najbolje vrednovana sorta. Drugu najvišu ocjenu dobila je sorta Kanzi, a zatim slijede Mairac i Diwa. Navedene sorte su pozitivno odstupale od ostalih sorata u ocjenjivanju. Prema prosječnoj ocjeni njima najbliže su sorte Fuji i Gala. Sorta Fuji je lošije ocijenjena prvenstveno zbog slabije obojenosti kože ploda. Slijede sorte Braeburn, Jonagold i Pinova koje su prema svim parametrima kakvoće ocjenjivane srednjim ocjenama. Pri tom je takvu ocjenu sorta Braeburn postigla zahvaljujući slabijoj obojenosti, iako je prema npr. tvrdoći ploda bila visoko ocijenjena. Najnižu prosječnu ocjenu dobile su sorte Zlatni i Crveni delišes, te Idared, posebice pri ocjeni čvrstoće, teksture i sočnosti. Sorta Idared je najzastupljenija u našim voćnjacima prvenstveno radi neproblematične tehnologije uzgoja i dobre skladišne sposobnosti, pa ju voćari i dalje sade. Sorte Idared i Zlatni delišes su standardne sorte u našem voćarstvu mada prema unutrašnjim parametrima kakvoće nisu baš najbolje. U ocjenjivanje je bio uključen i Crveni delišes prije svega zbog velike zastupljenosti u sortimentu u Sjevernoj Americi. Ova sorta je u našim ocjenjivanjima bila relativno slabo ocijenjena, uglavnom zbog izgleda ploda. Sorta Topaz, koja se preporuča za ekološki uzgoj, je dobila najniže ocjene, pa čak i u usporedbi s nekim drugim sortama prikladnim za sustav organske proizvodnje voća.

**Tablica 1: Prosječne vrijednosti opažanih svojstava za 13 sorti jabuke.**

Sorta	Vanjski izgled ploda			Fizikalne osobine ploda					Okus mesa ploda			Ukupno	
	Oblik	Veličina	Boja	Prosječna vrijednost	Čvrstoća	Tekstura	Sočnost	Prosječna vrijednost	Odnos slad.-kisel.	Aroma	Punoća		Prosječna vrijednost
1	5,78	5,86	5,86	5,83	6,75	6,59	6,33	6,56	5,58	5,92	6,05	5,85	6,08
2	6,39	6,73	6,72	6,61	6,54	5,88	5,98	6,13	5,88	5,60	5,66	5,71	6,15
3	7,64	7,52	7,43	7,53	5,69	6,06	6,02	5,92	6,07	5,87	6,06	6,00	6,45
4	7,10	7,20	7,20	7,17	6,14	6,01	6,38	6,18	6,17	5,94	6,04	6,05	6,46
5	7,53	7,59	7,13	7,42	5,84	6,49	6,81	6,38	6,55	6,52	6,49	6,52	6,77
6	7,28	7,21	7,15	7,21	7,06	6,51	6,55	6,71	6,57	6,53	6,58	6,56	6,83
7	6,81	6,77	6,45	6,68	8,11	7,18	7,18	7,49	6,34	6,35	6,52	6,40	6,86
8	6,94	7,00	7,57	7,17	7,09	6,92	7,27	7,09	7,03	6,87	6,58	6,83	7,03
9	7,18	7,07	6,12	6,79	7,85	7,09	7,46	7,47	7,00	6,76	6,93	6,90	7,05
10	7,57	7,47	8,27	7,77	7,17	7,05	7,49	7,24	6,77	7,14	7,10	7,00	7,34
11	7,49	7,79	7,86	7,71	7,95	7,52	7,65	7,71	6,90	6,96	7,26	7,04	7,49
12	7,32	7,73	7,90	7,65	8,23	7,92	8,27	8,14	7,29	7,34	7,65	7,43	7,74
13	7,57	8,02	7,11	7,57	8,27	7,87	8,02	8,05	7,75	7,75	8,01	7,89	7,84

Legenda: 1 - Topaz, 2 - Crveni delišes, 3 - Zlatni delišes, 4 - Idared, 5 - Jonagold, 6 - Pinova, 7 - Braeburn, 8 - Gala, 9 - Fuji, 10 - Diwa, 11 - Mairac, 12 - Kanzi, 13 - Cameo

### Zaključci

Kod nas su plodovi jabuke i kruške poznati po imenima sorte, što nije slučaj s ostalim voćnim vrstama. Kada se potrošači nauče na neku sortu teško mijenjaju naviku, odnosno teško se opredjeljuju za nove sorte. To je posebice činjenica ukoliko izgled ploda nije osobito atraktivan unatoč dobroj unutrašnjoj kakvoći. Takva je situacija bila sa sortama Fuji i Braeburn za koje je potrošačima trebalo duže vrijeme da ih prepoznaju i prihvate. Nasuprot tomu, ako nove sorte, pored odličnih unutrašnjih parametara kakvoće, imaju privlačan izgled i zadovoljavajuću krupnoću, perspektiva takvih sorata je odlična. Dakako da i dodatna kvalitetna promidžba pridonosi uspjehu pojedine sorte.

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