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AGRONOMA ON AGRICULTURE

ZBORNIK  
SAŽETAKA | BOOK  
OF ABSTRACTS

19. – 24. lipnja 2022. | Vodice | Hrvatska  
June 19 – 24, 2022 | Vodice | Croatia



Josip Juraj Strossmayer University of Osijek

**Faculty of Agrobiotechnical  
Sciences Osijek**

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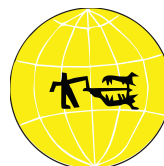
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# 07

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# 09

## Poljoprivredna tehnika

### Agricultural Technics

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**Agroekologija,  
ekološka poljoprivreda  
i zaštita okoliša**

**01**

**Agroecology,  
Organic Agriculture  
and Environment  
Protection**



## DNA barcoding of invertebrates inhabiting olive orchards and vineyards accelerates understudied mediterranean biodiversity assessment

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### Summary

Invertebrate diversity is high, yet poorly researched in the Mediterranean region, and this also applies to common agricultural lands like vineyards and olive orchards. Genetic-based approaches like DNA barcoding can be used for biodiversity assessment, and more data on species inhabiting agricultural lands can support biocontrol application. The goal of the study was to assess the diversity of seven invertebrate groups inhabiting olive orchards and vineyards in the Mediterranean part of Croatia. Groups studied are potential prey to predatory arthropods like carabids and spiders, and knowledge on their diversity can facilitate the analysis of trophic interactions and their implementation in biocontrol. The DNA barcoding results, which included sequences from 269 specimens collected in Zadar County, were used to identify species and quantify species richness by comparing our data to data available in DNA databases. Lepidopteran, hemipteran, dipteran, and hymenopteran species were identified through previous barcode data, whereas Collembolan and Oligochaetes species numbers were examined using species delimitation. Our findings revealed a large number of species unique to the studied area and confirmed that it is understudied, which was especially noticeable in taxonomically demanding groups like collembolans and oligochaetes. Furthermore, our research supports the need for studying Mediterranean agricultural land's diversity so that it can be used for future ecological studies on biocontrol, agricultural land biodiversity protection, and sustainable management.

**Key words:** DNA barcoding, diversity, Mediterranean region, olive orchards, vineyards

## Hlapive tvari masline kao mogući atraktanti maslinina moljca (*Prays oleae* Bern.)

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### Sažetak

Maslinin moljac (*Prays oleae* Bern.) jedan je od najvažnijih štetnika masline koji svake godine čini štete. Godinama je jedna od glavnih mjera suzbijanja istog bila primjena pesticida, čija je intenzivna uporaba imala negativan utjecaj na okoliš. Stoga je EU uvođenjem Europskog zelenog plana obvezala svoje članice na smanjenje utroška pesticida za 50 % do 2030. godine, te 100 % do 2050. godine. Zbog svega navedenog prijeko je potrebno iznaći nova rješenja koja bi bila učinkovita u suzbijanju moljca i ekološki povoljna za okoliš. Trenutne spoznaje govore da različite vrste kukaca privlače hlapive tvari biljke domaćina. Kako interakcija masline i moljca još uvijek nije istraživana, cilj istraživanja je bio identificirati hlapive tvari masline koje bi mogle biti odgovorne za privlačenje istog, te ih testirati u maslinicima. Na odabranim sortama masline uzorkovan je biljni materijal te su identificirane hlapive tvari pomoću HS-SPME/GC-MS uređaja. Tijekom istraživanja identificirano je oko 70 različitih hlapivih tvari, među kojima su odabrana dva aldehida, dva alkohola i ester, te su testirani pojedinačno i u kombinacijama u maslinicima pomoću delta lovki. Rezultati ovog istraživanja su pokazali kako su alkohol i kombinacija aldehid:alkohol:ester, kao dodatak feromonu, privukle puno veći broj moljaca od lovki koje sadrže samo feromon. Ovo otkriće može dovesti do razvoja novog i poboljšanog mamaca za maslinovog moljca, koji bi se u budućnosti mogao koristiti za monitoring i/ili suzbijanje istog.

**Ključne riječi:** zaštita bilja, IPM, ponašanje kukaca, hlapive tvari, *Olea europaea* L.

## Olive volatile compounds as possible attractants of olive moth (*Prays oleae* Bern.)

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### Summary

Olive moth, *Prays oleae* (Bern.) is one of the most important olive pests, causing damages every year. For years, the use of pesticides was the main method for *P. oleae* controlling, which intensive use had a negative effect on the environment. Therefore, the European Union is seeking to reduce pesticide use by 50% by 2030 and 100% by 2050. Due to all the above, it is necessary to find new solutions that would be effective in *P. oleae* controlling and in the same time environmentally friendly. Current knowledge suggests that different insect species are attracted to the host plants volatiles. Since the interaction between olive tree and olive moth has not been investigated yet, the aim of the study was to identify the olive tree volatiles that could be responsible for *P. oleae* attracting, and to test them in olive groves. Plant material was sampled on selected olive cultivars and volatile compounds were identified using HS-SPME/GC-MS. During investigation, around 70 different volatiles were identified, among which two aldehydes, two alcohols and an ester were selected. They were tested, individually and in blends, in selected olive groves, using delta traps. The results of this study showed that alcohol and the blend of aldehyde:alcohol:ester, attached to traps that contained pheromone, attracted a much larger amount of *P. oleae* than traps containing only the pheromone. This discovery may lead to the development and improvement of new attractants, that could be a useful tool for monitoring and/or controlling of *P. oleae* in the future.

**Key words:** plant protection, IPM, insect behavior, volatile compounds, *Olea europaea* L.



## **Straw mulch effect on soil and water losses in different growth phases of Maize sown on Pseudogley in Croatia**

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### **Summary**

Soil and water losses due to conventional agricultural management are high and non-sustainable in several Croatian croplands. A rainfall simulation experiment was conducted at 60 mm h<sup>-1</sup> over 30 min on 10 paired plots (0.785 m<sup>2</sup>), bare and straw covered. The experiment was carried out in maize cultivation (Blagorodovac, Croatia) established on Pseudogley on slopes. Measurements were conducted during April (bare soil, after seeding - VE), May (five leaves stage – V3) and June (intensive vegetative growth - V7) making 60 rainfall simulations in total. Straw reduced soil and water losses importantly. The highest water, sediment loss, and sediment concentrations were identified in tillage plots in the V3 stage. An addition of 2 t ha<sup>-1</sup> straw cover (200 g m<sup>-2</sup>) resulted in delayed ponding (for 7%, 63% and 50% at VE, V3 and V7 stage, respectively) and runoff generation (for 37%, 32% and 18% at VE, V3 and V7 stage, respectively). Compared to the straw mulched plot, tillage and bare soil increase water losses by 349%. Maize development reduced the differences between bare and straw mulched plots. In V3 and V7 stages bare plots increase water losses for 92% and 95%, respectively. The straw mulch reduced raindrop kinetic energy and sediment detachment from 9, 6 and 5 magnitude orders at VE, V3 and V7 stages. Overall, the straw mulch was revealed to be a highly efficient nature-based solution for soil conservation and maize cultivation protection.

**Key words:** Agriculture systems, silty-loam soil, high intensity rainfall, nature-based solutions, soil conservation

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## Utjecaj načina korištenja zemljišta i sezonalnosti na fizikalna svojstva tla u Zagrebu

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### Sažetak

Globalna urbanizacija i gubitak poljoprivrednih i šumarskih površina, ukazuju na važnost promatranja načina korištenja tla u urbanim sredinama. U ovom istraživanju prikazati ćemo utjecaj šumske sastojine (FOR), zapuštene poljoprivredne površine (ACROP), oranice (CROP), livade (MEAD) i voćnjaka (ORCH) na fizikalna svojstva (trenutačna vlažnost tla – SWC; kapacitet tla za vodu – WHC; volumna gustoća tla – BD) u Gradu Zagrebu. Sa svih lokacija uzeti su uzorci sa dubine 0-10 cm (8 po tretmanu; 40 ukupno), tijekom proljeća i jeseni 2021. godine. Način korištenja zemljišta značajno je utjecao ( $p < 0.05$ ) na sve parametre. Prema dobivenim rezultatima u proljetnom mjerenju BD bilježi značajno niže vrijednosti kod ACROP i MEAD, nego kod FOR, CROP i ORCH. U jesenskom mjerenju FOR je značajno niži od ACROP, CROP, MEAD i ORCH. Kapacitet tla za vodu bilježi kod FOR značajno veću vrijednost od ACROP, ali i značajno manju od MEAD, u jesenskom razdoblju FOR, CROP i MEAD su značajno niži od ACROP i ORCH. Kod trenutačne vlažnosti FOR i ORCH su značajno niži od MEAD, ali veći u odnosu na ACROP i CROP, u jesenskom mjerenju ORCH je značajno veći u odnosu na preostale načine korištenja. Način korištenja zemljišta, odnosno izostanak primjena agrotehničkih zahvata u FOR, MEAD i ACROP uzrok je povoljnih vrijednosti fizikalnih svojstava. Tretmani sa intenzivnim i učestalim agrotehničkim zahvatim (CROP i ORCH), zahtjevaju kontinuirani monitoring, kako bi se spriječila degradacija tla.

**Ključne riječi:** načini korištenja, fizikalna svojstva, degradacija tla

## Impact of land use and seasonal variability on soil physical properties in City of Zagreb

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### Summary

Global urbanization and the loss of agricultural and forest land highlight the importance of observing land use in urban areas. In this study, we show the effects of forest (FOR), neglected agricultural land (ACROP), cropland (CROP), meadows (MEAD) and orchards (ORCH) on physical properties (soil water content - SWC; water holding capacity - WHC; volume soil density - BD) in the City of Zagreb. Samples were collected from a depth of 0-10 cm at all sites in spring and autumn 2021 (8 per treatment; 40 in total). Land use significantly ( $p < 0.05$ ) influenced all parameters. According to the results of spring measurement, BD recorded significantly lower values in ACROP and MEAD than in FOR, CROP and ORCH. In autumn measurement, FOR is significantly lower than ACROP, CROP, MEAD and ORCH. The WHC value in FOR is significantly higher than in ACROP but also significantly lower than in MEAD, in the fall period FOR, CROP and MEAD are significantly lower than ACROP and ORCH. Finally, SWC in FOR and ORCH are significantly lower than MEAD, but higher than ACROP and CROP, in the fall measurement ORCH is significantly higher than other uses. The type way of land use, i.e., the lack of application of agrotechnical interventions in FOR, MEAD and ACROP is the cause of the favorable values of physical properties. Treatments with intensive and frequent agrotechnical interventions (CROP and ORCH) require continuous monitoring to prevent soil degradation.

**Key words:** land use, soil physical properties, soil degradation

## Soil water flow evaluation at top, middle and bottom position at the vineyard hillslope

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### Summary

In the soil vadose zone, one of the critical processes is the water flow which is important for the root uptake but could also enhance transport of potentially harmful agricultural substances to surface and groundwater. Thus, we established the first Croatian critical zone observatory SUPREHILL to specify subsurface preferential flow and nonlinear agrochemical transport processes. Among other instruments, wick lysimeters were installed at the 40 cm depth at the top, middle, and bottom of the vineyard hillslope. The water volumes collected in lysimeters were measured every two weeks. For estimation of soil hydraulic properties (SHP) using HYPROP and WP4C techniques, the undisturbed soil cores (250 cm<sup>3</sup>) were taken from the same positions at 15–20 and 35–40 cm depth in three repetitions. The first results from one-year research showed the highest amount of water collected in lysimeters at the hilltop and the lowest at the middle part of the hillslope. Estimated SHP showed that the middle position mostly has the highest values of bulk density and the lowest values of porosity which could cause slower vertical water movement. Furthermore, the water volume in lysimeters could be a result of variable slope in the investigated hillslope. For example, the slope on the top is minor compared to the middle and the bottom thus resulting in the slowest lateral subsurface flow and the highest amount of collected water. The middle and the bottom have similar slopes, but below the bottom position, the slope becomes less steep affecting the water movement at that position and reducing lateral subsurface flow causing a higher amount of water compared to the middle part. At the middle position, the subsurface runoff is possibly the main water pathway since the middle part has a steep slope that continues to the bottom of the hillslope. Thus, to precisely determine water movement at vineyard hillslope and therefore the agrochemical transport, later in research we will combine results obtained by sensors set at the field at various depths, undisturbed soil columns experiments, CT-scanning, and numerical simulations.

**Key words:** vineyard soil, hillslope, water flow, subsurface flow

## Potencijal komine grožđa kao supstrata u proizvodnji bioplina

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### Sažetak

Komina grožđa nezaobilazan je nusprodukt u proizvodnji vina koji zbog svoje velike količine predstavlja problem i potrebno ga je zbrinuti na ekološki prihvatljiv način. Jedan od načina zbrinjavanja može biti proizvodnja bioplina. Cilj ovog istraživanja je odrediti bioplinski potencijal komine različitih sorti grožđa i usporediti prinos bioplina između crnih i bijeli sorti. Istraživanje je provedeno koristeći govedu gnojovku u kodigestiji sa kominom 4 sorte grožđa (Merlot, Frankovka, Graševina i Rajnski rizling) u termofilnim uvjetima (55 °C) tijekom 24 dana. Prinos bioplina komine crnih sorti grožđa iznosio je za Merlot 385,82 ml g<sup>-1</sup> suhe organske tvari (SOT) i Frankovku 417,01 ml g<sup>-1</sup> SOT, dok je kod bijelih sorti Graševine iznosio 356,07 ml g<sup>-1</sup> SOT, a Rajnskog rizlinga 342,28 ml g<sup>-1</sup> SOT. Rezultati pokazuju da komina crnih sorti grožđa ima potencijal za proizvodnju veće količine bioplina. Prosječni sadržaj metana kod sorti merlot i rajnski rizling bio je viši (63,79 i 63,61 %) u odnosu na sorte frankovka i graševina (60,16 i 59,56 %). Ovo istraživanje pokazalo kako je komina grožđa pogodan supstrat za kodigestiju, te može proizvesti veće količine bioplina sa visokim sadržajem metana. Njena daljnja upotreba doprinijela bi cirkularnoj ekonomiji i održivom gospodarenju resursima u ruralnim dijelovima u kojima je vinarstvo jedna od primarnih proizvodnji.

**Ključne riječi:** biogorivo, komina grožđa, anaerobna fermentacija, zelena energija

## Potential of grape pomace as a substrate in biogas production

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### Summary

Grape pomace is an inevitable by-product in wine production which, due to its large quantity, is a problem and needs to be environmentally friendly way disposed. One way of disposal can be biogas production. The aim of this research is to determine the biogas potential of different varieties grape pomace and to compare the biogas yield between black and white varieties. The research was done using dairy cow manure in codigestion with pomace of 4 grape varieties (Merlot, Blaufränkisch, Graševina and Rhine riesling) in thermophilic conditions (55 °C) for 24 days. The biogas yield of black grape pomace was 385.82 and 417.01 mL g<sup>-1</sup> volatile solids (VS) for Merlot and Blaufränkisch, while white grape varieties Graševina and Rhine Riesling yield 356.07 and 342.28 mL g<sup>-1</sup> VS. The results show that the pomace of black grape varieties has the potential to produce more biogas. The average methane content of the Merlot and Rhine Riesling varieties was higher (63.79 and 63.61%) compared to the Blaufränkisch and Graševina varieties (60.16 and 59.56%). This research has shown that grape pomace is a suitable substrate for codigestion, and can produce larger amounts of biogas with a high methane content. Its further use would contribute to the circular economy and sustainable resource management in rural areas where winemaking is one of the primary productions.

**Key words:** biofuel, grape pomace, anaerobic digestion, green energy

## Soil management impact on soil physical properties and hydrological response in apple orchard (Croatia) during three seasons

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### Summary

Aim of this research was to determine the impact of different soil management practices in apple orchard on Cambisol, on a slope (14°) in Marija Magdalena (Croatia). Four treatments were studied: tilled, barley straw mulched (3.5 t ha<sup>-1</sup>), corn stark mulched (3.5 t ha<sup>-1</sup>), and permanent grass cover. Investigation was conducted through three seasons (Spring, Summer, and Fall). Each treatment consists of 10 plots, where rainfall simulations and soil samplings were conducted to determine runoff, soil loss (SL), and soil physical properties. In Spring the results showed no significant differences for bulk density (BD), soil water content (SWC), and mean weight diameter (MWD) between treatments. Time to ponding (PT) and time to runoff (RT) were significantly higher on the barley straw (279 sec, 720 sec) and corn stark (125.5 sec, 720 sec) mulch treatments compared to tilled and grass cover (88.5 sec, 726 sec; 70 sec, 396 sec) treatment. Significantly higher infiltration rate (IR) and lower SL was recorded on the mulched treatment when compared to tilled one. In Summer, there was an increase of BD when compared to Spring period on the tilled (1.3 g cm<sup>-3</sup>) and mulched treatments (1.2 g cm<sup>-3</sup>; 1.2 g cm<sup>-3</sup>), while the grass covered treatment had lower values (1.1 g cm<sup>-3</sup>). Overland flow was not created on all treatments in Summer period. In Fall there was a decrease of SWC on all treatment when compared to Spring and Summer period. Generation of overland flow was only noted on the tilled treatment. Significantly higher values of PT, RT and IR was noted on tilled treatment during Fall, when compared to Spring period. However, SL was significantly higher in Fall then in Spring (189%). Presented results show that application of barley straw mulch, corn stark mulch, and use of permanent grass cover are effective nature-based solutions to prevent the land degradation in apple orchards.

**Key words:** mulch application, runoff, soil degradation, mitigation

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## Dodatak inokulanta utječe na proizvodnju kiselina u prvim danima siliranja talijanskog ljulja

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### Sažetak

Proizvodnja silaža predstavlja konzerviranje zelene mase pri čemu proizvodnja mliječne kiseline i hlapivih masnih kiselina (HMK) koje proizvode bakterije mliječne kiseline (BMK) dovodi do pada pH. Proizvodnja kiselina, posebno u prvim danima siliranja, najvažniji je faktor koji utječe na kvalitetu silaže. Iz tog razloga pri siliranju često se dodaju aditivi u obliku inokulanta BMK kako bi se povećala proizvodnja kiselina. Cilj ovog rada je istražiti utjecaj dodatka inokulanta na proizvodnju mliječne (MK), octene (OK), propionske (PK), izomaslačne (IMK) kiseline i etanola u silaži talijanskog ljulja u prvih 10 dana siliranja (silaže uzorkovane 1., 3., 5. i 10. dan u peteroplikatu; određivanje HPLC metodom). Statistička analiza podataka odrađena je u SAS 9.3. U prvih 10 dana siliranja, u silaži talijanskog ljulja došlo je do povećanja MK (s 0 na 89,33 g kg<sup>-1</sup> ST;  $P < 0,001$ ), OK (s 0 na 11,94 g kg<sup>-1</sup> ST;  $P < 0,001$ ), PK (s 0 na 0,99 g kg<sup>-1</sup> ST;  $P < 0,001$ ), IMK (s 0 na 1,29 g kg<sup>-1</sup> ST;  $P < 0,001$ ) i etanola (s 0 na 6,09 g kg<sup>-1</sup> ST;  $P < 0,001$ ). Pri tome je dodatak inokulanta povećao proizvodnju MK (97,77 vs. 53,59 g kg<sup>-1</sup> ST;  $P < 0,001$ ) i IMK (0,92 vs. 0,51 g kg<sup>-1</sup> ST;  $P < 0,01$ ), smanjio proizvodnju OK (3,77 vs. 10,40 g kg<sup>-1</sup> ST;  $P < 0,001$ ) i PK (0,22 vs. 1,02 g kg<sup>-1</sup> ST;  $P < 0,001$ ), dok na proizvodnju etanola nije značajnije utjecao (6,07 vs. 6,63 g kg<sup>-1</sup> ST;  $P > 0,05$ ). Navedeni rezultati potvrđuju su intenzivne proizvodnje mliječne kiseline i HMK u prvim danima siliranja silaža te da dodatak inokulanta značajno utječe na profil sintetiziranih kiselina.

**Ključne riječi:** silaža talijanskog ljulja, inokulant, mliječna kiselina, hlapive masne kiseline



## The application of inoculant influences acid production in the first days of Italian ryegrass silage production

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### Summary

Silage production is the preservation of plant green mass in which lactic acid and volatile fatty acids (VFA) are produced by lactic acid bacteria (LAB) during ensiling. Acid production during the first days of ensiling is responsible for pH reduction and is the most important factor affecting preservation and silage quality. Therefore, LAB are often added in the form of inoculants during ensiling to increase acid production. The aim of this study was to investigate the effects of inoculant application on the production of lactic acid (LA), acetic acid (AA), propionic acid (PA), isobutyric acid (IBA) and ethanol in Italian ryegrass silage in the first 10 days of ensiling (sampling on days 1, 3, 5, and 10; five repetitions; HPLC determination). Statistical analysis of the data was performed using SAS 9.3. In the first 10 days of ensiling, there was an increase in LA (from 0 to 89.33 g kg<sup>-1</sup> DM;  $P < 0.001$ ), AA (from 0 to 11.94 g kg<sup>-1</sup> DM;  $P < 0.001$ ), PA (from 0 to 0.99 g kg<sup>-1</sup> DM;  $P < 0.001$ ), IBA (from 0 to 1.29 g kg<sup>-1</sup> DM;  $P < 0.001$ ) and ethanol (from 0 to 6.09 g kg<sup>-1</sup> DM;  $P < 0.001$ ). The application of inoculant increased the production of LA (97.77 vs 53.59 g kg<sup>-1</sup> DM;  $P < 0.001$ ) and IBA (0.92 vs 0.51 g kg<sup>-1</sup> DM;  $P < 0.01$ ), decreased production of AA (3.77 vs 10.40 g kg<sup>-1</sup> DM;  $P < 0.001$ ) and PA (0.22 vs 1.02 g kg<sup>-1</sup> DM,  $P < 0.001$ ) while ethanol production was not significantly affected (6.07 vs 6.63 g kg<sup>-1</sup> DM;  $P > 0.05$ ). The results confirm intense lactic acid and VFA production in the first days of ensiling Italian ryegrass and that the profile of synthesized acids is significantly affected by the use of inoculants.

**Key words:** Italian ryegrass silage, inoculant, lactic acid, volatile fatty acids

## Utjecaj supstrata i gnojidbe na mineralni sastav mirisave ljubičice (*Viola odorata* L.)

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### Sažetak

Mirisava ljubičica cvate u proljeće nježnim cvjetovima privlačnog mirisa zbog kojih se često sakuplja s prirodnih staništa, dok se u ukrasnoj hortikulturi koristi za rez i za sadnju u vrtove. Cijela biljka je jestiva i ljekovita tako da postoje brojne mogućnosti njezine primjene u prehrambene, farmaceutske i kozmetičke svrhe. Da bi uzgoj bio što uspješniji posebnu pozornost treba posvetiti supstratu i gnojidbi. U želji da se dobiju dodatne spoznaje o izboru najpovoljnijeg supstrata i optimalne doze gnojiva, provedeno je istraživanje s pet različitih vrsta supstrata, vrtnim tlom i tlom s prirodnog staništa te četiri varijante gnojidbe: kontrola, 0,1 % NPK-Mg; 0,2 % NPK-Mg i 0,2 % NPK-Mg + 4 % MgSO<sub>4</sub>. Rezultati pokazuju da je najveći sadržaj dušika u listu mirisave ljubičice zastupljen u biljkama uzgajanim na vrtnom tlu i kreće se od 3,13 % na negnojnim biljkama do 3,23 % na gnojnim. Najveći sadržaj fosfora i kalcija u listu mirisave ljubičice utvrđen je na biljkama uzgajanim na tlu sa staništa i kreće se od (0,39 %; 2,32 %) na negnojnim biljkama do (0,44 %; 2,33 %) na gnojnim. Najveći sadržaj kalija i magnezija u listu mirisave ljubičice utvrđen je na supstratu S3 i kretao se od (3,09 %; 0,81 %) na negnojnim biljkama do (3,29 %; 0,84 %) na gnojnim. Rezultati istraživanja proširiti će spoznaje o mogućnosti uzgoja mirisave ljubičice kao jestive, ljekovite i ukrasne vrste te je učiniti zanimljivom za komercijalni uzgoj te tako posredno smanjiti njezino uništavanje na prirodnim staništima.

**Ključne riječi:** mirisava ljubičica, supstrati, gnojidba, minerali

## Impact of Substrate and Fertilization on Growth, Development and Chemical Composition of Sweet Violet (*Viola odorata* L.)

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### Summary

Sweet violet (*Viola odorata* L.) blooms in the spring with delicate flowers of attractive scent for which is often collected from its natural habitats, while in decorative horticulture is used for cutting and for planting in gardens. The whole plant is edible and medicinal so that there are many possibilities of its application in food, pharmaceutical and cosmetic purposes. To make cultivation more successful, special attention should be paid to the substrate and fertilization. In order to obtain further insight into the selection of the preferred substrate and optimal doses of fertilizers, research was carried out with five different types of substrates, garden soil and soil from natural habitats and four variants of fertilization: (control, 0.1% NPK-Mg, 0.2% NPK-Mg and 0.2% NPK- Mg + 4% MgSO<sub>4</sub>). The highest content of nitrogen in leaves of sweet violet is present in plants grown in garden soil and ranges from 3.13% in the unfertilized plants to 3.23% in fertilized. The highest content of phosphorus and calcium in leaves of sweet violet was determined in plants grown on the soil from natural habitats and ranges from (0.39%, 2.32%) in the unfertilized plants (0.44%, 2.33%) in fertilized. Results of research will expand knowledge about the possibilities of growing sweet violet as edible, medicinal and ornamental species and make it interesting for commercial growth and thus indirectly reduce the destruction of its natural habitats.

**Key words:** Sweet violet, growing media, fertilizers, minerals

## Do rapeseed crops support the expansion of Yellow Wagtail *Motacilla flava* in Eastern Poland?

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### Summary

The last decade has witnessed an increase in the numbers of Yellow Wagtail *Motacilla flava* in Poland. Formerly strongly associated with wetlands, wet meadows and pastures, the species widely has entered into cultivated fields recently. In eastern Poland, Yellow Wagtail population grows very strongly in agricultural landscapes, while breeding sites in marshes and wet meadows are disappearing. The authors hypothesize that links an increase in the breeding population of Yellow Wagtail in the agricultural landscape of eastern Poland to an increase in the acreage planted to rapeseed. Studies carried out in different types of agricultural landscape of eastern Poland indicated very high breeding densities of Yellow Wagtail in areas dominated by rapeseed. The color similarity of the canola inflorescence and Yellow Wagtail plumage, as well as the compactness of the plants crop, promotes avoidance of predation by adult birds and protects the broods that start there. Besides, another factor promoting the occurrence of Yellow Wagtail in oilseed rape is the periodically higher soil moisture in this crop favoring the presence of insects which are food of considered bird.

**Key words:** Yellow Wagtail, *Motacilla flava*, agricultural landscape, biodiversity, Poland

## Total concentration and spatial distribution of metals in sloped vineyard soil at the SUPREHILL observatory

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### Summary

Frequent use of agrochemicals results in increased concentration of certain metals in vineyard soils, with the slope of terrain promoting their uneven spatial distribution. Therefore, at the SUPREHILL critical zone observatory (Jazbina experimental station, Zagreb), 27 vineyard soil samples were taken at three soil depths (0-30, 30-60, 60-90 cm) in October of 2020 at the top, middle, and the bottom of the slope, and digested in Aqua regia by microwave technique using MARSXpress system, CEM (HRN ISO 11466:2004). Metal (Fe, Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn, and Hg) total concentrations in soil extracts were then measured using ICP-OES (Vista MPX AX, Varian; HRN ISO 22036:2011). Data processing was done using Statistical Analysis Software (SAS Institute Inc., Version 8.3 Update 1, Cary NC USA, 2019-2020), with the analysis of variance done using One-Way ANOVA, and the significance of differences between the means determined using Tukey's test at  $P < 0.05$ . Significant difference between metal total concentrations in soil in regard to the position on the slope (top, middle, and bottom of the slope) was confirmed for Co (at 0-30 cm), with the highest concentration measured at the bottom of the slope ( $14.5 \text{ mg kg}^{-1}$ ), and for Cr (at 60-90 cm), with the highest concentration recorded at the hilltop ( $45.2 \text{ mg kg}^{-1}$ ). Results suggest that total concentration and spatial distribution of certain metals in vineyard soil is significantly affected by the slope of the vineyard.

**Key words:** metal pollution, hillslope, agrochemicals, vadose zone, metal spatial distribution

## Agrokemijske analize tla i klase opskrbljenosti tala u Republici Hrvatskoj

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### Sažetak

Monitoring i ispitivanje plodnosti tla najznačajnije su zakonski propisane aktivnosti vezane uz zaštitu poljoprivrednog zemljišta, a cilj je osigurati dostupnost podataka neophodnih za ocjenu stanja tla i provedbu politike održivog gospodarenja poljoprivrednim zemljištem. Cilj ovog rada je analiza rezultata dobivenih ispitivanjem plodnosti tla u 2020. godini, na ukupno 9869 uzoraka tla. Utvrđeno je ukupno 61,2 % uzoraka tala (6.043 od ukupno 9.869 uzoraka) kisele supstitucijske reakcije, od čega 20,8 % jako kisele reakcije (pH<4,5), 25,3 % kisele reakcije i 15,2 % slabo kisele reakcije. Neutralnih je tala 15 %, a preostalih 23,8 % uzoraka su alkalne reakcije. Kalcizacija je neophodna za 22,8 % tala (Hy>4 cmol/kg), a korisna za još 21 % tala. Humus je vrlo značajan pokazatelj elastičnosti i plodnosti tala, a ukupno 85,7 % tala ima < 3 % humusa uz prosječni sadržaj samo 1,94 %. Međutim, čak 48,8 % tala čine humusom najsiromašnije klase A, B i C s manje od 2 % humusa uz prosječni sadržaj 1,59 %. Raspoloživost fosfora nedovoljna je u čak 44,7 % analiziranih uzoraka (13,5 % vrlo slabo opskrbljenih tala klase A i 31,2 % slabo opskrbljenih tala klase B). Fosforom je dobro opskrbljeno (klasa C) 26,7 % analiziranih tala, a bogato je 28,5 % tala (klase D i E bogatih i vrlo bogatih tala). Većina analiziranih tala (53,9 %) dobro je opskrbljena kalijem (klasa C), slabo je opskrbljeno 21,6 % tala, a bogato je 23,5 % tala. Rezultati kemijskih analiza tala, kao i prethodne godine, detektiraju nedovoljnu humoznost tala kao najveću prijetnju plodnosti tala, posebice u kombinaciji s kiselom reakcijom i niskom raspoloživosti fosfora. S obzirom da je 20,9 % tala slabe humoznosti i istovremeno siromašno fosforom, 14,3 % tala slabe humoznosti i istovremeno jako kiselo (21,4 % slabe humoznosti uz pH<5), od čega je 7,7 % tala najniže plodnosti zbog slabe humoznosti i istovremeno jake kiselosti i najniže klase raspoloživosti fosfora, najvažnije agrotehničke mjere za očuvanje plodnosti tala su organska gnojidba i gospodarenje organskom tvari, optimizacija gnojidbe fosforom i kalcizacija kiselih tala.

**Ključne riječi:** agrokemijska svojstva tala, tumačenje rezultata, klase opskrbljenosti, humoznost, pH tla

## Agrochemical analyzes of soil and soil supply classes in the Republic of Croatia

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### Summary

Monitoring and testing of soil fertility are the most important legally prescribed activities related to the protection of agricultural land, aimed to ensure the availability of data necessary for evaluation soil condition and implementing a sustainable agricultural land management. The aim of this paper is to analyze the results obtained from the soil fertility control in 2020, on a total of 9869 soil samples. A total of 61.2% of soil samples (6,043 out of a total of 9,869 samples) of acid reaction were found, of which 20.8% strongly acid (pH <4.5), 25.3% acid and 15.2% weak acid reactions. Neutral soils are 15%, and the remaining 23.8% of samples are alkaline. Liming is necessary for 22.8% of soils (Hy > 4 cmol kg<sup>-1</sup>), and useful for another 21% of soils. Humus is a very important indicator of soil elasticity and fertility, and a total of 85.7% of soil has <3% humus with an average content of only 1.94%. However, as much as 48.8% of soils are in poorest classes A, B and C with less than 2% humus with an average content of 1.59%. Phosphorus availability is insufficient in as many as 44.7% of the analyzed samples (13.5% very low P - Class A and 31.2% of low P - Class B soils). Phosphorus is at medium level (class C) in 26.7% of the analyzed soils, and 28.5% of the soils are with high or very high P (classes D and E soils). Most of the analyzed soils (53.9%) are at medium level of potassium (class C), 21.6% of soils at low level and 23.5% at high level K. The results of soil chemical analyzes, as in previous years, detect insufficient soil humus as the greatest threat to soil fertility, especially in combination with acid reaction and low phosphorus level. Considering that 20.9% of soils are of low humus content and at the same time low P level, 14.3% of soils of low humus content and at the same time very acid (21.4% of low humus content with pH <5), of which 7.7% are soils of the lowest fertility due to low humus and at the same time strong acidity and the lowest P level, the most important agrotechnical measures for soil fertility preservation are organic fertilization and organic matter management, optimization of phosphorus fertilization and liming.

**Key words:** soil agrochemical properties, interpretation of results, supply classes, humus content, soil pH

## Korištenje, vlasništvo i pogodnost poljoprivrednog zemljišta u Republici Hrvatskoj prema stanju iz 2020.

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### Sažetak

Poznato je da se daljnji gospodarski razvoj Republike Hrvatske (RH), može pored ostalih djelatnosti, temeljiti i na razvoju poljoprivrede s obzirom na nedovoljno iskorištene agroekološke potencijale. Tome naročito može doprinijeti stavljanje u funkciju nekorištenog poljoprivrednog zemljišta. Cilj ovoga rada ukazati je na najnovije postojeće podatke iz 2020. g. koji se odnose na ukupnu površinu poljoprivrednog zemljišta te površinu korištenog i nekorištenog poljoprivrednog zemljišta, uvažavajući pri tome vlasništvo, pogodnost zemljišta za poljoprivredu te poljoprivredne regije Hrvatske. Ukupna površina šumskog zemljišta iznosi 2.630.742 ha (46,5 %) a poljoprivrednog 2.582.823 ha (45,6 %). Od ukupne površine poljoprivrednog zemljišta koristi se svega 1.712.197 ha (66,3 %) a ne koristi 870.626 ha (33,7 %). Najveći dio kako korištenog tako i nekorištenog poljoprivrednog zemljišta nalazi se u privatnom vlasništvu (82,6-80,2 %), potom u državnom (10-17,2 %) i mješovitom (7,4-2,6 %). Prema pogodnosti tla za poljoprivredu, na korištenom poljoprivrednom zemljištu najveća je zastupljenost dobro i umjereno dobro pogodnih tala (36 %), a potom ograničeno pogodnih tala (30 %), privremeno nepogodnih tala (19 %) i trajno nepogodnih tala (15 %). Na nekorištenom poljoprivrednom zemljištu najveća je zastupljenost trajno nepogodnih tala (42 %), a potom ograničeno pogodnih tala (27 %), dobro i umjereno dobro pogodnih tala (21 %) i privremeno nepogodnih tala (10 %). Uvažavajući površinu dobro, umjereno dobro i ograničeno pogodnih tala na nekorištenom poljoprivrednom zemljištu (48 %), može se potvrditi postojanje vrijednih zemljišnih resursa pogodnih za stavljanje u funkciju intenzivnog korištenja.

**Ključne riječi:** zemljište, korištenje, vlasništvo, pogodnost, regije, Hrvatska



## Use, ownership and suitability of agricultural land in the Republic of Croatia according to the situation of 2020

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### Summary

It is known that the further economic development of the Republic of Croatia (RH), among other activities, can be based on the development of agriculture with regard to unused agro-ecological potentials. The use of unused agricultural land in particular can contribute to this. The aim of this paper is to point out the latest existing data from 2020, which refer to the total area of agricultural land and the area of used and unused agricultural land, taking into account ownership, land suitability for agriculture and agricultural regions of Croatia. The total area of forest land is 2,630,742 ha (46.5%) and agricultural 2,582,823 ha (45.6%). Of the total area of agricultural land, only 1,712,197 ha (66.3%) are used and 870,626 ha (33.7%) are not used. The largest part of both used and unused agricultural land is in private ownership (82.6-80.2%), followed by state (10-17.2%) and mixed (7.4-2.6%). According to soil suitability for agriculture, good suitable and moderately good suitable soils (36%) are the most common on used agricultural land, followed by limited suitable soils (30%), temporarily unsuitable soils (19%) and permanently unsuitable soils (15%). Permanently unsuitable soils (42%) have the highest share of unused agricultural land, followed by limited suitable soils (27%), good and moderately good suitable soils (21%) and temporarily unsuitable soils (10%). Considering the area of good, moderately good and limited suitable soils on unused agricultural land (48%), the existence of valuable land resources suitable for putting into operation of intensive use can be confirmed.

**Key words:** land, use, ownership, suitability, regions, Croatia

## Utjecaj nedostatka hranjiva na izmjenu plinova kod graha (*Phaseolus Vulgaris* L.)

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### Sažetak

Grah (*Phaseolus vulgaris* L.) je jedna od glavnih leguminoza za ljudsku prehranu. Nedostatak makro i mikro hranjiva je glavni problem za poljoprivrednu proizvodnju. Kako bi biljka provela svoj životni ciklus, uz C, O i H, potrebno je još 13 elemenata: N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Cl, B i Mo. Nedostatak nekih elemenata smanjuje fotosintezu i inhibira normalno funkcioniranje fotosintetskog sustava. U ovome radu smo istražili utjecaj nedostatka N, P, K, Mg i Fe na fotosintetski sustav kod graha u kontroliranim uvjetima. Pokus je bio postavljen kao hidropon, plutajući sistem u 6 hidroponskih kada volumena 45 L. Svaka hidroponska kada je bila ispunjena sa modificiranom Hoaglandovom otopinom i sadržavala 10 biljaka. Jedna grupa biljaka je uzgajana u kompletnoj hranjivoj otopini (kontrola), dok kod drugih tretmana je falilo određeno hranjivo: N, P, K, Mg ili Fe. Tokom pokusa mjerili su se parametri stope fotosinteze (A), stope transpiracije (E), provodljivosti puči za H<sub>2</sub>O (g<sub>s</sub>), te intercelularne koncentracije CO<sub>2</sub> (C<sub>i</sub>). Pri završetku pokusa ustanovljen je sadržaj hranjiva u biljnome materijalu. Nedostatak hranjiva statistički je znatno utjecao na sve parametre izmjene plinova. Najmanje vrijednosti svih parametara u usporedbi sa kontrolom su zabilježene kod biljaka sa nedostatkom K, dok najmanje smanjenje vrijednosti parametara uspoređenih sa kontrolom je zabilježeno kod biljaka sa nedostatkom Fe.

**Ključne riječi:** grah, nedostatak hranjiva, transpiracija, stopa fotosinteze, provodljivost puči

## Effect of Nutrient Deficiency on Gas Exchange Capacity of Common Bean (*Phaseolus Vulgaris* L.)

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### Summary

Common bean (*Phaseolus vulgaris* L.) is the most important grain legumes for direct human consumption. Lack of macro and micro nutrients is a major problem for agriculture. To achieve their life cycle, in addition to C, O and H, vascular plants need another 13 elements: N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Cl, B and Mo. Lack of some nutrients depresses photosynthesis and disrupts efficient operation of photosynthetic apparatus. In this study, we investigated the influence of N, P, K, Mg, and Fe deficiency on photosynthetic machinery in leaves of common bean under controlled conditions. The experiment was set up as a hydroponic, fully aerated, floating system in 6 hydroponic tubs volume of 45 L. Each hydroponic tub contained 10 plants and was filled with a modified Hoagland nutrient solution. One group of plants was grown in a complete nutrient solution (control), while others treatments lacked one of following elements: N, P, K, Mg and Fe. During the experiment, parameters such as net photosynthetic rate (A), transpiration rate (E), stomatal conductance ( $g_s$ ), and intercellular CO<sub>2</sub> concentration (C<sub>i</sub>), were measured. At the end of the experiment, nutrient content of the plant tissue was determined. Nutrient deficiency significantly affected all measured gas exchanged parameters. Highest reduction of all measured traits compared to control was found for K deficient plants, whereas smallest reduction in gas exchange traits compared to control was found for Fe deficient plants.

**Key words:** common bean, nutrient deficiency, transpiration, net photosynthetic rate, stomatal conductance

## Utjecaj primjene mikrobioloških preparata na prinos salatnog krastavca u stakleničkom hidroponskom uzgoju

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### Sažetak

Hidroponski uzgoj salatnog krastavca u stakleniku zahtijeva visoku razinu kontrole mikroklimatskih uvjeta i dinamičnu primjenu hranjive otopine u skladu s genotipom krastavca, fenofazom, intenzitetom insolacije i temperaturom. Pored navedenih činitelja, moguće je dodatno optimizirati proizvodnju različitim pripravcima i biostimulatorima, uključujući različite mikrobiološke pripravke. Cilj istraživanja bio je utvrditi utjecaj primjene mikrobioloških pripravaka na prinos salatnog krastavca u hidroponskom stakleničkom uzgoju. Pokus s kontrolnim tretmanom bez pripravaka i tri različita načina primjene mikrobioloških pripravaka (1. kontrola; 2. primjena u jastuk; 3. folijarna primjena; 4. primjena u jastuk + folijarna) te 4 različita mikrobiološka pripravka (1. VAM; 2. bakterijski pripravak broj 1; 3. bakterijski pripravak broj 2; 4. pripravci 1+2+3) proveden je u stakleniku Tomašanci 2021. godine s ukupno 64 parcelice po 12 biljaka. Na kontrolnom tretmanu bez primjene mikrobioloških pripravaka utvrđen je prinos ploda 22,3 kg m<sup>-2</sup>. Mikorizni pripravak rezultirao je povećanjem prinosa od 3,7 % (primjena u jastuk) do 8,4 % (primjena u jastuk + folijarna primjena). Mikrobiološki pripravci broj 1 i 2 nisu rezultirali značajnim povećanjem prinosa, uz izuzetak primjene u jastuk mikrobiološkog pripravka broj 2 koji je povećao prinos za 2,3 %. Kombinacija pripravaka (mikorizni + bakterijski pripravci) rezultirala je malim povećanjem prinosa nakon primjene u jastuk i značajnim povećanjem prinosa (4,7 %) kombiniranom primjenom (u jastuk + folijarno). Utvrđeno je da postoji potencijal povećanja prinosa u kontroliranim uvjetima upotrebom mikrobioloških pripravaka, ali je značajan utjecaj vrste pripravka i načina primjene. Najučinkovitije su bile kombinirane primjene mikoriznog pripravka samostalno i u kombinaciji s bakterijskim pripravkom.

**Ključne riječi:** mikrobiološki pripravci, VAM, bakterije, kamena vuna, folijarna primjena

## Impact of microbial bioagents application on cucumber in hydroponic greenhouse cultivation

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### Summary

Hydroponic cultivation of cucumber in a greenhouse requires a high level of microclimatic conditions control and dynamic application of nutrient solution in accordance with the genotype, phenophase, insolation intensity and temperature. In addition to the above factors, it is possible to further optimize the production by using various preparations and biostimulators, including microbial bioagents. The aim of the study was to determine the effect of the application of microbial bioagents on the yield of cucumber in hydroponic greenhouse cultivation. Experiment includes control treatment without bioagents and three different application methods of microbial bioagents (1. control; 2. application in rock wool; 3. foliar application; 4. application in rock wool + foliar) and 4 different microbial bioagents (1. VAM; 2. bacterial bioagents number 1; 3. bacterial bioagents number 2; 4. bioagents mixture 1 + 2 + 3) was carried out in the Tomašanci greenhouse in 2021 with a total of 64 plots containing 12 plants per plot. Cucumber yield of 22.3 kg m<sup>-2</sup> was determined on the control treatment without microbial bioagents. The mycorrhizal bioagents resulted in a yield increase of 3.7% (application in rock wool) to 8.4% (application in rock wool + foliar application). Bacterial bioagents No. 1 and No. 2 did not result in a significant increase in yield, with the exception of application in rock wool of the bacterial bioagents No. 2 which increased the yield by 2.3%. The combination of bioagents (mycorrhizal + bacterial bioagents) resulted in a small increase in yield after application in the rock wool and a significant yield increase (4.7%) by combined application (in the rock wool + foliar). It has been found that there is a potential to increase yields under controlled conditions using microbial bioagents, but there is a significant importance of the type of bioagents and the application method. The most effective were the combined applications of mycorrhizal bioagents, alone or in combination with bacterial bioagents.

**Key words:** microbial bioagents, VAM, bacteria, rock wool, foliar application

## Genetska varijabilnost i struktura populacija krumpirove zlatice u Hrvatskoj

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### Sažetak

Krumpirova zlatica (*Leptinotarsa decemlineata* Say) jedan je od ekonomski najvažnijih štetnika krumpira. U proteklih šezdeset godina, zabilježeno je više od 300 slučajeva rezistentnosti, a krumpirova zlatica razvila je rezistentnost na 56 različitih aktivnih tvari diljem uzgojnih područja krumpira u svijetu. Razumijevanje genetske strukture, protoka gena i varijabilnosti posebno je važno kod ove vrste štetnika s obzirom da je rezistentnost široko rasprostranjena. Poznavanje evolucijskih promjena i ukupne promjene genetske varijabilnosti populacija može nam pružiti korisne informacije za razumijevanje genetskih promjena povezanih sa stupnjem razvoja rezistentnosti štetnika. U našem istraživanju koristili smo metodu polimorfizma pojedinačnog nukleotida (SNP) i metode geometrijske morfometrijske (GM) za procjenu strukture populacije i varijabilnost populacija krumpirove zlatice. Istraživanje je provedeno na 16 populacija krumpirove zlatice koje su prikupljene sa najvažnijih uzgojnih područja krumpira u kontinentalnoj Hrvatskoj. Dodatno, morfologija stražnjeg krila istih jedinki krumpirove zlatice ispitana je korištenjem geometrijsko morfometrijskih tehnika temeljenih na uzorcima žila. Rezultati su pokazali nisku genetsku strukturu u svim populacijama krumpirove zlatice bez značajne varijabilnosti. Također, ustanovljeno je da postoji jedna panmiktička populacija ili genetski klaster koji karakterizira populacije krumpirove zlatice u Hrvatskoj. Dobiveni rezultati ukazuju da metode suzbijanja koje se koriste za krumpirovu zlaticu uspješno smanjuju genetsku raznolikost, genetsku strukturu, diferencijaciju i protok gena, a time u konačnici smanjuju potencijal za razvoj mutacija povezanih s razvojem rezistentnosti na insekticide.

**Ključne riječi:** *Leptinotarsa decemlineata*, polimorfizam pojedinačnog nukleotida, geometrijska morfometrija, genetska varijabilnost

## Population structure and variability of Colorado potato beetle populations in Croatia

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### Summary

Colorado potato beetle, CPB, (*Leptinotarsa decemlineata* Say) is the most important potato pest. Over the past 60 years, more than 300 cases of CPB resistance to 56 active ingredients have been detected in potato-growing regions of the world. Understanding population structure, gene flow, and variability is particularly important for CPB management because insecticide resistance is widespread in this species. A detailed genomic description could potentially give us an answer to genetically driven population evolution, which is often related to the evolution of resistance. Therefore, in our study, we used single nucleotide polymorphism markers (SNPs) and geometric morphometric (GM) methods to investigate the population structure and variability of CPB populations. We used 16 CPB populations from the main potato growing areas in continental Croatia. In addition, the morphology of hindwings of the same CPB individuals was studied using geometric morphometric techniques based on vein patterns. Regardless of the low genetic structure found in all CPB populations without significant variability, a single panmictic population or genetic cluster has emerged that characterizes CPB in Croatia. This suggests that control practices are successfully reducing genetic diversity, genetic structure, differentiation, and gene flow, and thus ultimately reducing the potential for the development of mutations associated with CPB resistance.

**Key words:** *Leptinotarsa decemlineata*, single nucleotide polymorphism, geometric morphometric, genetic variability

## Long-term effects of organic fertilizers on macroelements status in grapevine leaf on calcareous soil

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### Summary

Growing grapevines on calcareous soils often leads to plant nutrition disorders. Vineyard fertilization practices on such soils differ significantly from the fertilization on acid soils because of influence of free calcium and high pH on the availability of nutrients. Three year trial was set up according to randomize complete block design with 6 treatments (unfertilized, farmyard manure 20 t ha<sup>-1</sup> and 40 t ha<sup>-1</sup>, peat 20 000 L ha<sup>-1</sup> and 40 000 L ha<sup>-1</sup>, NPK 5-20-30 500 kg ha<sup>-1</sup>+200 kg UREA kg ha<sup>-1</sup>) in 4 repetitions. Samples of grapevine leaves were taken three times during the growing period: at the flowering, two weeks after flowering and at the verasion. Total nitrogen was determined by the Modified Kjeldahl method, phosphorus was determined spectrophotometrically, potassium flamephotometrically and calcium and magnesium atomic absorption spectrometrically. Significant effect of fertilization was determined in the first year of the study on the amount of calcium (two weeks after flowering) and in the third year on the amount of potassium (flowering). Fertilization did not significantly affect the amount of nitrogen, phosphorus and magnesium in grapevine leaves.

**Key words:** grapevine, nitrogen, phosphorus, potassium, organic fertilizers



## High-resolution weighing lysimeter measurement implementation on a hillslope vineyard: first results

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### Summary

In late 2020, the first weighing lysimeters in Croatia were installed at the SUPREHILL vadose zone observatory, at the top and bottom of the hillslope. The use of undisturbed weighable lysimeters is commonly used to measure water and solute fluxes at the profile scale, which can also be representative at the field scale. The lysimeters are monolithically filled, equipped with a pressure-controlled lower boundary in order to mimic field dynamics (upward and downward fluxes), and are weighable so that high-precision calculations of hydraulic fluxes (i.e. rainfall, drainage, evapotranspiration, or dew) are possible. The first glance at the 2021 data shows differences between the top and bottom of the hillslope in observed evapotranspiration, while lesser differences are observed in measured precipitation using the system. As a result of the position on the hillslope, different behavior of the soil-water potential that serves as a reference value for establishing equilibrium between the field and lysimeters is observed. Along with the first data from the observatory, the presented material includes installation methodology, system specifications, and description of the feedback control of the lower hydraulic boundary condition with its main components.

**Key words:** vadose zone, precipitation, evapotranspiration, soil-water potential, hillslope

## Fiziološki odgovor pšenične trave na biofortifikaciju Se i Zn

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### Sažetak

Mladi izdanci pšenice (*Triticum aestivum* L.), odnosno pšenična trava se zbog svoje visoke nutritivne vrijednosti smatra funkcionalnom hranom. Selen i cink su dva elementa esencijalna za ljude te je na globalnoj razini utvrđen nedovoljan unos prehranom. Cilj ovog istraživanja bio je odrediti utjecaj biofortifikacije Se i Zn na sadržaj kloroplastnih pigmenata, vitamina C, fenola, flavonoida te na antioksidativnu aktivnost u soku pšenične trave. Biofortifikacija jednakim količinama Se i Zn provedena je na tri hrvatske sorte uzgajane na polju, u dvije varijante primjene, u cvatnji te u cvatnji i mliječnoj zriobi. Dobiveno sjeme korišteno je za uzgoj u kontroliranim uvjetima te je deseti dan od sjetve pripremljen sok od mladih izdanaka pšenice. U prosjeku za sve sorte, biofortifikacija je rezultirala značajno većim sadržajem fenola te većom antioksidativnom aktivnošću utvrđenom DPPH i FRAP metodom. Najveća antioksidativna aktivnost FRAP metodom utvrđena je kod sorti U1 i Srpanjke biofortificirane u cvatnji i mliječnoj zriobi te kod Srpanjke biofortificirane samo u cvatnji. Utvrđen je značajan utjecaj biofortifikacije na sadržaj ispitivanih bioloških komponenti u soku pšenične trave. Također, dokazana je genetska specifičnost pšenične trave u fiziološkom odgovoru na biofortifikaciju Se i Zn.

**Ključne riječi:** pšenična trava, biofortifikacija, antioksidansi, selen, cink

## Physiological response of wheatgrass on Se and Zn biofortification

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### Summary

Young shoots of wheat (*Triticum aestivum* L.), i.e. wheatgrass, is considered a functional food due to its high nutritional value. Selenium and zinc are two essential elements for humans, and insufficient dietary intake has been identified globally. The aim of this study was to determine the effect of biofortification of Se and Zn on the content of chloroplast pigments, vitamin C, phenol, flavonoids and antioxidant activity in wheatgrass juice. Biofortification with equal amounts of Se and Zn was performed on three Croatian cultivars grown in the field, in two variants of application, in flowering and in flowering and milk stage. The obtained seeds were used for cultivation in controlled conditions, and on the tenth day after sowing, juice from young wheat shoots was prepared. On average for all cultivars, biofortification resulted in significantly higher phenol content and higher antioxidant activity determined by DPPH and FRAP method. The highest antioxidant activity by the FRAP method was found in cultivars U1 and Srpanjka biofortified in flowering and milk stage, and in Srpanjka biofortified only in flowering. A significant influence of biofortification on the content of tested biological components in wheatgrass juice was determined. Also, the genetic specificity of wheatgrass in the physiological response to Se and Zn biofortification has been shown.

**Key words:** wheatgrass, biofortification, antioxidants, selenium, zinc

## Utjecaj agroekoloških uvjeta na varijabilnost i spolni dimorfizam šimširovog moljca *Cydalima perspectalis*

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### Sažetak

Šimširov moljac (*Cydalima perspectalis*, Walker) invazivna je vrsta koja pričinjava velike štete biljkama iz roda *Buxus*. Štetnik se brzo širi, ima visok reproduktivni potencijal i dobru prilagodljivost. Cilj ovog istraživanja bio je utvrditi morfološku varijabilnost *C. perspectalis* iz Hrvatske i procijeniti invazivni karakter geometrijsko morfometrijskim metodama. Provedena je analiza među lokacija, a skup podataka podijeljen je po zemljopisnom području, pri čemu su unutar-specifične varijacije utvrđene između sjevernih i južnih populacija. Rezultati pokazuju da je oblik krila pod utjecajem agroekoloških čimbenika (južna/obalna i sjeverna/kontinentalna populacija), pri čemu je utvrđeno da su prednja krila plastičnija od stražnjih. Sjeverne populacije imaju šira krila (s pomakom markera 6 i 4). Južne populacije imaju izduženija krila s pomakom markera 2 i 3 u bazi krila i markeru 6. U analizi spolnog dimorfizma, multivarijantna regresija oblika krila pokazuje minimalne razlike između prednjih krila mužjaka i ženki. Ipak krila ženki su varijabilnija i pokrivaju veliki postotak prostora u usporedbi s mužjacima gdje su varijacije minimalne. Poznavanje karakteristika krila *C. perspectalis* od velike je važnosti u procjeni rasprostranjenosti i proširenja, osobito s obzirom na njihov visok invazivni potencijal.

**Ključne riječi:** šimširov moljac, krila, geometrijska morfometrija, invazivnost

## Agroecological effect and sexual shape dimorphism in box tree moth *Cydalima perspectalis*

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### Summary

Box tree moth (*Cydalima perspectalis*, Walker) is an invasive species that causes great damage to plants of the genus *Buxus*. The pest spreads rapidly, has high reproductive potential and good adaptability. The aim of this study was to determine the morphological variability of *C. perspectalis* from Croatia and to evaluate its invasive character using geometric morphometric methods. An inter-sites analysis was performed, and the dataset was divided by geographic area, with intraspecific variation detected independently between northern and southern populations. Results show wing shape influenced by agroecological factors (southern/coastal and northern/continental populations), with forewings found to be more plastic than hindwings. Northern populations have broader wings (with a shift in landmark 6 and landmark 4). Southern populations have more elongated wings with a shift in landmarks 2 and 3 at the base of the wing and landmark 6. In terms of sexual differentiation, multivariate regression of wing shape on centroid size revealed minimal differences between male and female forewings, yet female wing shapes were more variable and covered a large percentage of the shape space compared to males where variation was minimal. Knowledge of *C. perspectalis* wing characteristics is of great importance in assessing dispersal, especially given their high invasive potential.

**Key words:** box tree moth, wings, geometric morphometrics, invasiveness

## Essential oil nano-emulsions as natural insecticides for stored product protection

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### Summary

Long-term use of synthetic pesticides is associated with the environmental pollution, negative impact on human health and environment and pest resistance. This, affected the urgent need for an alternative and safer solutions of pest management, including the use of essential oils (EOs) and their compounds with insecticidal activity. Besides their positive ecological aspects, some disadvantages related to low water solubility, rapid environmental degradation, and lack of stability during storage, impair the potential use of EOs for pest management purposes in natural situations. Nanotechnology as one of the new approach, is emerging with the goal of providing sustainable and efficient practices for the future demand of food. It allows the development of formulations through which the chemical and physical properties of EOs can be modified and improved. Thus, nano-emulsions are gaining extensive research attention in various areas of application including stored product protection against pests. Nano-emulsions based on EOs are kinetically stable oil-in-water dispersions characterised with droplet size in the range of 20–300 nm. The development of nano-emulsions from EOs may allow more efficient use of these compounds since such technology protects bioactive substances from degradation and losses by evaporations, and allowing a controlled release of these compounds. A multiple studies prove the stronger insecticidal activity of nanoformulations against stored product insects, even with the lower content of active substance compared to plain EO. Although, most of the results of nanoformulations application still refer to the laboratory tests, thus a major issue that remains to be addressed is more detailed assessments in field conditions.

**Key words:** essential oils, nanotechnology, stored product insects, nano-emulsions

## Dalmatinski bušak u sklopu Zoološkog vrta i park šume Marjan, Split

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### Sažetak

Park šuma Marjan je kulturno i prirodno dobro grada Splita. Na prvom vrhu Marjana nalazi se Zoološki vrt u čijim se prostorima nalaze autohtone pasmine domaćih životinja. U ZOO vrtu možemo pronaći i dvije jedinke u tipu jedine Dalmatinske pasmine konja - dalmatinskog bušaka koja je danas klasificirana kao nedovoljno poznata. Dalmatinski bušak je konj živahnog hoda koji se koristio kao tovarni i jahaći konj u mediteranskom dijelu Hrvatske. Danas bi mogao biti revitaliziran kao jedina pasmina hrvatskog jahaćeg ponija za djecu te kao terapijski poni. Klimatsko-geološko područje obitavanja dalmatinskog bušaka poklapa se s područjem park šume Marjan i grada Splita, što se može popratiti putem povijesnih izvora. Navedene jedinke su uključene u istraživanje genetsko-morfoloških karakteristika male populacije konja konformacijske građe dalmatinskog bušaka. U ovom radu usporedili smo jedinke prisutne u Zoološkom vrtu s ostalim primjercima konja iz populacije u tipu dalmatinskog bušaka te s opisima i fotografijama iz povijesti kako bi utvrdili pripadnost istoj. Prema opisu vanjštine i mjerenjima, jedinke ne odstupaju od sadašnje populacije konja u tipu dalmatinskog bušaka. S obzirom da se radi o pasmini koja je usko vezana uz kulturu i tradiciju kako grada Splita tako i njegove uže i šire okolice, slijedeći potreban korak je poduzimanje predradnji za registraciju i uspostavljanje pasmine (standard, uzgojni plan, matična knjiga, udruga uzgajivača).

**Ključne riječi:** park šuma Marjan, dalmatinski bušak, autohtone pasmine, kultura i tradicija

## Dalmatian bušak within Zoo and Forest Park Marjan, Split

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### Summary

Marjan Forest Park is a cultural and natural asset of Split. Split Zoo is located at the first peak of Marjan hill. The Zoo houses autochthonous breeds of domestic animals. There we can find two individuals in the type of the only Dalmatian horse breed - Dalmatian bušak. This breed is today classified as insufficiently known. Dalmatian bušak was used as a sumpter and riding horse in the Mediterranean part of Croatia. Today it could be revitalized as the only breed of Croatian riding pony for children and a therapeutic pony. Using the available historical sources, it can be traced that the climatic and geological area of Dalmatian bušak habitat coincides with Marjan area and the city of Split. Historically, the breed was closely related to the culture and tradition of the city of Split and its surroundings. The individuals in the Zoo are included in a study of genetic and morphological characteristics of a small population with conformational structure as Dalmatian bušak. In the study, we compared the individuals from Zoo with other horses from the population in type of Dalmatian bušak and with historical descriptions and photographs. According to the description and measurements, individuals from the Zoo do not deviate from current population of horses in type of Dalmatian bušak. The next step that should be done is all preliminary work needed for the registration and establishment of the breed (standard, breeding plan, registry book, breeders' association).

**Key words:** Marjan Forest Park, Dalmatian bušak, autochthonous breeds, culture and tradition



## Daljinsko istraživanje sukcesije poljoprivrednih površina na području Müllerovog brijega

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### Sažetak

Müllerov brijeg zauzima površinu od 28 ha i nalazi se na području općine Črnomerec u Zagrebu. Prije prvog svjetskog rata bio je u vlasništvu obitelji židovskih industrijalaca, kada se koristio kao suvremeni voćnjak i vinograd. Uglavnom su se uzgajale voćne vrste jabuka, krušaka i breskvi s međukulturom jagoda. Bile su zastupljene suvremene američke i europske sorte uglavnom razmnožene na vegetativnim podlogama, racionalnim razmacima sadnje i uzgojnim oblicima uz primjenu moderne zaštite i održavanja tla. Nakon 60-ih godina 20. stoljeća naglim porastom stanovništva u predgrađu, područje je iskorištavano za manje parcele s povrtnim kulturama. U posljednjih nekoliko desetljeća primijećeno je napuštanje poljoprivrednih djelatnosti zbog promjene vlasništva što je dovelo do sukcesijskih promjena vegetacijskog pokrova i zarastanja. Stoga je cilj bio napraviti kartiranje i digitalizaciju područja daljinskim promatranjem korištenjem arhivskih i recentnih ortofoto snimaka iz 1968. i 2021. godine u programu QGIS 3.10.8. Najveća promjena dogodila se u povećanju površina pod stambenim objektima dok su površine voćnjaka smanjene za 70 % u proteklih 50-ak godina, a čime je potvrđena hipoteza istraživanja. Površine pod makijom su u 2021. godini u odnosu na 1968. godinu također povećane, zbog neodržavanja i zapuštanja poljoprivredne voćarske proizvodnje. Ukupno je utvrđeno preko 100, uglavnom ruderalnih i invazivnih biljnih svojti.

**Ključne riječi:** GIS, sukcesija, vegetacija, flora, Müllerov brijeg

## Remote sensing of the succession of agricultural land in the area of Müllerov brijeg

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### Summary

Müllerov brijeg covers an area of 28 ha and is located in the municipality of Črnomerec in the city of Zagreb. Before the First World War, it was owned by a Jewish industrialist family, when it was used as a modern orchard and vineyard. Mainly apples, pears and peaches were grown there with an intercrop of strawberries. Modern American and European varieties were represented, propagated mainly on a vegetative basis, rational planting intervals and cropping patterns with the application of modern soil protection and maintenance measures. After the 1960s, when a suburban population increased significantly, the area was used for smaller plots of vegetable production. In recent decades, agricultural use was abandoned due to a change in ownership, which led to successive changes in vegetation cover and healing. Therefore, the objective was to map and digitize the area by remote sensing using archival and current orthophotos from 1968 and 2021 in QGIS 3.10.8. The greatest change occurred in the increase of areas under residential buildings, while the area of orchards decreased by 70% in the last 50 years, confirming the research hypothesis. Macchia areas also increased in 2021 compared to 1968, due to lack of maintenance and neglect of agricultural fruit production. In total, over 100, mostly ruderal and invasive plant taxa have been identified.

**Key words:** GIS, succession, vegetation, flora, Müllerov brijeg

## Fertilizacijska vrijednost stajskih gnojiva i utjecaj na potrebu gnojidbe mineralnim gnojivima

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### Sažetak

Stajska gnojiva su organski nusproizvod stočarske proizvodnje, sadrže za biljke neophodna hraniva, imaju produžno djelovanje te utječu na povećanje biogenosti i sadržaj organske tvari tla. Za potrebe uporabe stajskog gnoja na oraničnim površinama (IAKS Mjera 10.1.17.), analizirano je 610 uzoraka stajskih gnojiva s ciljem optimizacije gnojidbe na oraničnim površinama. Očekivano je najveći udio govedih stajskih gnojiva (83,3 %), zatim svinjskih (11,2 %), ovčjih i kozjih (3,1 %), a najmanje peradarskih (1,3 %) i konjskih gnojiva (1,1 %). Planirana je gnojidba analiziranim gnojivima na ukupno 22.121 ha za što je analizirano 4.266 uzoraka tala. Pravilnikom su propisane prosječne vrijednosti sadržaja N u različitim vrstama stajskih gnojiva (npr. 5 kg t<sup>-1</sup> N u govedem stajskom gnojivu). Međutim, te vrijednosti nije dobro koristiti kao referentne za donošenje odluke o količini stajskih gnojiva za gnojidbu sa 70-170 kg ha<sup>-1</sup> N jer su analizama utvrđene velike varijabilnosti i značajno različite koncentracije od navedenih prosječnih vrijednosti. Tako je u krutom govedem stajskom gnojivu utvrđeno 2,2-26,8 kg t<sup>-1</sup> N (prosječno 7,2), u svinjskom gnojivu 4,4-10 (prosječno 6,95), u brojlerskom 12,5-23,8 (prosječno 19,9), ovčjem 3,1-14,8 (prosječno 7,66) i u govedoj gnojovki 1,5-9,6 (prosječno 4,8). Također, velika je varijabilnost utvrđena i u koncentracijama fosfora i kalija, a zajednička su karakteristika značajno veće prosječne koncentracije od vrijednosti navedenih u Pravilniku. Koncentracije fosfora su 1,4 (ovčji) do 3,8 (svinjski), a kalija 1,6 (brojlerski) do 3,0 (kozji) puta veće od navedenih u Pravilniku. Upotreba navedenih stajskih gnojiva već u 1. godini smanjit će potrebu za gnojidbom mineralnim dušikom u osnovnoj gnojidbi za 35 kg ha<sup>-1</sup> (tj. 76 kg ha<sup>-1</sup> ureje manje) i u prihrani za 14 kg ha<sup>-1</sup> (53 kg ha<sup>-1</sup> KAN-a manje). Kumulativni učinak gnojidbe stajskim gnojivima tijekom 5 godina rezultirat će manjom gnojidbom mineralnim oblicima N, P i K. Gnojidba mineralnim gnojivima u 5. godini bit će smanjena na prosječno 26 % količina ureje u odnosu na mineralnu gnojidbu bez upotrebe stajskih gnojiva, 40 % količina N gnojiva u prihrani (npr. KAN), 35 % fosfornih gnojiva, a kalijeva će gnojiva biti potrebna samo na jako siromašnim tlima.

**Ključne riječi:** stajska gnojiva, dušik, fosfor, kalij, mineralna gnojiva

## Fertilization value of manures and the impact on the mineral fertilization

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### Summary

Manure as an organic by-product in livestock production contains the essential nutrients for plants. In addition, they have a long-lasting effect increasing biological activity and soil organic matter content. A 610 manure samples were analysed with the aim of optimizing crops fertilization using manure on arable land (IAKS Measure 10.1.17). As expected, the largest share was cattle manure (83.3%), followed by pig (11.2%), sheep and goat manure (3.1%), and the least poultry (1.3%) and horse manure (1.1%). Fertilization with the analyzed fertilizers on a total of 22,121 ha is planned, for which 4,266 soil samples were analyzed. It is not good to use average concentrations in fertilizers (eg 5 kg t<sup>-1</sup> N in cattle manure) to make the right decision on the amount of manure needed for fertilization with 70-170 kg ha<sup>-1</sup> of nitrogen, because the analyzes found great variability, but also significantly different concentrations of assumed average nitrogen values. Thus, 2.2-26.8 kg t<sup>-1</sup> N (average 7.2) was found in solid cattle manure, 4.4-10 (average 6.95) in pig manure, 12.5-23.8 in broiler manure (average 19.9), sheep 3.1-14.8 (average 7.66) and cattle slurry 1.5-9.6 (average 4.8). Also, great variability was found in the concentrations of phosphorus and potassium, and the common fact is significantly higher average concentrations than the values specified in regulations. For phosphorus, the values are 1.4 (sheep) to 3.8 (pig), and for potassium 1.6 (broiler) up to 3.0 (goat) times higher than those specified in regulations. The use of these manures in the 1<sup>st</sup> year will reduce the need for mineral nitrogen in basic fertilization by 35 kg ha<sup>-1</sup> (ie 76 kg ha<sup>-1</sup> less urea) and in top dressing by 14 kg ha<sup>-1</sup> (53 kg ha<sup>-1</sup> CAN less). The cumulative effect of fertilization with manure over 5 years will result in less fertilization with mineral forms of N, P and K. Fertilization with mineral fertilizers in the 5<sup>th</sup> year will be reduced to an average of 26% urea compared to mineral fertilizer without manure, 40% N fertilizers in top-dressing (eg KAN), 35% phosphorus fertilizers, and potassium fertilizers will be needed only on very poor soils.

**Key words:** manure, nitrogen, phosphorus, potassium, mineral fertilizer

## Utjecaj organske i mineralne gnojidbe na prinos suncokreta i iznošenje dušika

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### Sažetak

Gnojidba organskim gnojivima neophodna je u održivoj poljoprivrednoj proizvodnji zbog održavanja plodnosti tala uz smanjenu upotrebu mineralnih gnojiva. Pri tome je veliki značaj organskih gnojiva, ne samo zbog njihovog zbrinjavanja i održavanja humoznosti tala, već i zbog prilagodbe klimatskim promjenama, kontrole opterećenja okoliša i redukcije upotrebe mineralnih gnojiva. Cilj istraživanja bio je utvrditi utjecaj različitih gnojidbenih tretmana s mineralnim i organskim gnojivima na prinos zrna suncokreta i iznošenje dušika. Pokušaj s pet gnojidbenih tretmana u uzgoju suncokreta proveden je na pokušalištu Tenja Fakulteta agrobiotehničkih znanosti Osijek 2021. godine. Istraživanje je provedeno na umjereno humoznom tlu (2,34 % humusa), prosječne izmjenjive kiselosti 6,58, slabo opskrbljeno fosforom (10,87 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup> tla) i dobro opskrbljeno kalijem (24,80 mg K<sub>2</sub>O 100 g<sup>-1</sup> tla) uz gnojidbene tretmane: 1) kontrola bez primjene gnojidbe, 2) mineralna gnojidba, 3) gnojidba goveđim stajski gnojem (34 t ha<sup>-1</sup>), 4) gnojidba kompostom (17 t ha<sup>-1</sup>) i 5) kombinacija mineralne gnojidbe + gnojidba goveđim stajski gnojem (17 t ha<sup>-1</sup>). Utvrđen je najmanji prinos zrna suncokreta na kontrolnom tretmanu (2,92 t ha<sup>-1</sup>), dok su ostali tretmani rezultirali podjednakim prinosima od 3,94 t ha<sup>-1</sup> (mineralna gnojidba), 4,01 (kompost), 4,16 (goveđi stajski gnoj) do 4,17 t ha<sup>-1</sup> (kombinacija mineralne gnojidbe + goveđi stajski gnoj). Najmanja koncentracija N u zrnu suncokreta utvrđena je uz gnojidbu kompostom (2,46 %), tek malo veća na kontrolnom tretmanu (2,53 %), a značajno veće na ostalim tretmanima (2,82 – 2,91 %). Iznošenje N zrnom bilo je od 73,7 kg ha<sup>-1</sup> na kontrolnom tretmanu do 118,9 kg ha<sup>-1</sup> uz kombinacija mineralne gnojidbe s goveđim stajski gnojem. Istraživanjima je utvrđeno da se na tlima umjerene plodnosti goveđe stajsko gnojivo ili kompost mogu učinkovito koristiti u uzgoju suncokreta kao alternativa mineralnoj gnojidbi.

**Ključne riječi:** goveđi stajski gnoj, mineralna gnojidba, kompost, suncokret, iznošenje N

## Organic and mineral fertilization impact on sunflower yield and nitrogen removal

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### Summary

Fertilization with organic fertilizers is necessary in sustainable agricultural production to maintain soil fertility with reduced use of mineral fertilizers. At the same time, the correct use of organic fertilizers is of great importance, not only because of their reuse and maintenance of SOM, but also because of adaptation to climate change, control of the environment burden and reduction of the use of mineral fertilizers. The aim of the study was to determine the influence of different fertilization with mineral and organic fertilizers on sunflower grain yield and nitrogen removal. An experiment with five fertilization treatments in sunflower cultivation was conducted at the Tenja Experimental Station of the Faculty of Agrobiotechnical Sciences Osijek in 2021. The study was conducted on soil with moderately humus content (2.34% SOM), average exchange acidity 6.58, poorly supplied with phosphorus (10.87 mg P<sub>2</sub>O<sub>5</sub> 100 g<sup>-1</sup>) and moderately supplied with potassium (24.80 mg K<sub>2</sub>O 100 g<sup>-1</sup>) with fertilization treatments: 1) control without fertilization, 2) mineral fertilization, 3) cattle manure (34 t ha<sup>-1</sup>), 4) compost (17 t ha<sup>-1</sup>) and 5) combination of mineral fertilization + cattle manure (17 t ha<sup>-1</sup>). The lowest yield of sunflower grains was determined on the control treatment (2.92 t ha<sup>-1</sup>), while other treatments resulted in equal yields of 3.94 t ha<sup>-1</sup> (mineral fertilization), 4.01 (compost), 4.16 (cattle manure) up to 4.17 t ha<sup>-1</sup> (combination of mineral fertilization cattle manure). The lowest concentration of N in sunflower grain was determined after compost fertilization (2.46%), only slightly higher in the control treatment (2.53%), and significantly higher in other treatments (2.82 - 2.91%). The N removal by grain ranged from 73.7 kg ha<sup>-1</sup> in the control treatment to 118.9 kg ha<sup>-1</sup> with a combination of mineral fertilization and cattle manure. The results indicated that on soils of moderate fertility, cattle manure or compost can be used effectively in sunflower cultivation as an alternative to mineral fertilization.

**Key words:** cattle manure, mineral fertilization, compost, sunflower, N removal

## Antioksidacijski odgovor pšenice na različitu gnojidbu dušikom i *Fusarium* infekciju

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### Sažetak

Tijekom uzgoja na polju, pšenica je izložena mnogim negativnim abiotičkim i biotičkim stresnim uvjetima koji mogu negativno djelovati na prinos i kvalitetu. Nedostatak dušičnog gnojiva, kao abiotički stresni čimbenik, može uzrokovati pojavu oksidacijskog stresa u tkivu pšenice. Također, pojavu oksidacijskog stresa može inducirati i infekcija pšenice fitopatogenim gljivama iz roda *Fusarium*. Cilj je ovog istraživanja ispitati utjecaj abiotičkog stresa (dvije različite gnojidbe dušikom) i biotičkog stresa (infekcija vrstom *Fusarium culmorum*) na oksidacijski status i antioksidacijski odgovor različitih sorti pšenice. Mjereni su sljedeći pokazatelji oksidacijskog stresa: razina lipidne peroksidacije, aktivnosti antioksidacijskih enzima (katalaze, askorbat-peroksidaze, glutation-reduktaze), te koncentracije ukupnih topljivih fenola i fotosintetskih pigmenata. Sorta pšenice, tretman dušikom i *Fusarium* tretman imali su značajan utjecaj na ispitivane pokazatelje oksidacijskog stresa. Najznačajniji utjecaj imala je niska razina dušika, koja je većinom djelovala na smanjenje aktivnosti antioksidacijskih enzima te na smanjenje koncentracije pigmenata. Pri niskoj razini dušika, *Fusarium* tretman je djelovao na povećanje aktivnosti antioksidacijskih enzima, dok je u uvjetima visoke razine dušika aktivnost enzima većinom bila smanjena.

**Ključne riječi:** pšenica, *Fusarium culmorum*, dušik, antioksidacijski odgovor

## Antioxidant response of wheat to different nitrogen levels and *Fusarium* infection

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### Summary

During its growth on the field, wheat can be exposed to many negative abiotic and biotic stress conditions that can negatively affect yield and quality. Lack of nitrogen, as an abiotic stress factor, can cause oxidative stress in wheat tissue. Also, the occurrence of oxidative stress can be induced by wheat infection with phytopathogenic fungi of the genus *Fusarium*. This study aimed to examine the influence of abiotic stress (two different nitrogen fertilizers) and biotic stress (*Fusarium culmorum* infection) on the oxidative status and antioxidant response of different wheat varieties. The following biomarkers of oxidative stress were measured: level of lipid peroxidation, activities of antioxidant enzymes (catalase, ascorbate peroxidase, glutathione reductase), and the concentration of total soluble phenols and photosynthetic pigments. Wheat variety, nitrogen treatment, and *Fusarium* treatment had a significant effect on all examined biomarkers of oxidative stress. The most significant effect had a low nitrogen level, which mostly had the effect of decreasing the activity of antioxidant enzymes and reducing the concentration of pigments. At low nitrogen level, *Fusarium* treatment had the effect of increasing the activity of antioxidant enzymes, while in a condition of high nitrogen levels, enzyme activities were mostly decreased.

**Key words:** wheat, *Fusarium culmorum*, nitrogen, antioxidant response



## Effectiveness of a *Bacillus subtilis*-based biofungicide against green mould disease of mushrooms

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### Summary

The aim of the study was to evaluate a biofungicide based on *Bacillus subtilis* Ch-13 and its effectiveness in the control of green mould disease of *Agaricus bisporus* after its natural infection with *Trichoderma aggressivum* in a commercial mushroom growing facility, and its impact on mushroom yield. An assay was conducted in two different procedures involving either three or two split doses. The highest statistically significant effectiveness in green mould control was shown by the fungicide prochloraz (71.43%), followed by the biofungicide applied in three split doses (53.57%), and its two doses (45.46%). The biofungicide also significantly improved mushroom yield. Three split applications of *B. subtilis* strain Ch-13 enhanced mushroom yield to a larger extent than its two split doses, although the same final amount was used in both procedures. Biofungicide application in three split doses increased the total mass of harvested mushrooms 8.41% compared to the untreated control, and 10.53% compared to the fungicide prochloraz. These results implied that the biofungicide should be applied in three split applications: 30 ml (second day after casing) + 15 ml (two weeks after casing) + 15 ml (after first flush, 20-25 days after casing). The biofungicide *B. subtilis* Ch-13 showed remarkable characteristics by promoting mushroom yield and inhibiting the spread of *T. aggressivum*, thus proving as ecologically friendly alternative to fungicides in mushroom production.

**Key words:** *Bacillus subtilis*, biofungicides, mushrooms, *Trichoderma aggressivum*, disease

## Otpornost na antibiotike i antimikrobno djelovanje *Pseudomonas* spp. izoliranih iz krške špilje

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### Sažetak

Špilje su relativno neiskorišteni rezervoari bioaktivnosti, kao i slabo istražen okoliš s obzirom na otpornost bakterija na antibiotike. Do sada su mikrobiološka istraživanja špiljskog okoliša uglavnom fokusirana na aktinobakterije, dok su vrste roda *Pseudomonas* skoro potpuno neistražene. Stoga je cilj ovog istraživanja bio izolirati i identificirati *Pseudomonas* spp. iz špiljskih sedimenata i vode te utvrditi njihov uzorak rezistencije na antibiotike kao i antimikrobno djelovanje. Kako bi se postigao ovaj cilj, kultivabilna mikrobiota izolirana je iz sedimenata i vode (n=6) prikupljenih iz krške špilje u blizini Šibenika. Pojedinačne, nasumično odabrane kolonije su pročišćene i identificirane pomoću MALDI-TOF-a (n=62). Bakterije identificirane kao *Pseudomonas* spp. (n=18), genotipizirane su i selektirane na temelju rep-PCR obrazaca. Utvrđen je njihov uzorak rezistencije na pet klasa antibiotika, kao i antimikrobna aktivnost prema potencijalno patogenim mikroorganizmima u poljoprivredi (n=11). Među izoliranim pseudomonadama pronađena je visoka između vrsna i unutar vrsna varijabilnost. Oko 50 % *Pseudomonas* spp. rezistentno je na dvije klase antibiotika, a 27 % na tri klase antibiotika (višestruko otporni). Uočeno je antimikrobno djelovanje *Pseudomonas* spp. prema svim ispitivanim patogenima, međutim učinak je ovisan o vrsti i soju. Većina sojeva *Pseudomonas* spp. potpuno je inhibirala rast vrsta *Erwinia amylovora*, *Bacillus cereus*, *Listeria innocua* i *Weissella viridescens*.

**Ključne riječi:** krška špilja, *Pseudomonas* spp., antibiotska rezistencija, antimikrobna aktivnost

## Antibiotic resistance and antimicrobial activity of *Pseudomonas* spp. isolated from a karst cave

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### Summary

Caves are relatively unexploited reservoirs of bioactivity as well as unexplored environments considering antibiotic resistance. Up to now, microbiological investigations of cave environments mostly focused on *Actinobacteria*, while there is a lack of knowledge on antibiotic resistance and antimicrobial activity of *Pseudomonas* species isolated from caves. Therefore, the aim of this study was to isolate and identify *Pseudomonas* spp. from cave sediments and water and to determine their pattern of antibiotic resistance and antimicrobial activity. Cultivable microbiota was isolated from sediments and water (n=6) that were collected from karst cave located near Šibenik. The individual, randomly selected colonies were purified and identified by MALDI-TOF (n=62). Bacteria identified as *Pseudomonas* spp. (n=18), was genotyped and selected by rep-PCR and their resistance pattern against five classes of antibiotics as well as antimicrobial activity against potentially pathogenic microorganisms in agriculture (n=11) was determined. High inter- and intraspecies variability was found among isolated pseudomonads. About 50% of *Pseudomonas* spp. were resistant to two classes of antibiotics and 27% were multidrug-resistant (MDR). Antimicrobial activity was noticed against all tested pathogens, however, the effect was species and strain dependent. Most of the *Pseudomonas* strains completely inhibited the growth of *Erwinia amylovora*, *Bacillus cereus*, *Listeria innocua* and *Weissella viridescens*.

**Key words:** karst cave, *Pseudomonas* spp., antibiotic resistance, antimicrobial activity

## Kompostiranje konjskog stajskog gnoja i lišća uz dodatak mikrobioloških pripravaka

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### Sažetak

Kompostiranje je tehnološki proces gospodarenja otpadom koji se uz pomoć mikrobioloških aktivnosti u aerobnim uvjetima razgrađuje i stabilizira u kompost kao biološki razgrađivu smjesu. Cilj istraživanja bio je utvrditi kvalitetu komposta mjerenjem nekoliko parametara zrelosti te utvrditi vrijeme potrebno za kompostiranje konjskog stajskog gnoja (SG) i lišća (L) uz inokuliranje učinkovitim mikroorganizmima i dodatak fosfatnih minerala (F). Pokus je postavljen u kompostniku s pasivnim aeriranjem perforiranim cijevima na prostoru kompostane gradskog komunalnog poduzeća Unikom d.o.o. Osijek. Uz osnovne sirovine u kompost su inokulirani mikroorganizmi (*Azotobacter* sp., *Azospirillum* sp., *Pseudomonas* spp., *Trichoderma* spp., *Bacillus* sp.) kao akceleraotri procesa kompostiranja i drvena sječka. Ukupno je postavljeno pet različitih kompostnih tretmana. Tretman 1 (kontrola) čini smjesa lišća i konjskog stajskog gnoja, tretman 2 je ista smjesa (SG+L) uz mikroorganizme u obliku praha (*Pseudomonas* spp., *Trichoderma* spp., *Bacillus* sp. i kombinacija *Azotobacter* sp. i *Azospirillum* sp.), tretman 3 je smjesa tretmana 2 uz dodatak ureje. Tretman 4 je smjesa SG+L uz *Pseudomonas* spp. u tekućem obliku i fosforit, tretman 5 je smjesa tretmana 4 uz dodatak drvene sječke (DS), dok je tretman 6 smjesa SG+L+DS+F uz mikroorganizme u prahu (*Azotobacter* sp., *Azospirillum* sp. i *Pseudomonas* spp.). Proces kompostiranja trajao je 90 dana, a termofilna faza kompostiranja prosječno je trajala 14 dana, dok je najduža termofilna faza od 30 dana bila u tretmanu 4 uz najvišu maksimalnu temperaturu od 74,9 °C. Prosječna pH vrijednost u kompostnim smjesama bila je 9 dok se nakon 90 dana smanjila na 8,6. Najveći pad pH zabilježen je u tretmanu 4 gdje je s početnih 8,73 pala na 7,46. Na kraju pokusa najveća pH vrijednost bila je u tretmanu 6 gdje je iznosila 9,08. Najviši početni C/N odnos (312:1) zabilježen je u tretmanu 1, a najniži (26:1) u tretmanu 4. Tijekom procesa kompostiranja C/N odnos je opadao te je u tretmanu 4 iznosio 12:1 što indicira zrelost komposta, dok je najveći C/N odnos bio u tretmanu 1 (22:1). U tretmanu 4 NH<sub>4</sub>-N/NO<sub>3</sub>-N odnos na početku kompostiranja je iznosio 0,57, a nakon 90 dana iznosi 0,13 što također ukazuje na zrelost komposta. Zaključno, dodatak fosfornih gnojiva i mikroorganizama utjecao je na produženje termofilne faze i na neka svojstva komposta. Tretman 4 (SG+L+F+*Pseudomonas* sp.) je prema pokazateljima zrelosti najzreliji, a tretman 1 (SG+L) najmanje zreo kompost.

**Ključne riječi:** kompost, mikroorganizmi, pH, C/N, NH<sub>4</sub>-N/NO<sub>3</sub>-N, indikatori zrelosti

## Composting of horse manure and leaves with the addition of microorganisms

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### Summary

Composting is a technological process of waste management that, with the help of microbiological activities in aerobic conditions, decomposes and stabilizes biodegradable mixture into compost. The study aimed to determine the quality of compost by measuring several maturity parameters and to determine the time required for composting horse manure (HM) and leaves (L) with inoculation with effective microorganisms and the addition of phosphate minerals (F). The experiment was set up in a composter with passive aeration with perforated pipes in the composting area of the company Unikom d.o.o. Osijek. In addition to the basic raw materials, wood chips and microorganisms (*Azotobacter* sp., *Azospirillum* sp., *Pseudomonas* spp., *Trichoderma* spp., *Bacillus* sp.) were inoculated into the compost mixture as accelerators of the composting process. A total of five different compost treatments were installed. Treatment 1 (control) consists of a mixture of leaves and horse manure, treatment 2 was the same mixture (HM+L) with microorganisms (*Pseudomonas* spp., *Trichoderma* spp., *Bacillus* sp. and a combination of *Azotobacter* sp. and *Azospirillum* sp.), treatment 3 was a mixture of treatment 2 with urea. Treatment 4 was a mixture of HM+L with *Pseudomonas* in liquid form and phosphorite, treatment 5 a mixture of treatment 4 with wood chips (WC), while treatment 6 a mixture of HM+L+WC+F with microorganisms (*Azotobacter* sp., *Azospirillum* sp. and *Pseudomonas* spp.). The composting process lasted 90 days, and the thermophilic phase was in average 14 days, while the longest thermophilic phase of 30 days was in treatment 4 with a maximum temperature of 74.9 °C. The average pH value in compost mixtures was 9 while after 90 days it decreased to 8.6. The largest decrease in pH was recorded in treatment 4 where it dropped from an initial 8.73 to 7.46. At the end of the experiment, the highest pH value was in treatment 6 where it was 9.08. The highest initial C/N ratio (312:1) was recorded in treatment 1, and the lowest (26:1) in mixture 4. During the composting process, the C/N ratio decreased and in treatment 4 was 12:1, which indicates the maturity of the compost, while the highest C/N ratio was in treatment 1 (22:1). In treatment 4 NH<sub>4</sub>-N/NO<sub>3</sub>-N ratio at the beginning was 0.57, and after 90 days 0.13, which also indicates the maturity of the compost. According to results, it can be concluded that the addition of phosphorus and microorganisms affected the prolongation of the thermophilic phase, and some properties of compost. Treatment 4 (HM+L+F+*Pseudomonas* spp.) was the most mature compost, while treatment 1 (HM+L) was the least mature compost according to maturity indicators.

**Key words:** compost, microorganisms, pH, C/N, NH<sub>4</sub>-N/NO<sub>3</sub>-N, maturity indicators

## Sortna specifičnost agronomske kobiofortifikacije soje selenom i cinkom

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### Sažetak

Cink (Zn) i selen (Se) su esencijalni elementi neophodni za rast i razvoj ljudi i životinja, a niske koncentracije Se i Zn u tlu mogu rezultirati s pothranjenošću ljudi uslijed niskih koncentracija Se i Zn u biljkama i hrani. Problem pothranjenosti moguće je riješiti genetskom i agronomskom biofortifikacijom, tj. obogaćivanjem jestivih dijelova usjeva cinkom i selenom. Cilj istraživanja bio je usporediti učinkovitost pojedinačne (biofortifikacija) ili istovremene (kobiofortifikacija) folijarne aplikacije otopina cinkovog sulfata ( $6 \text{ kg ha}^{-1} \text{ Zn}$  u obliku  $\text{ZnSO}_4$ ) i natrijevog selenata ( $30 \text{ g ha}^{-1} \text{ Se}$  u obliku  $\text{Na}_2\text{SeO}_4$ ) na akumulaciju cinka i selena u zrnu šest sorata soje (*Glycine max* L.). Prosječno su u kontrolnim tretmanima zrna soje utvrđene koncentracije  $45,2 \text{ mg kg}^{-1} \text{ Zn}$  i  $0,061 \text{ mg kg}^{-1} \text{ Se}$ , a pojedinačne i istovremene biofortifikacije Zn i Se rezultirale su značajno većom akumulacijom Zn (37,1 i 41,9 %) i Se (41,8 i 39,3 puta) u odnosu na kontrolni tretman. Pri tome u prosjeku nije bilo značajnih razlika između pojedinačne i istovremene biofortifikacije, ali su utvrđene značajne razlike između sorata soje. Najveća koncentracija Se u zrnu utvrđena je kobiofortifikacijom (istovremena aplikacija Se i Zn) sorte Sunce ( $3,03 \text{ mg kg}^{-1}$ ), što je čak 96 puta veća koncentracija nego u zrnu bez biofortifikacije ( $0,031 \text{ mg kg}^{-1}$ ), a najveća koncentracija Zn kobiofortifikacijom sorte Toma ( $79,1 \text{ mg kg}^{-1}$ ). Kobiofortifikacija selenom i cinkom rezultirala je značajno manjom koncentracijom Se u zrnu sorata Korana ( $2,25 \text{ mg kg}^{-1}$ ) i Lucija ( $1,28 \text{ mg kg}^{-1}$ ) u odnosu na pojedinačnu biofortifikaciju selenom ( $2,90$  i  $2,09 \text{ mg kg}^{-1}$ ), kod sorte Sunce kobiofortifikacijom je značajno povećana koncentracija Se ( $3,03$  vs.  $2,37 \text{ mg kg}^{-1}$ ), a kod ostalih sorata nije bilo značajnih razlika. Istovremeno, kobiofortifikacija cinkom i selenom nije značajno smanjila koncentracije Zn u nijednoj sorti soje u odnosu na pojedinačnu biofortifikaciju cinkom (apliciran samo Zn), a značajno je povećala (9 %) koncentraciju Zn u zrnu sorte Toma ( $79,10$  vs.  $72,56 \text{ mg kg}^{-1}$ ), što je povećanje koncentracije Zn čak 54,7 % u odnosu na kontrolu ( $79,1$  vs.  $54,7 \text{ mg kg}^{-1}$ ). Zaključak je da je utvrđena sortno specifična reakcija soje na kobiofortifikaciju selenom i cinkom, da kobiofortifikacija vrlo učinkovito povećava koncentracije Se i Zn u zrnu soje, da dodatak Se u postupku biofortifikacije Zn ne smanjuje već kod nekih sorata (Toma) značajno povećava učinkovitost biofortifikacije cinkom. Dodatak Zn u postupku biofortifikacije selenom može smanjiti (Korana, Lucija) ili povećati (Sunce) učinkovitost biofortifikacije selenom.

**Ključne riječi:** soja, kobiofortifikacija, cink, selen, folijarna aplikacija

## Soybean cultivars in agronomic cobiofortification with selenium and zinc

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### Summary

Zinc (Zn) and selenium (Se) are essential for the growth and development of humans and animals, and low concentrations of Se and Zn in the soil can result in human malnutrition due to low concentrations in plants and food. The problem of malnutrition can be solved by genetic and agronomic biofortification, i.e. by enrichment of edible parts of crops with zinc and selenium. The study aimed to compare the effectiveness of single (biofortification) or simultaneous (cobiofortification) foliar application of solutions of zinc sulfate (6 kg ha<sup>-1</sup> Zn in the form of ZnSO<sub>4</sub>) and sodium selenate (30 g ha<sup>-1</sup> Se in the form of Na<sub>2</sub>SeO<sub>4</sub>) on the accumulation of zinc and selenium in grain of six soybean cultivars (*Glycine max* L.). On average, concentrations of 45.2 mg kg<sup>-1</sup> Zn and 0.061 mg kg<sup>-1</sup> Se were found in control treatments of soybean grains, and individual and simultaneous biofortifications of Zn and Se resulted in significantly higher accumulation of Zn (37.1 and 41.9%) and Se (34.7 to 39.2 times) relative to control treatment. On average, there were no significant differences between individual and simultaneous biofortification, but significant differences were found among soybean cultivars. The highest concentration of Se in the grain was determined by cobiofortification (simultaneous application of Se and Zn) of the Sunce cultivar (3.03 mg kg<sup>-1</sup>), which is 96 times higher than in grain without biofortification (0.031 mg kg<sup>-1</sup>), and the highest concentration Zn by cobiofortification of the Toma cultivar (79.1 mg kg<sup>-1</sup>). Selenium and zinc cobiofortification resulted in significantly lower concentrations of Se in the grain of Korana (2.25 mg kg<sup>-1</sup>) and Lucija (1.28 mg kg<sup>-1</sup>) compared to individual selenium biofortification (2.90 and 2.09 mg kg<sup>-1</sup>), in the cultivar Sunce cobiofortification significantly increased the concentration of Se (3.03 vs. 2.37 mg kg<sup>-1</sup>), and in other cultivars, there were no significant differences. At the same time, cobiofortification with zinc and selenium did not significantly reduce the concentration of Zn in any soybean cultivar compared to individual zinc biofortification (applied only Zn) and significantly increased (9%) the concentration of Zn in the grain variety Toma (79.10 vs. 72.56 mg kg<sup>-1</sup>), which was an increase of Zn concentration 54.7% compared to the control (79.1 vs. 54.7 mg kg<sup>-1</sup>). The conclusion is that there is a cultivar-specific reaction of soybeans to cobiofortification by selenium and zinc, that cobiofortification very effectively increases the concentrations of Se and Zn in soybeans, that the addition of Se in the process of biofortification Zn does not decrease but in some varieties (Toma) significantly increases the efficiency of zinc biofortification. The addition of Zn in the selenium biofortification process can reduce (Korana, Lucija) or increase (Sunce) the efficiency of selenium biofortification.

**Key words:** soybean, cobiofortification, zinc, selenium, foliar application

## Sortna specifičnost agronomske biofortifikacije soje cinkom

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### Sažetak

Cink (Zn) se kao element nepohodan za rast i razvoj biljaka, životinja i ljudi nalazi u tlima diljem svijeta u različitim ukupnim i bioraspoloživim koncentracijama. Posljedično, koncentracije Zn mogu biti vrlo niske u biljkama i u hrani te u mnogim krajevima svijeta nedovoljne koncentracije Zn u prehrani ljudi rezultiraju tzv. skrivenom gladi. S ciljem prevencije skrivene gladi razvijena je agronomska biofortifikacija temeljena na gnojidbi mikroelementima s ciljem povećanja koncentracije određenog elementa u jestivom dijelu biljke. Istovremeno, genetska biofortifikacija za isti cilj može iskoristiti genotipsku različitost određene biljne vrste. Cilj istraživanja bio je utvrditi: 1) učinkovitost agronomske biofortifikacije soje (*Glycine max* L.) cinkom, te 2) postojanje genetske varijabilnosti germplazme soje (sortne specifičnosti) u akumulaciji Zn u zrnu nakon folijarne aplikacije cinka. Pokus sa 6 sorata soje postavljen je na lokaciji pokušališta Tenja u blizini Osijeka uz folijarnu aplikaciju 3 i 6 kg ha<sup>-1</sup> Zn u obliku otopine ZnSO<sub>4</sub> u fenofazi cvatnje. Prosječno za 6 istraživanih sorata soje u kontrolnom je tretmanu u zrnu bez aplikacije Zn utvrđeno 45,24 mg kg<sup>-1</sup>Zn, a oba tretmana aplikacije značajno su povećala koncentraciju Zn za 28,33 % (58,06 mg kg<sup>-1</sup>) i 37,09 % (62,02 mg kg<sup>-1</sup>), ali između aplikacija 3 i 6 kg ha<sup>-1</sup> Zn prosječno nije bilo značajnih razlika. Međutim, sorte su se razlikovale već po prosječnim vrijednostima koje su za sva 3 tretmana bile od namanjih 46,88 mg kg<sup>-1</sup> (sorta Sunce) do najvećih 63,74 mg kg<sup>-1</sup> (sorta Toma). Još su veće razlike utvrđene u reakciji sorata na aplikaciju dvije različite količine Zn. Pri tome se značajno izdvajaju sorte Sunce i Ika. Sorta Sunce je jedina sorta kod koje nije utvrđeno značajno povećanje koncentracije Zn u zrnu (samo do 12,6 %, od 44,48 do 50,09 mg kg<sup>-1</sup>). Kod sorte Ika, ikao je utvrđeno značajno povećanje, bilo je samo 18,53 % i to već 17,16 % pri aplikaciji 3 kg ha<sup>-1</sup>. Ipak, sorta Ika imala je vrlo visoku koncentraciju na kontrolnom tretmanu (49,54 mg kg<sup>-1</sup>). Sorte Sunce i Ika su i jedine sorte kod kojih 6 kg ha<sup>-1</sup> Zn nije rezultiralo značajnim povećanjem koncentracije u odnosu na tretman 3 kg ha<sup>-1</sup>. Najveću grupu sorata čine Korana, Lucija i Sonja kod kojih je s početnih 37,03 do 46,27 mg kg<sup>-1</sup> značajno povećana koncentracija primjenom 3 kg ha<sup>-1</sup> (54,68-59,93), ali je i primjenom 6 kg ha<sup>-1</sup> dodatno značajno povećana koncentracija (64,62-65,52). Ukupno je povećanje koncentracije kod ovih sorata 39,7 % (Sonja) do 76,9 % (Korana). Navedenim sortama vrlo je slična sorta Toma, ali je ipak izdvojena jer je utvrđena najveća koncentracija Zn na kontrolnom (51,12 mg kg<sup>-1</sup>) i ostalim tretmanima (67,55 i 72,56 mg kg<sup>-1</sup>) uz ukupno povećanje koncentracije 41,9 %. Zaključno, utvrđen je veliki potencijal agronomske biofortifikacije soje s dokazano mogućim povećanjem koncentracije Zn blizu 77 % i ukupnom koncentracijom Zn u zrnu do 72,6 mg kg<sup>-1</sup>. Također, utvrđena je i sortna specifičnost s manjim brojem sorata niske učinkovitosti folijarne aplikacije Zn.

**Ključne riječi:** soja, biofortifikacija, cink, folijarna aplikacija, zrno, cinkov sulfat



## Soybean cultivars in agronomic biofortification with zinc

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### Summary

Zinc (Zn) as an essential element for plants, animals, and humans is found in soils around the world in various total and bioavailable concentrations. Consequently, Zn concentrations can be very low in plants and food, and in many parts of the world, insufficient Zn concentrations in human nutrition result in the so-called hidden hunger. To prevent hidden hunger, agronomic biofortification based on micronutrient fertilization has been developed to increase the concentration of a certain element in the edible part of the plant. At the same time, genetic biofortification can use the genotypic diversity of a particular plant species for the same purpose. The study aimed to determine: 1) efficiency of agronomic biofortification of soybean (*Glycine max* L.) with zinc, and 2) existence of genetic variability of soybean germplasm (germplasm diversity) in accumulation of Zn in grain after foliar application of zinc. An experiment with 6 soybean cultivars was set up at the Tenja experimental site near Osijek with foliar application of 3 and 6 kg ha<sup>-1</sup> Zn in the form of ZnSO<sub>4</sub> solution in flowering phenophase. On average, 45.24 mg kg<sup>-1</sup> Zn was found in the control treatment in grain without Zn application, and both application treatments significantly increased the Zn concentration by 28.33% (58.06 mg kg<sup>-1</sup>) and 37.09% (62.02 mg kg<sup>-1</sup>), but there were no significant differences on average between applications 3 and 6 kg ha<sup>-1</sup> Zn. However, the cultivars already differed in average values, which for all 3 treatments ranged from the lowest 46.88 mg kg<sup>-1</sup> (cultivar Sunce) to the highest 63.74 mg kg<sup>-1</sup> (cultivar Toma). Even higher differences were found in the reaction of cultivars to the application of two different amounts of Zn. The varieties Sunce and Ika differ significantly. The Sunce variety is the only variety in which no significant increase in the concentration of Zn in the grain was found (only up to 12.6%, from 44.48 to 50.09 mg kg<sup>-1</sup>). In the variety Ika, a significant increase was found, it was only 18.53% and already 17.16% with the application of 3 kg ha<sup>-1</sup>. However, the Ika variety had a very high concentration on the control treatment (49.54 mg kg<sup>-1</sup>). The Sunce and Ika cultivars are the only cultivars in which 6 kg ha<sup>-1</sup> Zn did not result in a significant increase in concentration compared to the 3 kg ha<sup>-1</sup> treatment. The largest group of cultivars were Korana, Lucija, and Sonja, in which the concentration was significantly increased from the initial 37.03 to 46.27 mg kg<sup>-1</sup> by applying 3 kg ha<sup>-1</sup> (54.68-59.93), but also applying 6 kg ha<sup>-1</sup> additionally significantly increased concentration (64.62-65.52). The total increase in concentration in these cultivars was 39.7% (Sonja) to 76.9% (Korana). The variety Toma is very similar to the mentioned varieties, but it was singled out because the highest concentration of Zn was determined in control (51.12 mg kg<sup>-1</sup>) and other treatments (67.55 and 72.56 mg kg<sup>-1</sup>) with a total increase in the concentration of 41.9%. In conclusion, a great potential of agronomic soybean biofortification was determined with a proven possible increase in Zn concentration close to 77% and total Zn grain concentration up to 72.6 mg kg<sup>-1</sup>. Also, variety diversity was determined with a few varieties with low efficiency of foliar Zn application.

**Key words:** soybean, biofortification, zinc, foliar application, grain, zinc sulfate

## Valorization of pumpkin and its by-products as a source of nutrients

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### Summary

Pumpkin (*Cucurbita L.*) is a squash and gourd fruit vegetable grown worldwide. The large production of pumpkin is related to the growing interest of consumers in the intake of a wide range of nutrients and phytochemicals through an adequate and balanced diet. As a result of the large use of pumpkin (cooked, baked, and processed), various by-products; such as peels and seeds are produced. Although these by-products are commonly used to fortify animal feed, much of them go unused. To find out whether these discharged fractions can be reused as a low-cost source of value-added compounds, the results of their chemical composition are presented in this study. The content of moisture, ash, fat, protein, and dietary fibre was analysed not only in the peels and seeds, but also in the raw pumpkin from which these residues are obtained. The results showed that peels and seeds contained higher amounts of ash (0.97-2.75%), fat (3.24-21.44%), proteins (4.27-14.88%), and dietary fibre (18.52-56.55%) compared to raw pumpkin. The content of ash, fat, protein and fibre in raw pumpkin was 0.55%, 1.54%, 1.76% and 17%, respectively. The moisture content decreased in the following order: raw pumpkin (93.97%), pumpkin peel (87.78%) and seeds (9.81%). From the results it can be concluded that the utilisation of pumpkin fractions is interesting not only from the environmental point of view, but also from the nutritional point of view due to the high content of ash, fat, protein and fibre. Of course, the mineral composition and content as well as the amino acid and fatty acid profiles still need to be completed to verify their status as sustainable food ingredients.

**Key words:** pumpkin, pumpkin by-products, chemical composition, nutrients

## The role of agricultural systems in Sustainable Development Goals. Benefits and threats

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### Summary

Agriculture systems are key to ensure food production and security, essential for nations safety. There is a need to produce food for a growing population. However, agriculture intensification is one of the major causes of biodiversity loss and climate change, two of the main challenges of our times. As consequence of the current global crises that involve environmental issues linked to biodiversity loss and climate change (e.g., poverty, resources overexploitation, pollution, urbanization), United Nations developed a set of 17 sustainable development goals (SDG's) revert this situation and improve wellbeing. Agriculture is key to full field several SDG's such as goal 1 (No Poverty) and goal 1 (Zero Hunger). Without productive agricultural systems it is not possible to achieve these SDG's. Nevertheless, at the same time we need to rethink the current agriculture intensive practices that are damaging dramatically the ecosystems and the services they supply (e.g., air quality, flood regulation, climate regulation, water purification, carbon sequestration, pollination). The ambition to feed the world using agriculture intensification practices is exhausting the resources (e.g., water, soil), damaging the biodiversity and increasing drastically climate change. This hampers the capacity to achieve other SDG's such as goal 6 (Clean Water and Sanitation), goal 13 (Climate Action), goal 14 (Life Bellow Water) and goal 15 (Life Bellow Water). To mention some of the most affected. Feed the world needs to be rethought. In this presentation we will discuss critically the benefits and threats of the current agriculture systems.

**Key words:** agriculture systems, sustainable development goals, biodiversity loss, climate change, ecosystem services

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## Kompostiranje lišća uz dodatak mikrobioloških pripravaka i drvene sječke

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### Sažetak

Poljoprivredna proizvodnja, proizvodnja hrane i ostale antropogne aktivnosti u agrosferi i ruderalnim staništima rezultiraju velikim količinama organskih nusproizvoda i ostataka koje je neophodno pripremiti za ponovnu upotrebu. Najčešći postupci stabilizacije organskih otpada su sustavi mikrobiološke razgradnje anaerobnim ili aerobnim postupcima, uključujući i proces kompostiranja. Cilj ovog istraživanja bio je utvrditi utjecaj mikrobioloških preparata i ureje na kompostiranje lišća te fizikalne i kemijske promjene tijekom kompostiranja. Osnovne komponentne kompostnih smjesa su bile lišće (L) prikupljano sa zelenih površina grada Osijek i drvena sječka (DS). U kompostne smjese dodavani su i mikrobiološki pripravci (*Azotobacter* sp., *Azospirillum* sp. i *Pseudomonas* spp.) i urea. Ukupno su pripravljene četiri različite kompostne smjese: smjesu 1 čine list i drvena sječka, smjesu 2 čine L+DS uz dodatak ureje, smjesu 3 čine L+DS uz mikrobiološke pripravke u praškastom stanju (*Azotobacter* sp., *Azospirillum* sp. i *Pseudomonas* spp.), a smjesu 4 čini smjesa 3 uz dodatak ureje. Kompostiranje je provedeno 90 dana u kompostniku s pasivnim aeriranjem perforiranim cijevima. Termofilna faza prosječno je trajala 11 dana, a najkraća (3 dana) je bila u smjesi 3, a najduža 17 dana u smjesi 2 uz najveću maksimalnu temperaturu od 63,5 °C. Najveća početna pH vrijednost zabilježena je u smjesi 2 i iznosila je 9,12, a nakon 90 dana vrijednost se smanjila na 7,64. Najviši početni C/N odnos (191:1) zabilježen u smjesi 3, a najniži (39:1) u smjesi 2. Nakon kompostiranja C/N odnos je u smjesi 2 snižen na 11:1, što je često dovoljan indikator zrelosti kompostne smjese. Primjenom ureje u kompostnim smjesama produžena je termofilna faza i intenziviran je proces kompostiranja. Smjesa 2 (L+DS+urea) je prema pokazateljima zrelosti najzrelija kompostna smjesa, dok je smjesa 1 (L+DS) prema istim pokazateljima najmanje zrela.

**Ključne riječi:** urea, C/N, pH, kompostiranje, zrelost, lišće, termofilna faza

## Composting of leaves with the addition of microorganisms and wood chips

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### Summary

Agricultural production, food production, and other anthropogenic activities in the agrosphere and ruderal habitats result in large amounts of organic by-products and residues that need to be prepared for reuse. The most common methods of stabilizing organic waste are microbiological decomposition by anaerobic or aerobic processes, including the composting process. This study aimed to determine the influence of microorganisms and urea on leaf composting and physical and chemical changes during composting. The main components of compost mixtures were leaves (L) collected from the green areas of the city of Osijek and wood chips (WC). Microorganisms (*Azotobacter* sp., *Azospirillum* sp., and *Pseudomonas* spp.) and urea were also added to the compost mixtures. A total of four different compost mixtures were prepared: mixture 1 with leaf and wood chips, mixture 2 also L + WC plus urea, mixture 3 L+WC plus microorganisms (*Azotobacter* sp., *Azospirillum* sp., and *Pseudomonas* spp.), and mixture 4 was mixture 3 plus urea. The 90-day composting was conducted in a composter with passive aeration using perforated pipes. The thermophilic phase lasted on average 11 days, the shortest (3 days) was in mixture 3, and the longest 17 days in mixture 2 with a maximum temperature of 63.5 °C. The highest initial pH value was in mixture 2 (9.12), and after 90 days the value decreased to 7.64. The highest initial C/N ratio (191:1) was in mixture 3 and the lowest (39:1) in mixture 2. After composting, the C/N ratio was reduced to 11:1 in mixture 2, which is often a sufficient indicator of compost maturity. The use of urea in compost mixtures prolongs the thermophilic phase and intensifies the composting process. Mixture 2 (L+WC+urea) was the most mature compost, while mixture 1 (L+WC) was the least mature according to maturity indicators.

**Key words:** urea, C/N, pH, composting, maturity, leaves, thermophilic phase

## Učinkovitost kobiofortifikacije kukuruza cinkom i selenom

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### Sažetak

Pothranjenost ljudi je vrlo značajan problem više od petine stanovništva diljem svijeta, a značajno mjesto među esencijalnim elementima s nedovoljnim unosom u prehrani ljudi zauzimaju cink (Zn) i selen (Se). Agronomska biofortifikacija je aplikacija mikroelemenata prije ili tijekom vegetacije usjeva s ciljem povećanja njihove koncentracije u prehrambenom proizvodu, a istovremena aplikacija dva ili više elemenata je kobiofortifikacija, koja bi mogla obogatiti prehranu ljudi i doprinijeti neutralizaciji pothranjenosti s dva ili više elemenata. Cilj istraživanja bio je usporediti učinkovitost pojedinačne i istovremene biofortifikacije (kobiofortifikacija) kukuruza (*Zea mays* L.) cinkom i selenom koja je provedena na dva lokaliteta (Rakitovica i Tenja) folijarnom aplikacijom  $6 \text{ kg ha}^{-1}$  Zn u obliku otopine cinkovog sulfata ( $\text{ZnSO}_4$ ) i  $30 \text{ g ha}^{-1}$  Se u obliku otopine natrijevog selenata ( $\text{Na}_2\text{SeO}_4$ ) u fenofazi cvatnje. Prosječno je biofortifikacija kukuruza selenom bila uspješna jer je povećana koncentracija Se u zrnu kukuruza. Pojedinačna biofortifikacija bila je uspješnija sa 72,8 puta većom koncentracijom Se ( $0,335 \text{ mg kg}^{-1}$ ) nego na kontrolnom tretmanu ( $0,0046 \text{ mg kg}^{-1}$ ), dok je kobiofortifikacija (Se uz dodatak Zn) rezultirala 61,1 puta većom koncentracijom Se ( $0,281 \text{ mg kg}^{-1}$ ). Pri tome je utvrđen značajan utjecaj lokaliteta jer je kobiofortifikacija (dodatak Zn u biofortifikaciji selenom) imala 41,1 % manji učinak od pojedinačne biofortifikacije selenom na lokalitetu Rakitovica, a na lokalitetu Tenja 12,8 % veći učinak. Pojedinačna biofortifikacija kukuruza cinkom je uz povećanje koncentracije 29 % ( $18,3$  vs.  $14,1 \text{ mg kg}^{-1}$ ) bila uspješnija od kobiofortifikacije (Zn uz dodatak Se) s povećanjem samo 15,8 % ( $16,4$  vs.  $14,1 \text{ mg kg}^{-1}$ ) u odnosu na kontrolni tretman bez biofortifikacije. Biofortifikacija kukuruza selenom uspješnija je od biofortifikacije cinkom, a kobiofortifikacija je nešto manje učinkovitosti nego pojedinačne biofortifikacije kukuruza selenom i cinkom.

**Ključne riječi:** folijarna aplikacija, cinkov sulfat, natrijev selenat, agronomska kobiofortifikacija

## Effectiveness of maize cobiofortification with zinc and selenium

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### Summary

Human malnutrition is a very significant problem in more than a fifth of the world's population, and zinc (Zn) and selenium (Se) occupy a significant place among the essential elements with insufficient intake in human nutrition. Agronomic biofortification is the application of microelements before or during vegetation to increase their concentration in the food, and the simultaneous application of two or more elements is cobiofortification. Cobiofortification could enrich human nutrition and contribute to neutralizing malnutrition with two or more elements simultaneously. The study aimed to compare the effectiveness of individual and simultaneous biofortification (cobiofortification) of maize (*Zea mays* L.) with zinc and selenium conducted at two sites (Rakitovica and Tenja) by foliar application of 6 kg ha<sup>-1</sup> Zn in the form of zinc sulfate solution (ZnSO<sub>4</sub>) and 30 g ha<sup>-1</sup> Se in the form of a sodium selenate (Na<sub>2</sub>SeO<sub>4</sub>) solution in the flowering phenophase. On average, maize biofortification with selenium was successful with increased Se concentration in maize grain. Individual biofortification was more successful with 72.8 times higher Se concentration (0.335 mg kg<sup>-1</sup>) than the control treatment (0.0046 mg kg<sup>-1</sup>), while cobiofortification (Se with Zn addition) resulted in 61.1 times higher Se concentration (0.281 mg kg<sup>-1</sup>). Significant locality impact was found since cobiofortification (addition of Zn in selenium biofortification) had a 41.1% lower effect than individual selenium biofortification at Rakitovica locality and 12.8% higher at Tenja locality. Single zinc biofortification with a 29% increase in Zn concentration (18.3 vs. 14.1 mg kg<sup>-1</sup>) was more successful than cobiofortification (Zn with Se addition) with an increase of only 15.8% (16.4 vs. 14.1 mg kg<sup>-1</sup>) comparing control treatment without biofortification. Maize biofortification with selenium was more successful than biofortification with zinc, and cobiofortification is slightly less effective than individual maize biofortifications with selenium or zinc.

**Key words:** foliar application, zinc sulfate, sodium selenate, agronomic cobiofortification

## Sortna specifičnost agronomske biofortifikacije soje selenom

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### Sažetak

Koncentracija selena (Se) u usjevima odraz je koncentracije i bioraspoloživosti Se u tlu. Koncentracija Se u biljkama za hranu i krmu vrlo je značajna za hranidbu životinja i prehranu ljudi, ali u mnogim zemljama diljem svijeta zabilježene su vrlo niske razine Se u žitaricama, voću i povrću što posljedično dovodi do pothranjenosti ljudi selenom. Agronomska biofortifikacija usjeva, uključujući i soju (*Glycine max* L.), može ublažiti pothranjenost Se, a na učinkovitost biofortifikacije mogu značajno utjecati različite reakcije sorti soje na folijarnu aplikaciju selena. Cilj ovog istraživanja bio je utvrditi: 1) učinkovitost agronomske biofortifikacije soje (*Glycine max* L.) selenom, te 2) postojanje genetske varijabilnosti germplazme soje (sortne specifičnosti) u akumulaciji selena u zrnu nakon folijarne primjene selena. Pokus sa 6 sorata soje postavljen je na lokaciji pokušališta Tenja u blizini Osijeka uz folijarnu aplikaciju 10, 20 ili 30 g ha<sup>-1</sup> Se u obliku Na<sub>2</sub>SeO<sub>4</sub> u fenofazi cvatnje. Biofortifikacija selenom rezultirala je prosječnim (prosjek za svih 6 sorata) povećanjem koncentracija Se u zrnu soje sa značajnim razlikama između svih tretmana, od kontrolnog tretmana (0,061 mg kg<sup>-1</sup>) do svih tretmana s aplikacijom Se (0,86; 1,86 i 2,55 mg kg<sup>-1</sup>). Pri tome nije bilo značajnih razlika između sorata prema prosječnim koncentracijama Se, iako je najmanja koncentracija utvrđena u zrnu sorte Lucija (1,18), a najveće u zrnu sorata Toma (1,42) i Ika (1,46). Međutim, sorte su se razlikovale u reakcijama na folijarnu primjenu rastućih količina Se, na temelju čega ih možemo svrstati u 2 grupe. U prvoj su grupi sorte Sunce, Lucija i Sonja s vrlo značajnim porastom koncentracija nakon aplikacije najniže (10 g ha<sup>-1</sup>) i srednje doze selena (20 g ha<sup>-1</sup>), ali bez značajnog daljnjeg povećanja nakon aplikacije najveće doze (30 g ha<sup>-1</sup>). Navedene su sorte pri srednjoj dozi imale veće koncentracije Se (1,95-2,00 mg kg<sup>-1</sup>) od ostalih sorata, ali koncentracije nakon aplikacije najveće doze Se (2,09-2,37 mg kg<sup>-1</sup>) bile su niže nego kod druge grupe sorata. U drugoj su grupi sorte Ika, Korana i Toma sa značajnim povećanjem koncentracija Se nakon aplikacije svake od tri doze Se te su najveće koncentracije utvrđene nakon aplikacije najveće doze (2,60-3,03 mg kg<sup>-1</sup>). Dakle, biofortifikacija soje selenom je vrlo uspješna kod svih sorata, ali postoji sortna specifičnost akumulacije Se u zrnu soje jer je kod polovice sorata značajno povećanje postignuto i nakon aplikacije najveće doze Se, a kod preostalih sorata samo nakon najmanje i srednje doze selena.

**Ključne riječi:** soja, biofortifikacija, selen, natrijev selenat, folijarna aplikacija, zrno



## Soybean cultivars in biofortification with selenium

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### Summary

The concentration of selenium (Se) in food plants is a reflection of the concentration and bioavailability of Se in soil. Concentration of Se in feed and food plants is very important for animals and human nutrition, but in many countries around the world very low levels of Se in cereals, fruit and vegetables has been reported what consequently results in human Se malnutrition. Agronomic biofortification of crops, including soybean (*Glycine max* L.), can alleviate Se malnutrition and the efficiency of biofortification can be significantly affected by the different reactions of soybean cultivars to selenium application. The aim of this study was to determine: 1) efficiency of agronomic biofortification of soybean (*Glycine max* L.) with selenium, and 2) existence of genetic variability of soybean germplasm (germplasm diversity) in accumulation of Se in grain after foliar application. An experiment with 6 soybean cultivars was set up at the Tenja experimental site near Osijek with foliar application of 10, 20 or 30 g ha<sup>-1</sup> Se in the form of Na<sub>2</sub>SeO<sub>4</sub> in the flowering phenophase. Selenium biofortification resulted in an average (average for all 6 cultivars) increase in Se concentration in soybean grain with significant differences between all treatments, from the control treatment (0.061 mg kg<sup>-1</sup>) to all treatments with Se application (0.86; 1.86 and 2.55 mg kg<sup>-1</sup>). There were no significant differences between cultivars according to the average concentrations of Se, although the lowest concentration was found in the grain of the Lucija (1.18), and the highest in the grains of the Toma (1.42) and Ika cultivar (1.46). However, cultivars differed in their reactions to foliar application of increasing amounts of Se, and therefore we can classify them into 2 groups. In the first group are Sunce, Lucija, and Sonja cultivars with a very significant increase in concentration after the application of the lowest (10 g ha<sup>-1</sup>) and a medium dose of selenium (20 g ha<sup>-1</sup>), but without significant further increase after the highest dose (30 g ha<sup>-1</sup>). These cultivars at 20 g ha<sup>-1</sup> dose had higher concentrations of Se (1.95-2.00 mg kg<sup>-1</sup>) than other cultivars, but the concentrations after the application of the highest dose of Se (2.09-2.37 mg kg<sup>-1</sup>) were lower than in other group. In the second group are Ika, Korana, and Toma cultivars with a significant increase in Se concentration after application of each of the three doses of Se, and the highest concentrations were determined after application of the highest dose (2.60-3.03 mg kg<sup>-1</sup>). Thus, soybean biofortification was very successful in all cultivars, but there was a specificity of Se accumulation in soybean cultivars because with a half of the cultivars a significant increase was achieved after the application of the highest dose of Se, and in other cultivars only after the lowest and middle selenium doses.

**Key words:** soybean, biofortification, selenium, sodium selenate, foliar application, grain

## Utvrđivanje fitotoksičnosti komponenti i smjesa za vermikompostiranje

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### Sažetak

Kompostiranje ili vermikompostiranje organskih ostataka poljoprivrednih, prehrambenih, šumarskih i komunalnih djelatnosti mogu rezultirati proizvodima s različitim stupnjevima zrelosti i fitotoksičnosti. Fitotoksičnost uslijed prisutnosti organskih kiselina, amonijskog oblika N, fenola, soli ili teških metala može biti posljedica svojstava sirovina ili načina kompostiranja, a najčešće se evaluira testom klijavosti. Cilj ovog istraživanja bio je utvrditi stupanj fitotoksičnosti 11 različitih svježih i kompostiranih poljoprivrednih, šumarskih i komunalnih nusproizvoda i njihovih smjesa (vinogradarski trop, konjski stajski gnoj, kamena vuna, piljevina, lišće, drvena sječka) prije i nakon 14 dana vermikompostiranja pomoću gujavica (*Eisenia andrei*). Test klijavosti kres salate (*Lepidium sativum* L.) proveden je u Petrijevim zdjelicama s po 20 sjemenki tretiranih ekstraktima 11 različitih smjesa prije i nakon vermikompostiranja (ukupno 22 ekstrakta). Utvrđena je visoka fitotoksičnost (indeks klijavosti  $GI < 0,5$ ) vinogradarskog tropa ( $GI = 0,23$ ), smjese kamene vune i vinogradarskog tropa ( $0,33$ ) te smjese vinogradarskog tropa i konjskog stajskog gnoja ( $0,49$ ), a umjerena fitotoksičnost ( $GI = 0,5-0,8$ ) vermikompostiranog vinogradarskog tropa ( $0,57$ ), smjese vinogradarskog tropa, kamene vune i piljevine ( $0,64$ ), smjese vinogradarskog tropa, kamene vune i konjskog stajskog gnoja ( $0,70$ ), vermikompostiranog komposta od lišća i sječke uz dodatak ureje ( $0,75$ ), smjese konjskog stajskog gnoja i kamene vune ( $0,77$ ) te kompostirane smjese lišća i drvene sječke uz dodataka mikrobiološkog preparata ( $0,78$ ). Statistički značajan i najveći fitostimulativni ili fitonutritivni učinak ( $GI > 1,0$ ) utvrđen je za vermikompostirane smjese vinogradarskog tropa, konjskog stajskog gnoja i kamene vune ( $1,68$ ) te vinogradarskog topa, kamene vune i piljevine ( $1,76$ ). Nešto manji fitostimulativni učinka utvrđen je i za vermikompostirane smjese konjskog stajskog gnoja i kamene vune ( $1,54$ ) te konjskog stajskog gnoja i vinogradarskog tropa ( $1,31$ ). Testom je utvrđena najveća fitotoksičnost vinogradarskog tropa, zatim konjskog stajskog gnoja i kamene vune, ali se fitotoksičnost smanjuje u njihovim smjesama. Piljevina učinkovito smanjuje fitotoksičnost vinogradarskog tropa i bez vermikompostiranja. Dvotjedno vermikompostiranje prosječno je povećalo GI na 11 ispitivanih smjesa za 68,13 % (s 0,71 na 1,19) i neutraliziralo sve fitotoksičnosti u potpunosti (djelomično samo za vinogradarski trop). Najveći učinak gujavica utvrđen je na smjesi vinogradarskog tropa i kamene vune sa ili bez konjskog stajskog gnoja gdje je umjerena fitotoksičnost ( $0,70-0,77$ ) transformirana do izrazito fitostimulativnog učinka ( $1,54-1,68$ ), što potvrđuje veliki potencijal vermikompostiranja u proizvodnji supstrata i organskih gnojiva.

**Ključne riječi:** vinogradarski trop, stajski gnoj, kamena vuna, piljevina, *Eisenia andrei*

## Determination of phytotoxicity of components and mixtures for vermicomposting

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### Summary

Composting or vermicomposting of organic residues from agricultural, food-industry, forestry and communal activities can result in products with different degrees of maturity and phytotoxicity. Phytotoxicity due to the presence of organic acids, ammonium form of N, phenols, salts or heavy metals may be consequences of the raw materials properties or composting methods, and is most often evaluated by a germination test. The aim of this study was to determine the degree of phytotoxicity of 11 different fresh and composted agricultural, forestry and municipal by-products and their mixtures (grape pomace, horse manure, rock wool, sawdust, leaves, wood chips) before and after 14 days of vermicomposting with earthworms (*Eisenia andrei*). Germination test with water cress (*Lepidium sativum* L.) was performed in Petri dishes with 20 seeds treated with extracts of 11 different mixtures before and after vermicomposting (a total of 22 extracts). High phytotoxicity (germination index  $GI < 0.5$ ) of grape pomace ( $GI = 0.23$ ), mixtures of rock wool and grape pomace (0.33) and mixtures of grape pomace and horse manure (0.49) was found, and moderate phytotoxicity ( $GI = 0.5-0.8$ ) of vermicomposted grape pomace (0.57), mixtures of grape pomace, rock wool and sawdust (0.64), mixtures of grape pomace, rock wool and horse manure (0.70), vermicomposted compost from leaves and wood chips with the addition of urea (0.75), a mixture of horse manure and rock wool (0.77) and composted mixtures of leaves and wood chips with the addition of microbial bioagents (0.78). Statistically significant and the highest phytostimulatory effect ( $GI > 1.0$ ) was found for vermicomposted mixtures of grape pomace, horse manure and rock wool (1.68) or grape pomace, rock wool and sawdust (1.76). A slightly lower phytostimulatory effect was also found for vermicomposted mixtures of horse manure and rock wool (1.54) and horse manure and grape pomace (1.31). The test determined the highest phytotoxicity of grape pomace, followed by horse manure and rock wool, but phytotoxicity was reduced in their mixtures. Sawdust effectively reduces the phytotoxicity of the grape pomace even without vermicomposting. Two-week vermicomposting increased the GI on average in 11 tested mixtures by 68,13% (from 0.71 to 1.19) and neutralized all phytotoxicities completely (partially only for the grape pomace). The highest effect of earthworms was found on a mixture of grape pomace and rock wool with or without horse manure where moderate phytotoxicity (0.70-0.77) was transformed to a significant phytostimulatory effect (1.54-1.68), which confirms the great vermicomposting potential in the production of substrates and organic fertilizers.

**Key words:** grape pomace, manure, rock wool, sawdust, earthworms

## Soil N<sub>min</sub> dynamics during short flood as result of the climate changes

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### Summary

Nowadays, climate changes are considered as one of the biggest challenges for the society overall, with a special highlight on vulnerable agriculture production as human activity which produce food. According to predictions As extreme climate events is gonig to be more often, and flood is one of them as a result of extreme heavy rain in short period of time a project “Potential of the rhizosphere microbiome in the adaptation of agriculture to climate change (PERSPIRE)”, funded by the EU Regional Development Fund, focused on the effects of this kind of flood. Aim of the research was to determine the effect of the short flood on model plant in seedling phenophase. Experiment in carried out in the controlled conditions (16 hours day/8 hours night; 25 °C per day/20 °C per night; 60-70% relative humidity), with the cabbage (*Brassica oleracea* var. *capitata* f. *alba*) used as a model plant. The experiment lasted, from seeding to the full end, for 57 days. Plants (triplicate trials) were subjected to either one (72 h duration) or two short-term flooding events (72 h duration, 10 days recovery between floods) at different stages of development. At different time points (day 0, after flooding and after recovery period) soil samples were taken and Nmin was determined. Result showed that flood treatment significantly decreased Nmin content in the soil (around 50%), both after first and second flood. During the recovery time Nmin content increased, but after second flood decreased again.

**Key words:** ammonium, *Brassica oleracea* var. *capitata* f. *alba*, excessive water, nitrates

## Kompostiranje otpadne mase iz destilacije voća

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### Sažetak

Kompostiranjem ostatka iz alkoholne destilacije fermentiranog koma organska se tvar reciklira, a daljnjom upotrebom kao gnojivo ili supstrat za biljnu proizvodnju smanjuje se utjecaj na klimatske promjene i potrošnju prirodnih resursa. Cilj istraživanja je utvrditi utjecaj različitih polaznih komponenti kompostnih smjesa na svojstva proizvedenog komposta. U pokusu su kao kompostna tvoriva korištene slama pšenice, kokošje stajsko gnojivo (pH 7,89), otpadna masa iz destilacije jabuke (pH 3,53) i šljive (pH 4,19) te preparati s mikroorganizmima. Utvrđen je konduktivitet (EC) kokošjeg stajskog gnojiva (3,35 dSm<sup>-1</sup>), otpadne mase jabuke (0,777) i šljive (1,404). Pokusna proizvodnja komposta je provedena na obiteljskom poljoprivrednom gospodarstvu u Đakovu. Kompostnici su izgrađeni od drvenog materijala volumena nešto većeg od 1 m<sup>3</sup>, sa pripremljenom podlogom pogodnom za pasivno aeriranje zbog perforiranih cijevi na koje je položena drvena sječka. Kompostne smjese su pripremljene u četiri smjese koje su se sastojale od iste količine otpadne mase iz destilacije voća (48 L) i slame pšenice (5 kg), a razlikovali u količini kokošjeg stajskog gnojiva (S<sub>1</sub>-12 kg ili S<sub>2</sub>-24 kg) i s ili bez dodatka mikrobiološkog preparata (MO<sub>0</sub> i MO<sub>1</sub>), pa su smjese označene: T<sub>1</sub> (S<sub>2</sub> MO<sub>0</sub>), T<sub>2</sub> (S<sub>1</sub> MO<sub>0</sub>), T<sub>3</sub> (S<sub>1</sub> MO<sub>1</sub>) i T<sub>4</sub> (S<sub>2</sub> MO<sub>1</sub>). U kompostiranju smjesa T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> i T<sub>4</sub> maksimalna temperatura je bila 72 °C, 63 °C, 60 °C, odnosno 70 °C, a termofilna faza započela je 7. dana nakon postavljanja pokusa i trajala je 13, 6, 8 i 10 dana. Tijekom druge mezofilne faze (170. dan) u svim tretmanima je utvrđen pad pH vrijednosti (od 9,4 do 7,81) u odnosu na uzorke smjesa uzetih na kraju termofilne faze (22. dan) dok se vrijednost EC blago povećala kod svih tretmana i iznosi najviše (1,284 dSm<sup>-1</sup>) u T<sub>4</sub>. Na kraju procesa u kompostima je utvrđen pad udjela ukupnog C, te porast udjela ukupnog N, pa se i CN odnos očekivano smanjio ispod 20:1, uz najveći pad (9,23:1) kod tretmana s dvostrukim udjelom stajskog gnojiva i apliciranim mikroorganizmima. Utvrđen je i pad amonijskog i porast nitratnog oblika dušika. Rezultati istraživanja ukazuju na moguću fitotoksičnost komposta koji na kraju procesa imaju pH vrijednost iznad 8 (svi osim T<sub>2</sub>-7,81), dok relativno niski EC (1,251) može značiti manju trenutnu fertilizacijsku vrijednost zbog nižeg sadržaja vodotopivih soli, tj. hraniva. CN odnos je < 20 i upućuje na zrelost sve četiri smjese, no ako se kao indikator zrelosti uzima odnos završnog i početnog CN, zrela je samo T<sub>3</sub> smjesa (0,75). Može se zaključiti da je otpadna masa iz destilacije voća pogodna komponenta za proizvodnju komposta.

**Ključne riječi:** kompostiranje, pH, EC, CN odnos, zrelost komposta

## Composting of waste from fruit distillation

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### Summary

Composting the residue from the alcoholic distillation of fermented coma recycles organic matter, and further use as a fertilizer or substrate for plant production reduces the impact on climate change and consumption of natural resources. The aim of the research is to determine the influence of different starting components of compost mixtures on the properties of produced compost. In the experiment, wheat straw, chicken manure (pH 7.89), waste from the distillation of apples (pH 3.53) and plums (pH 4.19) and preparations with microorganisms were used in composting. Conductivity (EC) of chicken manure (3.35 dSm<sup>-1</sup>), waste mass of apple (0.777) and plum (1.404) was determined. Experimental compost production was carried out on the family farm in Đakovo. Compost bins are built of wood material with a volume of slightly more than 1 m<sup>3</sup>, with a prepared substrate suitable for passive aeration due to perforated pipes covered with wood chips. Compost mixtures were prepared in four mixtures consisting of the same amount of waste from the distillation of fruit (48 L) and wheat straw (5 kg) and differed in the amount of chicken manure (S<sub>1</sub>-12 kg or S<sub>2</sub>-24 kg) and or without the addition of a microorganisms (MO<sub>0</sub> and MO<sub>1</sub>), so the mixtures are labeled: T<sub>1</sub> (S<sub>2</sub> MO<sub>0</sub>), T<sub>2</sub> (S<sub>1</sub> MO<sub>0</sub>), T<sub>3</sub> (S<sub>1</sub> MO<sub>1</sub>) and T<sub>4</sub> (S<sub>2</sub> MO<sub>1</sub>). In the composting of mixtures T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub>, the maximum temperature was 72 °C, 63 °C, 60 °C and 70 °C, respectively, and the thermophilic phase began on the 7th day after setting up the experiment and lasted 13, 6, 8 and 10 days. During the second mesophilic phase (day 170), a decrease in pH value (from 9.4 to 7.81) was found in all treatments compared to samples of mixtures taken at the end of the thermophilic phase (day 22), while the EC value increased slightly in all treatment and amounts to the highest (1,284 dSm<sup>-1</sup>) in T<sub>4</sub>. At the end of the process, a decrease in the share of total C and an increase in the share of total N was found in composts, so the CN ratio also decreased below 20:1, with the largest decrease (9.23:1) in treatments with double manure and applied microorganisms. A decrease in ammonia and an increase in the nitrate form of nitrogen were also found. The results of the study indicate the possible phytotoxicity of composts that have a pH value above 8 at the end of the process (all except T<sub>2</sub>-7.81), while relatively low EC (1.251) may mean lower direct fertilization value due to lower water-soluble salts, i.e. nutrients. The CN ratio was <20 and indicates the maturity of all four mixtures, but if the ratio of final and initial CN was taken as an indicator of maturity, only the T<sub>3</sub> mixture was mature (0.75). It can be concluded that the waste from fruit distillation is a suitable component for compost production.

**Key words:** composting, pH, EC, CN ratio, compost maturity

## **Nematode biodiversity as a soil health indicator in consociation of agricultural crop and walnut plantation**

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### **Summary**

Analyses of nematode community structure can serve as indicators of agricultural soil health and agroecosystem sustainability. One of the solutions for improving soil health and its biodiversity is agroforestry, a combination of woody species and crops. In this study, the biodiversity of nematodes was compared under 3 different agroecosystems: 1) agricultural crop (C), 2) consociation of agricultural crop and walnut plantation (C+W) and 3) walnut plantation (W), at two sites in Croatia, Đakovo (9 years old plantation) and Ivankovo (3 years old plantation). The agricultural crop in 2017/2018 was wheat, followed by rapeseed in 2018, and buckwheat in 2019. During the analysis of nematode communities at the Đakovo site, a total number of 55 different genera was determined: 21 genera of bacterivores, 7 genera of fungivores, 12 genera of phytoparasites, 10 genera of omnivores and 5 genera of predators. The total number of determined genera was 51 in treatments C+W and W, while treatment C had a lower number of determined genera (45). At the Ivankovo site, a total number of 56 different genera was determined: 23 genera of bacterivores, 7 genera of fungivores, 10 genera of phytoparasites, 11 genera of omnivores and 5 genera of predators. There was no significant difference in a number of total determined genera between the treatments W (48), C (47) and C+W (46). The results suggest that the consociation increases soil biodiversity in the older walnut plantation which can improve soil health, an important prerequisite for successful agricultural production.

**Key words:** trophic groups, agroforestry, wheat, rapeseed, buckwheat

## Važnost očuvanja bujičnih potoka sliva Rječine za održavanje bioraznolikosti travnjaka Grobničkog polja

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### Sažetak

Planine u zaleđu Riječkog zaljeva odlikuju se značajnom biološkom raznolikošću. S planina se prema Grobničkom polju slijeva nekolicina bujičnih potoka koji se u njihovom podnožju, ujedinjuju u bujici Sušici i slijevaju prema Rječini. U glaciofluvijanim naslagama Grobničkog polja bujice su izdubile korita podložna stalnim mijenama. Istražujući floru i vegetaciju na području Grobničkog polja došli smo do spoznaje da su bio-koridori uz korita bujičnih potoka imali i vjerojatno još uvijek imaju značajnu ulogu u oblikovanju botaničkog sastava okolne vegetacije. To se u najvećoj mjeri odnosi na obogaćivanje flore i formiranje specifičnog sastava vegetacije travnjaka. Cilj je ovog istraživanja utvrditi botanički sastav travnjaka uz bujične tokove te su u tu svrhu provedena floristička i vegetacijska istraživanja standardnim srednjoeuropskim metodama. Florni popisi s dvadesetak lokaliteta s nanosa u koritima bujica, pokosima korita i na okolnim travnjacima upisani su u florističku bazu FCD (Flora Croatica Database). Među značajnijim rezultatima provedenih istraživanja izdvajamo pronalazak endemične i rijetke Natura 2000 vrste cjelolatične žutilovke (*Genista holopetala* (W. D. J. Koch) Bald.), kao i travnjačkih zajednica s pretezanjem trave uskolisne šašike (*Sesleria tenuifolia* Schrad.) koje ujedinjuju najviše rijetkih flornih elemenata. Zbog recentnih hidrotehničkih zahvata u koritima bujica i zbog procesa urbanizacije specifična je endemična flora i vegetacija ugrožena pa se nameće potreba očuvanja prirodnosti bujičnih potoka.

**Ključne riječi:** bujični potoci, Grobničko polje, bio-koridori, *Genista holopetala*, travnjaci uskolisne šašike



## The importance of preserving the torrent streams of the Rječina River catchment for maintaining the biodiversity of grasslands on Grobnik Polje

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### Summary

The mountains in the hinterland of the Rijeka Bay are characterized by significant biological diversity. Several torrents flow from the mountains towards Grobnik Polje. Reaching the foothills, they unite in the torrent Sušica and flow towards the Rječina stream. Incised into the glaciofluvial deposits of Grobnik Polje, torrent beds are subject to constant changes. Exploring the flora and vegetation in the area of Grobnik Polje (Grobničko polje), we are concluded that bio-corridors along torrent beds had and probably still have a significant role in creations of botanical composition of the surrounding vegetation. This is mostly related to the enrichment of flora and the formation of a specific composition of grassland vegetation. The aim of this study is to determine the botanical composition of grasslands along torrent beds on Grobnik Polje. Floristic and vegetation research was conducted using standard Central European methods. Floristic lists with a dozen of sites from deposits in torrent beds, torrent slopes, and on surrounding grasslands are recorded in the Flora Croatica Database (FCD). Among the most interesting results we highlight the finding of endemic and rare Natura 2000 species *Genista holopetala* (W. D. J. Koch) Bald., as well as grasslands of narrow – leaved moor grass (*Sesleria tenuifolia* Schrad.) which unite the most floristic rarities. Due to recent hydrotechnical interventions in torrent beds and due to the process of urbanization, the specific endemic flora and vegetation are endangered, so there is a need to preserve the naturalness of torrent streams.

**Key words:** torrent streams, Grobnik Polje, bio-corridors, *Genista holopetala*, grasslands of *Sesleria tenuifolia*

## Ferulična, vanilična, *p*-hidroksibenzojeva i *p*-kumarična kiselina inhibiraju rast klijanaca ambrozije

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### Sažetak

Prethodna istraživanja ukazuju da određene fenolne kiseline mogu inhibirati rast korova. Cilj ovog istraživanja bio je utvrditi utjecaj klorogenične, kofeinske, ferulične, galične, protokatekuinske, *p*-hidroksibenzojeve, siringične, vanilične i *p*-kumarinske kiseline na početni rast klijanaca ambrozije. Svaka kiselina primijenjena je samostalno (FK) i u kombinaciji s ostalim kiselinama (MIX) u pet koncentracija (C1-C5). Početna koncentracija odgovarala je koncentraciji tih kiselina prethodno utvrđenoj u uzorcima suhog biljnog tkiva iz biljaka pokrovnih usjeva porodice Brassicaceae. Sjeme ambrozije posijano je u Petrijeve posude, tretirano s po 5 mL otopina (FK/MIX) i stavljeno u kontrolirane uvjete klima komore. Nakon 15 dana utvrđena je duljina korijenka i hipokotila te masa klijanaca ambrozije. Rezultati ukazuju na ovisnost inhibicije ranog rasta ambrozije o koncentraciji fenolnih kiselina. Najveće koncentracije fenolnih kiselina (C5) bolje su reducirale duljine mjerenih parametara od nižih koncentracija. Međutim, samo su kiseline: ferulična (220,8  $\mu\text{g ml}^{-1}$ ), vanilična (126,88  $\mu\text{g ml}^{-1}$ ), *p*-hydroxybenzoična (355,68  $\mu\text{g ml}^{-1}$ ) i *p*-kumarična (135,2  $\mu\text{g ml}^{-1}$ ) te mješavina kiselina (985,12  $\mu\text{g ml}^{-1}$ ) inhibirale rast mjerenih parametara ambrozije za više od 50 %. Procijenjena koncentracija fenolnih kiselina za 50 % inhibiciju duljine radikule ambrozije iznosi  $143,03 \pm 22,97 \mu\text{g ml}^{-1}$  za feruličnu kiselinu,  $122,54 \pm 16,97 \mu\text{g ml}^{-1}$  za *p*-kumaričnu kiselinu i  $813,03 \pm 6,4 \mu\text{g ml}^{-1}$  za kombinaciju fenolnih kiselina.

**Ključne riječi:** *Ambrosia artemisiifolia* L., fenolne kiseline, pokrovni usjevi, alelokemikalije, dose-response.

## Ferulic, vanillic, *p*-hydroxybenzoic and *p*-coumaric acid inhibit the growth of common ragweed seedlings

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### Summary

Previous studies suggest that certain phenolic acids may inhibit weed growth. The objective of this study was to determine the effect of the following acids: chlorogenic, caffeic, ferulic, gallic, protocatechuic, *p*-hydroxybenzoic, syringic, vanillic, and *p*-coumaric on the initial growth of common ragweed seedlings. Each acid was administered alone (XA) or in combination with other acids (MIX) at five concentrations (C1-C5). The initial concentration corresponded to the concentration of these acids previously determined in samples of dry plant tissue from plants of the Brassicaceae family. The common ragweed seeds were sown in Petri dishes, treated with 5 mL of the XA/MIX solution and placed in climate chamber. After 15 days, radicle and hypocotyl length and common ragweed seedling biomass were determined. The results show that inhibition depends on the concentration of phenolic acids. The highest concentrations of phenolic acids (C5) reduced the measured parameters better than the lower concentrations. However, only ferulic acid (220.8  $\mu\text{g mL}^{-1}$ ), vanillic acid (126.88  $\mu\text{g mL}^{-1}$ ), *p*-hydroxybenzoic acid (355.68  $\mu\text{g mL}^{-1}$ ), *p*-coumaric acid (135.2  $\mu\text{g mL}^{-1}$ ), and a mixture of acids (985.12  $\mu\text{g mL}^{-1}$ ) inhibited the growth of the measured parameters by more than 50%. The estimated phenolic acid concentration for 50% inhibition of ragweed radicle length is  $143.03 \pm 22.97 \mu\text{g mL}^{-1}$  for ferulic acid,  $122.54 \pm 16.97 \mu\text{g mL}^{-1}$  for *p*-coumaric acid, and  $813.03 \pm 6.4 \mu\text{g mL}^{-1}$  for a combination of phenolic acids.

**Key words:** *Ambrosia artemisiifolia* L., phenolic acids, cover crops, allelochemicals, dose-response.

## **Carabid beetle assemblages and functional traits distribution in olive orchards and vineyards within the Mediterranean basin**

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### **Summary**

Carabid beetles (Coleoptera, Carabidae) are mostly generalist predators who provide valuable ecosystem services including biocontrol on pest species in the agroecosystems. These services are connected to species traits such as feeding preferences, body size, and wing development. In this study we analysed the functional diversity of carabid beetles in Mediterranean vineyards and olive orchards based on the selected traits. Since earlier studies confirmed the impact of habitat structure on life traits composition in invertebrate assemblages, our hypothesis was that the agricultural practice like integrated pest management (IPM) and organic management (OM), would have an effect on the distribution of the traits in the ground beetle communities, and would differ from natural, unmanaged, habitats. To test our assumptions, we analysed data from previous studies on carabid community structures in vineyards and olive orchards in Italy and Greece, and our data collected in Zadar County, Croatia, in 2018 and 2019. We found that unmanaged habitats supported significantly more carnivorous species. Large, brachypterous species had the highest proportion at unmanaged sites as well, and lowest at IPM sites. However, unmanaged sites displayed significantly lower functional diversities in feeding preferences and body size groups of carabid beetles pointing to stable community structure dominated with large brachypterous predatory species. These findings can serve as guidelines in enhancing the agricultural practice that promote sustainability of predatory carabids and thus their service in biocontrol.

**Key words:** Agroecosystems, biocontrol, functional diversity, Mediterranean cultivars,

## Mushrooms as a functional food

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### Summary

The concept of functional foods comes from Far Eastern cultures where food was treated the same as medicine. Mushrooms belong to a distinct microbiological group of organisms that have significant nutritional, medicinal, and ecological value. In the 20th century they became a sought-after and exclusive food. The reason for this is the chemical composition and nutritional value of mushrooms. In addition, mushrooms are becoming increasingly important in our diets due to their high protein content and low fat/energy content. Mushroom proteins contain all nine essential amino acids needed by humans, making them an excellent substitute for meat and recommended for a vegetarian diet. In addition to their high protein content, mushrooms are also a good source of minerals such as phosphorus, iron, potassium, zinc, copper, selenium, B vitamins, vitamin C and D. They are a good source of dietary fiber, especially chitin, which inhibits fat absorption and helps with weight loss. Mushrooms as functional foods have a positive effect on human health and play an important role in the treatment and prevention of some diseases. They are a rich source of various bioactive compounds responsible for their antioxidant, antitumor and antimicrobial properties. Bioactive compounds (lentinan, eritadenin) have also been found in the species *Lentinula edodes* and *Pleurotus ostreatus*, which contribute to lowering cholesterol levels. The antioxidants found in mushrooms are mainly phenolic compounds (phenolic acid and flavonoids), tocopherols, ascorbic acid and carotenoids. Despite their pharmacological properties, mushrooms are gaining importance in human nutrition due to their low fat content, no cholesterol, high complete protein content and low energy value.

**Key words:** nutritional value, medicinal propertis, *Lentinula edodes*, *Pleurotus ostreatus*

## Utjecaj teksture na diferencijalnu poroznost tla

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### Sažetak

Diferencijalna poroznost tla (odnos između pojedinih kategorija pora) ima vrlo veliki utjecaj na vodozračni režim. Ekološki optimalan odnos mikropora (pora sa vodom) i makropora (pora sa zrakom) je 3:2 do 1:1. Cilj ovoga istraživanja bio je utvrditi utjecaj teksture na diferencijalnu poroznost tla (sadržaj pora većih od 10  $\mu\text{m}$ , srednjih pora veličine 10-0,2  $\mu\text{m}$  i pora manjih od 0,2  $\mu\text{m}$ ), konkretno odnos između mikropora i makropora u tlima širokog spektra teksturnih klasa. Istraživanje je provedeno temeljem postojećih podataka o teksturi i diferencijalnoj poroznosti tala (2060 reprezentativnih horizonata) koje posjeduje Zavod za pedologiju Agronomskog fakulteta Sveučilišta u Zagrebu. Podaci su prikupljeni za potrebe izrade Hidropedološke karte Republike Hrvatske. Diferencijalna poroznost tla je određena za 11 teksturnih klasa usporedbom omjera mikropora i makropora. Dobiveni rezultati ukazuju da se porastom udjela pijeska u tlu povećava kapaciteta tla za zrak koji se nalazi u porama većim od 10  $\mu\text{m}$ . Porast udjela gline u tlu uzrokuje povećanje količine vode nepristupačne biljkama koja se nalazi u porama manjim od 0,2  $\mu\text{m}$ . Površinski horizonti imaju bolju diferencijalnu poroznost u odnosu na podpovršinske horizonte. Tekstura tla ima značajniji utjecaj na kapacitet tla za vodu, dok je utjecaj na kapacitet tla za zrak manje izražen. Rezultati istraživanja ukazuju da je ekološki optimalan odnos mikropora i makropora u prirodi rijetko postignut.

**Ključne riječi:** tlo, tekstura, mikropore, makropore

## **Influence of texture on differential porosity of soil**

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### **Summary**

Differential porosity of the soil (relation between individual pore categories) has a quite large impact on the water-air regime. Ecologically optimal ratio of micropores (water pores) and macropores (air pores) ranges from 3:2 to 1:1. The aim of this study was to determine the influence of texture on the differential porosity of the soil (the content of pores larger than 10  $\mu\text{m}$ , medium pores sized between 10-0.2  $\mu\text{m}$ , and pores smaller than 0.2  $\mu\text{m}$ ), specifically the relationship between micropores and macropores in of wide texture classes range soils. The research was conducted based on existing data related to texture and differential porosity of soils (2060 representative horizons) owned by the Department of pedology, Faculty of Agriculture, University of Zagreb. The data were collected with the purpose of preparing the Hydropedological Map of the Republic of Croatia. Differential porosity of soil was determined for 11 texture classes by comparing micropores and macropores ratio. Obtained results indicate that with the increase amount of sand in the soil the soil capacity for air, located in pores greater than 10  $\mu\text{m}$ , increases accordingly. An increase in the proportion of clay in the soil causes an increase in the amount of water inaccessible to plants located in pores smaller than 0.2  $\mu\text{m}$ . Surface horizons have better differential porosity compared to subsurface horizons. Soil texture has a more significant impact on soil water capacity, while the impact of soil air capacity is lower. The results of the research show that the ecologically optimal ratio of micropores and macropores in nature is rarely achieved.

**Key words:** soil, texture, micropores, macropores

## Treatment of sugar beet with *Trametes versicolor* with the aim of producing biofertilizer

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### Summary

Sugar beet pulp is a by-product of the sugar industry, obtained after the extraction of sucrose from sugar beet roots. It is usually pressed and/or dried and used as animal feed. About 13.5 million tons of sugar beet pulp are produced annually in the European Union. Chemically, it consists mainly of the polysaccharides hemicellulose (30%<sub>DM</sub>), cellulose (22-24%<sub>DM</sub>) and pectin (15-25%<sub>DM</sub>), while having lower lignin content (5.9%<sub>DM</sub>). *Trametes versicolor* (syn. *Coriolus versicolor* and *Polyporus versicolor*) belongs to the phylum Basidiomycota of Kingdom Fungi, colloquially called basidiomycetes. The use of this fungus has recently been intensively investigated to utilize lignocellulosic waste biomass and industrial lignocellulosic byproducts in lignocellulosic biorefineries for the production of biofuels and value-added products. In this work, sugar beet pulp was treated with *Trametes versicolor* under solid-state conditions for 10 days. During the treatment, pH decreased steadily (from initial 4.58 to 3.99) as well as C/N ratio, while the concentration of minerals increased. After 10 days of treatment, the C/N ratio was 22.32, indicating possible maturation of the biomass. Significant concentration of essential elements were obtained after the treatment, as follows: Ca (1.2%<sub>DM</sub>), Mg (0.38%<sub>DM</sub>), K (0.22%<sub>DM</sub>), N (0.18%<sub>DM</sub>) and P (0.1%<sub>DM</sub>). The concentrations of microelements (Fe, Mn, Zn, Cu) also increased after the treatment reaching final values as follows: Fe (535 mg kg<sup>-1</sup>), Mn (72,8 mg kg<sup>-1</sup>), Zn (20,9 mg kg<sup>-1</sup>), Cu (8,9 mg kg<sup>-1</sup>). The concentrations of all tested heavy metals (Zn, Cu, Cr, Co, Ni, As, Mo, Cd, Hg, Pb) were below the maximum permissible levels. Germination tests for cucumber and watercress lettuce showed high fitotoxicity, which was also to be expected due to the low pH values.

**Key words:** sugar beet pulp, *Trametes versicolor*, biofertilizer



## Rezistencija bakterija na karbapeneme u otpadnoj vodi grada Zagreba

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### Sažetak

Rastuća prevalencija enterobakterija rezistentnih na karbapeneme, antibiotike koji predstavljaju zadnju liniju u liječenju infekcija uzrokovanih višestruko rezistentnim gram-negativnim bakterijama, zabrinjavajući je problem koji je poprimio globalne razmjere. Postrojenja za pročišćavanje otpadnih voda mogu biti rezervoari i izvori širenja ovih bakterija u prirodne vodotokove, ali i zemljišta putem navodnjavanja, što predstavlja rizik za zdravlje ljudi. Cilj ovog rada bio je izolirati i karakterizirati enterobakterije (200 izolata) koje ispoljavaju rezistenciju na karbapeneme u pročišćenoj otpadnoj vodi iz Centralnog uređaja za pročišćavanje otpadnih voda grada Zagreba. Metodom mikrodilucije testirana je osjetljivost bakterijskih izolata na 3 karbapenema (ertapenem, imipenem, meropenem) pri čemu je većina izolata bila otporna na sva 3 testirana karbapenema. Kolorimetrijskim CarbaNP testom potvrđeno je da je otpornost na karbapeneme u većini analiziranih izolata bila posredovana proizvodnjom karbapenemaza. Većina izolata je također ispoljavala višestruko rezistentan fenotip, tj rezistenciju na barem 3 klase antibiotika. PCR analizom potvrđena je prisutnost klinički značajnih gena za karbapenemaze (blaKPC, blaNDM, blaVIM, blaIMP ili blaOXA-48) u većini testiranih izolata. Rezultati ovog istraživanja ukazuju da je pročišćena komunalna otpadna voda rezervoar klinički značajnih enterobakterija rezistentnih na karbapeneme i da su potrebne dodatne mjere dezinfekcije kako bi se spriječilo njihovo daljnje širenje unutar i izvan okoliša.

**Ključne riječi:** antibiotska rezistencija, karbapenemi, enterobakterije, otpadna voda, uređaj za pročišćavanje otpadnih voda

## Bacterial resistance to carbapenems in Zagreb wastewater

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### Summary

The increasing prevalence of enterobacteria resistant to carbapenems, antibiotics that are the last resort for treating infections caused by multidrug-resistant Gram-negative bacteria, is a worrisome problem that has reached global proportions. Sewage treatment plants can be reservoirs and sources for the spread of these bacteria in natural watercourses, as well as on land through irrigation, posing a risk to human health. The aim of this study was to isolate and characterize enterobacteria (200 isolates) showing resistance to carbapenems in treated wastewater from the central wastewater treatment plant of the city of Zagreb. Sensitivity of bacterial isolates to 3 carbapenems (ertapenem, imipenem, meropenem) was tested by the microdilution method, and most isolates were resistant to all 3 carbapenems tested. The colorimetric CarbaNP assay confirmed that carbapenem resistance was mediated by carbapenemase production in most of the isolates tested. Most isolates also exhibited a multidrug-resistant phenotype, i.e., resistance to at least 3 classes of antibiotics. PCR analysis confirmed the presence of clinically relevant genes for carbapenemases (blaKPC, blaNDM, blaVIM, blaIMP, or blaOXA-48) in most of the isolates tested. The results of this study suggest that treated municipal wastewater is a reservoir of clinically relevant enterobacteria resistant to carbapenems and that additional disinfection measures are needed to prevent their further spread within and outside the environment.

**Key words:** antibiotic resistance, carbapenems, enterobacteria, wastewater, sewage treatment plant

## Učinci različitih supstrata na gujavicu *Eisenia andrei* – preferencije prema određenom supstratu

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### Sažetak

Stalni porast intenziteta poljoprivredne proizvodnje, potencijalno negativni učinak intenzivne mineralne gnojidbe na okoliš, potreba gospodarenja organskim nusproizvodima i očuvanja prirodnih resursa, nedvojbeno usmjeravaju ka intenzivnijoj upotrebi organskih gnojiva i supstrata. Nusproizvodi poljoprivredne, šumarske i prehrambene proizvodnje i ostale vrste organskog otpada, mogu se različitim procesima biološke stabilizacije koristiti kao sirovine u proizvodnji organskih gnojiva i supstrata za uzgoj presadnica. Na taj način se smanjuje količina otpada i koriste vlastiti proizvodi koji doprinose očuvanju plodnosti tala i održivom korištenju resursa. U procesu proizvodnje može se primijeniti vermikompostiranje – prerada i stabilizacija organske tvari pomoću gujavica. Cilj ovog istraživanja bio je utvrditi kako različiti supstrati, sastavljeni od različitih komponenti i njihovih smjesa, djeluju na gujavicu (*Eisenia andrei*). Gujavice su izlagane istraživanim supstratima te je utvrđen stupanj preživljavanja i praćeno je ponašanje gujavica, odnosno izbjegavanje određenih supstrata. Rezultati su pokazali da je najpogodniji supstrat vinogradarski trop, a izuzetno dobrim supstratom pokazala se smjesa vinogradarskog tropa, kamene vune i piljevine te smjesa lišća i konjskog stajskog gnoja. S obzirom na rezultate, možemo zaključiti da navedene komponente i smjese imaju najveći potencijal u proizvodnji supstrata za uzgoj presadnica povrća i cvijeća i u proizvodnji novih organskih gnojiva.

**Ključne riječi:** vermikompostiranje, supstrati, organska gnojiva, gujavice, test izbjegavanja

## Effects of different substrates on the earthworm *Eisenia andrei* -preferences to particular substrate

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### Summary

The constant increase in the intensity of agricultural production, the potentially negative effect of intensive mineral fertilization on the environment, the need to manage organic by-products and conserve natural resources, undoubtedly lead to more intensive use of organic fertilizers and substrates. By-products of agricultural, forestry and food production and other types of organic waste can, through various biological stabilization processes, be used as raw materials in the production of organic fertilizers and substrates for growing seedlings. In this way, the amount of waste is reduced and own products are used that contribute to the preservation of soil fertility and sustainable use of resources. In the production vermicomposting can be applied - processing and stabilization of organic matter by earthworms. The aim of this study was to determine how different substrates, composed of different components and their mixtures, affect earthworms (*Eisenia andrei*). Earthworms were exposed to the investigated substrates, and in addition to survival, the behavior of earthworms was monitored, i.e. the avoidance of certain substrates. The results showed that the most suitable substrate was vineyard trop. Mixture of vineyard trop, stone wool and sawdust, and a mixture of leaves and manure also proved to be an extremely good substrates. Considering the obtained results, it can be concluded that these components and mixtures have the greatest potential in the production of substrates for growing vegetable and flower seedlings and in the production of new organic fertilizers.

**Key words:** vermicomposting, substrates, organic fertilizers, earthworms, avoidance test

## Encapsulation and release kinetics of silver ions from alginate/chitosan-based microparticles

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### Summary

Plant pathogenic bacteria and fungi are one of the biggest threats to global commercial crop and food production resulting in significantly increased cost of production, reduced crop establishment and productivity. One of the most important tasks in plant protection is the process of using new agroecological formulations based on silver ions. The aim of this investigation is to explore how the method of ionic-gelation encapsulation method can produce biopolymer microcapsules enriched with silver ions, which could increase the stability and viability of silver ions over a longer time period. The optimization process of silver ion encapsulation in the biopolymers microcapsules was performed under optimal conditions of concentrations of alginate, chitosan, and calcium chloride: (1.5% sodium alginate, 0.5% chitosan, 2% calcium chloride). At optimal point microcapsules enriched with silver ions were produced and physicochemically characterized (microcapsules size, encapsulation efficiency, loading capacity, particle size). The process of encapsulation in biopolymer microcapsules did not have a negative impact on the properties of the silver ions and its activity remains very high. Also, the silver ions release data were fitted to the Korsmeyer-Peppas model and the  $n$  exponent indicated that the release mechanism was Fickian. The electrostatic interactions between silver ions, alginate and chitosan were confirmed by infrared spectroscopy. The obtained results showed that silver ions could be successfully encapsulated and applied in the process of plant protection against plant pathogens.

**Key words:** encapsulation, silver ions, microcapsules, plant protection, pathogens

## Ozone as a biofumigant in the control of stored product pests

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### Summary

Meeting the food needs of a growing population remains a global problem, given regulations to reduce pesticides and use environmentally friendly methods. Global food losses due to pests, including inadequate facilities, especially in low-income countries, can exceed 30% for cereals and 55% for fruits and vegetables. Cereals form the basis of staple foods in most developing countries, while fresh fruits, such as citrus, are essential for nutritional well-being. The main objective of the study was to determine the potential of ozone as a biofumigant in controlling *Sitophilus granarius* in storages including walking response and velocity, and green mold caused by *Penicillium digitatum* in mandarin storage. Ozone treatment on *S. granaries* was applied 10, 20, 30, 60, and 120 min in two variants (insect alone and within grains). In mandarin storage, ozone was applied for a period of 1 - 3 days and treatment duration of 10, 30 and 60 minutes. In the case of *S. granarius*, 15 days after treatment results showed 97-100% efficacy with inhibitory effect on insect mobility and speed. Ozone application during storage of mandarins proved to be up to 94% effective in both cardboard and closed styrofoam boxes. There was no significant difference between standard fungicide treatment and ozone application. The results of this study show that ozone has biofumigant potential for controlling pests and pathogens in food storage systems, either alone or as an adjunct to other methods.

**Key words:** cereals, mandarine, ozone, pesticides, styrofoam

## Primjena samoniklog tradicionalno korištenog bilja u ruralnoj okolici Gospića (Hrvatska)

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### Sažetak

U ovoj etnobotaničkoj studiji analizirana je upotreba samoniklog bilja u Lici. Podaci su prikupljeni u općinama Perušić i Lovinac te u gradu Gospiću kroz 40 dubinskih polustrukturiranih intervjua. Intervjui su obuhvatili 35 žena i 5 muškaraca u dobi od 55 do 88 godina. Biljke su prikupljene tijekom vegetacijske sezone 2020., herbarizirane i digitalizirane te dostupne u online herbariju ZAGR (<http://herbarium.agr.hr/>). Zabilježeno je ukupno 109 svojti, od čega 95 samoniklih i 14 kultiviranih. Rezultati pokazuju prilično velike razlike u etnobotaničkom i ekološkom znanju između tri proučavana područja. Na području Perušića spominje se najviše vrsta (102), a mnogi ispitanici i danas svakodnevno koriste samoniklo bilje u razne svrhe. Najčešće zabilježene biljke su: *Prunus spinosa*, *Taraxacum officinale*, *Rosa canina*, *Urtica dioica*, *Juglans regia* i *Fragaria vesca*. Na području Lovinca (76 spomenutih svojti) ispitanici također sakupljaju biljke, ali više su orijentirani na lov. Tamo su najčešće zastupljene: *Rosa canina*, *Achillea millefolium*, *Cornus mas*, *Crataegus monogyna*, *Sambucus nigra* i *Prunus domestica*. U gradu Gospiću sakupljanje i korištenje bilja je sezonsko i ograničeno na manji broj ljudi. Naglasak je na određenim ljekovitim biljkama, a među 61 spomenutom vrstom najčešće su: *Achillea millefolium*, *Cornus mas*, *Sambucus nigra*, *Viola sp.*, *Prunus domestica* i *Rosa canina*. U istraživanim područjima dobro je poznata ljekovita upotreba biljnog čaja *Rubus caesius* i *Cydonia oblonga* protiv proljeva. *Carum carvi* se uglavnom koristi kao ljekovita u ruralnim dijelovima gospićkog područja. Uporaba nekih vrsta poput onih iz roda *Sorbus* (*S. aria*, *S. domestica*, *S. torminalis*) poznata je samo u Perušiću i Lovincu. Vrste koje je danas teško pronaći u prirodi i više se ne koriste su: *Veratrum sp.*, *Rhamnus alpinum ssp. fallax*, *Gentiana lutea*, *Chenopodium album* i *Ribes uva-crispa*. Možemo pretpostaviti da su razlike u etnobotaničkim spoznajama između tri proučavana područja dijelom posljedica manjih razlika u klimi i topografiji, dok su drugi uzroci u većem stupnju ruralnosti i jačoj povezanosti s prirodom na području Lovinca i Perušića.

**Ključne riječi:** etnobotanika, etnoekologija, ruralno područje, jestivo samoniklo bilje, središnja Lika

## Application of wild growing traditionally used plants in the rural area of Gospić (Croatia)

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### Summary

In this ethnobotanical study, the use of wild plants in Lika was analyzed. Data were collected in the municipalities of Perušić and Lovinac and in the town of Gospić through 40 in-depth semi-structured interviews. The interviewees included 35 women and 5 men, aged 55 to 88 years. Plants were collected during the 2020 growing season, are herbarized, and digitalized in the online ZAGR Herbarium (<http://herbarium.agr.hr/>). A total of 109 taxa were recorded, of which 95 were wild and 14 cultivated. The results show quite large differences in ethnobotanical and ecological knowledge between the three studied areas. In the Perušić area the most species were mentioned (102) and many people still use wild plants on a daily basis for various purposes. The most commonly noted plants are: *Prunus spinosa*, *Taraxacum officinale*, *Rosa canina*, *Urtica dioica*, *Juglans regia* and *Fragaria vesca*. In the Lovinac region (76 species mentioned), people also collect wild plants, but are more engaged in hunting. The most common species there are: *Rosa canina*, *Achillea millefolium*, *Cornus mas*, *Crataegus monogyna*, *Sambucus nigra* and *Prunus domestica*. In the town of Gospić, the collection and use of plants is seasonal and limited to a small number of people. The emphasis is on certain medicinal plants and among the 61 species mentioned, the most common are: *Achillea millefolium*, *Cornus mas*, *Sambucus nigra*, *Viola* sp., *Prunus domestica* and *Rosa canina*. The medicinal use of herbal tea *Rubus caesius* and *Cydonia oblonga* against diarrhea is well known in the study areas. *Carum carvi* is used medicinally mainly in the rural parts of the Gospić area. The use of some species such as those of the genus *Sorbus* (*S. aria*, *S. domestica*, *S. torminalis*) is known only in Perušić and Lovinac. Species that are difficult to find in nature today and are no longer used are: *Veratrum* sp., *Rhamnus alpinum* ssp. *fallax*, *Gentiana lutea*, *Chenopodium album* and *Ribes uva-crispa*. We can assume that the differences in ethnobotanical knowledge between the three studied areas are partly due to minor differences in climate and topography, while other causes lie in the higher degree of rurality and stronger ties to nature in the Lovinac and Perušić areas.

**Key words:** ethnobotany, ethnoecology, rural area, edible wild plants, central Lika



## The fungicidal effect of nicotinamide-based compounds

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### Summary

The nicotinamide derivatives represent the promising candidate in the field of pesticides due to significant fungicidal activity, insecticidal activity, herbicidal activity, plant growth regulator activity and bactericidal activity. The series of nicotinamide-bromides with various alkyl chain lengths (from ethyl to octadecyl) were synthesized, and the toxicity of aqueous solutions towards *Fusarium graminearum*, *Sclerotinia sclerotiorum*, and *Botrytis cinerea* was examined. The obtained data were compared with DFT calculations results to understand the structural origin of fungicidal behavior and correlate it with the structural properties of investigated molecules. A significant correlation was established between the lipophilicity of the molecules (obtained from DFT calculations) and the growth rate of the examined phytopathogenic fungi. The results had suggested that *Sclerotinia sclerotiorum* is most sensitive to nicotinamide compounds exposure, while *F. graminearum* is most resistant to the change of lipophilicity of compounds. For all investigated compounds, the growth rate was decreased with the increase of carbon atoms in the side-chain until [C<sub>14</sub>Nic][Br]. Further prolongation increased the growth rate of fungus, as it was noted for [C<sub>16</sub>Nic][Br] and [C<sub>18</sub>Nic][Br]. This behavior was explained by the distinguished hydrophobic and hydrophilic surfaces in [C<sub>14</sub>Nic][Br] due to interactions between keto oxygen and bromide anion absent in the case of nicotinamides with a longer chain.

**Key words:** nicotinamide, DFT calculations, *Fusarium graminearum*, *Sclerotinia sclerotiorum*, *Botrytis cinerea*

## Ekspresija gena osjetljivih na sušu u različitim genotipova ozime pšenice uslijed osmotskog stresa

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### Sažetak

Suša utječe na klijanje sjemena i formiranje klijanaca, što rezultira smanjenim rastom, razvojem i prinosom zrna pšenice. Zbog klimatskih promjena sve su češće godine s duljim razdobljima nedostatka vode, što ugrožava proizvodnju pšenice na svjetskoj razini. Kao odgovor na osmotski stres, biljke su razvile različite mehanizme tolerantnosti na sušu, uključujući i ekspresiju različitih gena osjetljivih na stres. Cilj ovog istraživanja bio je odrediti utjecaj osmotskog stresa na ekspresiju gena osjetljivih na sušu u šest hrvatskih genotipova ozime pšenice u fazi klijanaca. Analizirana je ekspresija gena koji kodira pirolin-5-karboksilat sintazu (*P5CS*), ključnog enzima u biosintezi prolina, te gena koji kodiraju dehidrine (*DHN5* i *WZY2*). Uslijed osmotskog stresa klijanci pšenice akumulirali su prolin, koji je bio u korelaciji s ekspresijom gena *P5CS*. Ekspresija gena *P5CS* i *WZY2*, te posebno *DHN5* bila je vrlo visoka i značajno povećana u svih genotipova uslijed većeg osmotskog stresa, dok je u kontrolnim uvjetima bila izrazito niska. Ekspresija gena osjetljivih na sušu doprinijela je tolerantnosti pšenice na sušu, pri čemu je veća ekspresija gena bila prisutna u tolerantnih genotipova. Analiza ekspresije navedenih gena važna je za razumijevanje molekularnih mehanizama tolerantnosti pšenice na osmotski stres, te može doprinijeti selekciji genotipova korisnih za razvoj novih sorti otpornih na sušu.

**Ključne riječi:** ozima pšenica, suša, *P5CS* gen, dehidrini

### Napomena

Istraživanje je sufinancirano sredstvima Europske unije iz Europskog fonda za regionalni razvoj (KK.01.1.1.04.0067).

## Drought-responsive genes expression in different winter wheat genotypes under osmotic stress

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### Summary

Drought affects seed germination and seedling establishment, resulting in reduced wheat growth, development, and grain yield. Due to climate change, years with more extended periods of water deficit are becoming more frequent, thus threatening global wheat production. In response to osmotic stress, plants have adopted various drought tolerance mechanisms, including different stress-responsive genes expression. This study aimed to estimate drought-responsive genes expression in six Croatian winter wheat genotypes under osmotic stress at the seedling growth stage. Expression patterns of gene encoding pyrroline-5-carboxylate synthetase (*P5CS*), the key enzyme in proline biosynthesis, and genes encoding dehydrins (*DHN5* and *WZY2*) were analyzed. Under osmotic stress, wheat seedlings responded in proline accumulation that was correlated with the *P5CS* gene expression. The increase in the relative expression of the *P5CS*, *WZY2*, and especially *DHN5* was very high and upregulated in all genotypes under severe osmotic stress, while their expression under the control conditions was shallow. Expression of drought-responsive genes contributed to the wheat drought tolerance, with more extent genes expression revealed for the drought-tolerant genotypes. Expression patterns analysis of these genes is essential for understanding molecular mechanisms of wheat drought tolerance and could contribute to genotype selection useful for developing new drought-tolerant varieties.

**Key words:** winter wheat, drought, *P5CS* gene, dehydrins

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# **Agroekonomika i ruralni razvoj**

# **02**

## **Agricultural Economics and Rural Development**



## Sustainable rural development through sharing economy

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### Summary

The sharing economy and particularly peer-to-peer accommodation are spreading rapidly as alternatives for the classical hotels, benefiting from technological and ICT developments from one side, and from a growing popularity among tourists, on the other side. In recent years, there is an increase in both supply and demand for peer-to-peer accommodation units and experiences in rural areas, especially popular within young tourists. This fact could have an important impact on rural areas, which are traditionally less developed and facing significant challenges regarding depopulation. Our main aim is to investigate the supply-side of the sharing accommodation in rural areas, by examining issues such as: demographic characteristics of the renters, motivations to rent, perceived advantages and disadvantages, the impact on the local economy etc.

For addressing these issues, we opted for a qualitative approach and conducted 12 semi-structured interviews with Airbnb hosts from rural areas of Bihor county, Romania. The survey took place in September 2021 and the main characteristics of the sample are the following: out of the 12 hosts, 10 offer entire houses/villas, which are used entirely for being rented via Airbnb, and 2 hosts offer private rooms. The hosts are mostly young, with an average age of 38, ranging from 27 to 57, and 2/3 of them have higher education. The main motivations to rent out are related to: increasing the family income, lifestyle motives related to enjoying the life in that area, family reasons etc. The prices per night were ranged between 45 and 210 euros, depending on the type, capacity and facilities of the accommodation units.

Our preliminary conclusions indicate that Airbnb peer-to-peer accommodation in the rural areas of Romania, particularly in the investigated area of Bihor county, started to be a noticeable presence in the accommodation supply, complementary with the classical accommodation units which usually lack in rural areas. Offering not only accommodation, but also local food, wild nature, local experiences and attractions, they can contribute to fostering creative and sustainable tourism forms in the rural areas and thus to reinvigorating rural communities.

**Key words:** rural areas, sharing economy, peer-to-peer accommodation, Romania, qualitative study

## **Enhancing the performance of agri-food businesses through CSR: a survey-based research**

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### **Summary**

Individuals' concern for health, the environment and food quality, but also specific aspects like innovation, competition, information asymmetry and multiple scandals regarding the expansion of agricultural and food companies are all a reality of the modern world. These all lead to greater attention from decision makers in the agri-food sector to ensure the satisfaction of a variety of stakeholders, as well as expectations regarding the correct and honest implementation of the principles of corporate social responsibility (CSR), while at the same time being commercially and financially sustainable – that is, a good business strategy. In our article, starting from an ample scientific literature, we tried to outline the main determinants and effects of CSR, and especially their connection to the performance of agribusiness firms. These theoretical aspects underpin the design, application and interpretation of a survey-based research of 125 small and medium firms in the agri-food sector of Romania during 2021. The empirical findings highlight the importance of external pressure to increase production and improve financial and commercial results, but also contribute to the understanding of social responsibility as an instrument for the management and proper orientation of a firm's decisions. We attempted to discover to what extent determinants such as the age of the firm or of its manager, the revenue or the number of employees influence a firm's propensity for CSR involvement, its duration and intensity. We consider that firms' actual CSR intentions and behaviors are driven by multiple reasons, primarily stakeholder pressure and performance goals. Concurrently, we identified a variety of connections, some clear, others less conclusive, between different CSR strategies and their effect on the efficiency of managerial decisions, on firm's competitive position and financial performance. Finally, a majority of responses suggest that CSR can be a valuable instrument for managers to critically analyze stakeholders' perceptions of their own companies and adapt strategies to improve the companies' general performance.

**Key words:** CSR, agri-food businesses, performance, Romania

## Stav poljoprivrednih proizvođača o klimatskim promjenama

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### Sažetak

Cilj rada je utvrditi postojanje razlika među stavovima o klimatskim promjenama na uzorku poljoprivrednih proizvođača. Istraživanje je provedeno na uzorku od 275 nositelja poljoprivrednih proizvođača na području Jadranske Hrvatske. Podaci su prikupljeni u razdoblju od listopada 2020. do lipnja 2021. Anketa je uključivala više setova pitanja, a za potrebe ovog rada uzeta su u obzir pitanja o socio-demografskim osobinama ispitanika, te pitanja o stavovima prema klimatskim promjenama mjerena putem Likertove skale. Prikupljeni podaci obrađeni su putem frekvencija i klaster analize.

U uzorku prevladavaju osobe muškog spola (75,8 %), u dobi od 52 do 65 godina (44,4 %), sa završenom srednjom školom (58,2 %). Većina ispitanika nema formalno obrazovanje iz područja poljoprivrede (81,1 %). Za većinu nositelja poljoprivrede je dopunski izvor prihoda u kućanstvu (59,6 %). Provedena je klaster analiza i utvrđeno je postojanje dva klastera s obzirom na stavove o klimatskim promjenama. Veći klaster veličine 159 ispitanika nazvan je Klima skeptici, dok manji klaster veličine 116 ispitanika Klima osviješteni. Veći klaster ima neutralne do negativne stavove o klimatskim promjenama, dok manji klaster ima visoko slaganje o utjecaju klimatskih promjena na poljoprivredu.

Pomalo je zabrinjavajuće da članovi većeg klastera imaju neutralne do negativne stavove prema klimatskim promjenama što bi značilo da ih ne prepoznaju kao prijatnu njihovom poslovanju.

**Ključne riječi:** stav, klaster analiza, klimatske promjene

### Napomena

Istraživanje neophodno za ovaj rad dio je projekta „Agrobioraznolikost – osnova za prilagodbu i ublažavanje posljedica klimatskih promjena u poljoprivredi“ KK.05.1.1.02.0005 financiranog iz Europskog fonda za regionalni razvoj i Fonda za zaštitu okoliša i energetske učinkovitost u sklopu poziva Shema za jačanje primijenjenih istraživanja za mjere prilagodbe klimatskih promjena KK.05.1.1.02.0005.



## Attitudes of agricultural producers on climate change

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### Summary

The purpose of this paper is to determine the existence of differences among attitudes toward climate change in a sample of agricultural producers. The study was conducted on a sample of 275 farm owners in Adriatic Croatia. Data were collected via an online survey from October 2020 to June 2021. The survey included several sets of questions. For the purposes of this article, questions about respondents' sociodemographic characteristics and questions about attitudes toward climate change, as measured by the Likert scale, were included.

The collected data were processed by frequency and cluster analysis. In the sample is predominantly male respondents (75.8%), aged 52 to 65 years (44.4%), and graduated from high school (58.2%). The majority of respondents have no formal education in agriculture (81.1%). For most holders, agriculture is a source of additional income (59.6%). Cluster analysis was performed and the existence of 2 clusters related to attitudes toward climate change was found. The larger group of 159 respondents was labeled Climate skeptics, while the smaller group of 116 respondents was labeled Climate aware. The larger cluster has neutral to negative attitudes about climate change, while the smaller cluster has a high level of agreement on the impact of climate change on agriculture.

It is somewhat concerning that members of the larger cluster have a neutral to negative attitude toward climate change, which would imply that they do not see it as a threat to their business.

**Key words:** attitudes, cluster analysis, climate change

### Acknowledgement

The research necessary for this paper is part of the project „AgroBioDiversity - the basis for adaptation and mitigation of the consequences of climate change in agriculture“ KK.05.1.1.02.0005 funded by the European Regional Development Fund and the Environmental Protection and Energy Efficiency Fund as part of the call for a Scheme to strengthen applied research for climate change adaptation measures KK.05.1.1.02.0005.

## Analiza troškova i koristi (CBA) za prioritetne tehnologije Nutri-2-Cycle projekta

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### Sažetak

Opći cilj znanstveno-istraživačkog projekta NUTRI-2-CYCLE je procjena 16 inovativnih tehnologija koje osiguravaju zatvoreni sustav kruženja hranjivih tvari te osiguranje pozitivnog učinka na produktivnost, kvalitetu i utjecaj na okoliš provedbom optimiziranih sustava upravljanja. Jedan od ciljeva projekta je usmjerenost financijskih i ekonomskih učinaka odabranih tehnologija na poslovanje poljoprivrednih gospodarstava, te je pritom korištena metoda analize troškova i koristi (Cost Benefit Analysis - CBA). CBA je analitički alat za procjenu ekonomskih prednosti ili nedostataka jednog ili više vrsta ulaganja kroz izračun troškova i koristi.

U okviru Nutri-2-Cycle projekta CBA pokušava dati odgovore na pitanja ekonomske isplativosti i financijske održivosti ulaganja u pojedine tehnologije za krajnjeg korisnika – poljoprivrednika ili prerađivača sirovine. Pritom je u CBA analizi napravljena usporedba troškova standardnog i inovativnog načina proizvodnje određenih poljoprivrednih kultura u Hrvatskoj i Belgiji. Jasno definirane „funkcionalne jedinice“ i „referentni scenariji“ postavljaju okvir unutar kojeg dionici mogu ekonomski procijeniti isplativost inovativnih tehnologija.

Istraživanjem i analizom je utvrđeno kako su se cijene mnogih dobara nedavno značajno promijenile, što u konačnici ima veliki utjecaj na ekonomsku ocjenu istraživanih inovativnih tehnologija. Unatoč tome, poljoprivrednici će htjeti ulagati u ona inovativna rješenja koja dugoročno pružaju dovoljnu ekonomsku sigurnost.

**Ključne riječi:** analiza troškova i koristi (CBA), ekonomska isplativost, inovativne tehnologije, NUTRI-2-CYCLE

### Napomena

NUTRI-2-CYCLE je dobio financiranje iz programa Europske unije za istraživanje i inovacije Obzor 2020. prema sporazumu o dodjeli bespovratnih sredstava No. 773682.

## **Cost benefit analysis (CBA) for the Nutri-2-Cycle project priority technologies**

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### **Summary**

The overall aim of the NUTRI-2-CYCLE research and development project is to assess 16 innovative technologies that ensure a closed nutrient cycle and implementing optimized management systems, having a positive impact on productivity, quality, and environment. One of the project goals is to focus on the financial and economic effects of selected technologies on the operations of agricultural holdings, using the method of Cost benefit analysis (CBA). CBA is an analytical tool for assessing the economic advantages or disadvantages of one or more types of investments through the calculation of costs and benefits.

As part of the NUTRI-2-CYCLE project, the CBA is trying to provide answers to the questions of economic profitability and financial sustainability of investments in certain technologies for the end users – farmers or raw material processors. The CBA analysis compared the costs of standard and innovative methods of production of certain agricultural crops in Croatia and Belgium. Clearly defined “functional units” and “reference scenarios” set the framework within which stakeholders can economically assess the cost-effectiveness of innovative technologies.

Research and analysis have shown that prices for many goods have changed significantly in the recent past, ultimately having a major impact on the economic evaluation of the innovative technologies being researched. Nevertheless, farmers will want to invest in those innovative solutions that provide sufficient economic security in the long term.

**Key words:** cost benefit analysis (CBA), economic viability, innovative technologies, NUTRI-2-CYCLE

### **Acknowledgement**

NUTRI-2-CYCLE has received funding from the EU Horizon 2020. Research and Innovation Programme under grant agreement No. 773682.

## Kreiranje brenda autohtonih proizvoda Slavonije i Baranje

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### Sažetak

Slavonija i Baranja su kroz povijest bile poznate po svome bogatstvu i netaknutoj prirodi, dobroj hrani i pristupačnim ljudima te tradiciji koju čuvaju iz generacije u generaciju. Svojim geografskim položajem, klimatskim uvjetima i prirodnom zemljom pogoduju proizvodnji zdrave, ekološki prihvatljive proizvodnje žitarica i uljarica potrebnih za prehranu autohtonih sorti svinja. Ljudi su pretežito uzgajali svinje za vlastite proizvode, a većina svinjskog mesa prerađivala se u trajne proizvode jer je to bio jedini način konzerviranja mesa utovljenih svinja. Među najpoznatije tradicijske suhomesnate proizvode Slavonije i Baranje svrstavaju se: Slavonski i Baranjski kulen, Slavonska kobasica, Slavonska šunka, domaća suha slanina, kulenova seka, čvarci te krvavica. Proizvodnja navedenih tradicijskih proizvoda predstavlja značajan izvor prihoda za dio poljoprivrednih gospodarstava na području Slavonije i Baranje, no s obzirom na potencijal koji ima, postavlja se pitanje da li je dovoljno iskorišten.

Stoga će se pokušati uvidjeti koliko se na području Slavonije i Baranje radi na podizanju konkurentnosti i prepoznatljivosti tradicionalnih suhomesnatih proizvoda, što je sve potrebno, kakvi su stavovi samih proizvođača po tom pitanju te koje su mogućnosti iskorištavanja potencijala s naglaskom na označavanje i promociju navedene skupine proizvoda kako bi se omogućilo lakše raspoznavanje navedenih proizvoda na tržištu i povećala konkurentnost domaćih proizvođača. U tom smjeru išla je i Europska unija koja je još devedesetih godina uspostavila jedinstven sustav koji omogućuje zaštitu naziva tradicionalnih proizvoda čija kvaliteta i posebne značajke nastaju pod utjecajem ljudskih ili prirodnih čimbenika specifičnih za određeno zemljopisno područje ili su pak proizvedeni prema tradicionalnim recepturama. SWOT analizom razmotrene su sadašnje i buduće snage, slabosti, prilike i prijetnje s kojima se nose proizvođači navedenih proizvoda s područja Slavonije i Baranje.

**Ključne riječi:** brendiranje, tradicionalni proizvodi, Slavonija i Baranja, oznake kvalitete

## Branding of traditional products of Slavonia and Baranja

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### Summary

Throughout history, Slavonia and Baranja have been known for their wealth and untouched nature, good food and accessible people, and the tradition they preserve from generation to generation. With their geographical position, climatic conditions and natural soil, they favor the production of healthy, environmentally friendly production of cereals and oilseeds needed for the nutrition of indigenous varieties of pigs. People mostly raised pigs for their own products, and most pork was processed into durable products because it was the only way to preserve fattened pig meat. Among the most famous traditional cured meat products of Slavonia and Baranja are: Slavonian and Baranja kulen, Slavonian sausage, Slavonian ham, homemade dried bacon, kulen seka, greaves and blood sausage. The production of these traditional products is a significant source of income for some farms in Slavonia and Baranja, but given the potential it has, the question arises whether it is sufficiently used.

Therefore, we will try to see how much is being done in Slavonia and Baranja to raise the competitiveness and recognition of traditional cured meat products, what is needed, what are the attitudes of producers on this issue and what are the opportunities to exploit the potential with emphasis on labeling and promotion in order to facilitate the recognition of these products on the market and increase the competitiveness of domestic producers. The European Union has also followed this path, establishing a unique system in the 1990s to protect the names of traditional products whose quality and special characteristics are influenced by human or natural factors specific to a particular geographical area or produced according to traditional recipes. The SWOT analysis considers the current and future strengths, weaknesses, opportunities and threats faced by the producers of these products from Slavonia and Baranja.

**Key words:** branding, traditional products, Slavonia and Baranja, quality labels

## SWOT analiza korištenja nusproizvoda ribarske industrije kao gnojidbenih resursa u poljoprivrednoj proizvodnji Jadranske regije

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### Sažetak

Poljoprivredna proizvodnja EU oslanja se u velikoj mjeri na vanjske izvore opskrbe gnojivima te se s druge strane suočava s ispuštanjem značajnih količina vrijednih nutrijenata kroz organski otpad. Stoga su potrebna inovativna rješenja oporabe organskog otpada sa svrhom proizvodnje bio-gnojiva.

Primjer inovativnih rješenja za agro sektor je i projekt SEA2LAND koji ima za cilj optimizirati pretvorbu nusproizvoda ribarske industrije u bio-gnojiva na 7 pilot područja: Jadransko, Baltičko, Sjeverno, Kantabrijsko, Atlantsko i Sredozemno more. Pilot postrojenje na Jadranskom moru preradit će nusproizvode nastale preradom morskih plodova, kombinacijom tehnoloških procesa za proizvodnju bio-gnojiva.

SWOT analiza je jednostavan i moćan alat za vrednovanje unutarnjih faktora (snage i slabosti) i vanjskih čimbenika (prilike i prijetnje) u svrhe strateškog planiranja. Dio je višedioničke analize vrijednosnog lanca projekta koja je uzela u obzir poljoprivrednu proizvodnju i ribarski sektor pilot područja. Ima široku primjenu kao podloga za izgradnju organizacijske i konkurentne strategije u sklopu projekta, odnosno proizvodnje bio-gnojiva na pilot područjima.

SWOT analizom su utvrđeni vanjski i unutarnji čimbenici predmetnog pilota. Glavne snage uključuju niske troškove sirovina, smanjenje količine otpada, lakoća primjene korištenjem postojeće infrastrukture i povećanje proizvodnog kapaciteta. Slabosti predstavljaju visoke cijene implementacije tehnoloških rješenja, sezonalnost i male količine sirovina. Prilike uključuju otvaranje radnih mjesta, rast cijena mineralnih gnojiva i smanjenje troškova zbrinjavanja otpada. Prijetnje su problemi kod formulacije i harmonizacije hraniva u gnojivu, upitnost o održivosti proizvoda, izazovi za nacionalne i EU regulative.

**Ključne riječi:** ribarstvo, poljoprivreda, nusproizvodi, bio-gnojiva, SEA2LAND

## **SWOT analysis of using fishery by-products for agricultural production in the Adriatic region**

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### **Summary**

Agricultural production in the EU relies on significant external nutrient supplies though considerable quantities of nutrients from organic waste are being disposed of, meaning that innovative solutions for recovering organic waste for fertilizer production are more than required.

The SEA2LAND project has the goal of optimizing the transformation of fish by-products into bio-based fertilizers in 7 pilot areas: Adriatic, Baltic, North, Cantabrian, Atlantic and Mediterranean pilot. Adriatic pilot will use mollusc and fish waste by using combined technology methods to produce bio-based fertilizers.

SWOT analysis is a simple but powerful tool used to estimate internal (strengths and weaknesses) and external factors (opportunities and threats) for strategic planning purposes. It is a part of the multi-actor analysis of the project value chain which took into account agricultural production and the fish industry of the pilot area. It is widely used as a basis for building an organizational and competitive strategy within the project, the production of bio-based fertilizers in pilot areas.

SWOT analysis gives an overview of the internal and external factors of the mentioned pilot. Main strengths include low cost of input streams, reducing waste, ease of transferability, and upscaling of technologies. Weaknesses include implementation and technology costs, low quantity of raw materials to be relevant, and seasonality of fish production. Opportunities include the creation of jobs, the growing cost of conventional fertilizers and reducing disposal costs. Threats include difficulties in harmonization/standardization, uncertainty in product sustainability, and challenges to EU and national regulations and policies.

**Key words:** fish industry, agriculture, by-products, bio-based fertilizers, SEA2LAND

## Tehnički potencijal biomase Istočne Hrvatske

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### Sažetak

Osječko-baranjska i Vukovarsko-srijemska županija spadaju među najznačajne poljoprivredne regije u Republici Hrvatskoj, u prvom redu zbog biljne proizvodnje. Prema podacima Agencije za plaćanje u poljoprivredi, ribarstvu i ruralnom razvoju (APRRR) ove dvije županije predstavljaju skoro 30 % ukupnih poljoprivrednih površina te oko 11 % ukupnog broja ARKOD parcela u Hrvatskoj. Poljoprivredni ostaci predstavljaju organsku biomasu koja je lako dostupan izvor sirovina za proizvodnju bioenergije te, potencijalno, proizvoda više dodane vrijednosti posredstvom prehrambene i farmaceutske industrije. Cilj rada bio je utvrditi ekonomski i tehnički potencijal najznačajnijih usjeva (pšenica, ječam, kukuruz, suncokret, soja, šećerna repa i uljana repica) u dvije županije. Izvori podataka za izračunavanje tehničkog potencijala biomase bili su podaci Državnog zavoda za statistiku i APRRR – površina (ha), proizvodnja (t) i prinosi ( $t\ ha^{-1}$ ) u 2021. godini. U radu je korištena RenewIsland ADEG metodologija. Tehnički potencijal biomase izračunava se oduzimanjem biomase potrebne za održavanje tla i biomase potrebne za stočarstvo (pšenica i ječam) ili gubitaka pri žetvi (ostali usjevi) od osnovnog potencijala biomase. Rezultati istraživanja pokazali su da tehnički potencijal dvije županije u 2020. godini iznosi 1.440.211 t, od čega 77 % tehničkog potencijala iz poljoprivrede dolazi iz žitarica, a 23 % iz industrijskog bilja. Izračunate količine poljoprivrednih ostataka predstavljaju ogroman potencijal kao sirovnine za proizvodnju proizvoda više dodane vrijednosti – gnojiva, kompost, proizvodi prehrambene i farmaceutske industrija, stočna hrana, električna enetrija itd. Iskorištenje tehničkog potencijala biomase imalo bi ekonomski učinak na farmu poboljšanjem ekonomskog statusa, kao i ekološki učinak na gospodarstvo primjenom principa cirkularne bioekonomije.

**Ključne riječi:** tehnički potencijal, biomasa, žitarice, industrijsko bilje, Istočna Hrvatska

### Napomena

Rad je rezultat istraživanja na projektu KK.01.1.1.04.0052 „Inovativna proizvodnja organskih gnojiva i supstrata za uzgoj presadnica“ kojeg financira Europska unija u okviru Operativnog programa Konkurentnost i kohezija 2014.-2020. iz Europskog fonda za regionalni razvoj.



## Technical potential of biomass in Eastern Croatia

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### Summary

Osijek-Baranja and Vukovar-Srijem counties are among the most important agricultural regions in the Republic of Croatia, primarily due to crop production. According to the Payment Agency in Agriculture, Fisheries and Rural Development (PAAFRD), these two counties represent almost 30% of the total agricultural land and about 11% of the total number of ARKOD parcels in Croatia. Agricultural residues are organic biomass that is an easily available source of raw materials for bioenergy production and, potentially, higher value-added products through the food processing and pharmaceutical industries. The aim of this study was to determine the economic and technical potential of the most important crops (wheat, barley, corn, sunflower, soybean, sugar beet and oilseed rape) in the two counties. Sources of data for calculating the technical potential of biomass were from the Central Bureau of Statistics and PAAFRD - area (ha), production (t) and yields (t ha<sup>-1</sup>) in 2021. RenewIsland ADEG methodology was used in this paper. The technical potential of biomass is calculated by subtracting the biomass needed for soil maintenance and the biomass needed for livestock (wheat and barley) or the losses at harvest (other crops) from the total biomass potential. The research results showed that the technical biomass potential of the two counties in 2020 amounts 1,440,211 t, of which 77% of the technical potential from agriculture comes from cereals and 23% from industrial plants. The calculated amounts of agricultural residues represent a huge potential as raw materials for the production of higher value-added products - fertilizers, compost, food and pharmaceutical products, animal feed, electricity, etc. Utilizing the technical potential of biomass would have an economic impact on the farm by improvement of economic status as well as environmental impact on the economy by applying the principles of circular bioeconomy.

**Key words:** technical potential, biomass, cereals, industrial plants, Eastern Croatia

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## Zajednička poljoprivredna politika (ZPP) - usporedba trenutnog i novog programskog razdoblja

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### Sažetak

Poljoprivreda i ruralni razvoj u novom programskom razdoblju ZPP-a bit će orijentirani na pojačanu brigu za okoliš, investicije usmjerene na digitalnu i zelenu tranziciju, produktivnost i konkurentnost te na pružanje dodatne potpore za mlade poljoprivrednike. Važan segment ZPP-a je Zelena arhitektura koja podrazumijeva plaćanja za primjene poljoprivrednih praksi koje su povoljne za okoliš i pridonose smanjenju klimatskih promjena te onih praksi koje pridonose očuvanju poljoprivrednih krajolika i biološke raznolikosti.

U sklopu novog ZPP-a najmanje 35 % proračuna za ruralni razvoj bit će namijenjeno svim vrstama intervencija vezanih za okoliš i klimu. Zelena arhitektura trenutnog ZPP-a uključuje poljoprivredno-okolišno-klimatske mjere čije je provođenje dobrovoljno te zelena plaćanja i višestruku sukladnost koji su obvezni za korisnike izravnih plaćanja. U novom ZPP-u novost su eko-scheme koje su dobrovoljne i za koje je predviđeno minimalno 25 % proračuna izravnih plaćanja, i nova uvjetovanost koja je obvezna za korisnike izravnih plaćanja.

Projekt CAPTIVATE nastoji upoznati poljoprivrednike s uvjetima, eko-shemama i propisima iz područja ruralnog razvoja i potaknuti ih na primjenu mjera koje za cilj imaju zaštitu okoliša i smanjenje negativnog utjecaja na klimu u skladu s novim ZPP-om.

IPS Konzalting u sklopu predmetnog projekta sustavno obrađuje propise i pravila trenutnog i budućeg ZPP-a vezane uz održivu i ekološku poljoprivrednu proizvodnju, a koji su relevantni za poljoprivrednike. Analizom će se obuhvatiti način obrade zakonskih propisa s ciljem diseminacije propisa prema krajnjim korisnicima čime će se postići uspješnija implementacija ZPP pravila u stvarnim situacijama.

**Ključne riječi:** ZPP, okoliš, klima, modernizacija, CAPTIVATE

## **Common agricultural policy (CAP) - comparison of current and new programming period**

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### **Summary**

In the new CAP programming period, agriculture and rural development will focus on enhanced care for the environment, investment aimed at digital and green transition, productivity and competitiveness and providing additional support for young farmers. An important segment of the CAP is green architecture, which implies paying for the application of agricultural practices that are favourable for the environment and contribute to the reduction of climate change, and to those practices which contribute to the preservation of agricultural landscapes and biodiversity.

In the new CAP, at least 35% of the rural development budget will be devoted to all types of environmental and climate interventions. The Green architecture of the current CAP includes agri-environmental-climate measures whose implementation is voluntary and green payments and cross-compliance that is mandatory for users of direct payments. In new CAP, novelty is the eco-schemes that are voluntary and for which a minimum of 25% of the direct payments budget is foreseen, and a new conditionality that is mandatory for direct payments users.

The CAPTIVATE project aims to acquaint farmers with conditions, eco-schemes, and regulations in the field of rural development and encourage them to apply measures aimed at protecting the environment and reducing the negative impact on the climate in accordance with the new CAP.

As part of the project, IPS Konzalting systematically processes regulations and rules of the current and future CAP related to sustainable and organic farming which are relevant to farmers. The analysis will depict methods to research above mentioned legal frameworks with the intention to disseminate legal guidelines to end-users resulting in more successful implementation of CAP rules in real case scenarios.

**Key words:** CAP, environment, climate, modernization, CAPTIVATE

## Analiza mljekarskog sektora iz perspektive proizvođača

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### Sažetak

Mljekarstvo i proizvodnja mlijeka kao važna gospodarska grana od velike je važnosti za zadovoljenje prehrambenih potreba, gospodarskog rasta, stvaranja radnih mjesta i očuvanja ruralnog prostora Hrvatske. Danas ga karakteriziraju pad broja isporučitelja mlijeka, pad broja mliječnih krava, pad otkupnih cijena mlijeka, niska razina proizvodnje i deficit na vanjskotrgovinskoj bilanci u prometu mlijeka. Radom smo nastojali prikazati aktualno stanje i uvjete u proizvodnji kravljeg mlijeka. Istraživanje je provedeno putem on-line upitnika u razdoblju studeni/prosinac 2021. godine na 2.972 gospodarstva s ukupno 66.037 krava što predstavlja 85 % gospodarstava i krava u sustavu kontrole mliječnosti HAPIH-a. Rezultati ankete pokazuju da naši mljekari ne raspolažu s dovoljno stočne hrane za zadovoljenje svojih potreba, te iako većina gospodarstava raspolaže s odgovarajućom mehanizacijom za proizvodnju, skladištenje i pripremu stočne hrane nedostaje im poljoprivrednih površina i radne snage. Analizom dobivenih podataka zabrinjavajućim ocjenjujemo podatak da 18 % gospodarstava planira prodaju krava iz matičnog stada. Temeljem rezultata razvidno je da se cijela mljekarska industrija bori s niskim otkupnim cijenama, te da pri tome njih 75 % ne koristi mjere Programa ruralnog razvoja Republike Hrvatske. Analizom nije moguće sa sigurnošću utvrditi smjer razvoja mljekarstva, a buduće mjere i financijski instrumenti trebaju biti usmjereni očuvanju broja krava, povećanju produktivnosti i jačanju konkurentnosti gospodarstava u proizvodnji mlijeka.

**Ključne riječi:** mljekarstvo, perspektive, mljekarska gospodarstva

## **Analysis of the dairy sector from the perspective of producers**

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### **Summary**

Dairy farming and milk production as an important economic branch is of great importance to satisfy the nutritional needs, economic growth, job creation and preservation of the rural area of Croatia. Today, it is characterized by a reduction in milk suppliers, dairy cows, milk prices, low production levels and a deficit on the external trade of milk balance. This paper is here to present the current situation and conditions in the production of cow's milk. The survey was carried out through the online questionnaire in November/December 2021 within 2,972 farms with a total of 66,037 cows representing 85% of farms and cows in the HAPR control system. The results of the survey show that our dairy producers do not have enough feed to satisfy fodder needs, and although most holdings have adequate machinery for the production, storage and preparation of fodder crops, they lack agricultural areas and labor. The analysis of the data generated is troubling as we assess the fact that 18% of the farms are planning to sell cows from the parent herd. The result shows that the whole dairy industry is struggling with low purchase prices and 75% does not benefit from the measures of the Rural Development Program of the Republic of Croatia. The analysis is not able to argue with certainty the direction of the development of dairy farming, and future measures and financial instruments should aim at preserving the number of cows, increasing productivity and strengthening the competitiveness of farms in milk production.

**Key words:** dairy, perspectives, dairy farms

## Price risk management and challenges for arable crop farmers

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### Summary

Price volatility of both output and agricultural inputs has been threatening business results in arable crop production in 2022 due to the inflation and higher prices of the oil and gas. In the meantime, war in Ukraine brought huge disturbances in supply chains. It might have long term consequences on the global market, farmers' income and food security.

Price risk management encompass strategies like contracting or outgrowers schemes and hedging on the commodity markets. In the current situation, ex-post measures crises management applied mostly by governments and EU are the certainty. It includes activation of emergency stocks of food, export bans and financing autumn sowing to mention just a few.

The goal of the paper is assessment of price risk in grains and industrial crops. Monte Carlo simulation will be applied in order to measure consequences of price movement on the business results in a couple of scenarios on the selected crops (wheat, maize and soybean). Data from national statistics and World crop forecasts will be used. The price risk management strategies will be recommended based on the qualitative approach. The emphasis will be on hedging on the commodity markets by use of futures and options since involvement of Croatian farmers in the use of exchange instruments is insignificant. The paper analyses policy measures (announced and those already implemented in Croatia and EU) and their effects on macroeconomic situation.

**Key words:** price risk, arable crops, hedging, uncertainty, grain markets

## Osiguranje usjeva kao element troškova ratarske proizvodnje

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### Sažetak

Poljoprivredna proizvodnja je oduvijek izložena rizicima vremenskih nepogoda kao što su ekstremne temperature, suše i poplave, koji u većoj ili manjoj mjeri utječu na smanjenje prinosa i prihoda. Na razini poljoprivrednog gospodarstva, kao jedna od preventivnih mjera ublažavanja ovog rizika je osiguranje usjeva.

Cilj rada je utvrditi udio troška osiguranja u strukturi ukupnih i djelomičnih troškova proizvodnje najznačajnijih ratarskih kultura: pšenice, ječma, kukuruza, soje i uljane repice. Udio troška osiguranje se kreće od 5-7 % kod pune cijene koštanje dok je taj iznos kod obračuna na temelju varijabilnih troškova očekivano veći i iznosi 7-10 %.

Unatoč niskim iznosima troška osiguranja i subvencioniranoj premiji koju je moguće ostvariti kroz sustav Programa ruralnog razvoja, svega 40 % poljoprivrednih površina u Republici Hrvatskoj je osigurana. Uglavnom to čine veći pravni subjekti koji prepoznaju važnost osiguranja.

Stoga je potrebno učiniti veće napore kako bi se kod poljoprivrednih proizvođača razvila svijest kako je osiguranje usjeva od nepovoljnih klimatskih prilika u poljoprivredi dobar način stabiliziranja dohotka obiteljskog poljoprivrednog gospodarstva.

**Ključne riječi:** osiguranje, premija, trošak, ratarska proizvodnja

## Insurance as an element of crop production costs

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### Summary

Agricultural production has always been exposed to the risks of weather disasters such as extreme temperatures, droughts and floods, which to a greater or lesser extent affect the reduction of yields and incomes. At the level of the agricultural holding, one of the preventive measures to mitigate this risk is crop insurance.

The aim of this paper is to determine the share of insurance costs in the structure of total and partial production costs of the most important field crops: wheat, barley, corn, soybeans and oilseed rape. The share of insurance costs ranges from 5-7% at full cost, while this amount in the calculation based on variable costs is expected to be higher and amounts to 7-10%.

Despite low insurance costs and subsidized premiums received through the Rural Development Program system, only 40% of agricultural land in the Republic of Croatia is insured. Mostly this is done by larger companies that know the importance of insurance.

Therefore, greater efforts are needed to raise awareness among farmers that insuring crops against adverse climatic conditions in agriculture is a good way to stabilize the income of a family farm.

**Key words:** insurance, premium, cost, crop production



## Understanding organic farm, local, traditional and organic foods as a standard of gastronomy in agritourism

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### Summary

Some groups of tourists, who are oriented to the nature and environment, having such as healthy lifestyle at home, are looking for the same or better standard during their holidays. The aim of this paper is to analyze the actual situation and understand the service terms given through websites (a) to find data of the project EKO-GASTRO, CRP V4-1514 (b) and to analyze on site situations – project VINGATUR, V5-2030 (c). Hypothesis that ‘organic farm’ with certified organic production does not also mean ‘certified organic food/menu’ of farm gastronomy was confirmed, (b) information are misleading, while most of farms do not provide certification of organic foods. There are only two certified menus in Slovenia at organic farms. Keywords ‘organic farms Slovenia’ shows 18 organic farms (2 of them with organic wines), key words ‘organic wine producers Slovenia’ shows 20 wine producers and sellers, but only a few are organic producers (a). When we ask the farmers about gastronomy (c) the local foods are confirmed dominantly and sometimes traditional (just a few were protected and serving by trade marks in Slovenia). Practically we did not find in the study tour any organic product, and also, through the questionnaire in Podravje region we did not find any products from underutilized field crops from own local and traditional use. The question about local traditional organic products was redundant. Some of farmers agreed that it was a good idea. Also, findings of historical used foods in Slovenian heritage, like a project Iron-Age-Danube, except promotional materials, did not find long term implementation of historical used foods (except in one organic farm without certified organic menu) in Slovenian gastronomy.

We can conclude that without governmental support, the structure of organic foods, such as traditional and historical valued gastronomy will not change, like a wine tourism, which was supported only at national level.

**Key words:** organic farming, organic food, gastronomy, organic certification, project

## Poslovno planiranje u HORIZON znanstveno-istraživačkim projektima

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### Sažetak

Poslovno planiranje važan je segment svakog poslovanja kojim se postavljaju i utvrđuju ciljevi i aktivnosti koje je potrebno provesti za njihovo ostvarivanje. U znanstveno-istraživačkim projektima financiranim iz HORIZON programa, poslovno planiranje je od izrazite važnosti zbog utvrđivanja potencijalnih izazova za krajnje korisnike te glavnih aktivnosti projekta, kao i načina na koji iste doprinose ostvarenju projektnih ciljeva te u konačnici definiraju strategiju za uspješniji plasman inovativnih proizvoda i/ili usluga na tržište. Poslovni plan, kao pokazatelj ciljeva i načina prilagodbe projekta uvjetima u okruženju, od velikog je značaja za kontrolu uspješnosti očekivanih ishoda projekta.

Kao jedna od zanimljivih metoda planiranja se koristi Business Model Canvas (BMC) - alat koji služi za definiranje vrijednosti koju projekt pruža svojim rezultatima i glavnim sastavnicama. BMC se sastoji od devet dijelova: ključni partneri, ključne aktivnosti, ključni resursi, prijedlog vrijednosti, odnosi s korisnicima, kanali, segment korisnika, struktura troškova i izvori prihoda.

Na primjeru FERTIMANURE projekta će se prikazati važnost korištenja BMC alata te utjecaj kvalitetne identifikacije te kontinuirane interakcije s ciljnom skupinom na ishode istraživanja i plasman proizvoda na tržište.

**Ključne riječi:** poslovni plan, Business Model Canvas, ciljna skupina, FERTIMANURE

## **Business planning in HORIZON scientific research projects**

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### **Summary**

Business planning is an important segment of each business that sets and identifies the objectives and activities to be pursued for their achievement. In scientific research projects funded by the HORIZON programme, business planning is of crucial importance for the identification of potential challenges that end-users are facing as well as the main activities of the project and how they contribute to the achievement of project objectives and ultimately defining strategies for better marketing of innovative products and/or services. As an indicator of the objectives and means of adapting to the real case scenarios, a business plan is of great importance for controlling the performance of the expected outcomes of the project.

As one of the interesting planning methods is Business Model Canvas (BMC) - a tool used to define the value of the project with its results and main components. BMC consists of nine segments: key partners, key activities, key resources, value proposition, relations with customers, channels, customer segmentation, cost structure and revenue streams.

On the example of the FERTIMANURE project, one will demonstrate the importance of using the BMC tool and the impact of quality identification and continuous interaction with the target group on the outcomes of research and product placement on the market.

**Key words:** business plan, Business Model Canvas, target group, FERTIMANURE

## Implementation of CLLD in development of fisheries areas in Croatia

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### Summary

The implementation of Community Led Local Development (CLLD) in fisheries areas in Croatia started within the Operational Program for Maritime Affairs and Fisheries 2014-2020 (OPMF). CLLD Measure III. is exclusively implemented by the fisheries local action groups (FLAG). This paper presents an analysis of the current implementation of local development strategies in fisheries (LDSF) and the experience of FLAGs from 2014 till today.

For the purpose of presenting paper, research used managing and operational bodies annual reports and evaluations. Through on-line questionnaires and interviews with FLAG managers, an assessment was conducted on the impact on 1) the integrated development of fisheries areas through specific indicators of territorial cohesion, 2) capacity building and multi-sectoral approach through the involvement of different stakeholders in CLLD management and 3) the dynamics and structure of distribution of funds through the implementation of the LDSF, in order to assess the added value and contribution to the priority and objectives of the CLLD of the EU and Croatia in the regulatory framework for the implementation of OPMF 2014-2020.

Results show that since 2015, 14 FLAGs cover 14.19% of the national territory and 9.88% of the population. We conclude that today, regardless of the absence of a national framework for monitoring and evaluating the added value of CLLD, FLAGs have an increasingly strong role in the implementation of the OPMF and the development of fisheries areas in Croatia.

**Key words:** CLLD, LEADER, FLAG, fisheries, integrated development

## Prioriteti krajnjih korisnika prilikom uporabe biognojiva u EU i CELAC regiji

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### Sažetak

S ciljem boljeg razumijevanja te plasmana novoprodučenih gnojiva u sklopu znanstveno-istraživačkog projekta FERTIMANURE, ključnu ulogu ima razumijevanje tržišta gnojiva te prioriteti krajnjih korisnika. Provedenim istraživanjem, procijenjena je sklonost dionika i spremnost na kupnju organskih gnojiva te gnojiva po mjeri.

Pažljivo osmišljenim upitnikom osigurane su informacije o prihvaćanju novih tehnologija kao i organskih gnojiva između različitih dionika u EU i CELAC regiji. Upitnikom su obuhvaćena opća pitanja vezana uz utvrđivanje profila ispitanika, kao i ona koja se odnose na potrošnju i/ili proizvodnju gnojiva na farmi, tržišne cijene te prakse gnojidbe koje trenutno primjenjuju. U istraživanju je sudjelovalo 612 ispitanika, a najveći broj ispitanika dolazi iz Hrvatske (203) Argentine (131), Italije (130), Španjolske (57) te Francuske (54). U istraživanju su, osim prethodno navedenih zemalja, sudjelovale i Njemačka, Belgija te Nizozemska koje su zabilježile manji broj odgovora ispitanika.

Istraživanjem je utvrđeno da su ispitanici voljni prihvatiti organska gnojiva od stajskog gnoja, što i ne čudi s obzirom na to da trenutno na svojim farmama uglavnom koriste čvrstu frakciju stajskog gnoja i komposta. Ipak, kad se govori o financijskom aspektu prilikom donošenja odluke o kupnji bio-gnojiva, većina ispitanika nije spremna platiti više za organska gnojiva u odnosu na mineralna. Predmetni rezultat ukazuje na činjenicu da će za uspješno prihvaćanje krajnjih proizvoda od strane korisnika, novoprodučena gnojiva morati imati konkurentne tržišne cijene.

**Ključne riječi:** FERTIMANURE projekt, organsko gnojivo, upitnik, plasman gnojiva, krajnji korisnici

### Napomena

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## End user's priorities regarding the use of bio-based fertilisers in the EU and CELAC region

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### Summary

The HORIZON funded research project FERTIMANURE, with the aim of better understanding the placement of newly produced fertilisers on the market, places focus on understanding the fertiliser market and the priorities of end-users. The carried out research was based on investigating the willingness of stakeholders to buy bio-based and tailor-made fertilisers.

A carefully designed questionnaire provided information on the acceptance of new technologies as well as organic fertilisers between different stakeholders in the EU and the CELAC region. The questionnaire covered general questions related to determining the profile of respondents, as well as those related to the consumption and/or production of fertilisers on the farm, market prices and fertilization practices that they currently apply. In total 612 respondents participated in the research and the largest number of responses came from Croatia (203), Argentina (131), Italy (130), Spain (57) and France (54). In addition to the previously mentioned countries, Germany, Belgium, and the Netherlands also participated in the research but collected a significantly smaller number of responses.

The research determined that the stakeholders are willing to accept bio-based fertilisers from manure, which is not surprising considering that they already mostly use a solid fraction of manure and compost on their farms. However, when it comes to the financial aspect of decision making, most respondents are not willing to pay more for organic fertilisers relative to mineral ones. The results indicate that in order to successfully accept end products by users, newly produced fertilisers will have to establish competitive market prices.

**Key words:** FERTIMANURE project, organic fertilisers, questionnaire, fertilizer market, end-users

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**Genetika,  
oplemenjivanje bilja  
i sjemenarstvo**

**03**

**Genetics,  
Plant Breeding and  
Seed Production**





## Promjene genetske raznolikosti kroz četiri desetljeća oplemenjivanja soje u Hrvatskoj

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### Sažetak

Genetska raznolikost ključan je čimbenik za razvoj sorti prilagođenih klimatskim promjenama i za sigurnost usjeva u svijetu. U ovom radu uspoređene su promjene u genetskoj raznolikosti otkrivene SSR markerima hrvatske germplazme soje razvijene 1980-ih, 1990-ih, 2000-ih i 2010-ih godina te između dviju oplemenjivačkih kuća u Hrvatskoj, Agronomskog fakulteta Sveučilišta u Zagrebu i Poljoprivrednog instituta Osijek. Prosječan broj alela po SSR lokusu iznosio je 3,166, 3,357, 3,738 i 3,547 za genotipove iz 1980-ih, 1990-ih, 2000-ih, odnosno 2010-ih, dok je broj privatnih alela za ista četiri desetljeća iznosio 13, 11, 20 i 12. Najveće alelno bogatstvo opaženo je 2000-ih (118), a najniže 1990-ih godina (109). Prosječna genetska udaljenost između genotipova unutar desetljeća kretala se od 0,49 u 1990-ima do 0,53 u 1980-ima, ali uočene razlike nisu statistički značajne. U usporedbi između oplemenjivačkih kuća, Agronomski fakultet imao je veće alelno bogatstvo (162) i veći prosječni broj alela po lokusu (3,85) od Poljoprivrednog instituta Osijek (156; 3,71). Genetska udaljenost bila je značajno veća na Agronomskom fakultetu (0,538) nego na Poljoprivrednom institutu Osijek (0,512), vjerojatno zbog postojanja tri nezavisna oplemenjivačka programa u sklopu Agronomskog fakulteta. AMOVA analiza pokazala je samo 1% genetskih varijacija između desetljeća i 6% varijacija između dviju oplemenjivačkih kuća. Ukupni rezultati pokazuju da se genetska varijabilnost hrvatske germplazme soje nije smanjila tijekom proteklih 40 godina, ali i upozoravaju na niske razine nove genetske introgresije u oplemenjivačkim programima.

**Ključne riječi:** soja, genetska raznolikost, oplemenjivanje, SSR

## Changes of genetic diversity in four decades of soybean breeding in Croatia

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### Summary

Genetic diversity is a crucial factor for the development of varieties adapted to climate change and for the crop safety worldwide. In this work, the changes in genetic diversity revealed by SSR markers were compared for Croatian soybean germplasm developed in the 1980s, 1990s, 2000s, and 2010s and between two major breeding institutions in Croatia, the Faculty of Agriculture, University of Zagreb, and the Agricultural Institute Osijek. The average number of alleles per SSR locus was 3.166, 3.357, 3.738, and 3.547 for genotypes from the 1980s, 1990s, 2000s, and 2010s, respectively, while the number of private alleles in the same four decades was 13, 11, 20, and 12. Allelic richness was highest in the 2000s (118) and lowest in the 1990s (109). The mean genetic distance between genotypes within decades ranged from 0.49 in the 1990s to 0.53 in the 1980s, but the observed differences were not statistically significant. In comparison between breeding institutions, the Faculty of Agriculture had a higher allelic richness (162) and a higher average number of alleles per locus (3.85) than Agricultural Institute Osijek (156; 3.71). Within-institution genetic distance was significantly higher at the Faculty of Agriculture (0.538) than at the Agricultural institute Osijek (0.512), likely due to the existence of three independent breeding programs within the Faculty of Agriculture. The AMOVA analysis showed only 1% of genetic variation between decades and 6% of variation between two breeding institutions. The overall results show that genetic variation in Croatian soybean germplasm has not decreased over the past 40 years, but also caution against low levels of new genetic introgression in breeding programs.

**Key words:** soybean, genetic diversity, breeding, SSR

## Primjena stimulatora rasta u sjemenskoj proizvodnji hibrida kukuruza

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### Sažetak

Tretiranje sjemena roditeljskih linija kukuruza stimulatorom rasta jednostavna je mjera u procesu dorade sjemena. Cilj istraživanja bio je pratiti utjecaj stimulatora rasta na visinu i masu roditeljskih linija u proizvodnji hibrida kukuruza, te istražiti razlike u prinosu klipa i razlike u randmanu zrna prilikom krunjenja. Istraživanja su provedena u sjemenskoj proizvodnji s tri komercijalna hibrida kukuruza Poljoprivrednog instituta Osijek (Filigram OS 5126 x OS 7215; Kulak OS 23-48 x OS 5126; Velimir OS 024445 x OS KLT). Sjeme roditeljskih linija tretirano je u saržom zaprašivaču Hege 11 sa stimulatorom rasta koji predstavlja novu vrstu mineralnog gnojiva visoko koncentrirane huminske i fulvinske kiseline za poboljšanje metaboličke aktivnosti biljke u dozi od 120 ml 100 kg<sup>-1</sup> sjemena. U fazi početnog porasta roditeljskih linija obavljena su mjerenja visine biljaka i mase nadzemnog dijela biljaka. Utvrđen je statistički vrlo značajan utjecaj stimulatora rasta na visinu i masu mladih biljaka roditeljskih linija.

Najveći pozitivan utjecaj stimulatora rasta na početni porast zabilježen je kod linije oca hibrida Filigram dok je najmanji utjecaj zabilježen kod roditeljske linije majke hibrida Kulak. Mjerenja razlika prinosa klipa pokazala su pozitivan utjecaj stimulatora rasta koji je najizraženiji bio kod hibrida Kulak i iznosio je povećanje od 733 kg ha<sup>-1</sup> a najmanja izmjerena razlika iznosila je 571 kg ha<sup>-1</sup> i izmjerena je kod hibrida Velimir. Randman krunjenja klipa pokazao je pozitivan utjecaj stimulatora rasta na međudnos zrna i oklaska kod sva tri hibrida. Najveći randman izmjeren je kod zrna hibrida Velimir i iznosio je 3,5 % povećanje u odnosu na varijantu bez tretiranja sjemena roditeljskih linija stimulatorom rasta. Pozitivan utjecaj stimulatora rasta na početni porast biljaka pomaže u prevladavanju negativnih agroekoloških utjecaja tijekom vegetacije te se primjena stimulatora rasta na roditeljske linije može preporučiti u sjemenskoj proizvodnji hibrida kukuruza.

**Ključne riječi:** sjeme, kukuruz, randman dorade, stimulatori rasta

## Application of growth stimulators in seed production of maize hybrids

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### Summary

Simple measure in the process of seed processing is treating the seeds of the parent corn lines with a growth stimulator. The aim of this study was to monitor the influence of growth stimulators on the height and weight of parental lines in the production of maize hybrids, and to investigate differences in cob yield and differences in grain processing during coronation. The research was conducted in the seed production of three commercial maize hybrids of the Agricultural Institute Osijek (Filigram OS 5126 x OS 7215; Kulak OS 23-48 x OS 5126; Velimir OS 024445 x OS KLT). The seeds of the parental lines were treated in a batch of Hege 11 pollinator with a growth stimulant at a dose of 120 ml 100 kg<sup>-1</sup> of seeds. Growth stimulant is a new type of mineral fertilizer of highly concentrated humic and fulvic acid to improve the metabolic activity of the plants.

Measurements of plant height and weight of the aboveground part of plants were done in the phase of initial growth of parental lines. Results showed a statistically significant effect of growth stimulators on the height and weight of young plants of parental lines. The greatest positive influence of growth stimulators on the initial growth was recorded in the line of the father of the hybrid Filigram. The smallest influence was recorded in the parent line of the mother of the hybrid Kulak.

Piston yield differences showed a positive effect of growth stimulator, which was most pronounced in Kulak hybrids and amounted to an increase of 733 kg ha<sup>-1</sup>. The smallest measured difference was 571 kg ha<sup>-1</sup> and was measured in Velimir hybrids.

The results of research showed a positive effect of growth stimulator on the relationship between grain and cob in all three hybrids. The highest grain/cob ratio was measured in Velimir hybrids. There were 3.5% increase compared to the variant without treating the seeds with a growth stimulant.

The positive effect of growth stimulators on the initial growth of plants greatly helps to overcome negative agroecological influences during the growing season. The results of investigation showed that application of growth stimulants to parental lines can be recommended in the seed production of maize hybrids.

**Key words:** seeds, maize, grain/cob ratio, growth stimulators

## Promjene heterotičnih obrazaca u oplemenjivačkoj germplazmi kukuruza Poljoprivrednog instituta Osijek

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### Sažetak

Prinos kukuruza je kvantitativno svojstvo s izraženim fenomenom heterozisa. Heterotični učinak očituje se obrascima koji proizlaze iz kombinatornih sposobnosti inbred linija iz različitih heterotičnih skupina. Početkom 21. stoljeća, na Poljoprivrednom institutu Osijek korišteni su heterotični obrasci Lancaster/Oh43 x BSS/Iodent za dobivanje hibrida skupina zriobe FAO 300 do 500. U eri nakon 2010. godine zabilježen je porast korištenja obrasca B37/Oh43 x Iodent/Oh07 višeg potencijala prinosa za ove grupe zriobe. Time je postignuto povećanje prinosa hibrida, što predstavlja jedan od najvažnijih oplemenjivačkih ciljeva. Nove tehnologije genotipiziranja s visokom gustoćom markera predstavljaju vrijedan alat u oplemenjivanju kukuruza, posebno za klasifikaciju inbred linija u pripadajuće heterotične skupine. Cilj ovoga istraživanja bio je analizirati genetsku strukturu germplazme kukuruza korištene u zadnja dva desetljeća te utvrditi nastale promjene u heterotičnim obrascima. Ukupno 1300 primki iz dvije oplemenjivačke ere (do 2011./nakon 2011.) genotipizirano je upotrebom Illumina MaizeSNP50 tehnologijom s 56000 polimorfni SNP markera. Analiza Admixture metodom napravljena je korištenjem programa Admixture 1.3.0. Broj izvornih populacija (K) postavljen je od 1-15 nakon čega je provedena peterostruka unakrsna validacija. Pogreška unakrsne validacije bila je najniža za K=7 pa je za daljnju analizu upotrijebljen model sa sedam izvornih populacija. Rezultati Admixture analize potvrdili su oplemenjivačke pretpostavke, te je uočen porast linija kombiniranih pedigreea B37/Oh43 i Iodent/Ohio, kao i čistih linija grupa Iodent i B37. S ciljem ostvarenja dugoročnih oplemenjivačkih ciljeva poput povećanja otpornosti na abiotički stres i povećanja prinosa, nužno je iznaći nove oplemenjivačke obrasce i pratiti trendove u struci.

**Ključne riječi:** kukuruz, prinos, inbred linije, genotipizacija, heterotične skupine

## Changes in heterotic patterns of the Agricultural institute Osijek maize breeding germplasm

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### Summary

Maize yield is a quantitative trait influenced by heterosis. Heterotic effect is utilized through patterns based on combining abilities of inbred lines from different heterotic groups. From the beginning of the 21<sup>st</sup> century at the Agricultural Institute Osijek heterotic patterns Lancaster/Oh43 × BSSS/Iodent were used for development of hybrids in FAO 300 to FAO 500 maturity groups. After 2010 more extensive use of pattern with higher yield potential (B37/Oh43 × Iodent/Oh07) was observed, satisfying one of the main breeding goals; increase in yields. New genotyping technologies with high marker densities are a valuable tool in maize breeding, particularly for classification of inbred lines to heterotic groups. The aim of this study was to analyze genetic structure of maize germplasm used in last two decades, and to identify changes in heterotic patterns. Total of 1300 accessions from two breeding eras (until 2011/after 2011) were genotyped using Illumina MaizeSNP50 technology with 56000 polymorphic SNP markers. Admixture analysis was performed using Admixture 1.3.0 software. Number of ancestral populations (K) was set from 1 to 15 and quintuple cross validation was performed. Cross validation error was the lowest in K=7, so the model with seven ancestral populations was used for further analysis. The results of the Admixture analysis confirmed breeding assumptions. Increased number of inbred lines with combined pedigrees (B37/Oh43 and Iodent/Ohio) was determined, as well as inbred lines belonging to Iodent and B37 heterotic groups. In order to achieve long-term breeding goals such as abiotic stress tolerance and yield increase, one of the vital requirements is to detect new breeding patterns, along with following of trends in breeding and farming.

**Key words:** maize, yield, inbred lines, genotyping, heterotic groups

## Utjecaj predsjetvenih tretmana na klijanje bosiljka (*Ocimum basilicum* L.)

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### Sažetak

Bosiljak (*Ocimum basilicum* L.) je jedna od najvažnijih vrsta iz porodice Lamiaceae. Koristi se kao kulinarska, ljekovita i aromatična biljka u prehrambenoj, farmaceutskoj i kozmetičkoj industriji. Stres suše je jedan od najznačajnijih čimbenika abiotskog stresa koji utječe na produktivnost mnogih biljnih vrsta diljem svijeta. Predsjetveni tretmani sjemena jeftina su tehnika koja može poboljšati tolerantnost na stres suše poboljšanjem i ubrzavanjem klijanja sjemena. Cilj istraživanja je bio utvrditi utjecaja predsjetvenih tretmana sjemena na klijanje dva kultivara bosiljka 'Sweet Basil' i 'Genovese' u stresu suše. Sjeme je dobiveno iz Kolekcije ljekovitog i aromatičnog bilja Zavoda za sjemenarstvo, Sveučilišta u Zagrebu Agronomskog fakulteta. Ukupno je korišteno 800 sjemenki za svaki kultivar. Predsjetveni tretmani sjemena provedeni su u mraku močenjem 200 sjemenki u destiliranoj vodi (dH<sub>2</sub>O) tijekom 24 sata, 200 sjemenki u 500 ppm GA3 48 sati, 200 sjemenki u 0,2 KNO<sub>3</sub> (w/v %) 72 sata, dok je 200 sjemenki predstavljalo kontrolu. Klijavost je ispitana na papiru za klijanje tretiranim s dH<sub>2</sub>O i s -2,5 MPa PEG 8000 (stres suše) s 25 sjemenki po svakoj Petrijevoj zdjelici u četiri ponavljanja. Predsjetveni tretman s GA3 imao je pozitivan učinak na postotak klijavosti kod oba kultivara. Međutim, kod kultivara 'Genovese', svi predsjetveni tretmani imali su pozitivan učinak na postotak klijavosti te je sjeme predtretirano s GA3 imalo najveći postotak klijavosti u stresu suše.

**Ključne riječi:** GA3, ljekovito bilje, PEG, stres suše



## Effect of seed priming on germination of sweet basil (*Ocimum basilicum* L.)

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### Summary

Basil (*Ocimum basilicum* L.) is one of the most important species in the Lamiaceae family and is used as a culinary, medicinal and aromatic plant in the food, pharmaceutical and cosmetic industries. Drought stress is one of the most important abiotic stress factors affecting the productivity of many plant species worldwide. Seed priming is a low-cost technique that can improve tolerance to drought stress by improving and accelerating seed germination. In this study, the effect of seed priming on germination of two basil cultivars, 'Sweet Basil' and 'Genovese', under drought stress was investigated. The seeds were obtained from the Collection of Medicinal and Aromatic Plants held at the Department of Seed Science and Technology, University of Zagreb Faculty of Agriculture. A total of 800 seeds were used for each cultivar. Seed priming treatments were performed in the dark by soaking 200 seeds in distilled water (dH<sub>2</sub>O) for 24 hours, 200 seeds in 500 ppm GA3 for 48 hours, 200 seeds in 0.2 KNO<sub>3</sub> (w/v %) for 72 hours and 200 seeds as control. Germination was tested on germination paper treated with dH<sub>2</sub>O and -2.5 MPa PEG 8000 (drought stress) placing 25 seeds in each Petri dish in four replicates. Seed priming with GA3 had a positive effect on germination percentage in both cultivars. However, in 'Genovese' all seed priming treatments had a positive effect on germination percentage and the seed primed with GA3 had the highest germination percentage under drought stress.

**Key words:** drought stress, GA3, medicinal plants, PEG

## Early selection of wheat genotypes using root and shoot traits at seedling stage

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### Summary

Any plant breeding programme starts with evaluation of diverse germplasm. A set of 101 wheat genotypes was grown in optimum environment at the onset of two-leaf stage, 10 days after germination, in a hydroponic phenotyping system. This study aimed to characterize phenotypic variability in wheat root and shoot morphological traits at early vegetative stage and to determine the relationship among shoot and root traits. Phenotypic variation existed for both shoot and root traits, with a maximal 2.5-fold difference in shoot dry mass and over 3.0-fold difference in root dry mass, primary root length and root angle (measured between the first pair of seminal roots). Strong positive correlations were identified for some key root traits (i.e., root length, root dry mass, and root specific weight) and shoot traits (i.e., shoot dry mass and shoot specific weight). The cluster analysis, based on observed traits, showed the homogeneity of genotypes originating from Serbia and the region; their values of the root and stem length and weight were mostly around and below the average. However, the values of the angle of seminal roots, number of lateral roots and the branching interval were above average. A subset of 18 genotypes with different/exceptional root and shoot characteristic have been chosen as parents for 16 targeted crosses to produce novel germplasm in wheat for improving early vigour and tolerance to drought.

**Key words:** root, shoot, hydroponics, cluster, correlation

## Promjena CPVO tehničkih protokola za DUS ispitivanje pšenice i ječma

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### Sažetak

Počeci DUS ispitivanja vraćaju nas još u 1933. godinu kada je zbog brzog povećanja broja novih sorti pšenice u Francuskoj uvedeno zaštitno zakonodavstvo koje je zahtijevalo da nove sorte moraju ispunjavati određene uvjete različitosti, ujednačenosti i stabilnosti. Ti su zakoni modificirani od 1942. te još mnogo puta do današnjih dana. Posljednje izmjene CPVO (Ured za biljne sorte Europske zajednice) tehničkog protokola za DUS ispitivanje pšenice predstavljene su 19.03.2019. godine, a na snagu su stupile 01.08.2019. godine. Prema trenutno važećem protokolu CPVO-TP/003/5 broj svojstava koji se koristi za DUS ispitivanje i pripremu opisa sorti pšenice je 27 što je za dva svojstva više u odnosu na prethodni tehnički protokol. Također je promjenjen raspored ocjena kao i sorte primjeri.

U isto vrijeme promjenjen je i CPVO tehnički protokol za ječam. Prema trenutno važećem tehničkom protokolu za CPVO-TP/019/5 broj svojstava koji se koristi za DUS ispitivanje i pripremu opisa sorti ječma je 29 što je za jedno svojstvo više u odnosu na prethodni tehnički protokol. Kao i kod pšenice, raspored ocjena i sorte primjeri su promjenjeni.

Kao što je navedeno i u prethodnim tehničkim protokolima analizirana svojstva dobivena postupkom elektroforeze trebaju biti samo nadopuna morfološkim svojstvima. Referentna kolekcija je izrazito važna, a njena osnova treba biti sljedeća: sorte priznate ili zaštićene na razini Europske unije, sorte zaštićene u drugim zemljama članicama Međunarodne unije za zaštitu novih biljnih sorti (UPOV), druge opće poznate sorte, te u slučaju hibrida sve komponente hibridne sorte moraju biti dio referentne kolekcije.

**Ključne riječi:** DUS, CPVO, tehnički protokol, pšenica, ječam

## Modification of CPVO technical protocols for DUS testing of wheat and barley

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### Summary

The beginnings of DUS testing take us back to 1933, when due to the rapid increase in the number of new wheat varieties in France, protective legislation was introduced that required new varieties to meet certain prerequisites of diversity, uniformity and stability. These laws were modified in 1942 and many more times to this day. The last changes in CPVO (Community Plant Variety Office) technical protocol for DUS testing of wheat was adopted on March 19<sup>th</sup>, 2019, and entered into force on August 1<sup>st</sup>, 2019. According to the currently valid protocol CPVO-TP/003/5, the number of characteristics used for DUS testing and preparation of wheat variety descriptions is 27, which is two characteristics more than in the previous technical protocol. The arrangement trait scores as well as examples varieties have been changed.

At the same time, the CPVO technical protocol for barley was changed. According to the currently valid technical protocol for CPVO-TP-019-5, the number of characteristics used for DUS testing and preparation of barley variety descriptions is 29, which is one characteristic more than in the previous technical protocol. As wheat, the schedule of note and examples varieties have changed.

As in previous technical protocols, the properties obtained by electrophoresis testing should only be a supplement to the morphological properties. The reference collection is extremely important, and its basis should be the following: varieties recognized or protected at European Union level, varieties protected in other member states of The International Union for the Protection of New Varieties of Plants (UPOV), other generally known varieties, and in the case of hybrids all components varieties must be part of the reference collection.

**Key words:** DUS, CPVO, technical protocols, wheat, barley

## Ex situ očuvanje biljnih genetskih izvora u okviru Nacionalne banke biljnih gena

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### Sažetak

U okviru Nacionalne banke biljnih gena koja je sastavni dio Nacionalnog programa očuvanja i održive uporabe biljnih genetskih izvora u Republici Hrvatskoj provodi se *ex situ* očuvanje kao i opis i procjena svojstava primki biljnih genetskih izvora za hranu i poljoprivredu. Nacionalna banka biljnih gena je decentralizirna te ju čini veći broj kolekcija koje se čuvaju kod različitih subjekata u obliku sjemena, sadnog materijala i poljskih kolekcija. Kriteriji za određivanje prioriteta biljnih vrsta za uvrštavanje u Nacionalnu banku biljnih gena su njihov značaj za prehranu stanovništva, oplemenjivački rad ili njihov značaj kao dijela prirodne i kulturne baštine. Unutar svake prioriteta biljne vrste u Nacionalnu banku biljnih gena uključuju se prije svega populacije, autohtone sorte, ekotipovi, sorte povučene sa Sortne liste RH, divlji srodnici kultiviranog bilja i slično, koji su podrijetlom iz Republike Hrvatske. U pojedinu kolekciju uključuju se samo unikatne primke koje ne postoje u drugim kolekcijama u okviru Nacionalne banke biljnih gena. U HAPIH – Centru za sjemenarstvo i rasadničarstvo u Osijeku čuva se sigurnosna, a po potrebi i osnovna kolekcija primki koje se u okviru banke gena čuvaju u obliku sjemena u aktivnim kolekcijama drugih subjekata. Sigurnosne kolekcije primki koje se održavaju u obliku poljskih kolekcija čuvaju se kod različitih subjekata na različitim lokacijama, ovisno o zemljopisnom podrijetlu primki. Do sada su u Nacionalnu banku biljnih gena uključene sve najvažnije institucije koje, s obzirom na tehničku i kadrovsku osposobljenost, mogu adekvatno održavati kolekcije sjemena i/ili poljske kolekcije. Sve primke uključene u kolekcije su adekvatno dokumentirane putovničkim podacima upisanim u bazu CPGRD (Hrvatska baza podataka o biljnim genetskim izvorima). Od 4 404 primke upisane u CPGRD u grupi žitarice i kukuruz nalazi se 593, industrijsko bilje 102, povrće 310, krmno bilje 200, kontinentalno i mediteransko voće ukupno 431, vinova loza 147 te ljekovito i aromatično bilje 2 604 primke. Također, na odgovarajući način je dokumentirano rukovanje primkama i kvaliteta čuvanja. Za primke u obliku sjemena pohranjena količina sjemena dovoljna je za adekvatno očuvanje te za dostavu zainteresiranim institucijama, a kod poljskih kolekcija održava se dovoljan broj zdravih stabala/trsova po primci. Kljavost pohranjenih uzoraka redovito se provjerava za primke u obliku sjemena dok za primke s nedovoljnom količinom i/ili kvalitetom sjemena/stabala prema potrebi se provodi regeneracija. U nadolazećem razdoblju se očekuje dodatni razvoj resursa za čuvanje primki aktivnih kolekcija te aktivnosti koje bi trebale biti usmjerene na dopunjavanje postojećih kolekcija i povećanje kvalitete *ex situ* očuvanja.

**Ključne riječi:** *ex situ*, očuvanje, genetski izvor, banka gena

## Ex situ conservation of plant genetic resources in the framework of National Plant Genebank

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### Summary

In the framework of National Plant Genebank, which is an integral part of the National Program for the Conservation and Sustainable Use of Plant Genetic Resources in the Republic of Croatia, *ex situ* conservation is carried out as well as description and assessment of plant genetic resources for food and agriculture. The National Plant Genebank is decentralized and consists of a large number of collections kept by different entities in the form of seeds, planting material and field collections. The criteria for determining the priority plant species for inclusion in the National Plant Genebank are their importance for population nutrition, breeding work or their importance as part of the natural and cultural heritage. Within each priority plant species, the National Plant Genebank primarily includes populations, autochthonous varieties, ecotypes, varieties withdrawn from the Croatian Variety List, wild relatives of cultivated plants and similar, which originate from the Republic of Croatia. Only unique accessions that do not exist in other collections within the National Plant Genebank are included in each collection. The CAAF - Center for Seed and Seedlings in Osijek keeps a safety collection and, if necessary, a basic collection of accessions that are kept within the genebank in the form of seeds in the active collections of other entities. Safety collections of accessions maintained in the form of field collections are kept by different entities in different locations, depending on the geographical origin of the accessions. So far, the National Plant Genebank has included all the most important institutions that, given their technical and human resources, can adequately maintain seed collections and/or field collections. All accessions included in the collections are adequately documented by passport data entered into the CPGRD database (Croatian Plant Genetic Resources Database). Of the 4,404 accessions registered in CPGRD the cereals and maize group, there are 593, industrial crops 102, vegetables 310, fodder crops 200, continental and mediterranean fruits a total of 431, vitis 147 and medicinal and aromatic plants 2,604 accessions. Also, the handling of accessions and the quality of storage are properly documented. For accessions in the form of seeds, the stored quantity of seeds is sufficient for adequate conservation and for delivery to interested institutions, and in the case of field collections, a sufficient number of healthy trees/vines per accession is maintained. The germination of stored samples is regularly checked for seed accessions while for accessions with insufficient quantity and/or quality of seeds/trees, regeneration is carried out as necessary. In the coming period, further development of resources for the conservation of accessions of active collections is expected, as well as activities that should be aimed at supplementing existing collections and increasing the quality of *ex situ* conservation.

**Key words:** *ex situ*, conservation, genetic resource, genebank

## Učinak osmotskog stresa na rast biljaka i hormone u klijancima ozime pšenice

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### Sažetak

Uslijed klimatskih promjena, suše su sve češće u svijetu kao rezultat jačeg isušivanja tla što dovodi do osmotskog stresa koji ograničava produktivnost pšenice. Stoga je važno stvoriti sorte pšenice otporne na sušu s poboljšanom sposobnošću da izdrže dugotrajni nedostatak vode. Kako bi se ispitao učinak osmotskog stresa, pokus je postavljen u klima komori sa šest sorti ozime pšenice u fazi klijanaca u pet replikacija. Za simulaciju suše u dva tretmana korišten je polietilen glikol (PEG 6000) u koncentraciji od 10 i 20 % tijekom sedam dana. Izmjereni su morfološki parametri (duljina izdanka i korijena, energija klijanja i relativni sadržaj vode). Nakon ekstrakcija, analize apscizinske (ABA) i salicilne (SA) kiseline provedene su tekućinskom kromatografijom uz masenu spektrometriju (LC-MS/MS). Rezultati su pokazali da je kod svih šest sorti došlo do blagog smanjenja energije klijanja u tretmanu s 10 % PEG-a i izraženijeg smanjenja u tretmanu s 20 % PEG-a u odnosu na kontrolni tretman. U kontrolnim biljkama najveću duljinu izdanka imala je sorta Bubnjar (109,60 mm) koji je u tretmanima s 10 i 20 % PEG-a smanjen na 82,20 mm odnosno 49,20 mm. Promjene u razini hormona stresa ABA i SA u klijancima pšenice uslijed osmotskog stresa diskutirane su u skladu s fiziološkim parametrima.

**Ključne riječi:** klijanci, pšenica, PEG, suša, markeri stresa

### Napomena

Projekt je sufinancirala Europska unija iz europskog fonda za regionalni razvoj (KK.01.1.1.04.0067).

## Effects of osmotic stress on plant growth and hormones in seedlings of winter wheat

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### Summary

Due to climate change, droughts are becoming more common worldwide as soils increasingly dry out, causing osmotic stress and limiting wheat productivity. Therefore, it is important to breed drought-resistant wheat varieties that are better able to withstand prolonged water deficit. To study the effects of osmotic stress, an experiment was conducted in a climate chamber with six winter wheat cultivars at the seedling stage in five replicates. Polyethylene glycol (PEG 6000) was used to simulate drought in two treatments at a concentration of 10 and 20% for seven days. Morphological parameters (root and shoot length, germination energy and relative water content) were measured. After the extractions, analyses of abscisic acid (ABA) and salicylic acid (SA) were performed using liquid chromatography with tandem mass spectrometry (LC-MS /MS). The results showed that all six cultivars had a slight decrease in germination energy when treated with 10% PEG and a greater decrease when treated with 20% PEG compared to the control treatment. In the control plants, the cultivar Bubnjar had the largest shoot length (109.60 mm), which was reduced to 82.20 mm and 49.20 mm in treatments with 10% and 20% PEG, respectively. The changes in both plant stress hormones ABA and SA in wheat seedlings under osmotic stress were discussed in accordance with morphological parameters.

**Key words:** seedlings, wheat, PEG, drought, stress markers

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## Variability of quality parameters in different soybean germplasm

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### Summary

Soy (*Glycine max* (L.) Merr.) is most important legume crop, and a major source of protein globally. The aim of this paper is to examine variability of quality parameters of Croatian and foreign soybean genotypes. Total of 17 soybean cultivars were included in the research, with nine cultivars being the result of domestic breeding work, and the other eight cultivars are from foreign institutes. Quality parameters (proteins, oil, moisture, fiber, minerals percentages) in natural soybean seeds and flour were analysed. The amino acid composition was further analysed using near-infrared spectroscopy (NIR), and based on these results four cultivars were selected for the analysis of total soluble proteins by high pressure liquid chromatography (HPLC). According to the obtained results, significant variability was found between domestic and foreign cultivars, the percentage of soluble proteins (7S and 11S globulines) ranged from 119.37 to 156.84 mg g<sub>ST</sub><sup>-1</sup>.

**Key words:** soybean, protein, NIR, HPLC, variability

## Primjena dubokog učenja za analizu očitavanja blizinskog multispektralnog senzora u pokusima kukuruza

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### Sažetak

Tijekom vegetacije, promjene u okolini pozitivno ili negativno utječu na prinose kukuruza. Opažanja na kraju vegetacije kada je biljka odumrla ne daju informacije potrebne za primjenu korektivnih mjera. To nas je motiviralo na razvoj multispektralnog visokopropusnog senzora za stvarnovremensko motrenje statusa biljke u poljskim uvjetima. Senzor je baziran na 6x1 nizu dioda s odzivom pri valnim duljinama koje predstavljaju fluorescenciju koju emitira biljka, te neke druge važne fenomene. Očitavanja su dalje korištena za izračun različitih normaliziranih diferencijalnih vegetacijskih indeksa (NDVI). Cilj ovog istraživanja bio je primijeniti duboko učenje za analizu multispektralnih očitavanja senzora. Mjereni su pokusi kukuruza FAO skupina 200 do 700 s 10 do 61 hibrida. Mjerenja su uređena u tenzore i postavljena je konvolucijska neuronska mreža. Slojevi mreže bili su Conv1D (dimenzije 64), potpuno povezani sloj (dimenzije 16) i maxpooling sloj, te potpuno povezani klasifikacijski sloj. Aktivacijska funkcija *ReLU* korištena je za prva dva sloja, dok je za klasifikacijski sloj korištena funkcija *softmax*. Izračuni su provedeni u programskoj knjižnici TensorFlow 2.7 u Python programskom sučelju. Model je pokazao visoku upotrebljivost senzorskih očitavanja za klasifikaciju uzoraka u grupe na temelju različitih svojstava. Robusnost pristupa i usporedba s drugim modelima biti će demonstrirani.

**Ključne riječi:** strojno učenje, neuronske mreže, kukuruz, fluorescencija

## Application of deep learning for analysis of multispectral proximal sensing node reads in maize trials

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### Summary

Maize yields are positively or negatively influenced by environmental deviations throughout the growing season. Observations at the season's end, when the plant has already senesced, lack in information for undertaking corrective measures. This motivated us to develop a high throughput multispectral proximal sensor for real-time monitoring of plant status in field conditions. The sensor is based on a 6x1 diode array with spectral response peaks at wavelengths representing the plant-emitted fluorescence and other important reflectance/emittance features. The six reads are further arranged to obtain normalized difference vegetation indices (NDVIs). The aim of this research was to apply deep learning for analysis of sensor multispectral reads. Several maize experiments with 10 to 61 hybrids with FAO maturity from 200 to 700 were measured with our proximal sensing node. Measurements were arranged to tensors and convolutional neural network was set-up. Layers were Conv1D (size 64), dense layer (size 16) and maxpooling layer followed by dense classification layer. ReLu activation function was used for first two layers, and softmax for classification layer. Calculations were carried out in TensorFlow 2.7 in Python. Model showed high usability of the sensor reads, efficiently classifying samples to respective groups for different observations. Robustness of the approach and comparison with other models will be demonstrated.

**Key words:** machine learning, neural network, maize, fluorescence

## Varijabilnost makro i mikroelemenata iz soka pšenične trave (*Triticum aestivum* L.)

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### Sažetak

Zahvaljujući svojoj visokoj nutritivnoj vrijednosti, konzumacija pšenične trave kao prirodnog dodatka prehrani, postaje sve popularnija. Iako niz istraživanja potvrđuje dobrobiti primjene pšenične trave u liječenju i prevenciji raznih oboljenja, o ukupnom i bioraspoloživom mineralnom sastavu nema puno podataka. Stoga je cilj ovog istraživanja ispitati varijabilnosti ukupnih i *in vitro* bioraspoloživih koncentracija makroelemenata (K, Ca, Mg) i mikroelemenata (Fe, Mn, Zn) iz soka pšenične trave 100 kultivara pšenice. Simulacija probave *in vitro* provedena je prema standardiziranoj metodi, a ukupne i bioraspoložive koncentracije određene su ICP-OES tehnikom. Sve koncentracije izražene su u mg l<sup>-1</sup>. Prosječna ukupna koncentracija K iznosila je 3352 ± 292, Ca 367 ± 21, Mg 235 ± 14, Fe 3,56 ± 0,27, Mn 3,67 ± 0,31 i Zn 2,11 ± 0,15. Nakon *in vitro* simulacije prosječna koncentracija K iznosila je 2982 ± 289, Ca 296 ± 24,66, Mg 202 ± 13,64, Fe 1,47 ± 0,11, Mn 3,11 ± 0,31, Zn 0,71 ± 0,01. Općenito, za ukupne koncentracije je utvrđena niža varijabilnost između kultivara u odnosu na bioraspoložive koncentracije. Najveća varijabilnost između kultivara (37 %), utvrđena je za bioraspoložive koncentracije Zn, a najniža za ukupne koncentracije Mg (13 %). Osim toga, između ispitivanih kultivara utvrđena statistički značajna razlika za sve ispitivane makro i mikroelemente. Na temelju dobivenih informacija o mineralnom sastavu soka pšenične trave može se provesti izbor sorti za buduća istraživanja.

**Ključne riječi:** pšenična trava, mineralni sastav, *in vitro* simulacija probave, funkcionalna hrana, genetska varijabilnost

## Variability of macro and microelements from wheatgrass juice (*Triticum aestivum* L.)

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### Summary

Due to its high nutritional value, the consumption of wheatgrass as a natural dietary supplement is becoming increasingly popular. Although a number of studies confirm the benefits of using wheatgrass in the treatment of various human disease conditions, there is not much data on the total and bioavailable mineral composition. Therefore, the aim of this study was to examine the variability of total and *in vitro* bioavailable concentrations of macronutrients (K, Ca, Mg) and micronutrients (Fe, Mn, Zn) from wheatgrass juice per 100 wheat varieties. *In vitro* digestion simulation was performed according to the standardized method according to Minekus et al., 2014, while total concentrations were determined by wet digestion. All concentrations are expressed in mg L<sup>-1</sup>. The average total concentration for K was 3352 ± 292, Ca 367 ± 21, Mg 235 ± 14, Fe 3.56 ± 0.27, Mn 3.67 ± 0.31 and Zn 2.11 ± 0.15. After *in vitro* simulation, the average concentration for K was 2982 ± 289, Ca 296 ± 24.66, Mg 202 ± 13.64, Fe 1.47 ± 0.11, Mn 3.11 ± 0.31, Zn 0.71 ± 0.01. In general, lower variability between cultivars was found for total concentrations compared to bioavailable concentrations. The highest variability between cultivars (37%) was found for Zn bioavailable concentrations, and the lowest for total Mg concentrations (13%). In addition, a statistically significant difference was found between the cultivars for all examined macro and microelements. Based on obtained results of mineral composition of wheatgrass juice, the selection of varieties for future research can be carried out.

**Key words:** wheatgrass, mineral composition, *in vitro* digestion simulation, functional food, genetic variability

## Variability in germination traits of *Triticum* spp. under salt stress conditions

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### Summary

The aim of this study was to examine the variability in germination traits of different *Triticum* spp. under salt stress conditions. The experiment was set up with seven genotypes (*T. monococum*, *T. dicoccoides*, *T. durum*, *T. spelta*, *T. sphaerococcum*, *T. compactum* and *T. aestivum*) and four levels of NaCl (0 mM, 50 mM, 100 mM and 150 mM) in three replicates. Fifty seeds of each genotype were used per treatment and replicate. Rolled filter paper method was used for seed germination. The following traits were evaluated: germination energy, total germination, main root length, shoot length, fresh plant mass and dry plant mass. The research revealed a significant variation of the examined traits both between different genotypes and different levels of NaCl. Analysis of variance revealed a statistically significant influence of genotype, treatment and their interaction on all examined traits. In most genotypes, the values of germination energy, total germination, root length, shoot length and fresh plant mass decreased with increasing NaCl concentration. NaCl concentrations of 50 mM and 100 mM had a mildly stimulating effect on some germination traits and genotypes. *T. spelta* and *T. sphaerococcum* showed minimal variation of most of the examined traits under salt stress conditions.

**Key words:** salt stress, NaCl, germination traits, *Triticum*

## GMO analiza: neposredne metode nasuprot posrednim

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### Sažetak

Genetski modificirani organizmi dobiveni su primjenom rekombinantne DNA tehnologije. Najzastupljeniji su proizvodi kod kojih je strana DNA ubačena u genom domaćina. Takva novonastala DNA najčešće kodira novi protein što u konačnici rezultira ispoljavanjem novih svojstava. Zbog navedenog GMO analiza može se provesti na dva osnovna načina: neposrednim metodama (direktnim) gdje spadaju analize zasnovane na detekciji novonastale rekombinantne DNA, te posrednim metodama (indirektnim) gdje podrazumijevamo metode zasnovane na analizi proteina nastalih posredno izmjenom u lancu DNA. U neposredne metode spadaju PCR metode, a u posredne imunološki testovi poput ELISA testa i takozvani brzi testovi.

Rekombinantna DNA prisutna je u svakom genetski modificiranom organizmu, no rekombinantni proteini se mogu ili ne moraju eksprimirati. U slučajevima kada se tehnologija primjenjuje s ciljem utišavanja gena neće doći do produkcije novonastalog proteina, također kada govorimo o prerađevinama tehnološki procesi korišteni u preradi mogu dovesti do denaturacije proteina i tako utjecati na sposobnost sudjelovanja u imunološkim reakcijama. DNA metode specifične su za svaki pojedinačni događaj, dok proteinske metode detektiraju protein koji može nastati različitim modifikacijama. Zbog navedenog proteinski testovi ne jamče pouzdan nalaz, te nisu prihvatljivi za službene kontrole. Metode zasnovane na detekciji rekombinantne DNA metode su izbora jer jamče visoku osjetljivost, točnost i specifičnost.

**Ključne riječi:** GMO, PCR, brzi testovi, službene kontrole

## **GMO analysis: direct methods versus indirect ones**

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### **Summary**

Genetically modified organisms are obtained using recombinant DNA technology. The most common are products in which foreign DNA is inserted into the host genome. Such newly formed DNA usually encodes a new protein, which at the end results in the manifestation of new properties. Due to the above, GMO analysis can be performed in two basic principles: direct methods which include analyzes based on the detection of newly formed recombinant DNA, and indirect methods where we include methods based on analysis of proteins formed indirectly through changes in the DNA strand. Direct methods are PCR methods, and indirect methods are immunological tests such as ELISA and lateral flow test.

Recombinant DNA is present in every genetically modified organism, but recombinant proteins may or may not be expressed. In cases where technology is applied to gene silencing, there will be no production of newly formed protein, also when we talk about processed products, used processing techniques can lead to denaturation of protein and thus affect the ability to participate in immunological reactions. DNA methods are specific to each individual event, while protein methods detect a protein that can be formed by various modifications. Due to the above, protein tests do not guarantee a reliable finding and are not acceptable for official controls. Methods based on the detection of recombinant DNA methods are the method of choice because they guarantee high sensitivity, accuracy and specificity.

**Key words:** GMO, PCR, lateral flow test, official control



## ***In vitro* selekcija češnjaka te multispektralne analize regeneranata u uvjetima stresa suše**

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### **Sažetak**

Češnjak (*Allium sativum* L.) se uzgaja u cijeloj Hrvatskoj. Ranijim nastupom i dužim trajanjem sušnih perioda, češnjak smanjuje prinos. Zbog vegetativnog načina razmnožavanja u oplemenjivanju češnjaka se koristi metoda klonske selekcije ili metoda razvoja somaklonske varijabilnosti. Cilj ovog istraživanja bio je razvoj somaklonske varijabilnosti, regeneracija što većeg broja biljaka i izbor regeneranata potencijalno tolerantnih na sušu. Kao polazni materijal korištena je sorta 'Istarski crveni'. Početni eksplantati postavljeni su na medij za razvoj kalusa, a potom prenešeni na selektivni medij s polietilen glikolom 8000 ili bez njega. Nakon selekcije kalusa, biljke su regenerirane na različitim tretmanima. Regeneranti su posađeni u supstrat te nakon četiri mjeseca podvrgnuti stresu suše. U uvjetima suše, pomoću uređaja CropReporter<sup>TM</sup>, mjerena je klorofilna fluorescencija i provedene su multispektralne analize u svrhu procjene stanja regeneranata. Broj regeneriranih biljaka po Petrijevoj zdjelici bio je veći kad je u početnom mediju korišteno 2 mg l<sup>-1</sup> 2,4-D (3,4) u odnosu na 1 mg l<sup>-1</sup> (0,8) te kad je u mediju za regeneraciju korišten BAP (3,7) u odnosu na medij bez regulatora rasta (0,5). Rezultati mjerenih svojstava klorofilne fluorescencije i multispektralnih analiza ukazuju na postojanje varijabilnosti između regeneranata u mjerenim svojstvima te se može izdvojiti nekoliko regeneranata koji potencijalno predstavljaju somaklonove tolerantije na sušu.

**Ključne riječi:** češnjak, tolerantnost na sušu, somaklonska varijabilnost, multispektralne analize

## ***In vitro* selection of garlic and multispectral analysis of regenerants under drought stress conditions**

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### **Summary**

Garlic (*Allium sativum* L.) is grown throughout Croatia. With earlier onset and longer dry periods, garlic reduces yields. Due to the vegetative method of propagation, the method of clonal selection or development of somaclonal variability is used in garlic breeding. The aim of this study was development of somaclonal variation, regeneration of plants, and selection of potentially drought-tolerant regenerants. The variety 'Istarski crveni' was used as a starting material. The initial explants were placed on medium for callus development and then transferred to selective medium with or without polyethylene glycol 8000. After callus selection, the plants were regenerated on various treatments. The regenerants were planted in the substrate and after four months subjected to drought stress. Under drought conditions, chlorophyll fluorescence was measured and multispectral analyzes were performed using a CropReporter™ device to assess the condition of the regenerants. The number of regenerated plants per Petri dish was higher when 2 mg l<sup>-1</sup> 2,4-D was used in the initial medium (3.4) compared to 1 mg l<sup>-1</sup> (0.8) and when BAP was used in the regeneration medium (3.7) compared to medium without a growth regulators (0.5). The results of the measured traits of chlorophyll fluorescence and multispectral analyzes indicate the existence of variability between regenerants in the measured traits, and several regenerants can be singled out that potentially represent drought tolerant somaclones.

**Key words:** garlic, drought resistance, somaclonal variations, multispectral analysis

## Kemijski sastav sorti ozime pšenice iz osnovne gen kolekcije Republike Hrvatske

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### Sažetak

Nacionalni program za očuvanje i održivu uporabu biljnih genetskih izvora za hranu i poljoprivredu ima cilj doprinosti nacionalnom razvoju, sigurnosti hrane, održivoj poljoprivredi i održanju bioraznolikosti kroz očuvanje i uporabu biljnih genetskih izvora.

Tijekom povijesti oplemenjivanja pšenice oplemenjivački programi nastoje stvoriti sorte poboljšanih agronomskih odlika visokog i stabilnog uroda zrna, ali i sa što boljom namjenskom kakvoćom zrna pšenice, prvenstveno sorte pšenice krušnih odlika. Upravo nacionalni program ima za cilj očuvati stoljetni rad brojnih oplemenjivačkih ustanova koje su znanstvenim radom pomicala i mijenjale agronomске i gospodarske odlike sorti pšenice. U Hrvatskoj bazi podataka o biljnim genetskim izvorima prikupljeno je i upisano 199 primki sorti ozime pšenice.

U ovome radu na pokušalištu HAPIH-a na lokalitetu Osijek u vegetacijskim godinama 2017./2018., 2018./2019. i 2019./2020. ispitivano je 76 sorti ozime pšenice, a vegetacijske godine 2020./2021. 65 sorti pšenice iz Hrvatske baze podataka o biljnim genetskim izvorima. Sorte su ispitivane na parceli veličine 6,25 m<sup>2</sup>, sijane sijačicom Wintersteiger u jednom ponavljanju, te s normom sjetve od 200 zrna m<sup>2</sup>. Istraživani su parametri kvalitete zrna pšenice - sadržaj proteina i škroba, vlažni gluten i sedimentacijska vrijednost. Sadržaj proteina je varirao od 11,83 % (Panonija) do 17,96 % (U1), sadržaj škroba od 51,43 % (Helia) do 72,53 % (Jadranka), vlažni gluten se kretao od 26,05 % (Panonija) do 43,41 % (U1), a sedimentacijska vrijednost od 33,18 ml (Panonija) do 73,88 ml (U1). Istraživani parametri značajno su varirali i po godinama ispitivanja.

**Ključne riječi:** pšenica, sadržaj proteina, sadržaj škroba, vlažni gluten, sedimentacijska vrijednost

## Chemical structure of winter wheat varieties from the basic gen collection of the Republic of Croatia

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### Summary

The National program for conservation and sustainable use of plant genetic resources for food and agriculture has a goal to contribute to national development, food security, sustainable agriculture and maintenance of biodiversity through conservation and sustainable use of plant genetic resources.

During the history of wheat breeding, breeding programs tried to create new varieties with improved agronomic characteristics of high and stable grain yield, but also with the best quality properties of wheat grain, primarily wheat varieties with bread qualities. The national program has the goal to keep the centuries old work of numerous breeding institutions that have moved and changed the agronomic and economic characteristics of wheat varieties through scientific work. The Croatian plant genetic resources database has collected and registered 199 accession of winter wheat varieties.

In this work, on testing field of CAAF (location Osijek), in vegetative years 2017/2018, 2018/2019 and 2019/2020 total of 76 winter wheat varieties were tested and in vegetative year 2020/2021 total of 65 winter wheat varieties from Croatian plant genetic resources database were tested. Varieties were tested on a plot of 6.25 m<sup>2</sup>, sown with a seeder Wintersteiger in one replicate, and with a sowing rate of 200 grains m<sup>-2</sup>. The following parameters of wheat grain quality have been tested - the content of protein and starch, wet gluten and sedimentation value. Protein content varied from 11.83% (Panonija) to 17.96% (U1), starch content varied from 51.43% (Helia) to 72.53% (Jadranka), wet gluten ranged from 26.05% (Panonija) to 43.4% (U1), and sedimentation value from 33.18 ml (Panonija) to 73.88 ml (U1). Tested parameters varied significantly between the years.

**Key words:** wheat, protein content, starch content, wet gluten, sedimentation value

## Selekcija genotipova ozime pšenice s većom učinkovitosti korištenja dušika iz tla

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### Sažetak

Selekcija genotipova ozime pšenice s većom učinkovitosti korištenja dušika iz tla ima pozitivne ekonomske i ekološke učinke te ima za cilj optimizirati upotrebu dušičnog gnojiva u proizvodnji pšenice. Ne postoje opsežne i konkretne informacije o učinkovitosti korištenja dušika iz tla sortimenta pšenice prisutnog na tržištu Republike Hrvatske. Stoga je cilj ovog istraživanja kroz trogodišnje testiranje na dvije lokacije detektirati oplemenjivačke linije ozime pšenice s najvećom učinkovitosti korištenja dušika iz tla te ih uključiti u proces priznavanja sorata. U istraživanje je uključeno 20 oplemenjivačkih linija te pet standardnih sorata od kojih za neke znamo da imaju veliku učinkovitost korištenja dušika iz tla. Genotipovi u pokusu se testiraju u uvjetima s različitom količinom primjenjenog dušičnog gnojiva kroz četiri različita tretmana te će se selektirati oni s najboljom kombinacijom uroda i kvalitete kao pokazateljem najbolje učinkovitosti korištenja dušika iz tla. Istraživanjem se utvrđuje i doprinos svake pojedine komponente koja utječe na urod i kvalitetu te se želi detektirati one s najvećim utjecajem na učinkovitost korištenja dušika iz tla. Na taj način kroz istraživanje se želi detektirati genotipove s najboljom učinkovitosti korištenja dušika iz tla, a ujedno utvrditi koje su komponente najviše doprinjele tome. Ovakvim pristupom selekciji ozime pšenice žele se postići bolji ekonomski učinci u proizvodnji i nastoji se smanjiti nepotreban negativan utjecaj na okoliš.

**Ključne riječi:** pšenica, dušik, selekcija, urod, kvaliteta

## **Selection of winter wheat genotypes with higher nitrogen use efficiency from soil**

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### **Summary**

The selection of winter wheat genotypes with higher nitrogen use efficiency from soil has positive economic and environmental effects and aims to optimize the use of nitrogen fertilizer in wheat production. There are no extensive and specific pieces of information on nitrogen use efficiency from soil of the wheat assortment present on the market of the Republic of Croatia. Therefore, the aim of this study is to detect winter wheat breeding lines with the highest nitrogen use efficiency from soil through three-year testing at two locations and to include them in the variety recognition process. The study included 20 breeding lines and five standard varieties, some of which we know have high nitrogen use efficiency from soil. The genotypes in the experiment are tested under conditions with different amounts of applied nitrogen fertilizer through four different treatments and those with the best combination of yield and quality will be selected as indicators of the best nitrogen use efficiency from soil. The research also determines the contribution of each individual component that affects the yield and quality and seeks to detect those with the greatest impact on nitrogen use efficiency from soil. In that way, the research aims to detect genotypes with the best nitrogen use efficiency from soil, and at the same time to determine which components contributed the most to this. This approach to the selection of winter wheat aims to achieve better economic effects in production and seeks to reduce the unnecessary negative impact on the environment.

**Key words:** wheat, nitrogen, selection, yield, quality

## **Influence of storage and weather conditions on wheat seed germination**

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### **Summary**

The aim of this study was to determine the germination of six wheat genotypes considering the weather conditions and storage length. The field experiment was set up in 2016/2017 (second year of storage) and 2017/2018 (first year of storage) vegetation year on location Klisa. In July in 2016/2017 66.7mm of rain was recorded, while in the same month of the following year 115.6mm of rain was recorded. The germination test was performed in three repetitions for each tested cultivar according to ISTA regulations after one and after two years of storage. Germination in the first year of storage was significantly lower in five cultivars (Adriana 86.00%, Alka 84.67%, Bela 84.67%, Sana 48.00%, Tena 81.33%) in regards to second year of storage (Adriana 98.00%, Alka 97.33%, Bela 97.33%, Sana 74.00%, Tena 96.67%). In only one cultivar germination was higher in the first year compared to the second year is Kalista (first year of storage 98.00%, second year of storage 40.67%). Therefore, it can be concluded that the germination of wheat seeds is extremely affected by weather conditions and storage conditions.

**Key words:** germination, storage, weather condition, wheat

## Utjecaj biofortifikacije Zn i Se na koncentraciju minerala u zrnu devet genotipova pšenice

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### Sažetak

Posljednjih desetljeća uloženi su veliki naponi u utvrđivanje puteva usvajanja, translokacije i akumulacije minerala u zrno pšenice. Biofortifikacija se pokazala kao uspješna mjera koja se koristi za povećanje sadržaja minerala u zrnu. Uz to, poznato je da se genotipovi pšenice razlikuju po sposobnosti akumulacije minerala u zrno. Uzevši to u obzir, jasno je da se za postizanje ciljane koncentracije minerala i poželjnog odnosa minerala u zrnu, treba kombinirati biofortifikaciju s izborom odgovarajućeg genotipa. S obzirom na to, cilj ovog istraživanja bio je istražiti utjecaj biofortifikacije cinkom i selenom na koncentracije minerala u zrnu različitih genotipova pšenice.

Pokus je postavljen po planu potpuno slučajnog blok sustava s dva tretmana (genotip i biofortifikacija) u tri ponavljanja.

Najnižu koncentraciju Mg, Fe, Mn i Zn na svim razinama biofortifikacije imala je Srpanjka. Genotip U1 imao je najvišu koncentraciju K, Mg, Fe i Zn u tretmanima s biofortifikacijom, dok je na kontrolnom tretmanu najvišu koncentraciju K, Mg, Mn i Zn imala Divana. Biofortifikacija je imala najveći utjecaj na koncentraciju Zn i Se u zrnu. U prosjeku, koncentracija Zn se povećala za 41 %, dok se koncentracija Se povećala za 5,4 puta u tretmanu s biofortifikacijom u odnosu na kontrolni tretman.

Budući da se genotipovi razlikuju po stupnju povećanja koncentracija Zn i Se, potrebno je nastaviti istraživanje kako bi se pronašla optimalna kombinacija genotipa, stupnja i vremena primjene biofortifikacije.

**Ključne riječi:** biofortifikacija, sortna specifičnost, akumulacija, mikroelementi, pšenica



## **The effect of Zn and Se biofortification on grain mineral concentrations in nine wheat genotypes**

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### **Summary**

In the past decades a high effort is conducted in elucidation of adoption, translocation and accumulation of minerals in wheat grain. A biofortification is recognized as successful approach in increment of minerals in grain. Besides, it is well known that wheat genotypes differ in mineral accumulation in grain, so it is a recommended to combine biofortification with the most responsive genotypes to achieve desirable concentrations and relations between minerals in the grain. Accordingly, the aim of this research was to investigate the differences in wheat genotypes regarding mineral concentrations in grain under the effect of Zn and Se biofortification.

Experiment was carried out as a completely randomized block design with two treatments (genotype and biofortification) in three replicates.

In general, genotype Srpanjka had lowest concentration of Mg, Fe, Mn and Zn at all levels of biofortification. Genotype U1 had highest concentration of K, Mg, Fe and Zn under the biofortification, while on control treatment Divana had highest concentration of K, Mg, Mn and Zn. Biofortification had the strongest effect on Zn and Se concentration. In average, Zn concentration increased for 41%, while Se concentration increased for 5.4-fold on biofortified in comparison to control treatment.

Since genotypes differ in the level of Zn and Se concentration increase, further research should be done to find optimal combination of genotype, level of biofortification and time of application.

**Key words:** biofortification, genotype specificity, accumulation, microelements, wheat

## Odgovor prinosa hibrida kukuruza na deficit tlaka para u različitim fazama vegetativnog ciklusa

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### Sažetak

Kod većine uzgojnih regija kukuruza, ekstremne temperature predstavljaju rastuću prijetnju. Nedavna istraživanja pokazala su da je unatoč velikim ulozima u oplemenjivanje, osjetljivost kukuruza na visoke temperature i sušu porasla ili ostala nepromijenjena. Deficit tlaka para (VPD) predstavlja kompleksni klimatološki parametar informativan o nedostatku vlage u zraku. Više vrijednosti VPDa stoga predstavljaju snažniji transpiracijski pritisak na biljku. Visoki VPD prisutan je tijekom ljetnih mjeseci u većini uzgojnih regija kukuruza, posebno na mjestima gdje su izražene razlike između niskih i visokih temperatura. Višeokolinski pokusi (MET) su postavljeni na poljima Poljoprivrednog instituta Osijek u Hrvatskoj (umjereni VPD) i Turskoj (visoki VPD) od 2010. do 2019. godine, s 22 do 78 hibrida u dva do četiri ponavljanja. Broj okolina po godini bio je od dvije do osam. Meteorološki podatci prikupljeni su od nacionalnih meteoroloških servisa i VPD je izračunat prema referentnoj metodologiji. Parcele su pobrane ručno, te je izračunat prinos na osnovi 14 % vlage. Klaster analiza na osnovi korelacijske udaljenosti pokazala je dva različita uzorka reakcija na povišeni VPD u cvatnji i nalijevanju zrna: pozitivni i negativni. Pozitivne reakcije bile su praćene i većom stabilnosti prinosa kroz okoline. U drugim fazama, zabilježen je slabiji utjecaj VPD-a na prinos. Najnoviji rezultati i potpuna analiza biti će predstavljani na skupu.

**Ključne riječi:** VPD, kukuruz, stres izazvan visokim temperaturama, MET

## **Yield responses of maize hybrids to vapor pressure deficit during different stages of vegetative cycle**

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### **Summary**

In most of the world's maize-growing regions, extreme heat presents a growing threat to maize production. Recent studies have shown that despite the extensive breeding efforts, the sensitivity to high temperatures and drought has remained unfavorable. Vapor pressure deficit (VPD) is a complex climatological parameter addressing the lack of air saturation with water, with higher values imposing higher transpirational pressure on plant. High VPD is often present during summer months in most maize-growing regions, especially the ones with large difference between low and high daytime temperatures. Multi-environment trials (MET) were set at Agricultural Institute Osijek facilities in Croatia (mild VPD) and Turkey (high VPD) from 2010 to 2019 with 22 to 78 full-season hybrids in two to four replicates. Number of environments per year was from two to eight. Meteorological data was collected from national weather services and the VPD was calculated according to the reference methodology. Plots were hand harvested and the yields were calculated on the 14% moisture basis. Clustering based on correlation distance showed two distinct patterns of reactions to increased VPD during flowering and grain filling: positive and negative, corroborated by increased yield stability in positive group. VPD during other growth stages showed lower influence on grain yield. Recent results and full analysis will be presented.

**Key words:** VPD, maize, heat stress, MET

## Kvaliteta, opća otpornost i povezanost s polarnim metabolitima u zrnu ozime pšenice zaražene *Fusariumom*

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### Sažetak

Fuzarijska palež klasa (FPK) pšenice problem je za globalnu sigurnost hrane, a razumijevanje mehanizama otpornosti važno je za njenu regulaciju. Cilj istraživanja bio je ispitati reološka svojstva, opću otpornost na FPK te povezanost s polarnim metabolitima u kontrolnim i biljkama umjetno zaraženim *Fusariumom*. Poljski pokus je bio postavljen na dvije lokacije (Osijek i Tovarnik) gdje su umjetno zaražene biljke inokulirane u fazi cvatnje. Uzorci zrna iz oba tretmana analizirani su pomoću GC-MS-a, a očekuju se dobiti razlike u polarnim metabolitima između osjetljivih i otpornih sorti na FPK. Vrijednosti područja unutar krivulje zaraze (AUDPC) varirale su od 1,3 (Galoper) do >100 (El Nino i Golubica) u Osijeku te od 17,5 (Galoper) do >90 (El Nino i Golubica) u Tovarniku. Reološka svojstva pokazala su da kod osjetljivih sorti na FPK dolazi do većeg pogoršanja kvalitete u odnosu na otporne sorte. Osjetljiva sorta na FPK, El Nino, pripala je kvalitetnoj grupi B1 u prirodnoj infekciji (bez upotrebe fungicida), kod umjetnih zaraza pogoršala se na B2 u Osijeku te C1 u Tovarniku. Povećane količine oborina i optimalne temperature u Tovarniku izazvale su jače epidemične uvjete na što ukazuju povišene AUDPC vrijednosti i jače narušavanje kvalitete. Kombinacija ovih rezultata s koncentracijama polarnih metabolita pružit će nam informaciju o učinku FPK na metabolizam zrna pšenice.

**Ključne riječi:** *Fusarium*, pšenica, polarni metaboliti, otpornost, GC-MS

### Napomena

Projekt je sufinancirala Europska unija iz europskog fonda za regionalni razvoj (KK.01.1.1.04.0067).

## Quality, general resistance and relationship with polar metabolites in the winter wheat seed treated with *Fusarium*

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### Summary

*Fusarium* head blight (FHB) of wheat is a concern for food safety and understanding resistance mechanisms is critical for its regulation. This study aimed to analyze the rheological properties, general resistance to FHB and relationship with polar metabolites in control and inoculated plants. An experiment was conducted at two locations (Osijek and Tovarnik) where inoculations took place at the flowering stage. Grain samples were analyzed with GC-MS and it is expected to obtain differences in polar metabolites in susceptible and resistant varieties. Area under disease progress curve (AUDPC) values varied from 1.3 (Galopper) to >100 (El Nino and Golubica) at Osijek and from 17.5 (Galopper) to >90 (El Nino and Golubica) at Tovarnik. Rheological properties showed that varieties susceptible to FHB had greater deterioration compared with the resistant varieties. Susceptible variety to FHB, El Nino, was in the quality group B1 in the natural infection (without usage of fungicides), in the artificial infection in group B2 at Osijek and C1 at Tovarnik. Higher AUDPC values and quality deterioration indicated that higher precipitation and optimum temperatures at Tovarnik have caused increased epidemic conditions. These results together with concentrations of the polar metabolites will give us information about the effect of the FHB on wheat grain metabolism.

**Key words:** *Fusarium*, wheat, polar metabolites, resistance, GC-MS

### Acknowledgement

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## Uporaba strojnog učenja i FTIR spektroskopije kod sjemena kukuruza za predviđanje odgovora na stres u klijanaca

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### Sažetak

Predviđanje ishoda bioloških procesa jedan je od glavnih ciljeva modernih biljnih znanosti, a podrazumijeva uporabu modela. Strojno učenje (*machine learning* (ML)) predstavlja novi paradigmatički okvir s ciljem inkorporiranja velike količine podataka u svrhu predviđanja ishoda složenih bioloških procesa, doduše s ograničenom interpretabilnošću modela. Na temelju prethodnih istraživanja, pokušali smo predvidjeti dvije skupine signalnih puteva pomoću očitavanja infracrvene spektroskopije s Fourierovom transformacijom (FTIR) iz sjemenki inbred linija kukuruza. Dvije skupine fenotipova klijanaca su bile otkrivene u prethodnom radu prema odgovoru na stres sušom: prva skupina s promjenom u produktima lipidne peroksidacije (TBARS) koja nadilazi promjenu slobodnog vodikovog peroksida ( $H_2O_2$ ) i druga skupina sa suprotnim rezultatom. Prva skupina (TBARS $>H_2O_2$ ) je pokazala veću akumulaciju osmolita. Prepostavili smo kako je ovaj rezultat uzrokovan kvalitativnim razlikama u sjemenu različitih inbred linija. Analizirani su uzorci sjemena 109 inbred linija samljevenih u fini prah i podvrgnuti FTIR spektroskopiji. Rezultati mjerenja su uvršteni u ML algoritam „metoda potpornih vektora“ i pripadnost skupini TBARS $>H_2O_2$ , odnosno TBARS $<H_2O_2$  predviđana je uporabom unakrsne validacije izostavljanja jednog uzorka. Pokazalo se kako točnost klasifikacije od preko 80 % može biti ostvarena. Strojno učenje može biti koristan alat u biljnim znanostima no potreban je veći uzorak za robusnu analizu izvodljivosti predložene metode.

**Ključne riječi:** strojno učenje, stres, FTIR, sjeme kukuruza, klijanaci kukuruza

## Combining machine learning with FTIR spectroscopy in maize seeds to predict stress responses in seedlings

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### Summary

Predicting the outcomes of biological processes is one of the main goals of modern plant sciences, which relies on the use of models. Machine learning (ML) framework represents a paradigm shift, aiming to incorporate as much data as possible to predict complex biological responses, however with limited interpretability of the model. Based on our previous work, we aimed to predict two groups of signaling pathways using Fourier transformed infrared spectroscopy (FTIR) reads in seeds of maize inbred lines. Two groups of seedling phenotypes were discovered in previous work in response to water deficit, one with relative change in products of lipid peroxidation (TBARS) exceeding the relative change in free hydrogen peroxide ( $H_2O_2$ ) and the one with contrasting result. Interestingly, group with  $TBARS > H_2O_2$  showed ~50% increase in osmolyte accumulation. We speculated that this phenomenon might be induced by qualitative differences among seeds of inbreds. Seeds of 109 inbreds were ground to fine powder and measured by FTIR spectroscopy. Spectral responses were fit into a support vector machine ML algorithm and the group memberships ( $TBARS > H_2O_2$  or  $H_2O_2 > TBARS$ ) were predicted using a leave-one-out cross validation. It has been shown that accuracy of classification of over 80% can be achieved. Usability of ML in plant sciences will be demonstrated, although larger sample sizes are required for robust feasibility analysis of the proposed framework.

**Key words:** machine learning, stress, FTIR, maize seed, maize seedlings

**Povrćarstvo,  
ukrasno, aromatično  
i ljekovito bilje**

**04**

**Vegetable Growing,  
Ornamental, Aromatic  
and Medicinal Plants**





## Pojava i opstanak šimširovog moljca - *Cydalima perspectalis* u različitim prirodnim uvjetima Hrvatske

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### Sažetak

Šimširov moljac, *Cydalima perspectalis* (Walker, 1859.) invazivan je štetnik sa izrazitim utjecajem na okoliš i gospodarstvo unutar Europske unije. Cilj ovog istraživanja tijekom 2020. godine bila je procjena pojave odraslih, životni vijek odraslih, trajanje leta i dinamika smrtnosti na priobalnom području srednje Dalmacije pod utjecajem mediteranske klime te u unutrašnjosti s utjecajem kontinentalne klime. Šimširov moljac, prezimljuje u stadiju gusjenice u dijapauzi između listova šimšira. Dijapauza traje tijekom zime, a gusjenica svoj razvoj nastavlja u proljeće. Na obalnom području, odrasli moljci prezimljene generacije lete tijekom druge dekade svibnja, a moljci ljetne generacije od drugog tjedna srpnja do zadnjeg tjedna kolovoza. U unutrašnjosti je izlazak iz dijapauze odgođen za oko tri tjedna pa let odraslih iz prezimljene generacije traje od prvog tjedna lipnja do prvog tjedna srpnju, dok let ljetne generacije traje od zadnjeg tjedna u srpnja do prvog tjedna u rujnu. Dužina leta prezimljene generacije traje oko 30 dana te oko 50 dana za ljetnu generaciju. Pojava treće generacije na obalnom području je sredinom rujna, dok je u unutrašnjosti to zadnjoj dekadi rujna, a gusjenice ove generacije će ući u dijapauzu i prezimiti. Detaljni podaci o razdoblju leta i polaganju jaja od velike su važnosti za suzbijanje štetnika.

**Key words:** šimširov moljac, pojava, razdoblje leta

## **Box tree moth - *Cydalima perspectalis* emergence and survival in different natural conditions of Croatia**

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### **Summary**

Box tree moth, *Cydalima perspectalis* Walker 1859 (Lepidoptera, Crambidae) is a pest of significant economic importance with impact on environment and economy along European Union. The aim of this study was to evaluate dynamic of adult emergence, adult longevity, flight duration and dynamic of adult mortality at central Dalmatia coastal area influenced by Mediterranean climatic conditions and inland areas with continental climatic conditions during 2020. *C. perspectalis* overwinters in diapausing larval stage on *B. sempervirens* leaves. Larvae stays in diapause during winter and complete their development in spring. The flight period of adults of overwintering generation fits into 2<sup>nd</sup> decade of May and for summer generation from 2<sup>nd</sup> week of July till 4<sup>th</sup> week of August. The delay of the emergence and longevity in inland area is approximately three weeks later, meaning that flight of the 1<sup>st</sup> overwintering generation last from 1<sup>st</sup> week of June till first week of July and for summer generation starts 4<sup>th</sup> week of July and last till 1<sup>st</sup> week of September. Duration of flight period of overwintering generation last around 30 days and around 50 days for summer generation. Third flight starts in mid (coastal area) or last decade (inland) of September and larvae of this generation will enter into diapause for overwintering. Detailed data on flight period and egg laying is of great importance for pest suppression.

**Key words:** box tree moth, emergence, flight period

## The impact of storage conditions on quality of Istrian garlic landraces

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### Summary

Garlic is one of the most produced *Allium* species worldwide. Hardneck types of garlic are genetically distinct from softneck types and have different dormancy requirements. Local landraces 'Istarski crveni' and 'Istarski bijeli' are commonly grown on Istrian peninsula. They are usually harvested in June and stored at room temperature until sold or planted again in late autumn; however, the impact of storage conditions on the quality of two landraces is not well understood. The aim of this study was to monitor representative bulbs of two landraces at room temperature and controlled conditions (refrigerator). The bulb agronomical-yield traits, physical and chemical parameters were evaluated five times starting from July until October. The bulb weight was decreasing over storage time in both landraces, but more prominent weight loss was noticed at 'Istarski bijeli'. The bulb diameter and height did not change over time for both landraces. The dry matter and total soluble solids were slightly decreased over time regardless of the landrace and treatment. Red clove coloration was detected at both landraces, and was more intense at 'Istarski crveni'. The bulb firmness was generally constant in the refrigerator while a decrease was noticed at room temperature for both garlic types. There were changes in the pH value detected depending on the landrace and treatment. Both types of garlic studied can be stored at room and controlled conditions. Garlic quality can change depending on the storage duration, landrace and storage conditions.

**Key words:** consumers, flower scape, physiology, post-harvest, storage

## Utjecaj podloga za rajčicu na kvalitetu ploda cv. Matissimo

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### Sažetak

Korištenje podloga različito utječu na rast i razvoj rajčice te na kvalitetu ploda. Stoga je cilj ovog rada bio utvrditi utjecaj uzgoja na različitim podlogama na kvalitetu ploda rajčice. Pokus s kultivarom rajčice Matissimo F1, cijepljenim na sedam komercijalnih podloga za rajčicu Arnold (A) DR0141TX (DR), Maxifort (MX), Multifort (MF), Optifort (OF), Emperador (EM) i Suzuka (S) je postavljen u plasteniku na području Trogira u proljetno-ljetnoj sezoni. Biljke su posađene u tlo na PE crni film na razmak 50 x 140 cm i uzgojene su na dvije grane. Rani prinos bio je veći kod A (3,95 t 1000 m<sup>-2</sup>) i EM (3,84 t 1000 m<sup>-2</sup>), dok je ukupni najveći prinos bio na podlozi EM (33,15 t 1000 m<sup>-2</sup>). Plodovi uzgojeni na MF imali su veći paramter boje a\* i h (24,5 i 51,6). Boja mesa ploda a\* ovisila je o podlozi i poziciji mjerenja. Rub ploda najcrveniji je kod MF (13,6) i EM (13,5), dok je zona sjemena najmanje crvena kod MX (11,9) i EM (13,4). Središnji dio ploda najcrveniji je kod podloga OF (24,4) i A (23,1). Najviši udio topivih šećera postigli su plodovi uzgojeni na OF i S (3,95° Brix) dok je najmanji utvrđena MX (3,2° Brix). Kod A izmjeren je najviši EC soka ploda (4,96 dS m<sup>-1</sup>), dok je najviši pH zabilježen na S (4,33). Najveći gubitak mase ploda zabilježen je sedmog dana čuvanja kod DR (3 %). Čvršće plodove imale su biljke uzgojene na DR, OF, MX i EM. Iako su podloge različito utjecale na promatrana svojstva, podloga EM se ističe po prinosu, boji mesa i čvrstoći.

**Ključne riječi:** boja kože i mesa ploda, čvrstoća ploda, gubitak mase, rani ukupni prinos

## Influence of tomato rootstocks on cv. Matissimo fruit quality

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### Summary

Rootstock affect the tomato growth and development, as well as fruits quality. The aim of this study was to determine the effect of cultivation with different rootstocks on tomato fruit quality. Experiment with tomato cultivar Matissimo F1 grafted on seven commercial tomato rootstocks Arnold (A) DR0141TX (DR), Maxifort (MX), Multifort (MF), Optifort (OF) Emperador (EM) and Suzuka (S) were set up in greenhouse near Trogir in the spring-summer season. The plants were planted in the soil, on PE black mulch at 50 x 140 cm spacing and grown on two branches. Early yield was higher at A (3.95 t 1000 m<sup>-2</sup>) and EM (3.84 t 1000 m<sup>-2</sup>), while the total yield was highest at EM (33.15 t 1000 m<sup>-2</sup>). Fruits grown on MF had a higher color parameter a\* and h (24.5 and 51.6, respectively). The internal fruit color a\* depended on the rootstock. Fruit edge were the reddest at MF (13.6) and EM (13.5), while the seed zone was the less red at MX (11.9) and EM (13.4). Fruit central part were the reddest at OF (24.4) and A (23.1). The highest total soluble solids were achieved in fruits grown on OF and S (3.95° Brix) while the least was found on MX (3.2° Brix). The highest fruit juice EC was measured at rootstock A (4.96 dS m<sup>-1</sup>), while the highest pH was recorded at S (4.33). The greatest fruit weight loss was recorded after seven days of storage, at DR (3 %). Plants grown on DR, OF, MX and EM had firmer fruits. Although the rootstock had different effects on the obtained properties, the rootstock EM was distinguished by yield, internal fruit color and firmness.

**Key words:** skin and internal fruit color, fruit firmness, weight loss, early and total yield

## Application of plant-based natural additives to improve the bioactive properties of organic artisanal cheeses

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### Summary

The aim of research was to increase the content of bioactive substances and improving antioxidative properties of organic artisanal cheeses by application of selected organic herbs and their extracts into cheese production. The following organic herbs have been used: *Silene vulgaris*, *Ocimum basilicum*, *Mentha piperita* and *Origanum majorana*. In the produced organic cheeses containing selected organic herbs and their extracts the antioxidant properties were determined by analyzing the ferric reducing antioxidant power. Series of spectrophotometric measurement were performed to determine the content of polyphenolic substances. The texture of the organic cheeses was examined with a TA-XT2i Texture Analyser. The fatty acid profile was also investigated before and after the maturation of the cheeses. The findings revealed that the antioxidant activity of the tested herbs ranged from  $52.82 \pm 3.68 \mu\text{mol of Trolox g}^{-1}$  (*S. vulgaris*) to  $560.96 \pm 8.01 \mu\text{mol of Trolox g}^{-1}$  (*O. majorana*). The content of total phenolic compounds in herbs ranged from  $0.99 \pm 0.07 \text{ mg GAE } 100 \text{ g}^{-1}$  (*S. vulgaris*) to  $205.66 \pm 18.36 \text{ mg GAE } 100 \text{ g}^{-1}$  (*O. majorana*). The addition of dried herbs or water extracts of herbs modified the texture of the ripened cheeses. Cheeses obtained with the addition of dried herbs were characterized by higher hardness. The hardest cheeses were obtained with the addition of basil; the softest cheeses were obtained with the addition of mint and viscera extracts. The addition of dried herbs or water extracts influenced the organoleptic properties of ripened cheeses. The herbs used had no effect on the shape or the eyes of the cheeses, but had an effect on the texture, taste and smell. The highest in organoleptic evaluation were cheeses with the addition of marjoram, basil and mint. The addition of herbal preparations partially limited the oxidative processes of fats (fat rancidity). In the case of cow's milk cheeses with the addition of dried herbs, the best effects were observed after adding basil, then mint, marjoram and viscera.

**Key words:** herbs, cheese, basil, mint, marjoram, viscera

## Screening of garlic landraces for drought tolerance: photosynthetic and spectral response

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### Summary

Since drought is a major obstacle in agricultural production, a search for cultivars better adapted to a lack of water is needed. The wide spectrum of garlic diversity in Croatia provides a possible level of variation in its tolerance to drought. Since garlic is a sterile crop and propagated vegetatively, in searching for drought tolerance focus can be shifted to physiological parameters in order to choose tolerant landraces. In this research, 36 garlic landraces were analyzed in their morphological and physiological responses to water stress by measuring gas exchange (LI-6800, LI-COR, USA) and multispectral traits (PlantEye Microscanner, Phenospex, Netherlands). Drought led to a significant decrease in gas exchange parameters. Transpiration rate in drought stressed plants decreased for 48 % compared to well-watered plants and other photosynthetic parameters followed. Interaction between landrace and drought stress was found in assimilation and transpiration indicating differences in landrace response. A change in spectral vegetation indices was found, suggesting increased stress in drought exposed garlic plants compared to well-watered ones. However, no significant difference in digital biomass was observed. Differences among garlic landraces in drought stress tolerance could be used for selection of more adapted cultivars. Combining morphological and spectral traits with photosynthetic response to water shortage can give an insight into garlic adaptations to drought stress.

**Key words:** *Allium sativum* L., abiotic stress, gas exchange, NDVI, NPCI



## Seed morphology and germination percentage of two yellow gentian accessions from Učka

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### Summary

*Gentiana lutea* L. is a medicinal plant growing on the Balkan Peninsula mountain regions. Due to the uncontrolled harvest of its roots, it is under protection as an endangered species in Croatia. The over exploitation of this wild species can lead to depletion in its natural habitat. Majority of alpine species have dormant seeds, such is the case for yellow gentian, which can be a disadvantage in nursery plant production. The aim of this research was to evaluate seeds of two yellow gentian accessions from National Park Učka in their morphological characteristics, as well as testing the effect of different concentrations of gibberellic acid (0 - 1000 mg L<sup>-1</sup> GA<sub>3</sub>) and cold moist stratification (30 or 60 days at 4 °C) in breaking seed dormancy. The seeds were germinated at constant temperature of 15 °C and 12 h photoperiod during 30 days in the growth chamber conditions. We found significant differences among accessions in seed morphology as well as final germination percentage. Final germination percentage was highest in non-stratified seeds treated with 100 to 500 mg L<sup>-1</sup> GA<sub>3</sub> compared to other treatments. Significant interaction between treatments and accessions was found. Final germination percentages ranged from 0 to 74%. According to our results it seems that application of GA<sub>3</sub> is sufficient for breaking seed dormancy of yellow gentian seeds.

**Key words:** *Gentiana lutea* L., seed dormancy, GA<sub>3</sub>, cold stratification, alpine species

## Feasibility rainfed cultivation of *Thymus daenensis* Celak. via using different fertilizer sources

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### Summary

This split plot experiment was conducted on *Thymus daenensis* in 2014-2017 years aiming to overcome the problem related to water shortage and production of healthy food and environmental protection. The main plot included irrigation at three levels (normal irrigation, supplemental irrigation and rainfed condition) and the sub-plot with six levels consisting of fertilizer treatments, including bio-fertilizer (Azoto Barvar-1 + Phosphate Barvar-2), complete chemical fertilizer and complete nano-fertilizer with and without vermicompost. The sampling and analysis of traits were done in the third planting year. Results showed that with decreasing irrigation application from full irrigation to rainfed, the amount of carotenoid, proline, soluble carbohydrates and malondialdehyde (MDA) increased, but the amount of chlorophyll-a, total chlorophyll and total dry weight decreased. The combined application of nano-fertilizer with vermicompost had the positive effect on the leaves RWC (74.9 %). The efficiency of fertilizer treatments varied at different levels of irrigation so that fertilizers in full irrigation condition had the same effect on photosynthetic pigments, osmolytes and MDA, but in this condition biological fertilizer treatment improved the total dry weight. Under supplementary irrigation, fertilizer treatments with vermicompost improved photosynthetic pigments and osmolytes. However, in dryland conditions, most of the measurement traits improved in the application of fertilizer treatments with vermicompost. Therefore, it can be concluded that in *Thymus* cultivation at full irrigation condition, the use of biological fertilizer and in supplementary irrigation and rainfed conditions, the use of biological fertilizer with vermicompost is recommended due to compatibility with sustainable agriculture.

**Key words:** Bio-fertilizer, Chemical fertilizer, MDA, Nano-fertilizer, Vermicompost

## Drought induced variability of proline, phenolic content and antioxidant capacity in garlic (*Allium sativum* L.)

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### Summary

Plants during their lifespan are often subjected to multiple, various and inevitable types of abiotic stresses, which consequently limit the plants growth and yield. To battle such adverse conditions, plants have evolved mechanisms. Under abiotic stresses, such as drought, overproduction of proline imparts stress tolerance by maintaining osmotic balance, stabilizing membranes and preventing oxidative bursts. As such, proline is regarded as a stress marker for determining plant physiological state and level of stress tolerance. Besides affecting the plants physiological state, drought related stress also affects the biosynthesis of secondary metabolites, such as phenols, and thus changing the plants total antioxidant capacity. The aim of this study was to investigate 36 garlic (*Allium sativum* L.) landraces under drought stress conditions by measuring proline levels as well as antioxidant capacity. The average increase in proline level was evidenced in 64 % of the tested landraces, and 28 % of landraces showed significant increase in proline level at drought treatment compared to well-watered plants. Furthermore, average increase in total phenolic content under drought stress was observed in 11 % of landraces, while average increase in antioxidant capacity of drought stressed plants was evident in 19 % of landraces when measured by both DPPH and FRAP. Although, when measured by ORAC, average increase in antioxidant capacity was determined in 53 % of landraces exposed to drought.

**Key words:** abiotic stress, bioactive compounds, garlic landraces, stress tolerance, variability

## Biochemical diversity of bear's garlic (*Allium ursinum* L.) populations in Croatia

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### Summary

*Allium ursinum* L. is a perennial plant from the *Allium* genus of the Amaryllidaceae family and is native to the European and Asian forests. Organosulfur compounds and polyphenols contribute to overall health-promoting action, which makes *A. ursinum* a great medicinal plant, equally or even more valuable as its domestic relative garlic (*Allium sativum* L.). All parts of the plant are edible, although leaves and bulbs are the one mostly used. Used in traditional medicine throughout Europe, *A. ursinum* has been generally recommended as digestive stimulant, antimicrobial agent and strong antioxidant. To investigate the biochemical diversity of *A. ursinum* plant populations across Croatia eight locations were selected and the plants were sampled in the 2021 season. The plants were investigated for their total phenolic content, total antioxidant capacity (measured by FRAP, DPPH and ORAC), volatile organosulfur compounds and free amino acid content. In all investigated locations the *A. ursinum* plants exhibited excellent bioactive properties. Although the plants were similar across Croatia several locations were found to be distinctive based on specific bioactive properties. The highest antioxidant capacity measured by the FRAP method was found in plants at the Velanov Brijeg location, the most abundant plants in organosulfur compounds were found at the location of Brana Gornja while plants most abundant in free amino acid content were found at the Prodin Dol location.

**Key words:** bear's garlic, *Allium ursinum* L., organosulfur compounds, antioxidant capacity, amino acids

## Vegetativne karakteristike i prinos graha mahunara (*Phaseolus vulgaris* L.) pod utjecajem vodenog ekstrakta koprive (*Urtica dioica* L.)

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### Sažetak

Kopriva (*Urtica dioica* L.) je samonikla vrsta koja se također može uzgajati kao kultivirana. Ima veliki potencijal za korištenje kao vodeni ekstrakt. Svrha ovog istraživanja bila je utvrditi učinak različitih vodenih ekstrakata koprive na uzgoj graha mahunara (visina biljke, promjer biljke, masa suhe stabljike, masa suhog lista, broj listova, površina lista, prinos mahuna) u poljskim uvjetima, u usporedbi s mineralnom gnojidbom (Urea 46 %) i kontrolnim uzgojem bez gnojidbe. Pokus je proveden u dva roka sjetve (proljetni i jesenski) na lokaciji blizu Zadra. Korištene su dvije vrste vodenih ekstrakata. Kratkotrajni vodeni ekstrakt (SE) pripremljen je ekstrakcijom suhe biljke (183 g 10 L<sup>-1</sup> vode) u vodi 24 sata, dugi vodeni ekstrakt (LE) u istom omjeru s vodom uz ekstrakciju od 14 dana. Oba ekstrakta su procijeđena i razrijeđena 1:3 s vodom iz slavine prije upotrebe, SE je primijenjen folijarno, a LE je apliciran zalijevanjem tla. Vegetativni parametri visine biljke, mase suhe stabljike i suhog lista, lisne površine i prinosa mahuna bili su veći u jesenskom vegetacijskom razdoblju u odnosu na proljetni uzgoj. Ostali morfološki parametri poput broja listova i promjera stabljike nisu se statistički razlikovali. Najveći prinos zabilježen je kod biljaka tretiranih s ureom u usporedbi s drugim tretmanima koji se nisu međusobno razlikovali.

**Ključne riječi:** grah mahunar, kopriva, vegetativni parametri, vodeni ekstrakti

## Vegetative characteristics and yield of green bean (*Phaseolus vulgaris* L.) affected by aqueous nettle (*Urtica dioica* L.) extracts

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### Summary

Stinging nettle (*Urtica dioica* L.) is wild growing species which can be cultivated as well. It is great potential for using as an aqueous extract. The main purpose of this study was to determine the effect of different aqueous nettle extracts on the cultivation (plant height, plant diameter, dry stem weight, dry leaf weight, number of leaves, leaf area, pod yield) of green bean in field conditions, compared with mineral fertilization (Urea 46 %) and control fields with fertilization. Experiment was on two sowing date (spring and autumn) in the location near Zadar. Two types of aqueous extracts were used. The short-term aqueous extract (SE) was prepared by extraction of dry herb (183 g 10 L<sup>-1</sup> of water) in aqua for 24 hours, the long-term aqueous extract (LE) in the same ratio with aqua extraction lasted 14 days. Both extracts were strained and diluted 1:3 with tap water before use, SE was applied foliar and LE was applied by watering soil. Vegetative parameters of plant height, weight of dry stem and dry leaf, leaf area and yield of green bean were higher in the autumn growing period compared to the spring sowing period. Other morphological parameters such as number of leaves and stem diameter did not differ statistically. The highest yield was recorded in treatment with Urea compared to other treatments that did not differ statistically from each other.

**Key words:** green bean, stinging nettle, vegetative parameters, aqueous extracts

## Učinak borne i fenilboronske kiseline na bakterijske i gljivične patogene u uzgoju rajčice

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### Sažetak

Temeljni problem u suvremenoj proizvodnji bilja je vrlo sužen izbor dostupnih sredstava za suzbijanje biljnih patogena te razvitak rezistentnosti fitopatogenih gljiva i bakterija na njih. Problem se pokušava riješiti istraživanjem ekološki prihvatljivih spojeva koji imaju visoku antibiotsku učinkovitost i kad se primjenjuju u niskim koncentracijama. Spoj s takvim potencijalom je fenilboronska kiselina (PBA, eng. *phenylboronic acid*), derivat medicinski značajne borne kiseline (BA, eng. *boric acid*). Testiranjem baktericidnog i fungicidnog učinka različitih koncentracija PBA i kontrolne BA na izolirane uzročnike bolesti (bakteriju *Pseudomonas syringae* pv. *tomato* i gljivu *Alternaria alternata*) u uzgoju rajčice u uvjetima *in vitro*, utvrđeno je da PBA pri niskoj koncentraciji (0,05 %) u potpunosti inhibira rast gljivičnog i bakterijskog patogena rajčice u usporedbi s BA. Jednak učinak na *P. syringae* pv. *tomato* postiže u 6 puta većoj koncentraciji. Uočen je fungicidni učinak primjene 0,05 % PBA na gljivu *A. alternata*, dok je ista koncentracija BA imala fungistatički učinak. U uvjetima plastenika, testiranjem učinka PBA i kontrolne BA na jačinu simptoma bolesti rajčice, utvrđeno je da folijarna aplikacija PBA pri nižim koncentracijama (0,05 %), značajno smanjuje jačinu simptoma bolesti koncentrične (gljivične) (61 %) i bakterijske pjegavosti (79 %) rajčice u odnosu na BA aplicirane u 6 puta većoj koncentraciji. Rezultati pokazuju da PBA ima potencijal biti razmatrana u smjeru efikasnih sredstava za suzbijanje ekonomski značajnih fitopatogena u uzgoju rajčice, posebno u usporedbi s BA.

**Ključne riječi:** *Alternaria alternata*, BA, PBA, *Pseudomonas syringae* pv. *tomato*, rajčica

## Effect of boric and phenylboronic acid on bacterial and fungal pathogens of tomato

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### Summary

The lack of available means of controlling plant pathogens as well as the development of resistance of phytopathogenic fungi and bacteria are fundamental problems in modern plant production. The problem is dealt with by searching for environmentally friendly chemicals that have high antibiotic efficiency in low concentrations. Phenylboronic acid (PBA), a derivative of medicinally important boric acid (BA) may be such an agent. By testing the bactericidal and fungicidal activity of different concentrations of PBA and control BA on isolated pathogens (bacterium *Pseudomonas syringae* pv. *tomato* and fungus *Alternaria alternata*) *in vitro*, we have shown that PBA completely inhibits the growth and development of the fungal and bacterial pathogen at low concentrations (0.05%). Compared to PBA, about 6 fold higher BA concentration was required to achieve the same inhibitory effect on the *P. syringae* pv. *tomato*. When treating *A. alternata* with 0.05% of PBA we observed fungicidal effect, as opposed to fungistatic effect noted by applying the same concentration of BA. In greenhouse conditions, we have observed that foliar application of PBA at lower concentrations (0.05%), significantly reduced the severity of symptoms of fungal early blight (61%) and bacterial speck (79%), as compared to BA applied in 6 times higher concentration. The presented results reveal the PBA has the potential to be considered as an effective antibacterial compound for controlling economically important tomato phytopathogens, especially compared to BA.

**Key words:** *Alternaria alternata*, BA, PBA, *Pseudomonas syringae* pv. *tomato*, tomato



## Utjecaj različitih selenovih nanočestica na mineralni sastav rukole

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### Sažetak

Kao i ostali nanomaterijali, selenove nanočestice (SeNPs) posjeduju jedinstvena kemijska, fizikalna i biološka svojstva kao i funkcionalnost. Ovo istraživanje je imalo za cilj utvrditi utjecaj biofortifikacije rukole SeNPs na rast i razvoj te mineralni sastav korijena i lista rukole u usporedbi s konvencionalnom biofortifikacijom selenom u obliku selenata. Selen je primijenjen u četiri različita kemijska oblika kao selenat te tri vrste SeNPs. SeNPs su bile obložene polisorbatom (PS-SeNPs), huminskom kiselinom (HA-SeNPs) i polivinilpirolidonom (PVP-SeNPs). Selen je primijenjen u rasponu od 80 do 320  $\mu\text{mol m}^{-3}$  hranjive otopine. Istraživanje je provedeno u grijanom plasteniku s automatskom kontrolom temperature i prozračivanja u sustavu plutajućeg hidropona. Primjena SeNPs i selenata je značajno utjecala na koncentraciju N, P, S, Ca, Mn, Zn i Se u korijenu rukole. Također, oblik selenata je značajno utjecao i na koncentraciju N, K, Fe, Zn i Se u listu rukole. Nadalje, primjena selenovih nanočestica je rezultirala značajnim povećanjem koncentracije selenata u korijenu rukole u usporedbi s biljkama biofortificiranim selenatom. Suprotno, koncentracija selenata u listu rukole je bila značajno veća u slučaju biofortifikacije selenatom. Prema svemu navedenom se može zaključiti da primijenjeni oblici selenata značajno utječu na usvajanje i translokaciju selenata i ostalih elemenata ishrane u rukoli. Ovo istraživanje je financirano od strane Hrvatske zaklade za znanost u sklopu projekta HRZZ-IP-2018-01-8119.

**Ključne riječi:** selen, biofortifikacija, mineralni sastav, rukola, nanočestice

## **Influence of different selenium nanoparticles on rucola nutrient status**

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### **Summary**

Like other nanomaterials, selenium nanoparticles (SeNPs) possess unique chemical, physical, and biological properties as well as functionality. This study aimed to determine the impact of biofortification with SeNPs on growth and development as well as root and leaf mineral composition of rucola compared to conventional selenium biofortification with selenate. Se has been applied in four different chemical forms as selenate and three types of SeNPs. SeNPs were coated with polysorbate (PS-SeNPs), humic acid (HA-SeNPs) and polyvinylpyrrolidone (PVP-SeNPs). Selenium was administered in the range of 80 to 320  $\mu\text{mol m}^{-3}$  nutrient solution. The research was carried out in a heated greenhouse with automatic temperature and ventilation control in a floating hydroponic system. The application of SeNPs and selenate significantly affected the concentration of N, P, S, Ca, Mn, Zn and Se in rucola root. Also, the form of selenium significantly affected the concentration of N, K, Fe, Zn and Se in the rucola leaf. Furthermore, the application of SeNPs resulted in a significant increase in the concentration of Se in the rucola root compared to plants biofortified with selenate. In contrast, the concentration of Se in rucola leaves was significantly higher in case of biofortification with selenate. According to the above, it can be concluded that the applied forms of Se significantly affect the uptake and translocation of Se and other nutrients in rucola. This research was funded by the Croatian Science Foundation as part of the HRZZ-IP-2018-01-8119 project.

**Key words:** selenium, biofortification, mineral composition, rucola, nanoparticles

## Utjecaj stratifikacije i skarifikacije na klijavost sjemena divlje šparoge (*Asparagus acutifolius* L.)

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### Sažetak

*Asparagus acutifolius* L. višegodišnja je zimzelena biljna vrsta koja spontano raste na neobrađenim područjima, rubovima šuma, suhozidima, a posebice makijama koje karakteriziraju područje Mediterana. Mladi izbojci šparoga vrlo su cijenjeni te se koriste u brojnim regionalnim jelima. Divlja šparoga mogla bi postati nova kultura s visokim potencijalom prihoda. Njezin uzgoj na rubnim područjima pridonio bi bioraznolikosti i očuvanju okoliša, a savršeno bi se uklopio u okvire održive poljoprivrede. Budući da je sjeme divlje šparoge dormantno i niske klijavosti te iziskuje dugo vrijeme klijanja to je jedan od ograničavajućih čimbenika suvremenog uzgoja tog nutritivno vrijednog povrća. Stoga smo u ovom istraživanju za prekid dormantnosti koristili dvije duljine tople stratifikacije (kontrola bez stratifikacije, 30 i 90 dana) na 25°C i 60 % relativne vlage zraka kao i dva tipa skarifikacije (kontrola bez skarifikacije, brusni papir i KNO<sub>3</sub>). Pronađena je signifikantna razlika u konačnom postotku klijavosti između dviju promatranih primki. Nekarificirane sjemenke (73 %) i sjemenke tretirane KNO<sub>3</sub> (70 %) pokazale su bolji konačni postotak klijavosti uspoređujući s brušenjem brusnim papirom (7 %). Nije pronađen signifikantan utjecaj stratifikacije na konačan postotak klijavosti. Prema našim rezultatima čini se da primjenjeni tretmani nisu uspješni pri uklanjanju dormantnosti, međutim pronađena je signifikantna razlika u klijavosti između primki divljih šparoga.

**Ključne riječi:** šparoga, KNO<sub>3</sub>, temperatura, postotak klijavosti, dormantnost sjemena

## Influence of stratification and scarification on seed germination of wild asparagus (*Asparagus acutifolius* L.)

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### Summary

*Asparagus acutifolius* L. is a perennial evergreen plant species that grows spontaneously in uncultivated areas, forest edges, on dry stonewalls, especially maquis that characterize the Mediterranean area. Young spears of asparagus are highly valued and used in many regional dishes. Wild asparagus could become a new crop with high income potential. Its cultivation in peripheral areas would contribute to biodiversity and environmental protection, and would fit well into the framework of sustainable agriculture. Since wild asparagus seeds are dormant and have low germination rate and require a long time to germinate, this is one of the limiting factors in the cultivation of this nutritionally valuable vegetable. Therefore, in this study we used two lengths of warm stratification (non-stratified control, 30 and 90 days) at 25 °C and 60% relative humidity and two types of scarification (non-scarified control, sandpaper and KNO<sub>3</sub>) to break dormancy. We found significant difference between two studied asparagus accessions in final germination percentage. Non-scarified seeds (73%) and seeds treated with KNO<sub>3</sub> (70%) showed better final germination percentage compared to brushing with sand paper (7%). No significant impact of stratification on final germination percentage was found. According to our results it seems that applied treatments were not effective in dormancy breaking, however we found significant difference in germination between wild asparagus accessions.

**Key words:** asparagus, KNO<sub>3</sub>, temperature, germination percentage, seeds dormancy

## Utjecaj različitih selenovih nanočestica na antioksidacijski odgovor u mladim listovima rukole

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### Sažetak

Selen (Se) je esencijalan element za ljude i životinje, a njegov nedostatak može uzrokovati pojavu različitih bolesti. Budući da se većina Se unosi u organizam putem hrane biljnog porijekla, iznimno je važan sadržaj Se u biljnom tkivu. Jedan od načina rješavanja nedostatka Se u biljkama je agronomska biofortifikacija, kojoj je cilj gnojidbom povećati koncentraciju i bioraspoloživost Se. Biofortifikacija nanočesticama Se privlači u posljednje vrijeme sve više pozornosti zbog povećane bioapsorpcije i bioraspoloživosti te smanjene toksičnosti u usporedbi s ostalim oblicima Se. U sklopu ovog istraživanja odredit će se utjecaj različitih koncentracija tri tipa nanočestica Se stabiliziranih s huminskom kiselinom, polisorbatom i polivinilpirolidonom te natrijevog selenata na sadržaj produkata lipidne peroksidacije, sadržaj antioksidacijskih pokazatelja na aktivnost antioksidacijskih enzima. Nanočestice Se obložene polisorbatom su uzrokovale najizraženiji antioksidacijski odgovor, dok je pri svim tretmanima nanočesticama Se intenzitet lipidne peroksidacije bio manji nego u kontrolnim listovima i listovima tretiranim selenatom. Također, usvajanje Se bilo je najučinkovitije kod tretmana najvećim koncentracijama nanočestica. Iz navedenih rezultata može se zaključiti kako je biofortifikacija nanočesticama Se puno učinkovitija od natrijevog selenata zbog povećanog usvajanja Se i antioksidativnog odgovora u listovima mlade rukole. Ovo istraživanje je financirano od strane Hrvatske zaklade za znanost u sklopu projekta HRZZ-IP-2018-01-8119.

**Ključne riječi:** biofortifikacija, selen, nanočestice, antioksidacijski odgovor

## The effect of differently coated selenium nanoparticles on antioxidative response in baby rucola leaves

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### Summary

Selenium (Se) is an essential element for humans and animals, and its deficiency can cause various diseases. Since most Se is taken into the body through the food of plant origin, the content of Se in plant tissue is extremely important. One of the possible ways to solve the lack of Se in plants is agronomic biofortification, which aims to increase the concentration and bioavailability of Se by fertilization. Biofortification with Se nanoparticles has recently gained increasing attention due to their increased bioabsorption and bioavailability as well as reduced toxicity compared to other Se forms. This study will determine the effect of different concentrations of three different Se nanoparticles coated with humic acid, polysorbate, and polyvinylpyrrolidone and sodium selenate on the content of lipid peroxidation products, the content of antioxidants, and the activity of antioxidant enzymes. Polysorbate-coated Se nanoparticles caused the most pronounced antioxidant response, while lipid peroxidation intensity was lower in all Se nanoparticle treatments than in control and selenate-treated leaves. Also, Se uptake was most effective in treatment with the highest nanoparticle concentrations. The above results show that biofortification with Se nanoparticles is much more effective than sodium selenate due to increased Se uptake and antioxidant response in baby rucola leaves. This research was funded by the Croatian Science Foundation as part of the HRZZ-IP-2018-01-8119 project.

**Key words:** biofortification, selenium, nanoparticles, antioxidative response

## Mogućnost sterilizacije *in vitro* uzgojnog medija mikrovalnom pećnicom

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### Sažetak

Sterilizacija hranjive podloge u *in vitro* proizvodnji biljaka prvi je korak k uspješnom uzgoju i umnožavanju biljaka. Najčešće korištena metoda sterilizacije hranjive podloge je pomoću autoklava, odnosno sterilizacija vrućom vodenom parom pod utjecajem povišenog tlaka. Iako je ova metoda pouzdana, ukoliko se ispoštuju svi propisi, također je i dugotrajna, posebice ukoliko nam treba manja količina medija i u kratkom vremenskom periodu. U tu svrhu, alternativa autoklavu može biti i mikrovalna pećnica kao brzo i povoljno rješenje. Cilj ovog istraživanja bio je ispitati mogućnost upotrebe mikrovalne pećnice za sterilizaciju uzgojnog medija. Ispitivani tretamni bili su vremenski interval (1, 3, 4, 5 i 7 min pri 800 W) te intezitet zračenja (100, 180, 300, 450, 600 W tijekom 5 min) za sterilizaciju 5 tikvica sa 50 mL uzgojnog medija. Rezultati istraživanja pokazali su uspješnu sterilizaciju uzgojnog medija pri vremenskim intervalima 3, 4, 5 i 7 min  $800\text{ W}^{-1}$ , a kod tretmana inteziteta zračenja pri  $600\text{ W } 5\text{ min}^{-1}$ .

**Ključne riječi:** hranjiva podloga, kontaminacija, mikropropagacija

## Possibility of *in vitro* culture medium sterilization by microwave oven

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### Summary

Sterilization of nutrient medium for *in vitro* plant production is the first step towards successful plant propagation and multiplication. The most commonly used method of nutrient medium sterilization is by autoclave, i.e. sterilization with saturated steam under pressure. Although this method is reliable if all regulations are followed, it is also time consuming, especially if we need a smaller amount of media and in a short period of time. For this purpose, an alternative to an autoclave can be a microwave oven as a quick and affordable solution. The aim of this study was to examine the possibility of using a microwave oven to sterilize the culture medium. Experiment consisted of two treatments: time interval (1, 3, 4, 5 and 7 min at 800 W) and radiation intensity (100, 180, 300, 450, 600 W for 5 min) for sterilization of 5 flasks with 50 mL of culture medium. The results showed successful sterilization of the culture medium at time intervals of 3, 4, 5 and 7 min  $800\text{ W}^{-1}$ , and in radiation intensity treatment at  $600\text{ W }5\text{ min}^{-1}$ .

**Key words:** nutrient medium, contamination, micropropagation



## Bioaktivni potencijal mikrozeljenja raštike (*Brassica oleracea* L. var. *acephala*)

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### Sažetak

Raštika je dvogodišnja zeljasta biljka koja se tradicionalno uzgaja u obalnom području Hrvatske. Mikrozeljenje u odnosu na odrasle biljke ima puno veće koncentracije nutritivnih tvari te se može proizvesti u kratkom vremenskom periodu. Postavljen je dvofaktorijski pokus s ciljem utvrđivanja utjecaja roka berbe *Brassica oleracea* L. var. *acephala* i opterećenja na prinos, suhu tvar, ukupne glukozinolate i fenole, ukupni antioksidacijski kapacitet mjeren DPPH, FRAP i ORAC metodama te profil šećera. Značajno veći prinos utvrđen je u kasnijim rokovima berbe dok se udio suhe tvari istovremeno značajno smanjio. Produljeni tretman opterećenjem uzorkovao je značajno smanjenje prinosa kao i značajno smanjenje ukupnih fenola mikrozeljenja. Bioaktivni potencijal mikrozeljenja značajno se mijenjao s rokom berbe gdje su rana i srednja berba pokazale više ukupnih glukozinolata, veći antioksidacijski kapacitet mjeren FRAP metodom te veću količinu inulina u odnosu na kasnu berbu. Kasna berba je osim značajno većeg prinosa pokazala i značajno veću količinu ukupnih fenola u odnosu na ranije rokove berbe. Utvrđene količine različitih parametara u mikrozeljenju raštike pokazuju dobar potencijal za njihovu valorizaciju kao prehrambenog proizvoda.

**Ključne riječi:** DPPH, fenoli, FRAP, glukozinolati, prinos

## Bioactive potential of kale (*Brassica oleracea* L. var. *acephala*) microgreens

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### Abstract

Kale is a biennial herbaceous plant that is traditionally grown in the coastal area of Croatia. Microgreens have higher nutrient content compared to adult plants and can be produced in a short period of time. A two-factor experiment was set up on *Brassica oleracea* L. var. *acephala* to determine the influence of harvest time of and load on yield, dry matter, total glucosinolates and phenolic content, total antioxidant capacity measured by DPPH, FRAP and ORAC, as well as on the sugar profile. Significantly higher yields were found in the later harvest dates, while, at the same time, the dry matter content decreased significantly. Prolonged load treatment showed a significant reduction in yield as well as a significant reduction in total phenolic content of microgreens. The bioactive potential of microgreens changed significantly with the harvest date, where early and medium harvests showed more total glucosinolates, higher antioxidant capacity measured by the FRAP method, and a higher amount of inulin compared to the late harvest. In addition to significantly higher yields, the late harvest also showed a significantly higher total phenolic content compared to earlier harvest dates. The determined nutritional parameters in the kale microgreens represent excellent potential for their valorization as a food product.

**Key words:** DPPH, phenols, FRAP, glucosinolates, yield

## Application of 'Rhyzo BZ' fertilizer microparticles during pepper cultivation in urban gardens

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### Summary

The possibility of growing vegetables in public spaces and social gardens in modern cities has become an increasingly popular research topic in recent years, as well as the application of encapsulated bioactive substances as a modern technique in sustainable agricultural production. Therefore, research was conducted to determine the effects of the application of the fertilizer 'Rhyzo BZ' in the form of microparticles on the content of polyphenols and carotenoids content and the yield of pepper fruits grown in urban gardens. The research was conducted in 2021 in the urban garden of the Faculty of Electrical Engineering and Computing in Zagreb. Pepper plants of the cultivar 'Slonovo uho' were planted in raised beds on May 26 at spacing 0.4 m × 0.3 m and treated with the encapsulated fertilizer 'Rhyzo BZ' (4 grams per plant), while untreated plants represented a control. Alginate microparticle formulations filled with fertilizer 'Rhyzo BZ' were prepared in the laboratory of the Department of Chemistry (Faculty of Agriculture, Zagreb) by the ionic gelling method, by dissolving 20 g of 'Rhyzo BZ' in 1 L of sodium alginate (2%) and calcium nitrate (1.5%). An agrometeorological station has been set up in the urban garden using IoT Vertical Kit sensors and IoT devices to continuously monitor air temperature and relative humidity, precipitation, and substrate temperature on a daily basis during pepper cultivation. Organic straw mulch was used in the cultivation of pepper and irrigation was applied according to substrate moisture data from the agrometeorological station. During the harvest period from July 13 to October 12, the yield of pepper was evaluated and the content of polyphenols and carotenoids was determined in the samples of pepper fruits. The obtained results showed that the application of 'Rhyzo BZ' microparticles had a positive effect on the yield and content of polyphenols and carotenoids of pepper.

**Key words:** encapsulation, *Capsicum annuum* L., polyphenols, carotenoids, raised beds

## Biofortifikacija matovilca različitim kemijskim oblicima selena

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### Sažetak

U ovom istraživanju je prikazan utjecaj biofortifikacije matovilca s različitim kemijskim oblicima selena. Selen je primijenjen u obliku selenata te dvije vrste selenovih nanočestica (SeNPs) koje su obložene huminskom kiselinom (HA-SeNPs) ili polisorbatom (PS-SeNPs) u dvije koncentracije ( $200 \mu\text{M m}^{-3}$  i  $400 \mu\text{M m}^{-3}$  hranjive otopine). Pokus je proveden tijekom 2021. godine u plasteniku, a tretmani su primijenjeni u zasebnim bazenima u uvjetima plutajućeg hidropona. Vegetacija je trajala ukupno 30 dana nakon čega su biljke uzorkovane u cilju mjerenja svježe i suhe mase lista i korijena te broja listova. Nakon obrade podataka, utvrđeno je da biofortifikacija selenom utječe na rast i razvoj matovilca. Najveća masa lista je tako zabilježena kod tretmana PS-SeNPs-200, a najmanja masa kod tretmana SEL-200 iako nije bilo značajnih razlika između svih pokusnih varijanata. Također, zabilježene su značajne razlike u masi i dužini korijena te broju listova u ovisnosti o tretmanu te je najduži korijen izmjeren kod tretmana HA-SeNPs-200, masa korijena kod SEL-200, a najveći broj listova kod PS-SeNPs-200. Sukladno navedenim rezultatima se može zaključiti da je biofortifikacija različitim oblicima selena utjecala na rast i razvoj matovilca gdje su se očitovale jasne specifičnosti u ovisnosti u obliku selena. Ovo istraživanje je financirano od strane Hrvatske zaklade za znanost u sklopu projekta HRZZ IP-2018-01-8119.

**Ključne riječi:** matovilac, biofortifikacija, nanočestice, selen, hidropon

## Biofortification of lamb's lettuce with different chemical forms of selenium

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### Summary

In this study, the influence of biofortification with different chemical forms of selenium on lamb's lettuce was investigated. Selenium was applied in the form of selenate and two types of selenium nanoparticles (SeNPs) coated with humic acid (HA-SeNPs) or polysorbate (PS-SeNPs) each in two concentrations (200  $\mu\text{M m}^{-3}$  and 400  $\mu\text{M m}^{-3}$  nutrient solution). The experiment was conducted during 2021 in a heated greenhouse, and the treatments were applied in separate pools using floating hydroponic technique. The vegetation lasted for 30 days, after which the plants were sampled and fresh and dry mass of leaves and roots as well as the number of leaves were recorded. Data analysis showed that selenium biofortification affects the growth and development of lamb's lettuce. The highest fresh leaves weight was thus recorded in the PS-SeNPs-200 treatment, and the lowest in the SEL-200 treatment, although there were no significant differences between all experimental variants. Also, significant differences in root mass and length and number of leaves depending on treatment were observed, where the longest root was measured in HA-SeNPs-200 treatment, root mass in SEL-200, and the largest number of leaves in PS-SeNPs-200 treatment. According to the above results, it can be concluded that biofortification with different forms of selenium influenced the growth and development of lamb's lettuce where each treatment had specific effect on lamb's lettuce growth and development. This research was funded by the Croatian Science Foundation as part of the HRZZ-IP-2018-01-8119 project.

**Key words:** lamb's lettuce, biofortification, nanoparticles, selenium, hydroponics

## Phylogenetic evidence for specialization and dissemination route of *Waitea circinata* var. *zeae*

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### Summary

*Waitea circinata* var. *zeae* (multinuclear *Rhizoctonia* spp.) is a causal agent of root rot of many monocotyledonous and a small number of dicotyledonous plants. During 2017, *W. circinata* var. *zeae* was isolated from cabbage and oilseed rape with symptoms of root necrosis and rot plants, sampled in Serbia. This was the first record of natural infection of plants from family Brassicaceae and overall the first record of infection of dicotyledonous plants in Europe. Extensive phylogenetic analyses revealed a closer relationship among *W. circinata* var. *zeae* isolates originating from dicotyledonous hosts compared to the isolates originating from monocotyledonous plants. Furthermore, our analyses supported previously proposed dissemination route of *W. circinata* var. *zeae*. Initial origin of *W. circinata* var. *zeae* is associated with Americas, from which pathogen advanced via Far East and Asia to Turkey and Eastern Europe. Until this study, *W. circinata* var. *zeae* was reported only in Hungary, as pathogen of monocots *Lolium perenne* and *Festuca* sp. It is likely that the introduction in Serbia was a part of the same dissemination route.

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**Key words:** cabbage, oilseed rape, multinuclear *Rhizoctonia* spp., phylogeography, detection



**Ratarstvo**

**05**

**Field Crop  
Production**





## The adaptability of seed materials as a precondition for organic production

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### Summary

The total organic farming (OF) area has increased till 7.5% of agricultural land of EU, but due to Farm to fork strategy is expected to achieve 25% of total agriculture land under OF by 2030. According to the situation and further development of certified organic seeds, especially its quality, is a big demand for further development of the organic sector. The contribution (and part of the project CRP V4-2007) aims analyse the further activities for sustainable utilization of quality seeds for development of the organic sector. Based on data analyses, situation, especially in Slovenia, and findings of the projects (like COBRA, Ecobreed Improving Crops, Live seed, Bresov) we can find out that for covering organic seeds by 2036, their production should be increased for 6 times. According to Slovenian experiences we can conclude that organic certified seeds are mostly imported. The question is a low quality, due to minimum EU standards and low potential for phenotype expression with the stable yields in the new climatic circumstances. Otherwise, most seeds used in OF are the product of conventional breeding methods with the genes supported from very intensive production. Seed adaptation for organic production must be approved according to the specific standards for climate adaptation of crop varieties. Adaptation to the organic production system with many special components leads to more natural interactions of genes with production and climate characteristics. The main target is stable and quality yields, high nutrient use efficiency based on organic fertilizers, low damage of plant diseases and pests, etc. For activities of own creation of seed materials, clear official testing of organic seeds of conventional varieties, organic varieties and heterogeneous seed material according to (EU) 2018/848 is needed. Appropriate organic seed production for OF in the open EU market are the main tasks for success of organic production.

**Key words:** variety, organic farming, resistance, yield, adaptability

## Utjecaj konzervacijske obrade tla na kemijski sastav i energetska vrijednost zrna jare pšenice

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### Sažetak

Konzervacijska poljoprivredna praksa čijom se obradom nastoji što manje djelovati na tlo i koristi slamu kao malč, poboljšava agronomska svojstva usjeva te akumulira hranjive tvari u tlu. Istraživanje je provedeno prema slučajnom blok rasporedu kako bi se utvrdio utjecaj obrade tla i korištenje slame kao malča na nutritivnu vrijednost jare pšenice (*Triticum aestivum* L.). Pokus je postavljen u sjeverozapadnoj Hrvatskoj na fluvisolu u vlažnim uvjetima s tri sustava obrade tla: a) konvencionalna obrada tla uz oranje do 20 cm u jesen i tanjuranje u proljeće (CT); b) primjena kombiniranih alata do 15 cm u proljeće (MT) i c) podrivanje na 35-40 cm u jesen i rahljenje kombiniranim alatom do 15 cm u proljeće (RT). Svaki sustav obrade podijeljen je na parcele sa i bez slame. Tretman slamom nije utjecao ni na jedan od ispitivanih čimbenika za jaru pšenicu. Na trećem tretmanu obrade tla (RT) pšenica je postigla najviši sadržaj proteina i najmanji sadržaj **škroba**, dok je prvi tretman (CT) postigao suprotne vrijednosti, ali navedeno se razlikovalo samo matematički. Obrada tla imala je značajan utjecaj na metaboličku energiju za perad ( $p < 0,05$ ) i neto energetske vrijednosti za goveda ( $p < 0,01$ ), dok interakcija čimbenika nije imala značajan učinak ni na jedno od ispitivanih svojstava. Navedeno upućuje da različiti tretmani obrade tla utječu na složene, energetske vrijednosti za životinje, više nego na pojedinačne komponente kemijskog sastava jare pšenice.

**Ključne riječi:** jara pšenica, obrada tla, kemijski sastav, energetska vrijednost

## Effect of conservation tillage on chemical composition and energy value of spring wheat

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### Summary

Conservation farming practices, by using the least soil disturbance and straw, benefits the crop agronomic attributes and soil nutrient accumulation. The study was conducted according to a randomized block design to determine the impact of tillage systems and use of straw as mulch on the nutritional value of spring wheat (*Triticum aestivum* L.). The experiment was set up in northwestern Croatia on fluvial soil in humid conditions with three tillage systems: a) conventional tillage with plowing up to 20 cm in autumn and disking in spring (CT); b) application of combined tools up to 15 cm in spring (MT) and c) subsoiling 35-40 cm in autumn and loosening with a combined tool up to 15 cm in spring (RT). Each tillage system is divided into plots with and without straw. Straw treatment had no effect on any of the investigated factors for spring wheat. Tillage treatment (RT) gives the highest protein content and the lowest starch content while the CT treatment gives the opposite. However, mentioned nutritional values differed only mathematically. Tillage had a significant effect on metabolic energy for poultry ( $p < 0.05$ ) and net energy values for cattle ( $p < 0.01$ ), while the interaction of these factors did not have a significant effect on any of the studied traits. This indicates that different tillage treatments affect complex, energy values for animals, more than individual components of the chemical composition of spring wheat.

**Key words:** spring wheat, tillage, chemical composition, energy value

## Zaštita uljane repice od repičinog sjajnika (*Brassicogethes aeneus*) na Agrovpolje d.o.o. u 2020. godini

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### Sažetak

Repičin sjajnik (*Brassicogethes aeneus*, Fabricius 1775) važan je štetnik uljane repice. Velik problem poljoprivrednim proizvođačima stvara pojava rezistentnosti ovog štetnika te sužava izbor kemijskih insekticida koji se mogu primijeniti za zaštitu uljane repice. Istraživanje je provedeno u 2020. godini na području općine Vrpolje na pokusnoj površini od 15 ha. Cilj istraživanja bio je utvrditi veličinu populacije repičinog sjajnika te učinkovitost suzbijanja kemijskim insekticidima. U pokusu je bio zasijan hibrid Bluestar tvrtke Syngenta, a sjeme je tretirano insekticidom Lumiposa 625 FS (cijantraniliprol). Populacija repičinog sjajnika praćena je pomoću Merikovih posuda od početka ožujka do kraja travnja 2020., a posude su pregledavane svakih sedam dana. Za suzbijanje repičinog sjajnika korišteni su insekticidi Nurell D (klorpirifos-etil+cipermetrin) u fazi izduživanja stabljike i Pyrinex 48 EC (klorpirifos) u fazi izduživanja bočnih grana. Insekticidni tretmani primjenjeni su na osnovi brojnosti populacije štetnika u Merikovim posudama. Nurell D imao je djelotvornost od 56 %, dok je Pyrinex 48 EC imao djelotvornost od 44 %. Prinos uljane repice iznosio je 2,8 t ha<sup>-1</sup>. Djelotvornost insekticida nije bila visoka, a jedan od razloga može biti i pojava otpornosti štetnika na navedene aktivne tvari. Potreban je integrirani pristup u zaštiti uljane repice od repičinog sjajnika, s obzirom da kemijske mjere zaštite nisu bile dovoljno učinkovite u ovom istraživanju.

**Ključne riječi:** repičin sjajnik, uljana repica, Merikove posude, Nurell D, Pyrinex 48 EC

## Protection of oilseed rape from pollen beetle (*Brassicogethes aeneus*) at Agrovrapolje d.o.o. in 2020

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### Summary

Pollen beetle (*Brassicogethes aeneus* Fabricius 1775) is an important pest of oilseed rape. A major problem for farmers is the resistance of this pest to different active ingredients, which affects the potential number of efficient insecticides in oilseed rape. The research was conducted in 2020 in the municipality of Vrapolje at experimental plot of 15 ha. The aim was to determine the size of the pollen beetle population and the effectiveness of chemical insecticides against this pest. Syngenta's Bluestar hybrid of oilseed rape was sown in the experiment and the seed was treated with Lumiposa 625 FS (cyantraniliprole) insecticide. The pollen beetle population was monitored using yellow water traps from the beginning of the March to the end of April 2020, and traps were checked every seven days. Insecticide Nurell D (chlorpyrifos+cypermethrin) was used in the stem elongation phase and Pyrinex 48 EC (chlorpyrifos) in the lateral branches elongation phase for control this pest. Insecticide application was based on population size in water traps. Nurell D had an efficiency of 56%, while Pyrinex 48 EC had an efficiency of 44%. The oilseed rape yield was 2.8 t ha<sup>-1</sup>. The effectiveness of insecticides was not very high, and one of the reasons may be the resistance of pests to these active ingredients. Integrated approach for protection of oilseed rape should be taken into consideration, since chemical protection solely did not provide efficient results.

**Key words:** pollen beetle, rapeseed oil, yellow water traps, Nurell D, Pyrinex 48 EC

## Phenolic compounds – natural antioxidants of whole grain cereals

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### Summary

Cereals are an important source of biologically active phenolic compounds. Antioxidant activity (AOA) of whole grain of wheat, winter and spring barley, corn and popcorn were analysed over two growing seasons (2018-2019). The Folin-Ciocalteu test was used to assess the total phenolic content (TPC) of cereal extracts. On average, the highest TPC was found in winter barley (1322–1448  $\mu\text{g GAE/g}_{\text{dm}}$ ) and popcorn (1195–1486  $\mu\text{g GAE/g}_{\text{dm}}$ ) and the lowest in wheat samples (713–1032  $\mu\text{g GAE/g}_{\text{dm}}$ ). AOA of cereal grains was evaluated by DPPH radical scavenging assay as a rapid, simple and widely used method to measure the ability of phenolic compounds to act as free radical scavengers or hydrogen donors. The AOA of cereals varied from 13%–15% in wheat to 64–69% in winter barley. A significant difference between two growing seasons was found for TPC and AOA and on average their values were lower in 2018 compared to 2019.

**Key words:** cereals, total phenolic content, DPPH, antioxidant activity

## Influence of spelt bran addition on the properties of corn extrudates

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### Summary

Extruded snack products are one of the most popular snacks consumed worldwide. These products are rich in carbohydrates, fats and salt. The main raw material for their production is corn grits. In order to improve nutritive value, physical and chemical properties, flours of different grains, dehydrated fruits and vegetables can be added to corn grits, and in recent times, various by-products of the food industry have become especially popular. Spelt bran is a valuable by-product of spelt processing. It is primarily interesting due to its high proportion of dietary fiber. The aim of this study was to investigate the influence of spelt bran addition (in proportions of 4, 8 and 12% dry matter) on the properties of corn extrudates. The mixtures were prepared at 15% moisture with the addition of 1% pectin in order to obtain directly expanded snack products. The samples were extruded in a laboratory single-screw extruder, dried at room temperature and the following parameters were determined: expansion ratio, bulk density, color, hardness and fracturability, water absorption index and water solubility index as well as dietary fiber content. The addition of spelt bran caused a decrease in expansion ratio and an increase in bulk density. Hardness increased, while fracturability decreased with the increase in spelt bran content. The color change became more pronounced with the addition of spelt bran. The dietary fiber content increased proportionally to the addition of spelt bran. The extrusion process caused a decrease in dietary fiber content and a significant increase in water absorption index and water solubility index.

**Key words:** extrusion, by-products, spelt bran, corn snack products, dietary fiber



## Osjetljivost proljetnih repičinih pipa na insekticide tijekom 2019. i 2021.

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### Sažetak

Mala i velika repičina pipa suzbijaju se isključivo primjenom kemijskih insekticida te je rezistentnost na pojedine aktivne tvari već utvrđena. Cilj ovog istraživanja bio je testirati populacije repičinih pipa na insekticide koji su dozvoljeni za tu namjenu, a provedeno je u sklopu programa „Monitoring rezistentnosti štetnih organizama na sredstva za zaštitu bilja“. Tijekom 2019. i 2021. godine na 10 lokaliteta s netretiranih usjeva, prikupljeni su odrasli oblici proljetnih repičinih pipa. Testovi su provedeni prema IRAC test metodi broj 031, a korišteni su pripravci na osnovi aktivnih tvari klorpirifos, cipermetrin, lambda – cihalotrin, deltametrin, tiaklopid i acetamiprid. Tijekom 2019. sumnja na rezistentnost na aktivnu tvar lambda-cihalotrin utvrđena je kod 25 % populacija. Smanjena osjetljivost na aktivnu tvar tiaklopid utvrđena kod 80 % populacija, a na aktivnu tvar acetamiprid kod 25% populacija. Tijekom 2021. sumnja na rezistentnost na aktivne tvari lambda-cihalotrin i deltametrin utvrđena je kod 40 % testiranih populacija. Kod 20% populacija utvrđena je smanjena osjetljivost na aktivnu tvar deltametrin, a na aktivnu tvar acetamiprid utvrđeno je 40% populacija sa smanjenom osjetljivošću. S obzirom na rezultate osjetljivost kod pojedinih populacija potrebno je koristiti insekticide za koje nije utvrđena sumnja na rezistentnost ili smanjena osjetljivost te primijeniti alternativne mjere suzbijanja.

**Ključne riječi:** uljana repica, repičine pipe, organofosforni insekticidi, piretroidi, neonikotinoide

## Sensitivity of stem mining weevils to insecticides in 2019 and 2021

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### Summary

Stem weevils in oilseed rape are controlled exclusively by the use of chemical insecticides, and resistance to certain active ingredients has already been detected. The aim of this study was to test stem weevil populations to insecticides approved for this purpose. It was conducted as part of the program “Monitoring of resistance of harmful organisms to plant protection products” program. Adult forms of stem weevils were collected from 10 locations from untreated crops in 2019 and 2021. The tests were carried out according to IRAC test method No. 031 and preparations based on the active ingredients chlorpyrifos, cypermethrin, lambda-cyhalothrin, deltamethrin, thiacloprid and acetamiprid were used. In 2019, 25% of the population was found to have suspected resistance to the active ingredient lambda-cyhalothrin, while 80% of the population was found to have reduced susceptibility to the active ingredient thiacloprid and 25% of the population to the active ingredient acetamiprid. In 2021, resistance to the active ingredient’s lambda-cyhalothrin and deltamethrin was suspected in 40% of the populations. Reduced susceptibility to the active ingredient deltamethrin was detected in 20% and to the active ingredient acetamiprid in 40% of the populations. Based on the results on susceptibility of individual populations, it is necessary to use insecticides for which no resistance or reduced susceptibility was found and to apply alternative control measures.

**Key words:** oilseed rape, weevils, OP insecticides, pyrethroids, neonicotinoids

## Osjetljivost crvenog žitnog balca na insekticide u razdoblju 2018.-2021.

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### Sažetak

Crveni žitni balac (*Oulema melanopus* L., 1758) jedan je od najvažnijih štetnika strnih žitarica čije se suzbijanje temelji isključivo na primjeni insekticida. Istraživanje osjetljivosti odraslih oblika crvenog žitnog balca na insekticide, koji su dozvoljeni za tu namjenu, provedeno je u sklopu programa „Monitoring rezistentnosti štetnih organizama na sredstva za zaštitu bilja“. Tijekom 2018., 2019. i 2021. godine na 34 lokaliteta, s netretiranih usjeva prikupljene su populacije crvenoga žitnoga balca. Testovi osjetljivosti provedeni su prema IRAC test metodi broj 007, a korišteni su pripravci na osnovi aktivnih tvari klorpirifos, cipermetrin, lambda-cihalotrin, deltametrin i tiaklopid. Tijekom 2018. utvrđena je smanjena osjetljivost na cipermetrin kod 40% testiranih populacija. Tijekom 2019. kod samo jedne testirane populacije utvrđena je smanjena osjetljivost na klorpirifos, dok je na aktivne tvari cipermetrin i tiaklopid utvrđena smanjena osjetljivost kod 83 % testiranih populacija. Tijekom 2021. kod 17 % testiranih populacija utvrđena je smanjena osjetljivost na aktivnu tvar lambda-cihalotrin, a kod 54 % testiranih populacija na aktivnu tvar deltametrin. S obzirom da je na pojedinim lokalitetima utvrđena smanjena osjetljivost testiranih aktivnih tvari potrebno je koristiti insekticide različitog mehanizma djelovanja kako bi se spriječio razvoj i širenje moguće rezistentnosti crvenog žitnog balca na testirane insekticide.

**Ključne riječi:** crveni žitni balac, osjetljivost, organofosforni insekticidi, piretroidi, neonikotinoide

## Sensitivity of cereal leaf beetle to insecticides in period 2018-2021

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### Summary

The cereal leaf beetle (*Oulema melanopus* L., 1758) is one of the most important cereal pests, and its control relies exclusively on the use of insecticides. The study of the susceptibility of the adult forms of the cereal leaf beetle to the insecticides approved for this purpose was carried out within the program “Monitoring of resistance of harmful organisms to pesticides”. Populations of cereal leaf beetle were collected from untreated crops at 34 locations in 2018, 2019, and 2021. Sensitivity tests were conducted according to IRAC Test Method No. 007 and preparations based on the active ingredients chlorpyrifos, cypermethrin, lambda-cyhalothrin, deltamethrin, and thiacloprid were used. In 2018, reduced sensitivity to cypermethrin was found in 40% of the tested populations. In 2019, only one test population was found to have reduced sensitivity to chlorpyrifos, while the active ingredients cypermethrin and thiacloprid were found to have reduced sensitivity in 83% of the tested populations. In 2021, 17% of tested populations showed reduced sensitivity to the active ingredient lambda-cyhalothrin and 54% of tested populations showed reduced sensitivity to the active ingredient deltamethrin. Because reduced sensitivity to the tested active ingredients was observed at some locations, it is necessary to use insecticides with different mode of action to avoid and prevent the development and spread of possible resistance of the cereal leaf beetle to the tested insecticides.

**Key words:** cereal leaf beetle, sensitivity, OP insecticides, pyrethroids, neonicotinoids

## **Prinos hibrida kukuruza FAO grupe 300 – 700 ostvaren na tretmanima pojedinačnih i kombiniranih NPK hraniva u sušnoj godini**

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### **Sažetak**

Cilj istraživanja je bio uporediti prinose kukuruza FAO grupe od 300 do 700 ostvarenih gnojidbom koju prakticiraju poljoprivrednici u Vojvodini ( $150 \text{ kg ha}^{-1} \text{ N}$ ,  $50 \text{ kg ha}^{-1} \text{ P}$ ,  $50 \text{ kg ha}^{-1} \text{ K}$ ) sa prinosima koji su ostvareni na ostalih 19 varijanti pojedinačne i kombinirane gnojidbe NPK hraniva kako bi se utvrdila pogodnost količine hraniva u sušnoj 2021. godini. U prosjeku za sve hibride, značajno veći prinosi su ostvareni upotrebom manje doze N od prakse poljoprivrednika. Značajno veći prinosi su ostvareni primjenom  $100 \text{ kg ha}^{-1} \text{ N}$ ,  $100 \text{ kg ha}^{-1} \text{ N i K}$  ili  $50 \text{ kg ha}^{-1} \text{ N, P i K}$ . Utvrđeno je da u NPK kombinacijama sa  $50 \text{ kg ha}^{-1} \text{ P i K}$ , sa svakim kg dodanog N dolazi do smanjenja prinosa za  $3,7 \text{ kg ha}^{-1}$ . Hibridi FAO grupa od 300 do 500 nisu pokazali značajno povećanje prinosa variranjem N, P, K hraniva u odnosu na praksu. Usporedbom prinosa ostvarenog u praksi poljoprivrednih proizvođača sa onim na varijanti  $50 \text{ kg ha}^{-1} \text{ NPK}$ , prinos ovih hibrida se u prosjeku smanjio za  $2,4 \text{ kg ha}^{-1}$  sa svakim kilogramom dodanog N. Primjenom  $100 \text{ kg ha}^{-1} \text{ N}$ ,  $100 \text{ kg ha}^{-1} \text{ P i K}$  ili  $50 \text{ kg ha}^{-1} \text{ N, P, K}$ , prinos hibrida FAO grupe 600 bio je značajno veći u odnosu na praksu. Kod FAO grupe 700 povećanje prinosa od  $620 \text{ kg ha}^{-1}$  sa  $50 \text{ kg ha}^{-1} \text{ N, P, K}$  bilo je značajnije od prinosa koji je ostvaren uobičajenom gnojidbom u praksi. Bez obzira na FAO grupu, najmanje doze N u kombinaciji sa najmanjim dozama P i K su u sušnoj godini imale bolji učinak na prinose kukuruza od doze N koja se primenjuje u praksi.

**Ključne riječi:** prinos kukuruza, suša, NPK, Vojvodina, poljoprivredna praksa

## **Yield of FAO 300 – 700 corn hybrids achieved with individual and combined NPK in a dry year**

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### **Summary**

The study's aim was to compare the corn yields of FAO groups 300-700 attained by farmers' practice in Vojvodina province ( $150 \text{ kg ha}^{-1} \text{ N}$ ,  $50 \text{ kg ha}^{-1} \text{ P}$ ,  $50 \text{ kg ha}^{-1} \text{ K}$ ) with yields attained on the other 19 individual and combined fertilization variants in order to determine the suitability of the amount of nutrients in the dry year of 2021. On average, for all hybrids, significantly greater yields were obtained with a lower dose of N than farmers' practice. Yields were significantly greater with  $100 \text{ kg ha}^{-1} \text{ N}$ ,  $100 \text{ kg ha}^{-1} \text{ N}$  and K, or  $50 \text{ kg ha}^{-1} \text{ N}$ , P, and K. It was found that in NPK combinations with  $50 \text{ kg ha}^{-1} \text{ P}$  and K, each kg of N added reduced yield by  $3.7 \text{ kg ha}^{-1}$ . Compared to farmers' practices, FAO 300-500 hybrids didn't show a significant increase in yield by altering N, P, and K. When the yield achieved by farmers' practices was compared to that of  $50 \text{ kg ha}^{-1} \text{ NPK}$ , the yield of these hybrids declined by  $2.4 \text{ kg ha}^{-1}$  with each kg of N added, on average. The FAO 600 hybrid yielded significantly more than the farmers' practice with  $100 \text{ kg ha}^{-1} \text{ N}$ ,  $100 \text{ kg ha}^{-1} \text{ P}$  and K, or  $50 \text{ kg ha}^{-1} \text{ N}$ , P, K. In the FAO 700 hybrid, the yield with  $50 \text{ kg ha}^{-1} \text{ N}$ , P, K was significantly higher than the yield achieved by farmers' practice, with the difference of  $620 \text{ kg ha}^{-1}$ . Regardless of FAO group, the smallest N doses combined with the smallest P and K doses in the dry year had a better effect on grain production than the N dose used in farmers' practice.

**Key words:** corn yield, drought, NPK, Vojvodina province, farmers' practice

## Utjecaj ponovljene sjetve kukuruza na pojavu i štetnost kukuruzne zlatice tijekom 2020. godine

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### Sažetak

Kukuruzna zlatica (*Diabrotica virgifera virgifera* LeConte) štetnik je kukuruza koji se javlja u uvjetima ponovljene sjetve. Cilj istraživanja bio je utvrditi veličinu populacije i oštećenje kukuruza od kukuruzne zlatice u uvjetima ponovljene sjetve. Istraživanje je provedeno u Gorjanima tijekom 2020. godine na hibridu kukuruza OS 378. U istraživanje su uključena dva tretmana ponovljene sjetve (P1 – kukuruz zasijan drugu godinu za redom, P2 – treću godinu za redom). Let kukuruzne zlatice pratio se žutim ljepljivim pločama od lipnja do listopada. Štete od ishrane ličinki utvrđene su očitanjem: oštećenja korijena, veličine korijena i razvoja sekundarnog korijenja. Za ocjenu šteta na korijenu uzimano je 5 biljaka u 8 ponavljanja po tretmanu. Pojava kukuruzne zlatice zabilježena je na obje parcele. Brojnost imaga u prosjeku po danu i mamcu iznosila je 1,07 na P1 i 0,99 na P2. Utvrđeno je prosječno oštećenje korijena 0,59 (P1), odnosno 1,22 (P2). Prosječna veličina korijena bila je 2,73 na P1, a 3,70 na P2, prosječni porast sekundarnog korijenja iznosio je 2,88 (P1), odnosno 3,45 (P2). Veća oštećenja te slabiji porast korijena i sekundarnog korijenja zabilježeni su na P2, što ukazuje kako svaka dodatna godina monokulture može uzrokovati smanjenje prinosa. Prinos kukuruza na P2 bio je manji za 1,09 t/ha u odnosu na P1. Na ovim površinama ne preporuča se daljnji uzgoj kukuruza u monokulturi te se preporuča višegodišnji plodored.

**Ključne riječi:** kukuruz, kukuruzna zlatica, oštećenje korijena, ponovljena sjetva

## **Influence of repeated sowing of maize on the occurrence and damage of the western corn rootworm during 2020**

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### **Summary**

The western corn rootworm (WCR) (*Diabrotica virgifera virgifera* LeConte) is a significant pest of maize that occurs under conditions of repeated sowing. The aim of the study was to determine the size of WCR population and maize root damage from larvae in the conditions of repeated sowing. The research was conducted in Gorjani in 2020 on the maize hybrid OS 378. The research included two treatments of repeated sowing (P1 – two years maize monoculture, P2 – three years maize monoculture). Yellow sticky traps are used to monitor the flight of the WCR from June to October. Maize root damage from WCR larvae was determined by: root damage, root size and development of secondary root. Damage assessment was made on 5 plants in 8 replicates per treatment. The occurrence of WCR was recorded on both treatments. The number of adults per day and trap was 1.07 on P1 on average and 0.99 on P2. The average root damage was 0.59 (P1) and 1.22 (P2). The average root size was 2.73 on P1 and 3.70 on P2, the average secondary root regrowth was 2.88 (P1) and 3.45 (P2). Greater damage and lower root regrowth were recorded on P2, indicating that each additional year of maize monoculture may cause yield reduction. Maize yield on P2 was lower by 1.09 t/ha compared to P1. The further cultivation of maize monoculture is not recommended on these plots and crop rotation is recommended.

**Key words:** maize, western corn rootworm, root damage, repeated sowing



## Prinos BC hibrida kukuruza u proizvodnim pokusima u 2021. godini

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### Sažetak

U proizvodnoj 2021. godini obrađeno je 86 lokacija s prosječno osam BC hibrida kukuruza po lokaciji. Sjetva pokusa obavljena je na gotovo svim lokacijama u optimalnom roku, uvjeti za sjetvu su bili uglavnom dobri što je dovelo do brzog nicanja i ostvarenja zadanih sklopova. Zaštita od korova, kultivacija i prihrana obavljene su u povoljnim vremenskim prilikama i stanju umjerene vlažnosti tla. Nakon prihrane slijedio je dugi period bez oborina (cijeli lipanj) što je utjecalo na porast kukuruza i u konačnici na znatno skraćenje stabljike. U srpnju kada je kukuruz bio u oplodnji, bile su povoljne vremenske prilike što se tiče temperatura uz zadovoljavajuće količine oborina izraženije na zapadnom dijelu Hrvatske. U prvoj dekadi kolovoza nastavljeni su povoljni uvjeti za razvoj kukuruza. Zadnja dva tjedna u kolovozu izostale su uobičajene ekstremno visoke temperature uz potpuni nedostatak oborina. U rujnu imamo nastavak sušnog perioda u Slavoniji i središnjoj Hrvatskoj te učestale oborine na zapadu zemlje koje su produžile vegetaciju što je utjecalo na urode i sadržaj vode u zrnu. Rezultati obrade podataka svih članova u svim pokusima pokazuju prosječni prinos od 10,31 t ha<sup>-1</sup>, prosječni sadržaj vode u zrnu pri berbi od 21,63% uz ostvarenje prosječnog sklopa od 69.244 biljaka ha<sup>-1</sup>. Iz provedene analize rezultata vidljiva je razlika uroda u Slavoniji u odnosu na zapadni dio Hrvatske, a što je direktna posljedica većeg stresa na istoku zemlje zbog nedostatka oborina. Tako je najnoviji hibrid BC415 u četiri najistočnije županije imao prosječni urod 8,85 t ha<sup>-1</sup> s prosječnim sadržajem vode u zrnu 22,83%, dok je u ostalim županijama iznosio 11,59 t ha<sup>-1</sup> i sadržajem vode 23,31%. Ovakva značajna razlika u urodu i sadržaju vode u zrnu vidljiva je i kod ostalih hibrida (Agram, BC323, Majstor i Instruktor). Najbolji rezultat u 2021. godini od 17,19 t ha<sup>-1</sup> postigao je hibrid BC415 na lokaciji Badličan u Međimurskoj županiji.

**Ključne riječi:** proizvodni pokusi, kukuruz, hibridi, prinos

## BC maize hybrids yield in performance trials in 2021

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### Summary

A total of 86 trials were processed in 2021 with an average of eight BC maize hybrids per location. The planting of the trials was performed at almost all locations at the optimum planting time, the planting conditions were generally favourable, which led to the rapid seed germination and the expected plant densities were achieved. Crops protection, same as cultivation and fertilization of crops, was performed in favourable weather conditions and in a state of moderate soil moisture. After the fertilization was completed in June, there was a long period without the precipitation which had affected the growth of maize and ultimately resulted with a significant shortening of the stem. During the July, at the peak of maize fecundation, we had favourable weather conditions in terms of temperature level, with satisfactory amounts of precipitation again. This was more pronounced in the western part of Croatia. In the first decade of August, preferred conditions for the development of maize continued. For the last two weeks in August there was an absence of the usual, extremely high, temperatures along with a complete absence of precipitation. The period without rain continued during September in Slavonia and Central Croatia, and on the other hand, frequent precipitation in western parts of Croatia prolongate vegetation which affected both yield and grain moisture. The outcome of all processed results shows the average yield of 10.31 t ha<sup>-1</sup>, average grain moisture at harvest of 21.63% with an average plant density of 69.244 plants ha<sup>-1</sup>. The analysis of the results shows the difference between maize yield from trials in Slavonia in relation to the yield from trials in western part of Croatia. This is a direct consequence of greater stress that maize suffered in the east of the country due to lack of precipitation. Thus, the newest hybrid BC415 in the four easternmost counties had an average yield of 8.85 t ha<sup>-1</sup> with an average grain moisture of 22.83% and in other counties 11.59 t ha<sup>-1</sup> and grain moisture of 23.31%. This significant difference in yield and grain moisture is visible in other hybrids also (Agram, BC323, Majstor and Instruktor). The best trial results in 2021 are at the location of Badličan (Međimurje county) of 17.19 t ha<sup>-1</sup> in a field planted with hybrid BC415.

**Key words:** production trials, maize, hybrids, yield

## Identifikacija i rasprostranjenost rezistentnih populacija divljeg sirka na nikosulfuron u Hrvatskoj

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### Sažetak

Cilj istraživanja bio je utvrditi razlike u osjetljivosti populacija divljeg sirka (*Sorghum halepense*) na herbicid nikosulfuron u Republici Hrvatskoj. Za vrijeme trajanja trogodišnjeg monitoringa sakupljeno je 38 uzoraka divljeg sirka u usjevima kukuruza tretiranim ALS inhibitorima uzastopno više godina. Uzorci su sakupljeni na području 12 županija. Herbicidno sredstvo na osovi nikosulfurona primijenjeno je na uzgojene biljke divljeg sirka u najvišoj registriranoj dozi za primjenu u kukuruзу i trostruko većoj dozi. Obzirom na postotak preživljavanja, populacije divljeg sirka klasificirane su na visoko rezistentne, rezistentne, umjereno rezistentne i osjetljive. Rezultatima je potvrđena prisutnost visoko rezistentnih populacija divljeg sirka na 15 lokaliteta u šest županija. Rezistentne populacije utvrđene su u dvije županije te je utvrđena jedna umjereno osjetljiva populacija. Rezistentne populacije divljeg sirka utvrđene su na područjima Koprivničko-križevačke, Zagrebačke, Sisačko-moslavačke, Vukovarsko-srijemske, Osječko-baranjske i Brodsko-posavske županije. Utvrđene rezistentne populacije divljeg sirka na nikosulfuron u usjevima kukuruza ukazuju na nužne promjene u pristupu suzbijanja korova. Potrebna je primjena antirezistentnih strategija koje, između ostalog, uključuju integrirani pristup suzbijanju korova te praćenje pojave rezistentnih populacija divljeg sirka, ali i drugih korovnih vrsta.

**Ključne riječi:** ALS inhibitori, kukuruz, nikosulfuron, rezistentnost, *Sorghum halepense*

## Identification and distribution of *Sorghum halepense* populations resistant to nicosulfuron in Croatia

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### Summary

The aim of the study was to determine the differences in the susceptibility of johnsongrass (*Sorghum halepense*) populations to the herbicide nicosulfuron in the Republic of Croatia. During the three-year monitoring, 38 samples of johnsongrass were collected in maize fields which were known to have been treated with ALS inhibitors for several years. Samples were collected in the area of 12 counties. The nicosulfuron based product was applied on cultivated johnsongrass plants in the highest registered dose for use in maize and three times higher dose. According to the survival rate of plants, johnsongrass populations were classified as highly resistant, resistant, moderately resistant and susceptible. The results of the study confirmed the presence of highly resistant johnsongrass populations at 15 localities in six counties. Resistant populations were identified in two counties. One moderately sensitive population was also identified. Resistant populations of johnsongrass have been determined in the Koprivnica-Križevci, Zagreb, Sisak-Moslavina, Vukovar-Srijem, Osijek-Baranja and Brod-Posavina counties. Established resistant populations of johnsongrass to nicosulfuron in maize fields indicate need for changes in the approach to weed control. The application of anti-resistance strategies is needed, which, among other things, include an integrated approach to weed control and monitoring the occurrence of resistant populations of johnsongrass, but also other weed species.

**Key words:** ALS inhibitors, johnsongrass, maize, nicosulfuron, resistance

## Rezultati sustavnog praćenja krumpirovih cistolikih nematoda u Hrvatskoj od 2001. do 2021.

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### Sažetak

Sustavno praćenje pojave i raširenosti krumpirovih cistolikih nematoda (KCN), zlatnožute krumpirove cistolike nematode - *Globodera rostochiensis* (Wollenweber, 1923) i blijedožute krumpirove cistolike nematode - *Globodera pallida* (Stone, 1973), u Hrvatskoj se provodi od 2001. godine kada je potvrđen prvi nalaz zlatnožute krumpirove cistolike nematode na području Belice u Međimurskoj županiji. Krumpirove cistolike nematode (KCN) su najvažniji štetni organizmi krumpira u svijetu. Osim na krumpiru, najvažnijem domaćinu, ove nematode se mogu razvijati i na drugim vrstama iz porodice *Solanaceae* (npr. rajčica, patlidžan, neke korovne vrste). Obje vrste su regulirane kao karantenski štetni organizmi za koje je poznato da se pojavljuju na području EU (Provedbena Uredba Komisije (EU) 2019/2072 Prilog II dio B) i njihova prisutnost je potvrđena u većini zemalja EU. Prvi nalaz sa visokom populacijom *G. rostochiensis* potvrđen je na poljima gdje je konzumni krumpir uzgajan u monokulturi. Od tada se u sklopu programa posebnog nadzora provodi sustavno praćenje pojave i raširenosti KCN vizualnim pregledima u vegetaciji i prikupljanjem uzoraka tla na cijelom području Hrvatske. Programom posebnog nadzora kroz laboratorijske analize uzoraka tla potvrđena je prisutnost vrste *G. rostochiensis* na pojedinim lokalitetima Međimurske, Varaždinske, Zagrebačke i Primorsko-goranske županije, a *Globodera pallida* na nekoliko lokaliteta u Međimurskoj i Varaždinskoj županiji. U posljednjih nekoliko godina laboratorijskim analizama potvrđuje se vrlo niska i nevitarna populacija ovih nematoda.

**Ključne riječi:** KCN, *Globodera rostochiensis*, *Globodera pallida*, program posebnog nadzora, laboratorijska analiza

## The results of the monitoring of the potato cyst nematodes in Croatia from 2001 to 2021

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### Summary

Since 2001 in Croatia has been carried the systematic monitoring of occurrence and widespread of potato cyst nematodes (PCN), golden-yellow potato cyst nematode - *Globodera rostochiensis* (Wollenweber, 1923) and pale-yellow potato cyst nematode - *Globodera pallida* (Stone, 1973), when was confirmed for the first time of golden-yellow potato cyst nematode at the area of Belica in the Međimurska County. Potato cyst nematodes (PCN) are the most important potato pests in the world. In addition to potato, of the most important host of these nematodes, there can also develop on other species of the *Solanaceae* family (e.g. tomatoes, eggplant, some weed species). Both species are regulated as quarantine pests known to occur in the EU (Commission Implementing Regulation (EU) 2019/2072 Annex II, Part B) and their presence has been confirmed in most of the EU countries. The presence of *G. rostochiensis* was first recorded in fields where the consume potatoes were grown in monoculture with high the nematode population. Since then, as part of the surveillance program, it has been carried out the systematic monitoring of occurrence and widespread of PCN by visual inspections in a growing season and by collecting soil samples on the whole Croatian territory. The program of survey through the laboratory analyses of the soil samples confirmed the presence of *G. rostochiensis* at some locations of the Međimurska, Varaždinska, Zagrebačka and Primorsko-Goranska Counties and *Globodera pallida* at several locations in the Međimurska and Varaždinska Counties. In the last few years, the laboratory analyses to have confirmed a very low and non-vital the nematode population.

**Key words:** PCN, *Globodera rostochiensis*, *Globodera pallida*, survey program, laboratory analyses

## Influence of reduced N-fertilization with the use of microbial bioagents on corn, soybean and sunflower yields

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### Summary

Nitrogen mineral fertilizers are the major production input for grain crops. Due to rapid leaching, denitrification and volatilization N-fertilizers should be applied nearest the time when needed by a crop. For these reasons, and others such as price, environmental protection, manipulation, storage, etc., scientists are investigating how the use of mineral fertilizers can be reduced by using microbial bioagents. Among the most well-known nitrogen fixators are certainly the nodule forming bacteria of the genera *Bradyrhizobium* and *Rhizobium*, which have been used for decades in soybean production around the world. However, there are also non-symbiotic nitrogen fixators such as rhizosphere bacteria from the genera *Azotobacter*, *Azospirillum*, etc., which can also fix atmospheric nitrogen. The aim of this study was to investigate the impact of reduced N-fertilization with the use of microbial bioagents on corn, soybean and sunflower yields. Used N-fertilizers were urea, calcium ammonium nitrate (CAN) and ammonium sulfo-nitrate (ASN) and their reductions by 50% with the use of microbial bioagents. Sunflower average yield ranged from 4.03 t ha<sup>-1</sup> (control) up to 4.72 t ha<sup>-1</sup> (urea). Reduced ASN application with microbial bioagent resulted only in a 0.6% lower yield (4.69 t ha<sup>-1</sup>) compared to urea application. Highest soybean grain yield was also achieved at urea application (5.21 t ha<sup>-1</sup>) and lowest at the control plot (4.41 t ha<sup>-1</sup>) whereby reduced ASN application with microbial bioagent resulted in a 1.9% lower yield (5.11 t ha<sup>-1</sup>). Corn average yield ranged from 8.47 t ha<sup>-1</sup> (control) up to 10.97 t ha<sup>-1</sup> (urea). The N-fertilizer reductions resulted in average with about 13% lower yields. Due to the reduction of nitrogen fertilizers we can expect lower grain yields of cultivated crops but depending on the rising prices of fertilizers, these yield losses can be acceptable.

**Key words:** nitrogen, soybean, corn, sunflower, nitrogen fixators

## Utjecaj tretiranja sjemena kukuruza polimerskom emulzijom i biostimulatorima na prinos i komponente prinosa

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### Sažetak

U 2021. postavljen je pokus na Visokom gospodarskom učilištu u Križevcima s dva vegetacijski različita hibrida kukuruza, FAO 400 (Delon) i FAO 500 (Atomic). Pokus je postavljen po slučajnom bloknom rasporedu u tri repeticije i šest varijanata: kontrola, Flobond SC 100, BPH04, Flobond SC 100 + BPH04, BSH05, Flobond SC 100 + BSH05. Flobond SC100 je vodotopiva emulzija nanescna na sjeme, koja tijekom vegetacije pospješuje usvajanje vode iz tla te u sušnom periodu smanjuje stres. Biostimulator BPH04 sadži bakteriju *Bacillus pulminis*, a BSH05 *Bacillus subtilis*. Cilj istraživanja bio je utvrditi utjecaj preparata te vremenskih prilika na prinos zrna i komponente prinosa kuruza: sklop, vlaga zrna u berbi, hektolitarska masa i masa 1000 zrna. Tijekom vegetacije, vremenski uvjeti bili su nepovoljni, osobito u lipnju i srpnju kada je palo 20,4 mm oborina. Oba hibrida ostvarili su u prosjeku značajno veći sklop kod tretmana Flobond 100 SC, te smjesama Flobond SC 100 + BPH04 i Flobond SC 100 + BSH05 (64890 biljaka ha<sup>-1</sup>) u odnosu na kontrolu (58800 biljaka ha<sup>-1</sup>). Tretmani Flobond SC 100, Flobond 100 SC + BPH04 i Flobond 100 SC + BSH05 ostvarili su značajno veći prinos (13,04 t ha<sup>-1</sup>) u odnosu na kontrolu (10,62 t ha<sup>-1</sup>). Oba biostimuladora ostvarila su značajno veći prinos (12,01 t ha<sup>-1</sup>) u odnosu na kontrolu. U pogledu mase 1000 zrna nije bilo značajnih razlika između varijanata, dok je kod hektolitarske mase ostvarena značajno veća vrijednost Flobandom SC 100 u usporedbi s ostalim varijantama.

**Ključne riječi:** hibridi kukuruza, Flobond SC 100, BPH04, BSH05, prinos i komponente prinosa zrna



## Influence of treatment of maize seeds with polymer emulsion and biostimulators on yield and yield components

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### Summary

In 2021, an experiment was set up at the Križevci College of Agriculture with two vegetation different maize hybrids, FAO 400 (Delon) and FAO 500 (Atomic). The experiment was set up according to a complete randomized design in three repetitions and six variants: control, Flobond SC 100, BPH04, Flobond SC 100 + BPH04, BSH05, Flobond SC 100 + BSH05. Flobond SC100 is a water-soluble emulsion applied to seeds, which during vegetation improves the absorption of water from the soil and reduces stress during the dry season. Biostimulator BPH04 contains *Bacillus pulminis* and BSH05 *Bacillus subtilis*. The aim of the study was to determine the influence of preparations and weather conditions on grain yield and maize yield components: plant density, grain moisture at harvest, hectoliter mass and weight of 1000 grains. During the vegetation, weather conditions were unfavorable, especially in June and July with 20.4 mm of precipitations. Both hybrids achieved on average a significantly higher composition in the treatment of Flobond 100 SC, and mixtures of Flobond 100 SC + BPH04 and Flobond 100 SC + BSH05 (64890 plants ha<sup>-1</sup>) compared to the control (58800 plants ha<sup>-1</sup>). The treatments Flobond SC 100, Flobond 100 SC + BPH04 and Flobond 100 SC + BSH05 achieved significantly higher yields (13.04 t ha<sup>-1</sup>) compared to the control (10.62 t ha<sup>-1</sup>). Both biostimulators achieved significantly higher yields (12.01 t ha<sup>-1</sup>) compared to the control. There were no significant differences between the variants in the mass of 1000 grains, while a significantly higher value of Flobondom SC100 was achieved compared to other variants in the hectoliter mass.

**Key words:** maize hybrids, Flobond SC 100, BPH04, BSH05, yield and grain yield components

## Učinak tretiranja sjemena polimerskom emulzijom i biostimulatorima u proizvodnji jarog ječma

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### Sažetak

Na Visokom gospodarskom učilištu u Križevcima u 2021. postavljen je pokus tretiranjem sjemena jarog ječma (sorta Dado) polimerom Flobond SC100, bakterijskim biostimulatorima i smjesom Flobond-a SC 100 i biostimulatora. Pokus je zasijan po slučajnom bloknom rasporedu u šest varijanta: (1) Kontrola, (2) Flobond SC 100, (3) BPH04, (4) Flobond SC 100 + BPH04, (5) BSH05 i (6) Flobond SC 100 + BSH05 u četiri repeticije. Flobond SC100 je superabsorbirajući polimer na vodenoj bazi kojim se obavlja sjeme, a tijekom vegetacije pospješuje usvajanje vode iz tla, te u sušnom periodu smanjuje stres biljke. BPH04 i BSH05 su mikrobiološki preparati. BPH04 sadrži bakteriju *Bacillus pulminis*, a BSH05 sadrži *Bacillus subtilis*. Cilj istraživanja bio je utvrditi utjecaj preparata na prinos zrna i komponente prinosa jarog ječma: sklop, dužina klasa, broj zrna u klasu, hektolitarska masa i masa 1000 zrna. Signifikantno najrjeđi sklop bio je u varijanti Flobond SC 100 (489,5 biljaka m<sup>2</sup>) i signifikantno najniži prinos (6,63 t ha<sup>-1</sup>). Razlog prorjeđenja sklopa je veći udio vode u biljkama zbog djelovanja absorbirajućeg polimera i višednevnih niskih temperature do -5 °C u fazi busanja sredinom travnja. Navedeno je dovelo do smanjenja sklopa za 16,5% i prinosa za 17,1% u odnosu na kontrolnu varijantu. U gustoći sklopa nije bilo statistički značajnih razlika između ostalih varijanti. Nadalje, nema statistički značajnih razlika u prinosu između ispitivanih varijanti: kontrola, BPH04 i BPH04 + Flobond SC100. Međutim, varijante BSH05 i BSH05 + Flobond SC100 imaju statistički značajno veći prinos u odnosu na ostale varijante.

**Ključne riječi:** ječam, Flobond SC 100, biostimulatori, komponente prinosa, prinos

## Effect of seed treatment with polymer emulsion and biostimulators in spring barley production

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### Summary

In 2021, an experiment was set up at the Križevci College of Agriculture by treating spring barley seeds (Dado variety) with the Flobond SC100 polymer, bacterial biostimulators and a mixture of Flobond SC 100 and biostimulators. The experiment was sown in a randomized block schedule in six variants: (1) Control, (2) Flobond SC 100, (3) BPH04, (4) Flobond SC 100 + BPH04, (5) BSH05 and (6) Flobond SC 100 + BSH05 in four repetitions. Flobond SC100 is water based, liquid, super absorbent polymer for seed coating. Applied to the seeds, during the growing season it enhances the absorption of water from the soil and reduces plant stress during the dry season. BPH04 and BSH05 are microbiological preparations to improve the plant growth. BPH04 contains *Bacillus pulminis* and BSH05 contains *Bacillus subtilis*. The aim of the study was to determine the effect of the preparation on grain yield and yield components of spring barley: plant density, ear length, number of grains per ear, hectoliter mass and weight of 1000 grains. Significantly the rarest plants density was in the Flobond SC 100 variant (489.5 plants m<sup>2</sup>) and significantly the lowest yield (6.63 ha<sup>-1</sup>). At the end of the tillering phase in mid-April, due to negative temperatures, the assembly decreased by 16.5% and the yield by 17.1% compared to the control variant. There were no statistically significant differences of the assembly between the other variants. There are no statistically significant differences in yield between the variants: control, BPH04 and BPH04 + Flobond SC100. Variants BSH05 and BSH05 + Flobond SC100 have a statistically significantly higher yield compared to other variants.

**Key words:** barley, Flobond SC 100, biostimulators, yield components, yield

## Investigation of the different sporidium numbers of the corn smut infection on the morphological and biochemical parameters of a fodder corn hybrid

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### Summary

The corn smut (*Ustilago maydis* (DC.) Corda) infection causes many problems in corn production in Hungary and worldwide as well. The fungus infects corn in vegetative and generative stages. The symptoms of infection are chlorosis, necrosis, tumor growth, and appearance of galls. This study aimed to investigate the effects of different sporidium numbers of the corn smut infection on morphological (plant height and stem diameter) and biochemical characteristics (relative chlorophyll and malondialdehyde (MDA) content) of corn (*Zea mays* cv. Armagnac). This study was conducted under field conditions and plants were infected in the 4-5 leaf stage. The inoculum was prepared in a laboratory from corn smut infected corn cobs, and spore numbers were set at 2 500, 5 000, and 10 000 in a Burkholder chamber. Parameters were measured 7 and 14 days after the corn smut infection. The relative chlorophyll content was significantly lower in the infected plants due to the different sporidium numbers of fungus at both measurement times. The different sporidium numbers of corn smut infection resulted in a high MDA concentration compared to the control plants at both sampling times. Plant height was shorter, stem diameter was thickened by the 10 000 sporidium number ml<sup>-1</sup> of corn smut infection 14 days after infection compared to the control plants. The lower concentrations (2 500 and 5 000 sporidium number ml<sup>-1</sup>) of corn smut did not affect the morphological parameters of corn. However, the biochemical parameters (relative chlorophyll and MDA content) were significantly affected by the corn smut infection. Thus, it appears that host plants can tolerate lower concentrations of the pathogen, but the biochemical parameters indicate that the lower concentrations of the pathogen also had impacts on these parameters.

**Key words:** corn smut, malondialdehyde, plant height, relative chlorophyll content, stem diameter



**Ribarstvo,  
lovstvo i  
pčelarstvo**

**06**

**Fisheries,  
Game Management  
and Beekeeping**



## Establishment of novel cyprinid genebanks in the National Centre for Biodiversity and Gene Conservation

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### Summary

Crucian carp (*Carassius carassius*) and Tench (*Tinca tinca*) are lentic cyprinid species native in the catchment area of Danube River in Hungary. Both species are facing the decline of their populations due to the loss and degradation of habitat and spawning areas, spread of invasive species and climate change. None of these species play a major role in present day aquaculture but their economic importance can grow in medium term. Their special characteristics such as tolerance against extremely high water temperatures and low levels of oxygen can make them ideal targets for future aquaculture. To preserve this potential for the future, the conservation of Tench and Crucian carp became inevitable. In order to reach this goal, the Hungarian University of Agriculture and Life Sciences and the National Centre for Biodiversity and Gene Conservation joined forces to establish the *ex situ in-vitro* and *in-vivo* gene banks of the species. As a first step molecular genetic studies were carried out in natural populations of both species. Samples were collected from populations covering the local habitats of the species. Nuclear and mitochondrial markers were used to describe the genetic variability and phylogenetic relations. The results of these studies supported us to choose the source populations of the gene banks. Finally, 301 Tench and 314 Crucian carp individuals were collected in the live genebank while 75 samples of Tench and 75 samples of Crucian carp are stored in the cryobank. The gene banks can serve as a good basis of breeding work and can also support restocking or stocking activities. It is important to emphasize that our conservation efforts cannot be successful without the protection and restoration of habitats and spawning grounds.

**Key words:** Tench, Crucian carp, conservation, genebank, molecular markers

### Acknowledgements

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## Selection programme for better performance of African catfish (*Clarias gariepinus*)

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### Summary

African catfish (*Clarias gariepinus*) is an important cultured fish species with high economic value. Despite its importance, the number of improvement programmes performed on this species is very limited, therefore, its genetic potential has not been completely explored yet. Besides, recent research suggests that the utilization of feed can also be improved by selection.

This study aimed to perform a selection programme on African catfish on half-industrial scale, in flow-through system for better growth-rate. F1 and F2 generations (n=3466) were fed with a commercial (control) feed and an experimental feed with low fish-meal content (treated) in duplicate for genetic mapping. Additionally, two positive selected lines (n=1861) were developed from specimens with the highest body mass fed with the experimental feed. The success of the selection was tested on the F3 generation (n=3083).

In the F1 generation, the control group has significantly higher average body mass compared to the treated groups, whereas in F2 one of the treated groups had higher body mass, which might be explained by habituation. The F3 generation proved that the positive selected lines have better performance fed with both the control and the experimental feed. Our results suggest that artificial selection is an effective tool to advance the growth rate and the feed utilization of this species.

**Key words:** African catfish, *Clarias gariepinus*, low fish-meal feed, selection

### Acknowledgements

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## Characteristics of fascioloidosis in cervids from Bjelovarsko-bilogorska County: a three year study

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### Summary

Fascioloidosis is a parasitic disease caused by invasive, alien trematode *Fascioloides magna*. Since its initial description in Baranja region in 2002, fascioloidosis has spread through majority of lowland and hilly habitats in Croatia, including Bjelovarsko-bilogorska County. During the three year period we have analyzed 217 red deer livers and 355 roe deer livers. Each liver was sectioned at approx. 2 cm thick slices, and thoroughly examined for gross lesions and various developmental stages of flukes. Determined total prevalence of infected livers was 65.4% in red deer and 11.3% in roe deer. According to hunting units, recorded prevalence in Bjelovar was 46.2% in red deer and 5.6% in roe deer, Grubišno polje (91.2%; 20.0%), Daruvar (77.8%; 13.9%), Garešnica (55.3%; 30.9%) and Čazma (63.6%, 11.1%). Determined stages of the parasite in total were as follows: migratory stages – average 1.87 (max. 12), juvenile fluke – 1.64 (max. 12), adult fluke – 6.93 (48), pseudocyst 3.58 (24), destroyed pseudocyst – 2.35 (76). Highest average number of migratory stages and juvenile flukes was determined in Grubišno polje unit (2.57; 1.93), adult flukes and pseudocyst in Daruvar unit (11.93; 6.03), and destroyed pseudocyst in Grubišno polje unit (4.59). Our results suggest that Bjelovar unit is least contaminated which corresponds to the number of red deer as definitive host. In the same time average number of destroyed and active pseudocysts shows positive effects of treatment in Grubišno polje unit. Highest risk of infection is present in Grubišno polje and Daruvar units.

**Key words:** red deer, *Fascioloides magna*, Bjelovarsko-bilogorska County, gross lesions

### Acknowledgement

The study was fully supported by Bjelovarsko-bilogorska County, Hunting Clubs and Croatian Science Foundation grant IP 8963: "Host-parasite interactions: a relation between three different types of hosts and *Fascioloides magna* infection"

## Novi nalazi invazivnog plavog raka *Callinectes sapidus* Rathbun, 1896 u jugoistočnom Jadranu

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### Sažetak

Plavi rak *Callinectes sapidus* Rathbun 1896, porijeklom je iz voda zapadnog Atlantskog oceana i jedan je od 100 najinvazivnijih vrsta na svijetu. U Hrvatskoj je prvi put zabilježen 2004. godine na području Stonske solane i ušća rijeke Neretve. U lagunama ušća Neretve plavi je rak uspostavio snažnu i potencijalno komercijalnu populaciju. Ovaj rad opisuje recentne nalaze duž obale jugoistočnog Jadrana. Područje istraživanja nalazilo se u Dubrovačko-neretvanskoj županiji u blizini gradova Stona i Mlina. Korištene su žičane vrše dimenzija 64x63x24 cm, u obliku pravokutne prizme s dva ulaza (26x10 cm). Vrše su postavljane u poslijepodnevnim satima i ostavljene u moru 24 sata. Ulovljeni rakovi obrađeni su u laboratoriju, gdje je izmjerena širina i masa. Tijekom ovog istraživanja ukupno je ulovljena i analizirana 61 jedinka. U kanalima koje koristi Stonska solana ulovljeno je 29 jedinki. Tijekom svibnja u analiziranom uzorku sve jedinke su bili mužjaci, dok je prva ženka ulovljena krajem srpnja. Prosječna širina iznosila je 136 mm ( $\pm 19,76$ ), a prosječna masa 203 g ( $\pm 86,87$ ). Na području Mlina ulovljena je 31 jedinka, 1 mužjak a 30 ženka, prosječne širine 136 mm ( $\pm 11,86$ ) i prosječne mase 133 g ( $\pm 32,35$ ). U rujnu je u uvali Bistrina na području izvora ulovljen jedan mužjak, širine 136 mm i mase 216,18 g. Rezultati ovog istraživanja pokazuju da se plavi rak udomaćio u nekoliko novih područja na obali jugoistočnog Jadrana i da će svojom invazijom ugroziti ove prirodne ekosustave, a s obzirom na njegovu agresivnost moguć je i negativni utjecaj na uzgoj školjkaša u Malostonskom zaljevu u bliskoj budućnosti.

**Ključne riječi:** plavi rak, *Callinectes sapidus*, novi nalazi, Jugoistočni Jadran

## New records of invasive blue crab *Callinectes sapidus* Rathbun, 1896 in the South-Eastern Adriatic

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### Summary

The blue crab *Callinectes sapidus* Rathbun 1896, is native to waters of the western Atlantic, but is also one of the 100 most invasive species in the world. In Croatia, it was firstly reported in 2004 in the Ston salt work waters area and River Neretva estuary. A strong and potentially commercial population of blue crab has become established in the lagoons of the Neretva estuary. This paper describes recent records along the southeastern Adriatic coast. The study area was located in Dubrovnik-Neretva County near the towns of Ston and Mlini. Wire traps with dimensions 64x63x24 cm were used, shaped like a rectangular prism with two entrances (26x10 cm) and baited with trash fish. The traps were set in the afternoon and left in the sea for 24 hours. The captured crabs were taken to the laboratory where the width and weight were measured. A total of 61 specimens were caught during this 2021 survey. 29 of them were caught in the artificial channels used by the Ston salt work. The crabs caught in May were all males, while the first female was caught in late July. The average width was 136 mm ( $\pm 19.76$ ) and the average weight was 203 g ( $\pm 86.87$ ). The 31 specimens were caught in Mlini area and 30 of them were females with average width of 136 mm ( $\pm 11.86$ ) and average weight of 133 g ( $\pm 32.35$ ). In September, a single blue crab was caught in Bistrina Bay in the area of the springs. The specimen was male, 136 mm wide, and weighed 216.18 g. The results of this study show that the blue crab has established its population in several new areas in the southeastern Adriatic coast, and its invasion threatens these natural ecosystems, while we can conclude that a threat to bivalve farming in the Mali Ston Bay can be expected in the near future.

**Key words:** blue crab, *Callinectes sapidus*, new records, South-Eastern Adriatic

## Funkcionalni pokazatelji u mesu divljači

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### Sažetak

Meso divljači predstavlja nutritivno vrijednu namirnicu, obzirom na nizak sadržaj masti, kolesterola i kalorija, ali značajan izvor bjelančevina, kalija, fosfora, željeza, cinka, vitamina B12 i polinezasićenih masnih kiselina, uz poželjan aminokiselinski sastav. Sadržaj masti kreće se od <3 g/100 g kod krupne, do <4 g/100 g kod sitne divljači. Energija (kcal/100 g mišićnog tkiva) kreće se, primjerice, od 90 - 101 kod jelena, do 91,5 – 95 kod srnjaka. Ove vrijednosti su značajno niže u odnosu na meso goveda, svinja, janjadi ili peradi, kod kojih se one kreću od 114 do 231 kcal. Sadržaj mineralnih tvari sličan je kod svih vrsta divljači, pri čemu srednje vrijednosti iznose oko 1,3 %. Udio bjelančevina kreće se od 20,5 do 22,8 %. Također, nekoliko studija pokazalo je kako divlji preživaci imaju posebno povoljan odnos  $\omega$ -6/ $\omega$ -3 masnih kiselina, blizu 4, što je u skladu sa zdravstvenim smjernicama o prehrani. Sadržaj masti u mesu divljači može varirati obzirom na spol, dob, fiziološko stanje i reproduktivni status jedinke, godišnje doba, odnosno količinu i sastav raspoložive hrane u lovištu, te način lova. Međutim, na kvalitetu mesa divljači, po kojoj se ona razlikuje od mesa domaćih životinja, utječe način hranidbe i način života. Stoga je cilj ovog rada sakupiti referentne podatke iz dostupne literature o funkcionalnim pokazateljima u mesu divljači i usporediti ih s onima u srodnih domaćih životinja.

**Ključne riječi:** meso divljači, kvaliteta, funkcionalni pokazatelji

## Functional indicators of game meat

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### Summary

Game meat is a nutritionally valuable food, due to its low content of fat, cholesterol and calories, but a significant source of protein, potassium, phosphorus, iron, zinc, vitamin B12 and polyunsaturated fatty acids, with a desirable amino acid composition. Fat content ranges from <3 g / 100 g in large, to <4 g / 100 g in small game. Energy (kcal / 100 g of muscle tissue) ranges, for example, from 90 - 101 in red deer, to 91.5 - 95 in fallow deer. These values are significantly lower compared to the meat of cattle, pigs, lambs or poultry, where they range from 114 to 231 kcal. The mineral content is similar in all game species, with average values of about 1.3%. The protein content ranges from 20.5 to 22.8%. Also, several studies have shown that wild ruminants have a particularly favorable ratio of  $\omega$ -6 /  $\omega$ -3 fatty acids, close to 4, which is in line with health guidelines on diet. The fat content in game meat can vary depending on the sex, age, physiological condition and reproductive status of the individual, the season, i.e. the amount and composition of available food in the hunting ground, as well as the hunting methods. However, the quality of game meat, which distinguishes it from farm animal meat, is influenced by diet and lifestyle. Therefore, the aim of this paper is to collect reference data from the available literature on functional indicators in game meat and compare them with those in related farm animals.

**Key words:** game meat, quality, functional indicators

## Morfometrijska i kranimetrijska obilježja kune bjelice (*Martes foina*) s područja Dalmatinske zagore

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### Sažetak

Kuna bjelica (*Martes foina*) je zvijer iz porodice kuna (*Mustelidae*) koja je rasprostranjena na cijelom teritoriju Hrvatske. Cilj ovog rada je utvrditi morfometrijska i kranimetrijska obilježja kune bjelice s područja mediteranske Hrvatske. Tijekom dvije lovne godine (2020./21. i 2021./22.) prikupljena je 21 jedinka kune bjelice (13 mužjaka i 8 ženki) iz dva lovišta s područja Dalmatinske zagore. Svakoj jedinki je određen spol i utvrđena masa te je izmjereno 8 morfometrijskih i 16 kranimetrijskih mjera. Spolni dimorfizam je slabo izražen iako su mužjaci u prosjeku veći od ženki. Utvrđeno je da prosječna masa mužjaka iznosi  $1,297 \pm 0,245$  kg, a za ženke  $1,061 \pm 0,191$  kg, dok je prosječna dužina tijela s repom  $63,97 \pm 4,13$  cm kod mužjaka i  $60,4 \pm 5,47$  cm kod ženki, od čega na rep otpada 22 cm u prosjeku. Ukupna dužina lubanje za mužjake iznosi  $82,59 \pm 1,6$  mm, za ženke  $78,73 \pm 2,5$  mm, dok zigomatična širina iznosi  $49,81 \pm 2,35$  mm za mužjake odnosno  $45,7 \pm 3,76$  mm za ženke.

**Ključne riječi:** *Martes foina*, morfometrija, kranimetrija, kuna bjelica, Dalmatinska zagora

## Morfometric and craniometric characteristics of stone marten (*Martes foina*) from the Dalmatian hinterland

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### Summary

The stone marten (*Martes foina*) is a carnivore from the marten family (*Mustelidae*) which is widespread throughout Croatia. The aim of this paper is to determine the morphometric and craniometric characteristics of stone marten from the area of Mediterranean Croatia. During the two hunting years (2020/21 and 2021/22), 21 stone martens (13 males and 8 females) were collected from two hunting grounds in the Dalmatian hinterland. The sex and weight of each individual were determined and 8 morphometric and 16 craniometric measures were taken. There are no significant signs of sexual dimorphism, although males are on average larger than females. The average weight of males was found to be  $1.297 \pm 0.245$  kg, and for females  $1.061 \pm 0.191$  kg, while the average body length with tail was  $63.97 \pm 4.13$  cm in males and  $60.4 \pm 5.47$  cm in females. The tail accounts 22 cm on average. The total length of the skull for males is  $82.59 \pm 1.6$  mm, for females  $78.73 \pm 2.5$  mm, while the zygomatic width is  $49.81 \pm 2.35$  mm for males and  $45.7 \pm 3.76$  mm for females.

**Key words:** *Martes foina*, morphometry, craniometry, stone marten, Dalmatian hinterland



## Inherited cryoresistance of fish sperm: is it real?

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### Summary

Inherited cryoresistance of fish sperm was investigated in several subsequent generations of zebrafish (*Danio rerio*) and common carp (*Cyprinus carpio*). A set of experiments was designed to investigate the phenomenon observed earlier in salmonids, that the sperm of individuals hatched from fertilization with cryopreserved sperm performed better following cryopreservation in terms of motility and fertilizing capacity than the sperm of those hatched from fertilization with fresh sperm.

In order to investigate this, 8 full-sib families were created using the cryopreserved and fresh sperm of selected males in the zebrafish and six full-sib families in the common carp. Zebrafish families were grown until generation  $F_3$  while those of the common carp until generation  $F_2$  in a closed recirculating system. In each subsequent generation, sperm samples were collected, their fresh as well as post-thaw motility, concentration as well as fertilizing capacity was determined.

In the zebrafish, no statistically significant differences were found between the sperm quality parameters of fish originating from fresh or cryopreserved sperm in any of the investigated generations ( $F_1$ ,  $F_2$  and  $F_3$ ). This was partly due to the low volumes of sperm that can be collected from a single individual. In conclusion, zebrafish was not found to be a suitable model for this experiment. In the common carp, Of the originally created 7 families, 5 were selected for growout. Motility tests of males in the  $F_1$  generation have shown that the family of fish had no significant effect, while both the sampling date ( $p < 0.001$ ) and the origin of males had a significant effect ( $p = 0.024$ ,  $N = 46$  for cryopreserved,  $N = 63$  for fresh) on the progressive motility of cryopreserved carp sperm. No significant difference ( $p = 0.86$ ,  $N = 4$ ) was found between the fertilizing capacity of cryopreserved ( $87 \pm 5\%$ ) and fresh sperm ( $86 \pm 13\%$ ) of  $F_1$  males used to establish the  $F_2$  generation.

**Key words:** zebrafish, carp, sperm, cryopreservation, inheritance

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## Optimization of Leibovitz L-15 media for *in vitro* maturation of common carp ovarian follicles

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### Summary

Culture media conditions are key for successful stimulation of *in vitro* oocyte maturation (IVM). Here we describe the use and optimization of Leibovitz L-15, a galactose- and amino acid-rich medium, to support maturation of ovarian follicles isolated from common carp (*Cyprinus carpio*). Fully grown, postvitellogenic follicles were placed in maturation media consisting of 90% L-15 with antibiotics. The pH of the media was adjusted to either 7.5 or 8.5, with or without the addition of 0.1% Bovine Serum Albumin (BSA) or 10% Fetal Bovine Serum (FBS). Maturation was induced with 17 $\alpha$ ,20 $\beta$ -dihydroxy-4-pregnen-3-one (DHP), and its progress evaluated by scoring the percentage of follicles that underwent germinal vesicle breakdown (GVBD) and ooplasm clearing.

The pH of the maturation medium markedly influenced the outcome of IVM. Alkaline conditions (pH 8.5) resulted in higher percentage of GVBD (69%) compared to pH of 7.5 (52%). Incorporation of exogenous protein sources, such as BSA or FBS, additionally promoted DHP-induced maturation. The highest percentage of GVBD (93%) was present in media with 0.1% BSA, at pH 8.5. There was no spontaneous maturation in any of the control groups without DHP. Therefore, optimized L-15 media used in this study successfully maintained the viability of fish oocytes and their ability to mature, supporting its potential use in an IVM culture systems for further refining of spawning practices and providing alternative methods of egg production.

**Key words:** oocytes, DHP, Leibovitz L-15, GVBD

### Acknowledgements

The work/publication is supported by the EFOP-3.6.3-VEKOP-16-2017-00008 project co-financed by the European Union and the European Social Fund, by the Ministry of Innovation and Technology within the framework of the Thematic Excellence Programme 2020, National Challenges Subprogramme (TKP2020-NKA-16), as well as the NKFIH (OTKA) project number K138425.

## Wintering ecology of Common Buzzard *Buteo buteo* in the agricultural landscape of Eastern Poland

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### Summary

Common Buzzard is the most numerous wintering raptor in the agricultural landscape of eastern Poland. Due to the economic importance of the species (limiting the population of rodents in farmland) it is important to know its ecology not only during the breeding but also during the wintering period. A study in the eastern Poland assessed the behavior and habitat selection of the first sighted birds during a road survey. Road survey was used, with a car driving at a low speed, and two observers counting birds, recording distance, their behavior, habitat where Buzzards occurred. Most first sighted individuals were perched. Perch sites were mainly liked to different arable land and pastures. Perched individuals of Common Buzzards were also recorded very close to inhabited houses and other used buildings. Detailed analyses of land cover forms using QGIS software indicated that the perching buzzards rather preferred areas on the border of land cover forms. The studied birds avoided perch sites in the core (central) part of land cover forms. We discussed our results not only in ecological but also in crop protection dimension.

**Key words:** Common Buzzard *Buteo buteo*, farmland, East Poland

## Catch selection of small pelagic fish as a method for conservation of fish stocks in the Adriatic Sea

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### Summary

Small pelagic fish such as the European sardine (*Sardina pilchardus*) and the anchovy (*Engraulis encrasicolus*) are of great economic and ecological importance worldwide and account for about 20% of the global catch. According to the Croatian Bureau of Statistics, anchovies and sardines in the Adriatic Sea accounted for about 84% of the total marine fish catch in 2020. The world stock of sardines has declined drastically in recent years, as recruitment rates are at an all-time low. This decline is of particular concern in the context of the vulnerability of these populations, as they often respond quickly to environmental fluctuations that lead to rapid changes in their abundance, with several global collapses having occurred over time.

Overfishing has long been recognized as a leading ecological and socioeconomic problem in the marine environment, reducing biodiversity and altering ecosystem functioning. Bycatch is the part of the catch that was unintentional in fishing and that may then be retained and landed or discarded at sea; discards are the returned part of the catch. Fishing selectively means minimizing bycatch and discards and primarily catching target fish. Improving fishery selectivity is increasingly cited as a fishery management goal to address the unintended effects of fishing on non-target species, minimize waste, and improve fishery efficiency.

The research aims to determine the possibility of diversifying and adapting the fishing gear on board a fishing vessel to manipulate and improve the quality of the small pelagic fish catch, with the potential to separate juvenile fish from unwanted fish already caught, in order to conserve the small pelagic fish stock in the Adriatic Sea. The use of a fish pump (FAIVRE 8, France) to facilitate manipulation of the fishery is described, focusing on specific adaptation to separate seawater from catch in combination with potential fish selection.

**Key words:** small pelagic fish, *Sardina pilchardus*, *Engraulis encrasicolus*, overfishing, bycatch, selection

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## Genetic analyses of Invasive Bigheaded Carp (*Hypophthalmichthys spp.*) populations in Hungary.

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### Summary

Silver carp, (*Hypophthalmichthys nobilis*), bighead carp (*Hypophthalmichthys molitrix*) and their hybrids play an important role in aquaculture. The introduced stocks pose serious ecological risks worldwide. To address questions about the persistence and invasiveness of these fish, we need to better understand their population structure. The genetic structure of these filter-feeding fish populations inhabiting Lake Balaton and the Tisza River were examined with microsatellites and mitochondrial DNA markers. The Lake Balaton stock showed higher genetic diversity compared to the Tisza River stock.

The results showed that the two stocks are genetically different. Based on hierarchical clustering the Balaton stock included hybrid and silver carp individuals. All mitochondrial haplotypes originated from the Yangtze River. Based on the high genomic and mitochondrial diversity, along with heterozygosity surplus, the significant deviation from H–W equilibrium and the lack of evidence of bottleneck effect, it can be assumed that bigheaded carps do not reproduce in Lake Balaton. The present stock in Balaton may originate from repeated stockings and escapes from the surrounding fishponds. In contrast to this, the Tisza stock consists solely of silver carp individuals. This stock appears to have significant reproductive potential and may become invasive if environmental factors change due to climate change.

**Key words:** Silver carp, bighead carp, hybridization; genetic variability; invasiveness

### Acknowledgements

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## **Efikasnost meda od kestena u inhibiciji rasta višestruko otpornih sojeva *Klebsiella pneumoniae* i *Enterococcus faecium***

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### **Sažetak**

Višestruko otporni sojevi *Klebsiella pneumoniae* i *Enterococcus faecium* nalaze se na popisu najvećih prijetnji ljudskom zdravlju prema Svjetskoj zdravstvenoj organizaciji te su stoga potrebne alternativne metode njihove kontrole. Manuka med, jedan od najpoznatijih vrsta meda na svijetu, učinkovit je u inhibiciji njihovog rasta. Međutim, nedostaju dokazi o antimikrobnom djelovanju europskih unifloralnih vrsta meda, kao što je med od kestena (*Castanea sativa* Mill.) na ove patogene. U ovom istraživanju, ispitano je antimikrobno djelovanje kestenovog meda (n=10) prikupljenog u Hrvatskoj izravno od pčelara na višestruko otporne izolate *K. pneumoniae* (n=49) i *E. faecium* (n=20) prikupljene iz otpadnih voda i bolničkog okoliša. Nadalje, učinkovitost djelovanja meda od kestena uspoređena je s medom od manuke (*Leptospermum scoparium* JR et G. Forst) sakupljenog s Novog Zelanda (UMF 5+ i UMF 20+; UMF – engl. *Unique Manuka Factor*) budući da je popularnost manuka meda uvelike posljedica njegovog antimikrobnog djelovanja. Vrijednosti MIK i MBK za sve uzorke meda od kestena bile su u rasponu od 7,3 do 50,0 % za oba patogene. Uspoređujući MIK i MBK vrijednosti meda od kestena i manuke, svi uzorci meda od kestena bili su učinkovitiji od manuka UMF 5+ meda i bili su jednako ili više učinkoviti od manuka UMF 20+ meda, što jasno pokazuje da autentični med od kestena pokazuje isti ili bolji potencijal u inhibiciji višestruko otpornih patogena.

**Ključne riječi:** kestenov med, manuka med, antimikrobna aktivnost, višestruko otporne bakterije

## The efficiency of chestnut honey to inhibit the growth of multidrug-resistant strains of *Klebsiella pneumoniae* and *Enterococcus faecium*

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### Summary

Multidrug-resistant strains of *Klebsiella pneumoniae* and *Enterococcus faecium* are on the World Health Organization's list of the greatest threats to human health, and therefore alternative methods of their control are needed. Manuka honey, one of the world's most famous types of honey is effective in inhibiting their growth. However, there is a lack of evidence on the antimicrobial activity of European unifloral types of honey, such as chestnut honey (*Castanea sativa* Mill.), against those pathogens. In this study, the antimicrobial activity of chestnut honey (n=10) collected in Croatia directly from beekeepers was evaluated against multi-resistant isolates of *K. pneumoniae* (n=49) and *E. faecium* (n=20) from wastewater and hospital environment. Moreover, the efficiency of inhibition of chestnut honey was compared to manuka honey (*Leptospermum scoparium* JR et G. Forst) from New Zealand (UMF 5+ and UMF 20+; UMF - *Unique Manuka Factor*) as the popularity of manuka honey is largely due to its antimicrobial action. MIC and MBC values for all chestnut honey samples ranged from 7.3 to 50.0% for both pathogens. Comparing the MIC and MBC values of chestnut and manuka honey, all chestnut honey samples were more effective than manuka UMF 5+ honey, and were equally or more effective than manuka UMF 20+, clearly showing that authentic chestnut honey has the same or better inhibition potential against multidrug-resistant pathogens.

**Key words:** chestnut honey, manuka honey, antimicrobial activity, multidrug-resistant bacteria

## Morphological changes in common carp (*Cyprinus carpio*) progeny induced by the use of cryopreserved sperm

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### Summary

Cryopreservation of sperm in aquatic species is a common tool, however almost no research is conducted concerning the morphological changes caused by cryopreservation in the offspring.

In this research common carp P0 generation's sperm parameters were measured before creating the F1 generation. Firstly, a quicker method was tested for measuring the sperm concentration which was measured with CASA and also with a spectrophotometer. Both methods were suitable for concentration measurement however CASA was chosen for further investigations. Also, concentration was measured before cryopreservation to discover if the various concentrations can affect the cryoresistance of sperm. After thawing and measuring the motility of the differently diluted sperm (0.5; 1; 2;  $4 \times 10^9$  spermatozoa ml<sup>-1</sup>, standard, 1:9 dilution ratio) there was no significant main effect found on any of the parameters measured by CASA. In the fertilization rate there was only significant difference when eggs were fertilized with  $4 \times 10^9$  spermatozoa per ml, however it can be considered trivial due to the higher sperm-egg ratio. As a conclusion, pre-setting sperm concentration of common carp before cryopreservation offers no advantages over the traditional 10-fold dilution so for the further measurements 1:9 dilution ratio was used. The F1 generation was created using the same male's cryopreserved and fresh sperm creating a full-sib generation.

The F2 generation was created using the F1 generation sperm as follows: the fresh sperm of the F1 generation males originated from fresh sperm and cryopreserved sperm from the males originated from cryopreserved sperm was used creating another full-sib generation. Images were taken of the F2 generation fish and morphology parameters were compared between the two groups with canonical variates analysis (CVA). Fish originated from cryopreserved sperm generally had significantly smaller head, lower back and narrower caudal peduncle than those originated from fresh sperm. Our results suggest that the repeated use of cryopreserved sperm of common carp results in alterations in the post-thaw motility of sperm as well as in the morphology of individuals.

**Key words:** carp, sperm, CASA, concentration, morphology, cryopreservation

### Acknowledgements

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## Standardiziranje tehnologije sakupljanja pčelinjeg otrova

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### Sažetak

Pčelinji otrov je proizvod otrovne žlijezde radilica medonosne pčele (*Apis mellifera*) koji na tržištu postiže vrlo visoku cijenu te uz dovoljan broj pčelinjih zajednica na OPG-u i bolju organizaciju proizvodnje može biti dodatni izvor prihoda. Kao takav može amortizirati nestabilnost na tržištu meda, koji je još uvijek na mnogim pčelarskim OPG-ovima jedini proizvod. Međutim, nepostojanje standardizirane tehnologije proizvodnje pčelinjeg otrova potencijal proizvodnje pčelinjeg otrova nije ni približno dostignut. Kroz projekt „Standardiziranje tehnologije sakupljanja pčelinjeg otrova u svrhu povećanja održivosti OPG-a“ financiranog od strane Agencije za plaćanja u poljoprivredi, ribarstvu i ruralnom razvoju bi se testirale postojeće metode sakupljanja pčelinjeg otrova – sakupljanje na ulazu u košnicu i sakupljanje unutar košnice. Tijekom prve godine provedbe projekta, na dvije lokacije u Hrvatskoj (Osječko-baranjska županija i Primorsko-goranska županija) mjerila se kvaliteta sakupljenog pčelinjeg otrova mjerenjem udjela melitina. Prosječni udio melitina u uzorcima iz kontinentalnog dijela ( $63,16 \pm 2,68$  %) bio je značajno veći ( $U = 16,00$ ,  $p = 0,021$ ) od uzoraka iz primorskog dijela ( $50,32 \pm 2,68$  %). U drugoj godini projekta planirano je ponavljanje mjerenja.

**Ključne riječi:** medonosna pčela, pčelinji otrov, melitin

## Standardization of bee venom collection technology

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### Summary

Bee venom is a product of venom gland of honey bees (*Apis mellifera*) which achieves a very high price on the market and with a sufficient number of bee colonies on the family farm and better organization of production, it can be an additional source of income. As such, it can amortize instability in the honey market, which is still the only product on many beekeeping farms. However, the lack of standardized technology of bee venom production, the potential of bee venom production is not achieved. The project “Standardization of bee venom collection technology to increase the sustainability of family farms” funded by the Agency for Payments in Agriculture, Fisheries and Rural Development would test existing methods of bee venom collection - collection at the entrance to the hive and collection inside the hive. During the first year of project implementation, the quantity of collected bee venom were measured at two locations in Croatia (Osijek-Baranja County and Primorje-Gorski Kotar County) by measuring the content of melittin. The average share of melittin in the samples from the continental part ( $63.16 \pm 2.68\%$ ) was significantly higher ( $U = 16.00$ ,  $p = 0.021$ ) than the samples from the coastal part ( $50.32 \pm 2.68\%$ ). In the second year of the project, it is planned to repeat the measurements.

**Key words:** honey bee, bee venom, melittin

## Usporedba probojnosti olovne i čelične sačme u balističkom gelu

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### Sažetak

U posljednje vrijeme prisutan je trend redukcije olovnog streljiva u svijetu. Jedno od zamjenskih rješenja za olovnu sačmu je čelična sačma koja uzrokuje nepovjerenje kod nekih lovaca. Cilj ovog istraživanja je utvrditi upotrebljivost čelične sačme u praktičnom lovu. Analiza probojnosti vršena je na streljani Luže u Zagrebu pri temperaturi zraka od 6 °C. U testu je korištena sačmarica s cijevi duljine 73 cm kalibra 12/70. Konstrukcija cijevi je za olovnu sačmu sa suženjem od ½ čoka. U testu su korišteni blokovi 20 %-tnog balističkog gela izrađenog od goveđe želatine dimenzija 227x143x90 mm. Udaljenosti meta bile su 25, 30, 35 i 40 m. Korišteno je streljivo proizvođača M90, mase punjenja 28 grama i promjera sačme 2,1 mm. Broj kuglica u metku punjenom čeličnom sačmom je 756, barutnog punjenja težine 1,6 g te 518 zrna u onima punjenih olovom barutnog punjenja 1,3 g. U mete je pucano po jednim metkom. Ukupno je pucano sa 4 komada streljiva punjenog s čeličnom i 4 komada s olovnom sačmom. Ustanovljena je veća probojnost olovne sačme i to 21,7 % na 25 m, 27,4 % na 30 m, 19,3 % na 35 m te 47,1 % na 40 m. Obavljen je i test u lovu na divljeg kunića (*Oryctolagus cuniculus*) na području otoka Paga. Odstrijeljeno je po 10 kunića sa streljivom iz analize probojnosti pri čemu nisu zapažene razlike u efikasnosti između ova dva streljiva. Rezultati istraživanja pokazuju kako u ciljnoj balistici postoje značajne razlike između ove dvije vrste streljiva, no one su prihvatljive za lov na udaljenostima do 35 m.

**Ključne riječi:** čelična sačma, olovna sačma, balistički gel, probojnost

## Comparison of penetration of lead and steel shot in ballistic gel

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### Summary

Recently, there has been a trend of reducing lead ammunition in the world. One of the alternative solutions for lead shot is steel shot, which causes distrust among some hunters. The aim of this research is to determine the usability of steel shot in practical hunting. Penetration analysis was performed at the Luže shooting range in Zagreb at an air temperature of 6 ° C. A 73 cm 12/70 caliber shotgun was used in the test. The construction of the barrel is for lead shot with of ½ choke. Blocks of 20% ballistic gel made of bovine gelatin measuring 227x143x90 mm were used in the test. Target distances were 25, 30, 35 and 40 m. M90 ammunition with a loading weight of 28 grams and a shot diameter of 2.1 mm was used. The number of bullets in a bullet filled with steel shot is 756, gunpowder charge weighing 1.6 g and 518 grains in those filled with lead powder filling 1.3 g. Targets were shot at one bullet each. A total of 4 pieces of ammunition filled with steel and 4 pieces of lead shot were fired. A higher permeability of lead shot was found, namely 21.7% at 25 m, 27.4% at 30 m, 19.3% at 35 m and 47.1% at 40 m. A test in hunting wild rabbit (*Oryctolagus cuniculus*) in the area of the island of Pag was also performed. 10 rabbits were shot with ammunition from the penetration analysis, and no differences in efficiency were observed between these two ammunition. The results of the research show that in target ballistics there are significant differences between these two types of ammunition, but they are acceptable for hunting at distances up to 35 m.

**Key words:** steel shot, lead shot, ballistic gel, penetration

## Vremenska dinamika markiranja teritorija kod euroazijskog risa (*Lynx lynx*)

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### Sažetak

Euroazijski ris (*Lynx lynx*) spada u najugroženije sisavce u Hrvatskoj, primarno zbog parenja u uskom srodstvu. U istraživanju ove vrste, fotozamke su vrijedan alat jer omogućuju identifikaciju, determinaciju spola, bilježenje reprodukcije i dinamike korištenja prostora. Lokacije od posebnog značaja za postavljanje fotozamki su risja markirališta koja risovi često koriste za obilježavanje teritorija. U okviru projekta LIFE Lynx (LIFE16 NAT/SI/00634), na području Gorskog kotara su od 30. 04. 2018. do 10. 02. 2022. godine korištene fotozamke na 57 lokacija od čega na 39 risjih markirališta. Za potrebe ovog istraživanja analizirani su podaci prikupljeni s 9 najaktivnijih risjih markirališta u razdoblju od 1. 1. 2019. do 31. 12. 2021. godine na kojima je u ukupno 9510 fotozamka/dana zabilježeno 310 risjih posjeta, od čega 191 posjet mužjaka, 95 posjeta ženki te 24 posjeta risova nepoznatog spola. Analizom sezonske dinamike posjećivanja markirališta zabilježena je najveća risja aktivnost u veljači (37), rujnu (35), studenom (36) i prosincu (37), dok je u svibnju (14) i lipnju (10) zabilježen najmanji broj posjeta. Dnevna dinamika pokazala je najveću risju aktivnost na markiralištima u periodu od 17:00 do 20:00, dok je od 8:00 do 15:00 risja aktivnost bila najniža. Na temelju ovog istraživanja moguće je zaključiti kako monitoring risa na markiralištima ima smisla ograničiti na razdoblje od rujna do ožujka čime bi se optimizirao istraživački rad i smanjio rizik gubitka opreme na terenu.

**Ključne riječi:** euroazijski ris, *Lynx lynx*, fotozamke, aktivnost, markirališta

## Temporal dynamics of Eurasian lynx (*Lynx lynx*) territorial marking activity

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### Summary

The Eurasian lynx (*Lynx lynx*) is one of the most endangered mammals in Croatia, primarily due to inbreeding. In lynx research, camera traps are a valuable tool because they enable identification, gender determination, monitoring of reproduction and dynamics of habitat use. Locations of particular importance for camera trapping are lynx marking sites, often used for territory marking. Within the LIFE Lynx project (LIFE16 NAT/SI/00634), camera traps were set in Gorski kotar area from 30.04.2022 to 10.02.2022 on 57 different locations, of which 39 were lynx marking sites. For the purposes of this research, data collected from 9 most visited lynx marking sites was analyzed. In 9510 camera trap/days 310 lynx visits were recorded, of which 191 were male visits, 95 female visits and 24 visits by lynxes of unknown gender. The analysis of the seasonal visit dynamics has shown the highest number of visits in February (37), September (35), November (36) and December (37), while the lowest number of visits was recorded in May (14) and June (10). Daily dynamics analysis has shown the highest lynx marking activity in the period from 17:00 to 20:00, while from 8:00 to 15:00 activity was the lowest. Based on this research, it is concluded that lynx monitoring on marking sites can be limited to the period from September to March, in order to optimize research work and reduce the risk of equipment loss in the field.

**Key words:** Eurasian lynx, *Lynx lynx*, camera traps, activity, marking sites

## Fixation of histological specimens of juvenile testicular tissue of pikeperch (*Sander lucioperca*) and Euperch (*Perca fluviatilis*)

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### Summary

In order to be able to make detailed histological and immunoassays on the tissue of pikeperch (*Sander lucioperca*) and Euroasian perch (*Perca fluviatilis*), as two representatives of the Percidae family, it was necessary to make histological preparations. Primordial cells in percids have been shown to be very sensitive tissue in histological processing. We examined the effect of different fixatives: Formalin solution, neutral buffered, 10%; Formalin solution, 10%; NBF supplemented with 5% acetic acid; Formalin solution, 10% supplemented with 5% acetic acid; Davidson's fixative solution; Modified Davidson's Fixative (Hartmann's Fixative); Bouin's fixative and Carnoy's fixative. Samples of tissues, in two replicates were treated the same way before fixation- after excision they were placed in ice chilled Leibovitz-15 solution. Fixation was performed in an equal amount of fixative-1.8 ml for 24 h at a temperature of 4 °C. After stopping the fixation process, samples were washed in a row of several ethanol solutions with increasing concentrations. Staining of tissue was performed the same way for all the samples with eosin and hematoxylin. From the results of the trial it was concluded that in the case of juvenile testicles in both species, pikeperch and Euroasian perch, groups with the lowest degree of autolysis, and the best preservation was -10% Neutral Buffered Formalin solution, and the Simple formalin solution gave the weakest preserved cells of controlled tissue.

**Key words:** juvenile testicular, pikerperch, euperch

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## Microplastics in the bivalve *Venus verrucosa* L. in the Adriatic Sea

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### Summary

As an emerging pollutant microplastic has been confirmed in all marine habitats. Major environmental risks concerning microplastics would be their bioavailability to marine organisms particularly bivalves due to their sessile way of life and filter-feeding which exposes them directly to microplastic particles present in the water column. In present study we investigate the microplastic pollution in commercially important clams *Venus verrucosa* L. from 3 sites along coastline of Croatia (Lim bay, Šibenik bay and Mali Ston bay) including determination of number, shape and particle size of microplastic in individuals (N=36). The number of total microplastics varied from 1,16 MP/g in Šibenik bay to 2,11 MP/g in Lim bay. The most common microplastics were fibers (0,97 - 1,96 MP/g) followed by fragments (0,024 – 0,19 MP/g). The average size of microplastics found was 59,07µm and most common color was transparent. More comprehensive research should be conducted on microplastics in *Venus verrucosa* L. in the Adriatic Sea.

**Key words:** microplastics, Adriatic Sea, clams, *Venus verrucosa*



## Komparativna analiza fizikalno-kemijskih, spektralnih i morfoloških svojstava kestenova i manuka meda

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### Sažetak

Cilj je ovog rada bio utvrditi komparativne razlike između fizikalno-kemijskih, spektralnih i morfoloških svojstava kestenova i manuka meda. Uzorci meda od kestena (*Castanea sativa* Mill.) prikupljeni su s područja Hrvatske (n=10), a uzorci manuka meda (*Leptospermum scoparium* J.R. et G. Forst) s Novog Zelanda (n=2; UMF 5+ i UMF 20+). Uzorci su analizirani klasičnim fizikalno-kemijskim metodama (određivanje udjela vode, ukupnih šećera, električne provodnosti i pH vrijednosti), instrumentalnim analitičkim alatima (infracrvena spektroskopija s Fourierovom transformacijom: FTIR; plinska kromatografija-masena spektrometrija: GC-MS) te mikroskopskim tehnikama (optička mikroskopija; mikroskopija atomskih sila - AFM). Rezultati analiza pokazali su značajne razlike u vrijednostima fizikalno-kemijskih parametara. Prosječan udio vode u uzorcima kestenova meda iznosio je 15,7%, udio šećera 80,7 %, dok se raspon vrijednosti električne provodnosti kretao od 1,53 do 2,22 mS/cm, a pH vrijednost od 4,56 do 5,28. Prosječan udio vode u uzorcima manuka meda iznosio je 17,0 %, udio šećera 81,8 %, raspon vrijednosti električne provodnosti od 0,63 do 0,64 mS/cm, a pH vrijednost od 3,8 do 4,0. Utvrđene su i karakteristične FTIR-spektralne značajke, specifični kemijski profili isparljivih spojeva (u kestenovu medu dominiraju fenilpropanski derivati i nonanal, a u manuka medu fenilpropanski derivati) te razlike u morfološkim i površinskim svojstvima istraživanih vrsta meda.

**Ključne riječi:** kestenov med, manuka med, fizikalno-kemijska svojstva, spektralni profili, morfološka svojstva

## Comparative analysis of physico-chemical, spectral and morphological properties of sweet chestnut and manuka honey

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### Summary

The aim of this study was to determine comparative differences between physico-chemical, spectral and morphological properties of sweet chestnuts and manuka honey. Samples of sweet chestnut honey (*Castanea sativa* Mill.) were collected from Croatia (n = 10), and samples of manuka honey (*Leptospermum scoparium* JR et G. Forst) from New Zealand (n = 2; UMF 5+ and UMF 20+ ). Samples were analyzed by means of classical physico-chemical methods (determination of water content, total sugars, electrical conductivity and pH value), instrumental analytical tools (Fourier transform infrared spectroscopy: FTIR; gas chromatography-mass spectrometry: GC-MS), and microscopic techniques (optical microscopy, and Atomic Force Microscopy - AFM). The results have revealed significant differences in the values of the physico-chemical parameters. The average water content in sweet chestnut honey samples was 15.7%, the sugar content 80.7%, while electrical conductivity values ranged from 1.53 to 2.22 mS / cm, and the pH value from 4.56 to 5, 28. The average water content in analysed manuka honey samples was 17.0%, the sugar content 81.8%, and electrical conductivity and pH value ranged from 0.63 to 0.64 mS / cm and 3.8 to 4.0, respectively. Characteristic FTIR spectral features, specific chemical profiles of volatile compounds (chestnut honey was dominated by phenylpropane derivatives and nonanal, and manuka honey by phenylpropane derivatives), and differences in morphological and surface properties between the studied honey types were also determined.

**Key words:** sweet chestnut honey, manuka honey, physico-chemical properties, spectral profiles, morphological properties

## **Histological structure of mineralised red deer antler: application of three staining methods**

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### **Summary**

Red deer (*Cervus elaphus*) antlers are unique structures and only mammalian tissue capable of complete regeneration. The fact that their growth is completed within 4 months, makes them one of the fastest growing tissues in mammals. Starting from the near second year of life, antlers are casted and regrown each year in red deer, in a so-called antler growth cycle. It consists of 4 phases: growth, mineralisation, velvet shedding and casting. Mineralised antlers are made of a central cancellous (spongy) bone surrounded by a compact (cortical) bone extending longitudinally through the main beam and tines. We have collected antlers of red deer spikers 10 days after velvet shedding. Tissue samples were fixed with 10% buffered formalin and 70% alcohol. Demineralisation was made using Osteosoft® (mild decalcifier-solution based on EDTA). Differences in the histological structure were shown by routine staining method (H&E) and special staining methods: modified method for ossification process, Alizarin Red S - Alcian Blue and Villanueva's tetrachrome bone stain. Following the modified staining method for ossification process bone was presented as orange, while cartilage was blue. Alizarin Red S - Alcian Blue staining showed bone as red and cartilage as blue. Villanueva's tetrachrome bone stain showed osteoid as green, bone orange to red, osteocytes and canaliculi red, while nuclei of osteoblasts were dark purple. The results of our staining showed that mineralisation process is not completed with velvet shedding. Parts of the compact and cancellous bone are still containing remnants of non-mineralised cartilage. External thin layer of antlers still resembles to non-calcified tissue, which may eventually be lost during the maturation of antlers.

**Key words:** antler, red deer, staining methods, histology

**Stočarstvo**

**07**

**Animal  
Husbandry**



## Hranjiva i energetska vrijednost kukuruzne silaže na mliječnim farmama tri županije Istočne Hrvatske

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### Sažetak

Tržišno konkurentna visoka proizvodnja i kvaliteta mlijeka moguća je samo korištenjem krmiva visoke nutritivne i higijenske vrijednosti. Polazeći od prethodne pretpostavke, cilj ovog istraživanja bio je utvrditi kvalitetu kukuruzne silaže kao dominantne komponente u hrani mliječnih krava u tri županije: Brodsko-posavske, Osječko-baranjske i Vukovarsko-srijemske. Praktični dio istraživanja obuhvatio je 25 mliječnih farmi u svakoj Županiji u kojima je uzorkovana i potom analizirana kukuruzna silaža.

Praćeni nutritivni, fermentativni i fizički pokazatelji izraženi kao prosječne vrijednosti bili su zadovoljavajući, i kretali se: suha tvar (ST) = 349 g kg<sup>-1</sup>, sirove bjelančevine = 71 g kg<sup>-1</sup> ST, sirovi pepeo = 39 g kg<sup>-1</sup> ST, sirova vlaknina = 186 g kg<sup>-1</sup> ST, KDV = 212 g kg<sup>-1</sup> ST, NDV = 393 g kg<sup>-1</sup> ST, KDL = 17 g kg<sup>-1</sup> ST, škrob = 325 g kg<sup>-1</sup> ST i energetska vrijednost izražena u neto energiji mlijeka (NEL, MJ kg<sup>-1</sup> ST) = 6,78. Pokazatelji fermentacije buraga izraženi su kao prosječna probavljivost organske tvari (pOT) = 75,8 % u ST i probavljivost NDV-a (pNDV) = 53,7 % u ST. Pokazatelji fermentacije silaže uključili su mjerenje prosječne pH vrijednosti koja je iznosila 3,86, koncentraciju mliječne kiseline = 56,37 g kg<sup>-1</sup> ST i octenu kiselinu 20,68 g kg<sup>-1</sup> ST. Fizički pokazatelj se odnosi na određivanje distribucije veličine čestica silaže prosijavanjem preko tri sita, a vrijednosti su: sito 1 = 7,1 %, sito 2 = 56,3 %, sito 3 = 24,8 % i kutija na dnu = 11,7 %.

Na temelju značajnijih odstupanja u minimumu i maksimumu te utvrđivanjem većeg broja nesukladnih uzoraka kod nekih pokazatelja od prosječnih vrijednosti, navodi na zaključak o neujednačenoj kvaliteti silaže kod pojedinih proizvođača. Rezultati praćenih pokazatelja upućuju da je niža kvaliteta silaže posljedica krivo procjenjenog trenutka žetve kao i tehničko-tehnološki propusti tijekom postupka siliranja.

**Ključne riječi:** silaža, kukuruz, mliječne krave, nutritivna vrijednost

## Nutritional and energy value of corn silage on dairy farms in three counties of Eastern Croatia

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### Summary

Market competitive high production and quality of milk is possible only by using feeds of high nutritional and hygienic value. Following the previous assumption, the aim of this study was to determine the quality of corn silage as the dominant component in the diet of dairy cows in three counties: Brod-Posavina County, Osijek-Baranja County, and Vukovar-Srijem County. The practical part of this research included 25 dairy farms in each County in which corn silage was sampled and then analyzed.

The monitored nutritional, fermentative and physical indicators expressed as average values were satisfactory, and ranged: dry matter (DM) = 349 g kg<sup>-1</sup>, crude protein = 71 g kg<sup>-1</sup> DM, crude ash = 39 g kg<sup>-1</sup> DM, crude fiber = 186 g kg<sup>-1</sup> DM, ADF = 212 g kg<sup>-1</sup> DM, NDF = 393 g kg<sup>-1</sup> DM, ADL = 17 g kg<sup>-1</sup> DM, starch = 325 g kg<sup>-1</sup> DM and energy value expressed in net milk energy (NEL, MJ kg<sup>-1</sup> DM) = 6.78. Indicators of rumen fermentation expressed as average digestibility of organic matter (dOM) = 75.8% in DM and digestibility of NDF (dNDF) = 53.7% in DM. Indicators of silage fermentation included the measurement of an average pH of 3.86, a concentration of lactic acid = 56.37 g kg<sup>-1</sup> DM and acetic acid 20.68 g kg<sup>-1</sup> DM. Physical indicator refers to determining the size distribution of silage particles by sieving over three sieves, and the values are: sieve 1 = 7.1%, sieve 2 = 56.3%, sieve 3 = 24.8% and box at the bottom = 11.7%.

Based on significant deviations in the minimum and maximum, and by determining a larger number of non-compliant samples in some indicators than the average values, it can be concluded that there is an uneven quality of silage in some producers. The results of the monitored indicators indicate that the lower quality of silage is a consequence of the incorrectly estimated harvest time as well as technical and technological omissions during the ensiling process.

**Key words:** silage, corn, dairy cows, nutritional value, nutritional value

## Implementacija procjene životnog ciklusa (LCA) u održive sustave svinjogojske proizvodnje

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### Sažetak

Nova strategija Europske Unije, Europski zeleni plan odnosi se na razdoblje do 2030. godine te ima za cilj prelazak na kružno gospodarstvo uz smanjenje onečišćenja te održavanje bioraznolikosti. Najvažniju ulogu u osmišljavanju sustava proizvodnje hrane koji su prihvatljivi za okoliš te istovremeno osiguravaju proizvodnju sigurne hrane ima strategija „Od polja do stola“. Navedena strategija jedna je od ključnih mjera Europskog zelenog plana koja zajedno s postavljenim ciljevima zajedničke poljoprivredne politike vodi razvoju održivih poljoprivrednih sustava uz istovremenu zaštitu prirode te borbu protiv klimatskih promjena. Primjena metodologije procjene životnog ciklusa (LCA) podupire ciljeve postavljene Europskim zelenim planom u pogledu održivosti te razvoja resursno učinkovite ekonomije. Procjena životnog ciklusa predstavlja standardizirani okvir koji omogućuje identifikaciju ključnih točaka proizvodnje, a s ciljem pronalaska rješenja koji vode smanjenju negativnog utjecaja na okoliš. Provedba LCA studije rezultira zaštitom okoliša, ali također ima ekonomski, društveni te socijalni aspekt. Implementacija LCA okvira u sustav svinjogojske proizvodnje Republike Hrvatske ima potencijal u pogledu razvoja i standardizacije uzgoja autohtonih pasmina svinja u alternativnim sustavima, a s ciljem proizvodnje tradicionalnih proizvoda s dodanom vrijednosti.

**Ključne riječi:** autohtona pasmina, svinje, održivost, europski zeleni plan, procjena životnog ciklusa



## **Implementation of life cycle assessment (LCA) in sustainable pig production systems**

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### **Summary**

The new strategy of the European Union, the European Green Deal, referring to a period up to 2030, aims at the transition of agriculture to a circular economy while reducing pollution and maintaining biodiversity. In this aspect, the most important role in designing environmentally friendly food production systems and ensuring the production of safe food has “From farm to fork” strategy. This strategy is one of the key measures of the European Green Deal, which, together with the objectives of the common agricultural policy, leads to the development of sustainable agricultural systems while protecting nature and combating climate change. The implementation of the Life Cycle Assessment (LCA) methodology supports the goals set by the European Green Deal for sustainability and the development of a resource-efficient economy. Life cycle assessment is a standardized framework that allows the identification of key production points, with the aim of finding solutions that lead to the reduction of negative environmental impact. The implementation of the LCA study results in environmental protection, but also has economic, social, and societal impacts. The implementation of the LCA framework in Croatian pig production has the potential to develop and standardize the breeding of indigenous pig breeds in alternative systems, aiming at the production of traditional products with added value.

**Key words:** indigenous breed, pigs, sustainability, European green deal, life cycle assessment

## Mogućnosti proizvodnje jarećeg mesa na farmama mliječnih koza sjeverozapadne Hrvatske

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### Sažetak

Intenzivni uzgoj mliječnih pasmina koza ima dugu tradiciju u Međimurskoj i Varaždinskoj županiji. Obzirom da je osnovni cilj navedene proizvodnje mlijeko, od samog početka pokretanja proizvodnje na navedenom području prisutan je problem zbrinjavanja viška jaradi. Dio jaradi namijenjen je za obnovu stada, dio se prodaje za rasplod, a temeljni problem je nemogućnost plasmana jaradi za klanje. Cilj istraživanja bio je utvrditi mogućnosti proizvodnje jaradi za klanje na farmama koza u intenzivnoj proizvodnji mlijeka. Istraživanje je provedeno na 10 farmi koza u Međimurskoj i 5 u Varaždinskoj županiji. Na temelju podataka Hrvatske agencije za poljoprivredu i hranu vidljivo je da je u 2020. godini u obje županije bilo 3110 uzgojno valjanih grla koza. Plodnost je iznosila 1,1 iz čega možemo zaključiti da se uzgojilo približno 3400 jaradi. Utvrđeno je da većina uzgajivača ne registrira svu jarad upravo zbog nemogućnosti plasman za klanje tako da je broj jaradi uzgojene u obje županije značajno veći. Ako se od navedenog broja izuzme jarad za obnovu i prodaju za rasplod na tržište se potencijalno može plasirati najmanje od 2000 do 2500 jarećih trupova. Istraživanjem je utvrđeno da je glavni razlog nezainteresiranosti za proizvodnju jaradi za klanje, visoka otkupna cijena mlijeka i nedostatak organiziranog tržišta jarećeg mesa. Na dvije farme uzgajivači koriste mliječnu zamjenu u hranidbi jaradi čime su značajno smanjili troškove uzgoja i mogu biti konkurentni cijeni jarećeg mesa iz uvoza. Također, istraživanjem je utvrđeno da postoji veliki interes za jarećim mesom posebno među potrošačima na području grada Zagreba. Iz svega navedenog možemo zaključiti da uz odgovarajuću tehnologiju uzgoja i organizirani otkup i plasman, prodaja jaradi za klanje može osigurati povećanje prihoda farmi mliječnih koza na području sjeverozapadne Hrvatske.

**Ključne riječi:** jarad, meso, proizvodnja, prodaja

## Possibilities of goat kid meat production on dairy goat farms in North-West Croatia

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### Summary

Intensive breeding of dairy goat breeds has a long-standing tradition in Međimurje and Varaždin Counties. Considering the primary goal of this breeding is milk production, disposing of surplus goat kids had been an issue from the very beginning. A portion of the kids is intended for flock renewal, a portion is sold for breeding, but the fundamental problem remains in goat kid meat placement. The goal of this research was to establish the possibilities of kid meat production on dairy goat farms in intensive milk production. The research was conducted on 10 goat farms in Međimurje County and 5 in Varaždin County. The data obtained from the Croatian Agency for Agriculture and Food show that in 2020 both Counties had 3110 breeding goats. Fertility was 1.1 which points to the conclusion that around 3400 goat kids were bred. It was established that most breeders do not register all their goat kids precisely because of poor meat placement which means the number of goat kids is considerably higher in both Counties. If we were to deduct the goats used for flock renewal and those sold from the aforementioned number, there remains at least 2000 to 2500 goat kids for placement. The research established that the main reason for disinterest in producing goats for slaughter is the high goat milk redemption price and the lack of an organized market for goat meat. On two farms the breeders use milk formula when feeding goat kids thus reducing the cost of production, and they can compete with the price of imported goat meat. Furthermore, the researchers concluded there is great interest in goat kid meat, especially among consumers in Zagreb. Concluding from all of the above, we can state that by using the right technology and organizing redemption and placement, goat kid meat production can increase income on dairy goat farms in North-West Croatia.

**Key words:** goat kid, meat, production, sale

## Utjecaj zrenja polutvrđog kozjeg sira u ulju na njegov fizikalno-kemijski sastav

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### Sažetak

Cilj istraživanja bio je utvrditi utjecaj zrenja polutvrđog kozjeg sira u ulju (mješavina mljetskog ekstra djevičanskog maslinovog i rafiniranog suncokretovog ulja; 50:50) na njegov fizikalno-kemijski sastav. Proizvedeno je 5 šarži sira. Sirevi iste šarže podijeljeni su u 3 skupine s obzirom na način zrenja: 1) zrenje na zraku (kontrolna skupina), 2) zrenje u ulju nakon 10 dana zrenja na zraku, 3) zrenje u ulju nakon 20 dana zrenja na zraku. Sirevi su uzorkovani 0., 10., 20., 30., 45. i 60. dana zrenja te su provedene osnovne fizikalno-kemijske analize. Najmanji sadržaj suhe tvari, proteina, masti i soli ( $p < 0,01$ ) zabilježen je u skupini 2. Ulje kao medij za zrenje sira spriječilo je gubitak vode iz sira kada je uronjen u ulje 10. dana (skupina 2) čime se sadržaj suhe tvari, proteina, masti i soli nije značajno mijenjao. Međutim, njihov sadržaj se tijekom zrenja sireva iz skupina 1 i 3 značajno povećavao ( $p < 0,01$ ), s obzirom da se najveći gubitak vode odvija u prvih 20 dana zrenja na zraku. Sirevi iz skupine 3 imali su najveći sadržaj masti ( $p < 0,01$ ). Duže zrenje sira na zraku prije polaganja u ulje uvjetovalo je veći gubitak vode iz sira te nastajanje porozne strukture, što je vjerojatno omogućilo prodiranje ulja u tijesto sira. Zadržavanje vode u siru tijekom zrenja u ulju, odnosno ulazak ulja u tijesto sira mogu povoljno djelovati na konzistenciju sira te time omogućiti njegovu konzumaciju u periodima godine kada zbog sezonalne prirode nema proizvodnje kozjih sireva.

**Ključne riječi:** kozji sir, ulje, fizikalno-kemijski sastav, zrenje u ulju, polutvrđi sir

## **Influence of semi-hard goat cheese ripening in oil on its physicochemical composition**

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### **Summary**

The aim of this study was to determine the influence of semi-hard goat cheese ripening in oil (mixture of Mljet's extra virgin olive oil and refined sunflower oil; 50:50) on its physicochemical composition. Five batches of cheese were produced, and cheeses of the same batch were divided into 3 groups according to the ripening method: 1) ripening in the air (control group), 2) ripening in oil after 10 days of ripening in air, 3) ripening in oil after 20 days of ripening in air. Cheeses were sampled during ripening on days 0, 10, 20, 30, 45, and 60, and physicochemical analyses were performed. The lowest content of dry matter, protein, fat, and salt ( $p < 0.01$ ) was found in group 2. Oil as a cheese ripening medium prevented the water loss from the cheese (group 2), thus the content of dry matter, protein, fat, and salt didn't change significantly during ripening in oil. However, their content increased significantly ( $p < 0.01$ ) in cheeses from groups 1 and 3, since the noticeable water loss occurred in the first 20 days of ripening in the air. Group 3 had the highest fat content ( $p < 0.01$ ). Prolonged cheese ripening in the air before its immersion into the oil caused a greater water loss and the formation of a porous structure, which probably allowed oil to penetrate into the cheese. The water retention and oil entry into the cheese can have a beneficial effect on the cheese consistency and thus enable its consumption during periods of the year when there is no goat milk production due to seasonality.

**Key words:** goat milk cheese, oil, physicochemical composition, ripening in oil, semi-hard cheese

## A new microsatellite marker set for parentage testing and population analyses optimized for Croatian pig breeds

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### Summary

Microsatellite markers (MS) are widely used for parentage testing and population analyses in all types of livestock, including pigs. Since there is no commercially available MS set for genetic testing in pigs, there was a need to develop an appropriate set of markers for genotyping, parentage testing, and population analyses in Croatian autochthonous and commercial pig breeds.

Parentage analysis and parentage verification are very important for efficient genetic management in livestock breeding as they prevent unexpected, accidental, and undesired errors which can otherwise occur in pedigree records. Besides parentage testing, MS genotypes represent a successful and widely used tool of population genetics. For the needs of parentage testing, conservation, and population genetics, a new 16MS marker set was developed and tested in 578 samples of Croatian autochthonous and commercial pig breeds. All MS markers are from the ISAG/FAO recommendation list and show high polymorphism and heterozygosity in all tested Croatian pig breed populations (Banija spotted, Black Slavonian, Turopolje, Large White, Yorkshire, Pietren and Duroc). The mean number of alleles per locus of 16MS marker set ranged from 4.3 in Turopolje pig breed to 8.8 in Black Slavonian pig breed, expected heterozygosity from 0.4 in Turopolje pig breed to 0.7 in Banija spotted, Black Slavonian, Large White, Yorkshire and Pietren pig breeds. Polymorphic information content (PIC) was above 0.6 in all breeds except Turopolje and Duroc pig breeds. The combined non-exclusion probability for identity and parentage testing was high in all tested breeds.

All these parameters indicate that the set of 16MS markers is suitable for identity and parentage testing, as well as for population studies in Croatian pig breed populations.

**Key words:** microsatellite markers, parentage testing, identity verification, population genetics, pig breeding

## Novi alati za procjenu dobrobiti krava na mliječnim farmama

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### Sažetak

Dobrobit životinja oduvijek je bila važna vlasnicima farmi, jer je o stanju životinja i koristima koje su imali od njih ovisila kvaliteta života kako farmera tako i njihovih obitelji. Cilj ovog rada je ukazati na nove načine i mogućnosti koji mogu poslužiti za procjenu dobrobiti životinja, a u ovom slučaju mliječnih krava na farmama. Mnoge stočarski razvijene zemlje razvile su određene modele procjene dobrobiti životinja poput Švedske, Italije Norveške i drugih. Kao podloga za ovu temu korišten je Kanadski model.

Ovaj model procjenjuje dobrobit kroz četiri područja, odnosno 14 indikatora: dugovječnost (indikator: laktacija, izlučene i uginule krave), hranidba i proizvodnja (indikator: urea u mlijeku, menadžment, krave u tranziciji, krave u proizvodnji), telad i pomladak (indikator: smrtnost teladi i dob junica pri teljenju), te zdravlje i reprodukcija (indikator: pobačaj, razina beta-hidroksibutirata, broj somatskih stanica u mlijeku, odnos bjelančevina i masti u mlijeku, te hromosti i ozljeda krava). Krajnji rezultat modela je ocjena koja se izražava kroz indeks dobrobiti farme. Izračunati indeksi moći će uspoređivati farme, podaci o dobrobiti će se moći lakše tumačiti, a savjetovanje farmera o mjerama unaprjeđenja dobrobiti biti će učinkovitije.

**Ključne riječi:** procjena dobrobit, mliječne krave, novi alati

## New tools for assessing the welfare of cows on dairy farms

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### Summary

Animal welfare has always been important to farm owners, as the quality of life of both farmers and their families depended on the condition of the animals and the benefits they received. The aim of this paper is to point out new ways and possibilities that can be used to assess the welfare of animals, and in this case dairy cows on farms. Many livestock developed countries have developed certain models of animal welfare assessment such as Sweden, Italy, Norway, etc. The Canadian model has been used as a basis for this topic.

This model assesses well-being through four areas, i.e. 14 indicators: longevity (indicators: lactation, weaned and dead cows), feeding and production (indicators: urea in milk, management, cows in transition, cows in production), calves and young categories (indicators: calf mortality and calf age at calving), and health and reproduction (indicators: abortion, beta-hydroxybutyrate levels, number of somatic cells in milk, protein-fat ratio in milk, and lameness and injury of cows). The end result of the model is an estimate expressed through the farm welfare index. The calculated indices will be able to compare farms, welfare data will be easier to interpret, and advising farmers on welfare improvement measures will be more effective.

**Key words:** welfare assessment, dairy cows, new tools



## Effect of two different LED spectrum compositions on hatching egg production in hens

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### Summary

For birds, light plays a crucial role, which can primarily affect their reproduction cycle. The impact of the lengths and intensity of lighting is well-known, but little is known about the wavelength of light in the poultry sector. Therefore, two different light spectrums of LED (LED1: UV supplementation, 500-650 nm, the intensity is 50% less than LED2, the light spectrum of LED1 bulbs is more similar to the spectrum of natural light) were examined under the same light program and same light intensity. Broiler breeding pairs were kept in an intensive system with deep litter (6000 birds/house – 6 birds/m<sup>2</sup> – 9:1 sex ratio). Egg production intensity during the egg production period (23-46 weeks of age) and the number of hatching and table eggs were recorded.

In the case of the total production period, LED1 group performance was 0.6% better than the LED2 group. The egg production intensity of LED1 group was significantly ( $p < 0.05$ ) higher compare to LED2 group on week 29, 30, 38, 39, 40, 43 and 45. The decrease of egg production intensity of LED1 group after the peak production period was smaller compared to the LED2 group. However, the production of the LED2 group showed a fluctuating trend. The ratio of hatching eggs was significantly ( $p < 0.05$ ) higher in the LED1 group on weeks 28, 29, 31-34, 36-39 and 41.

The higher and more balanced production of the LED1 group can be the result of the similarity of the spectrum composition and the sunlight.

**Key words:** egg production, LED, lighting

## Genetska raznolikost u populaciji istarske ovce – preliminarni rezultati

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### Sažetak

Uzgoj ovaca predstavlja jedan je od najvažnijih izvora prihoda u južno-mediteranskom dijelu Hrvatske koji se temelji na izvornim pasminama. Jedna od njih je istarska ovca čiji je uzgoj orijentiran na proizvodnju mlijeka koje se prerađuje u sir visoke kvalitete. Posljednjih desetljeća dolazi do smanjenja brojnog stanja populacije istarske ovce što može dovesti do povećanja uzgoja u srodstvu i općeg gubitka genetske raznolikosti. Cilj ovog istraživanja bio dobiti uvid i procijeniti genetsku raznolikost i strukturu populacije istarske ovce. U tu svrhu iz 12 stada genotipizirano je ukupno 84 jedinki korištenjem Ovine SNP50 BeadChip-a. Kontrola kvalitete genotipizacije provedena je slijedećim parametrima (*SNP call rate* > 0,9, najmanja frekvencija alela > 0,01 i *individual call rate* > 0,9) nakon koje je set podataka sadržavao 84 jedinke i 45.806 SNP-a. Uočena heterozigotnost iznosila je 0,351, a očekivana heterozigotnost i Nei's genetska raznolikost 0,365. U proučavanom uzorku koeficijent uzgoja u srodstvu iznosio je 0,04. U PCA analizi uočeno je odvajanje tri stada pri čemu PC1 i PC2 komponenta pokazuju 6,45 % i 5,08 % genetske varijacije. Iako uzorkovana populacija istarske ovce pokazuje znatnu razinu heterozigotnosti, umjerena razina uzgoja u srodstvu zahtijeva pozornost u provedbi uzgoja i shema sparivanja. Navedeni preliminarni rezultati ističu važnost praćenja genetske strukture istarskih ovaca i potrebu za daljnjim istraživanjem.

**Ključne riječi:** istarska ovca, SNP, genetska raznolikost, očuvanje

## Genetic diversity in Istrian sheep – preliminary results

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### Summary

Sheep breeding is one of the most important sources of income in the southern Mediterranean part of Croatia and is based on local breeds. One of them is the Istrian sheep, mainly bred for milk production which is processed into high-quality cheese. In recent decades, the population size of Istrian sheep has decreased, which may lead to an increase in inbreeding and a general loss of genetic diversity. The aim of this study was to estimate genetic diversity and population structure to get insight into the current status of Istrian sheep. 84 individuals from 12 flocks were genotyped with the Ovine SNP50 BeadChip. Quality control was performed with standard thresholds (SNP call rate > 0.9, minor allele frequency > 0.01, and individual genotype call rate > 0.9). Only autosomal SNPs were used for the analyses, resulting in a data set of 84 individuals and 45,806 SNPs. The observed heterozygosity was 0.351, whereas both, the expected heterozygosity and Nei's genetic diversity were 0.365. In the data set used, the coefficient of inbreeding was 0.04. PCA analysis showed the separation of three flocks, with PC1 and PC2 accounting for 6.45% and 5.08% of the genetic variation, respectively. Although Istrian sheep show a considerable level of heterozygosity, the moderate level of inbreeding requires attention in breeding and matting schemes. These preliminary results highlight the importance of monitoring the genetic composition of Istrian sheep and the need for further analysis.

**Key words:** Istrian sheep, SNP, genetic variability, conservation

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## Primjena fitobiotika u hranidbi sisajuće teladi

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### Sažetak

Provedeno je istraživanje s ciljem utvrđivanja utjecaja mješavine fitobiotika na zdravstvene i proizvodne pokazatelje u sisajuće teladi. U istraživanju su bile dvije skupine teladi: kontrolna (K) i pokusna (P), pri čemu je u svakoj skupini bilo 14 životinja ravnomjerno raspoređenih prema spolovima (7♂ : 7♀). Istraživanje je trajalo 10 dana. Obje skupine napajane su mliječnom zamjenicom pomoću automata za napajanje s 4 L/teletu dnevno. Pokusnoj skupini dodana je mješavina fitobiotika u količini od 3 g/teletu dnevno. Telad je izvagana odmah nakon teljenja te deseti dan istraživanja. Uzorkovanje krvi za refraktometriju rađeno je 48 sati nakon teljenja, a za određivanje hematoloških pokazatelja deseti dan istraživanja, osim uzorkovanja krvi deseti dan istraživanja sakupljeni su i uzorci fecesa. Od proizvodnih pokazatelja praćeni su tjelesna masa, prosječni dnevni prirast te konverzija hrane, dok su od zdravstvenih pokazatelja praćeni pasivni imunitet, hematološki pokazatelji te pojavnost kriptosporidija u fecesu. Rezultati istraživanja nisu pokazali statistički značajne razlike između praćenih pokazatelja, ali je pokusna skupina imala tendenciju viših vrijednosti ( $p = 0,088$ ) tjelesne mase te leukocita ( $p = 0,082$ ) deseti dan istraživanja. Osim toga, pojavnost kriptosporidija u fecesu bila je manja kod pokusne u odnosu na kontrolnu skupinu (3 : 6). Prema dobivenim rezultatima može se izvući zaključak kako dodavanje fitobiotika u mliječnu zamjenicu ima potencijalno povoljno djelovanje na promatrane pokazatelje te da je potrebno provesti daljnja istraživanja.

**Ključne riječi:** fitobiotici, mliječna zamjenica, proizvodni pokazatelji, zdravstveni pokazatelji, telad

## Application of phytobiotics in suckling calves feeding

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### Summary

A study was conducted to determine the effect of a mixture of phytobiotics on health and production traits in suckling calves. The study included two groups of calves: control (K) and experimental (P), with 14 animals in each group evenly distributed by sex (7♂ : 7♀). The study lasted 10 days. Both groups were fed with a milk replacer using a 4 L / calf feeder per day. A mixture of phytobiotics in the amount of 3 g/calf per day was added to the experimental group. The calves were weighed immediately after calving and on the tenth day of the study. Blood sampling for refractometry was performed 48 hours after calving, and for the determination of hematological parameters on the tenth day of the study, in addition to blood sampling on the tenth day of the study, fecal samples were collected. Body weight, average daily gain, and feed conversion were monitored by production traits, while passive immunity, hematological indicators, and the occurrence of cryptosporidium in faeces were monitored by health indicators. The results of the study did not show statistically significant differences between the observed indicators, but the experimental group had a tendency to higher values ( $p = 0.088$ ) of body weight and leukocytes ( $p = 0.082$ ) on the tenth day of the study. In addition, the incidence of cryptosporidium in faeces was lower in the experimental group compared to the control group (3 : 6). Based on the obtained results, it can be concluded that the addition of phytobiotics to milk replacer has a potentially beneficial effect on the observed indicators and that further research is needed.

**Key words:** phytobiotics, milk replacer, production traits, health indicators, calves

## Ponašanje krmača i prasadi u različitim sustavima prasnjenja

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### Sažetak

U suvremenoj svinjogojskoj proizvodnji dobrobit svinja dobiva sve značajnije mjesto u planiranju i provođenju proizvodnih procesa. Tome pridonosi i sve zahtjevnija zakonska regulativa koja predviđa poboljšanje uvjeta držanja svih kategorija svinja. U fokusu se posebice nalazi držanje krmača u boksovima za prasnjenje, čije potpuno ukidanje najavljuje Europska komisija. Cilj rada bio je utvrditi razlike u ponašanju krmača banijske šare svinje u različitim sustavima prasnjenja: konvencionalnim boksovima za prasnjenje s betonskim podom s uklještenjem krmača, te u nadstrešnicama bez uklještenja sa zemljanim podom. Podaci su prikupljeni snimanjem krmača pasmine banijska šara svinja video kamerama u boksu i nadstrešnici. Preliminarni rezultati prikazani su za jednu krmaču u konvencionalnom boksu i nadstrešnici. Ukupno analizirano vrijeme snimanja je 120 sati po boksu, prvih 5 dana nakon prasnjenja. Prilikom obrade videozapisa, utvrđen je broj i interval trajanja različitih aktivnosti krmača: stajanje, ležanje i sjedenje. Također, pratio se broj prignječene prasadi, kao i frekvencija te prosječno vrijeme sisanja prasadi. Najzastupljeniji položaj u boksu sa uklještenjem (85 % vremena) bio je ležeći položaj, zatim stajaći položaj (15 % vremena), dok je vrijeme sjedenja bilo zanemarivo. U nadstrešnici bez uklještenja najzastupljeniji položaj je također bio ležeći (89 % vremena), zatim stajaći (11 % vremena). Viši udio stajaćeg položaja u boksu s uklještenjem može se objasniti utjecajem sezone prasnjenja i vrste poda, pri čemu hladniji betonski pod i temperatura zraka utječu na aktivnost krmača. Tijekom laktacije u oba sustava nisu uočena prignječena prasadi. Veća frekvencija sisanja prasadi uočena je u sustavu prasnjenja s uklještenjem, dok je prosječno vrijeme sisanja bilo slično u oba sustava prasnjenja (7 minuta). Sljedeći koraci u istraživanju uključuju detaljnu statističku analizu na većem broju ponavljanja te uključivanje dodatnih oblika ponašanja poput interakcije između prasadi, učestalosti agresivnog ponašanja u različitim sustavima prasnjenja te pojave stereotipnih ponašanja kod krmača i prasadi.

**Ključne riječi:** svinje, dobrobit, ponašanje, video analiza

## Behaviour of piglets and sows in different farrowing systems

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### Summary

In modern pig production, pig welfare is taking an increasingly important place in the planning and execution of production processes. This is also contributed by the increasingly demanding legislation, which demands improved housing conditions for all categories of pigs. In particular, the focus is on the keeping of sows in farrowing crates, the complete abolition of which is announced by the European Commission. The aim of the work was to determine the differences in behaviour of Banian spotted pig sows in different farrowing systems: conventional farrowing pens with concrete floor and crates for sows and in outdoor canopies with clay floor without crates. Data were collected by recording sows of the Banija spotted pig breed with video cameras in crates and canopies. Preliminary results are presented for one sow in conventional box and one in a canopy. The total recording time was 120 hours per box during the first 5 days after farrowing. In the analysis of the videos, the number and interval of the duration of the different body positions of the sows were determined: standing, lying, and sitting. The most common position in the pen with crates (85% of the time) was the lying position, then the sitting position (15% of the time), while the time spent sitting was negligible. The most common position in the canopy without crates was also a lying position (89% of the time), and 11% of the time in a standing position or moving. The higher proportion of standing and moving position in the pen with crate can be explained by the influence of farrowing season and type of floor, with the cooler concrete floor and air temperature affecting sow activity. During lactation, crushing of piglets was not observed in either system. A higher frequency of nursing piglets was observed in the farrowing system, while the average nursing time was similar in both farrowing systems (7 minutes). The next steps in the study include a detailed statistical analysis of a series of replicates and the inclusion of additional behaviours such as interactions between piglets, frequency of aggressive behaviour in different farrowing systems, and the occurrence of stereotypic behaviours in sows and piglets.

**Key words:** pigs, welfare, behaviour, video analysis

## Važnost nekih svojstava krava za uspješnu robotiziranu mužnju

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### Sažetak

Razlozi automatizacije i robotizacije mliječnih farmi proizlaze iz prednosti koje robotizirana mužnja omogućuje farmerima, poput veće učinkovitosti, zamjene radne snage, nižih troškova rada itd. Prvi roboti za mužnju krava u Republici Hrvatskoj ugrađeni su 2008. godine. Danas hrvatski farmeri raspolažu s preko 50 robota na više od 30 farmi. Ovaj trend širenja zasigurno će se ubrzati u narednom razdoblju. Stoga je važno imati sve spoznaje bitne za uspješnu implementaciju robotizirane mužnje krava. Prije svega misli se na fenotipske značajke vimena poput položaja sisa, forme vimena, mliječnosti i dr. Međutim, sve veću važnost dobivaju i neke druge informacije poput broja posjeta krava robotu, temperamenta krava, vrijeme provedeno u boksu za mužnju, broj uspješnih mužnji i sl.. Ove informacije ukazuju koliko se neka krava uspješno uklopila u sustav robotizirane mužnje. Robotizirani sustavi su opremljeni elektronskom identifikacijom krava, te pomoću senzora prate cjelokupan tijek mužnje. Prikupljeni podaci se pohranjuju u bazu podataka gdje farmer dalje koristeći program vođenja farme nadzire i upravlja uvjetima za kravu koja je na mužnji. Popisi opažanja i izvještaja vidljivi su na ekranu kompjutera, na ispisu ili putem mobilne aplikacije.

Cilj ovog rada je ukazati na važnost nekih svojstava krava koja su bitna za uspješnu robotiziranu mužnju. Na temelju ovih informacija mogu se analizirati brojni podaci pri čemu se mogu davati i određene smjernice za unapređenje uzgojnog programa.

**Ključne riječi:** mliječne krave, robotizirana mužnja, muzna svojstva, uzgojni program



## The importance of some cow traits for successful robotic milking

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### Summary

The reasons for automation and robotization of dairy farms stem from the advantages that robotic milking provides to farmers, such as greater efficiency, replacement of labor, lower labor costs, etc. The first robots for milking cows in the Republic of Croatia were installed in 2008. Today, Croatian farmers have over 50 robots on more than 30 farms. This trend of expansion will certainly accelerate in the coming period. Therefore, it is important to have all the knowledge essential for the successful implementation of robotic milking cows. First of all, we think about the phenotypic characteristics of the udder such as teat position, udder shape, milk yield, etc. However, some other information such as the number of visits to the robot, temperament of cows, time spent in the milking box, number of successful milking, etc. This information indicates how successfully a cow has successfully integrated into a robotic milking system. Robotic systems are equipped with electronic identification of cows, and with the help of sensors monitor the entire course of milking. The collected data is stored in a database where the farmer further uses a farm management program to monitor and manage the conditions for the dairy cow. Lists of observations and reports are visible on a computer screen, on a printout, or via a mobile app.

The aim of this paper is to point out the importance of some properties of cows that are essential for successful robotic milking. Based on this information, a number of data can be analyzed, and certain guidelines can be given for the improvement of the breeding program.

**Key words:** dairy cows, robotic milking, milking traits, breeding program

## Encapsulation and release kinetics of rennet from alginate/chitosan-based microparticles

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### Summary

Rennet is the milk-coagulating enzyme widely used in the process of cheese making. One of the most important tasks to be solved in the process of cheese making is adequate delivery of rennet. The aim of this investigation is to explore how the ionic-gelation encapsulation method can perform the immobilization of rennet. This is an important step because the conventional addition of the “free” enzyme is generally not recommended due to the negative influence on the flavor and texture. The process of rennet encapsulation in the biopolymers microcapsules was performed under previously optimized conditions. The concentration of sodium alginate was set to 1.5% (w/v) while chitosan concentration was 0.5% (w/v), and calcium chloride concentration 4%. The final concentration of rennet was set to 20% (w/v). Microcapsules loaded with rennet were produced and physicochemically characterized (microcapsules size, encapsulation efficiency, loading capacity, particle size, and zeta potential). The process of encapsulation in biopolymer microcapsules did not have a negative impact on the rennet properties keeping its activity very high. Also, the rennet release data were fitted to the Korsmeyer-Peppas model and the  $n$  exponent indicated that the release mechanism was Fickian. The electrostatic interactions between rennet, alginate, and chitosan were confirmed by infrared spectroscopy. The obtained results showed that rennet could be successfully encapsulated and applied in the process of cheese production.

**Key words:** encapsulation, rennet, microcapsules, immobilization, cheese



**Voćarstvo,  
Vinogradarstvo  
i vinarstvo**

**08**

**Viticulture,  
Enology and  
Pomology**



## Utjecaj reflektirajuće folije na kvalitetu plodova jabuke cv. FUJI Raku Raku

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### Sažetak

Boja pokožice, pomološka i interna kvaliteta ploda predstavljaju jedan od ključnih i pokazatelja kvalitete u intenzivnoj proizvodnji jabuke. Istraživanje sa ciljem utvrđivanja utjecaja reflektivnog mulča na poboljšanje i očuvanje interne kvalitete jabuke cv. FUJI Raku Raku u pre- i post-harvest periodu provedeno je 2020. godine u pokusnom nasadu jabuka (Istočna Hrvatska). Sorta je cijepljena na podlogu M. N.9 NAKB T 339, uzgojnog oblika vitko vreteno s gustoćom sklopa 0.9 x 3.2 m. Pokus je postavljen po split-plot metodi (4 repeticije po 6 stabala). Tretmani su uključivali stabla ispod kojih je postavljena reflektirajuća folija i kontrolni tretman. Tretman folijom je postavljen 20 dana prije očekivane tehnološke berbe plodova s obje strane reda (istok i zapad). Pri berbi plodovi su odvajani po strani reda s kojeg su ubrani (istok i zapad) te su obavljena pomološka mjerenja (promjer, visina, masa, tvrdoća, Brix i JŠI), intenzitet obojenosti plodova chromametrom po CIE L\*a\*b\* sustavu te mjerenja internih pokazatelja kvalitete plodova (antocijani, fenoli i vitamin C). Navedeni interni pokazatelji kvalitete plodova mjereni su neposredno nakon berbe te su ponovljeni nakon 3 mjeseca skladištenja (hladnjača s kontroliranom atmosferom). Na razini cijelog pokusa između plodova ubranih s istočne i zapadne strane reda nije bilo značajne razlike u intenzitetu obojenosti plodova te internoj kvaliteti dok je koncentracija šećera i JŠI bila značajno veća na plodovima sa zapadne strane. Plodovi ubrani na istočnoj strani reda bili su jedino značajno veće mase. Vitamin C bio je značajno veći u plodovima analiziranim neposredno nakon berbe dok su fenoli bili značajno veći u plodovima analiziranim nakon skladištenja. Plodovi na tretmanu pod folijom rezultirali su značajno većim promjerom, visinom i masom te sadržajem antocijana i fenola. Također plodovi pod reflektirajućom folijom bili su tamniji i s više crvene, odnosno manje žute boje prema CIE L\*a\*b\* sustavu (saturiraniji bojom); značajno niži L\* i b\* u odnosu na plodove bez folije. Dobiveni rezultati istraživanja upućuju na veliki potencijal reflektirajuće folije u dostizanju, odnosno povećanju dopunske boje i interne kvalitete plodova. Standardiziranje ove dopunske pomotehničke mjere nameće se kao kvalitativno rješenje u prevladavanju nepovoljnih klimatskih prilika u periodu dozrijevanja.

**Ključne riječi:** jabuka, reflektirajuća folija, boja, kvaliteta ploda

## Influence of reflective foil on the fruit quality of apple cv. FUJI Raku Raku

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### Summary

The color of the skin, pomological and internal quality of the fruit are one of the key and quality indicators in intensive apple production. Research aimed at determining the impact of reflective mulch on improving and preserving the internal quality of apple cv. FUJI Raku Raku in the pre- and post-harvest period was conducted in 2020 in an experimental apple orchard (Eastern Croatia). The variety is grafted on a rootstock M.9 NAKB T 339, a slender spindle system with a planting density of 0.9 x 3.2 m. The experiment was set up by the split-plot method (4 repetitions of 6 trees). Treatments included trees under which reflective foil and control treatment were placed. The foil treatment was set 20 days before the expected technological harvest of fruits from both sides of the row (east and west). During the harvest, the fruits were separated on the side of the row from which they were harvested (east and west) and pomological measurements were performed (diameter, height, weight, hardness, Brix and starch-iodine index), the intensity of fruit color chromatometer according to CIE L \* a \* b \* system and measurements of internal fruit quality indicators (anthocyanins, phenols and vitamin C). These internal indicators of fruit quality were measured immediately after harvest and repeated after 3 months of storage (refrigerated with controlled atmosphere). At the level of the whole experiment, there was no significant difference in fruit color intensity and internal quality between fruits harvested on the east and west sides of the row, while the concentration of sugar and starch – iodine index was significantly higher on fruits on the west side. The fruits harvested on the east side of the row were only significantly larger in mass. Vitamin C was significantly higher in fruits analyzed immediately after harvest while phenols were significantly higher in fruits analyzed after storage. The fruits on the treatment under the foil resulted in a significantly larger diameter, height and weight, as well as the content of anthocyanins and phenols. Also, the fruits under the reflective foil were darker and with more red or less yellow color according to the CIE L \* a \* b \* system (more saturated with color); significantly lower L \* and b \*. in relation to fruits without foil. The obtained research results indicate a great potential of reflective foil in reaching, ie increasing the complementary color and internal quality of fruits. The standardization of this additional pomotechnical measure is imposed as a qualitative solution in overcoming unfavorable climatic conditions during the ripening period.

**Key words:** apple, reflective foil, color, fruit quality

## Pomološka evaluacija tradicionalnih sorti jabuka u intenzivnom uzgoju

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### Sažetak

Tradicionalne sorte voćnih vrsta dragocjeno su bogatstvo i prirodna baština svake zemlje i značajne su iz gospodarskih, agronomskih, bioloških i zdravstvenih razloga. Hrvatska je zemlja s vrlo dugom tradicijom u proizvodnji voća u kojoj autohtone i udomaćene sorte zauzimaju važno mjesto. Kako bi se spriječilo njihovo izumiranje u Republici Hrvatskoj, odnosno očuvala bio-raznolikost i dragocjen genetski izvor u voćarskom sektoru Centar za voćarstvo i povrćarstvo se 2014. godine uključio u Nacionalni program očuvanja i održive uporabe biljnih genetskih izvora za hranu i poljoprivredu u Republici Hrvatskoj. Nacionalni program uključuje inventarizaciju i prikupljanje biljnih genetskih izvora i izgradnju kapaciteta za njihovo čuvanje, održavanje, regeneraciju, opis i procjenu primki. U Bazu podataka biljnih genetskih izvora Republike Hrvatske (CPGRD) trenutno je upisano 169 primki jabuka. Upisivanjem putovničkih podataka u bazu, primka se smatra uključenom u Nacionalnu banku biljnih gena. Centar je započeo sa opisima kolekcioniranih sorti, te formiranjem vlastite baze podataka.

Na pokušalištu Hrvatske agencije za poljoprivredu i hranu, Centra za voćarstvo i povrćarstvo u Donjoj Zelini 2013. godine posađeno su tradicionalne sorte jabuka od kojih smo izdvojili slijedećih 10: Ananas reneta, Crveni Berlepš, Jonatan, Kanada, Lavantaler banana, Lijepocvjetka, Malinovka iz Holovousia, Ribston peping, Ružica iz Ilza i Zimska banana. Svaka sorta je zastupljena sa 5 stabala koja su cijepljena na podlogu MM 106. Razmak sadnje u redu iznosi 2,5 m, a između redova 3,6 m. U nasadu je postavljena armatura, navodnjavanje i zaštitna mreža. Tijekom vegetacijske sezone u 2021. godini mjerena su slijedeća svojstva: masa ploda (g), visina ploda (mm), opseg ploda (mm), tvrdoća ploda ( $\text{kg cm}^{-2}$ ), topljiva suha tvar refraktometrijski ( $^{\circ}\text{Brix}$ ), ukupne kiseline ( $\text{g l}^{-1}$ ), pH i bilježene pomološke karakteristike plodova. Cilj istraživanja je bio utvrditi pomološke i kemijske karakteristike ispitivanih sorti u agroekološkim uvjetima Donje Zeline.

**Ključne riječi:** jabuka, tradicionalne sorte, kolekcijski nasad, pomološka evaluacija



## Pomological evaluation of traditional cultivars of apples in the intensive breeding

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### Summary

Traditional fruit crop cultivars are valuable richness and natural heritage of each country and are important from economical, agronomical, biological and health reasons. Croatia is a country with long tradition of fruit production in which autochthonous and domesticated cultivars are prominent. In order to prevent their further extinction in the Republic of Croatia, that is to preserve the biodiversity and valuable genetic pool in fruit sector, Center of Pomology and Vegetable Crops has involved in the National programme of preservation and sustainable use of plant genetic resources for food and agriculture in the Republic of Croatia as of 2014. National programme comprises of inventory and collection of plant genetic resources and capacity building for their preservation, maintenance, regeneration, accession description and evaluation. In the database of plant genetic resources of the Republic of Croatia (CPGRD) is currently enrolled 169 accessions of apple. Accession is considered included in the national plant gene bank by listing of passport data. The Center has started with the description of collected cultivars and formation of custom made database.

In Experimental orchard of the Croatian Agency for Agriculture and Food, Center of Pomology and Vegetable Crops in 2013. were planted the traditional apple varieties from which we extracted the following 10: Ananasrenette, Red Berlepsch, Jonathan, Canada Renette, Mother (Lavanttaler Bananenapfel), Yellow Bellflower, Malinové Holovouské, Ribston Pepping, Ilzer Rosenapfel and Winterbanana. Each variety was represented with 5 trees grafted on MM 106 rootstock. Distance within the row was 2,5 m, and between rows 3,6 m. Drip irrigation system and anti-hail nets were installed in the plantation. During the 2021. vegetation season following characteristics were measured: fruit weight (g), fruit height (mm), fruit circumference (mm), fruit firmness (kg cm<sup>-2</sup>), total soluble solids (°Brix), total acids (g l<sup>-1</sup>), pH and other pomological characteristics. The aim of this research was to identify pomological and chemical characteristics of mentioned varieties in agro-ecological conditions of Donja Zelina.

**Key words:** apple, traditional cultivars, collection orchard, pomological evaluation

## Razvijanje automatiziranog uređaja za praćenje ekonomskih štetnika jabuke

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### Sažetak

Zahvaljujući ubrzanom razvoju umjetne inteligencije, automatizirani sustavi za praćenje štetnika postali su neizostavni alat u tzv. preciznoj poljoprivredi. Takvi sustavi omogućuju točniju i bržu prognozu pojave štetnika, čime se ujedno optimizira broj kemijskih tretmana, te se pridonosi rentabilnosti proizvodnje. Finalni proizvod manje je opterećen kemikalijama što doprinosi zdravlju ljudi i okoliša a primjenom inovativnih digitalnih sustava unaprijeđuje se integrirana zaštita bilja čime se doprinosi održivoj poljoprivrednoj proizvodnji. U konačnici uzgajaju se visokokvalitetni proizvodi koji na tržištu postižu bolji plasman. Trenutačno na tržištu postoji nekoliko inovativnih rješenja automatiziranog praćenja štetnika, no u Hrvatskoj za sada takav proizvod nije prisutan. U sklopu projekta “AgriART” kojeg sufinancira Europska unija iz Europskih strukturnih i investicijskih fondova razvijat će se sveobuhvatni upravljački sustav u području precizne poljoprivrede koji će biti usmjeren na povećanje kvalitete i kvantitete plodova jabuke te na smanjenje primjene kemijskih sredstava, pomoću ključnih tehnoloških koncepata računalnog vida i umjetne inteligencije. Takav sustav trebao bi uvelike olakšati praćenje i suzbijanje ekonomskih štetnika jabuke te na taj način poboljšati kvalitetu poljoprivrednih proizvoda i doprinjeti održivoj voćarskoj proizvodnji Hrvatske.

**Ključne riječi:** AgriART, digitalni sustav za praćenje štetnika, umjetna inteligencija, jabuka, održiva poljoprivredna proizvodnja

## Development of an automatic device for monitoring economic pests on apples

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### Summary

Thanks to the rapid development of artificial intelligence, automated pest monitoring systems have become an indispensable tool in so-called precision agriculture. Such systems allow more accurate and faster prediction of pest occurrence, which also optimizes the number of chemical treatments, and contribute to the profitability of production. The final product is less contaminated with chemicals, which benefits human health and the environment, and the use of digital systems contributes to integrated pest management and thus sustainable agricultural production. Ultimately, high-quality products are grown that are easier to market. There are currently several innovative solutions for automatic pest monitoring on the market, but such a product is not yet available in Croatia. The “AgriART” project, co-financed by the European Union from the European Structural and Investment Funds, will develop a comprehensive management system in the field of precision agriculture aimed at increasing the quality and quantity of apples and reducing the use of chemicals by using key technological concepts of computer vision and artificial intelligence. Such a system should greatly facilitate the monitoring and control of economic pests in apples, thus improving the quality of agricultural products and contributing to sustainable fruit production in Croatia.

**Key words:** AgriART, digital system for pest monitoring, artificial intelligence, apple, sustainable agricultural production

## Monitoring of flight of plum fruit moth with pheromon traps

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### Summary

The aim of this research was to evaluate number of caught male moths of overwintering generation of *Grapholita funebrana* – plum fruit moth in pheromone traps and relate it to climatic conditions. The monitoring was done in 2019 on eight spots in a 70 ha plum orchard in Bakinci, Bosnia and Herzegovina. The flight monitoring lasted from 15<sup>th</sup> of April till 6<sup>th</sup> of June. The highest number of moths was caught in the third week of monitoring (246) and the lowest in the fourth week (45.1). The lowest number of moths was caught in the week with highest number of rainy days. Flight activity was more intensive in the first three weeks of the monitoring (232, 194 and 246 moths per trap) compared with the last three weeks (127, 121 and 134 moths per trap). Standard deviation varied from 18.2 in the week with the highest flight activity to 36.2 in the week with the lowest flight activity. The lowest average temperature was in the week with lowest average temperature 11.3°C, while in the week with highest flight activity it was 13.6 °C. Flight activity of plum fruit moth was influenced whit weather conditions, where rain deters flight activity. Flight was more dynamic in the first part of monitoring period, indicating that early infestation might be the most important.

**Key words:** monitoring, plum pests, temperature

## Influence of non-*Saccharomyces* yeasts on the volatile aroma profile of white grape must in early fermentation

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### Summary

The purpose of this study was to investigate the effect of different non-*Saccharomyces* yeasts on volatile aroma profile in early fermentation of a white cultivar Malvazija istarska (*Vitis vinifera* L.). The grape must was inoculated in monoculture with *Torulaspota delbrueckii*, *Metschnikowia pulcherrima*, *Pichia kluyveri*, *Lachancea thermotolerans* and *Schizosaccharomyces pombe*. *Saccharomyces cerevisiae* was inoculated as a control. The identification and quantification of volatile compounds was done with gas chromatography-mass spectrometry, after headspace solid-phase microextraction. The chromatographic data were elaborated by statistical analysis. Each of the studied non-*Saccharomyces* yeasts influenced volatile aroma composition in a unique way in early fermentation. The analysis showed that many of the investigated yeasts caused an increase in linalool and  $\beta$ -damascenone concentrations and improved synthesis of many major and minor esters, while simultaneously caused lower production of higher alcohols and fatty acids. *T. delbrueckii* and *M. pulcherrima* induced the synthesis of compounds not commonly found in *S. cerevisiae* fermented wines. Multivariate statistical analysis confirmed that each of the investigated yeasts generated a particular volatile profile in early fermentation. The obtained results showed that non-*Saccharomyces* yeasts have a potential that could be used to produce wines with complex and distinct volatile aroma compound profiles.

**Ključne riječi:** non-*Saccharomyces* yeasts, sequential inoculation, volatile aroma compounds, esters, Malvazija istarska wine

## Usporedba kakvoće plodova pet sorata mandarine uzgojene na području Neretve

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### Sažetak

Mandarina (*Citrus reticulata* Blanco) u Hrvatskoj zauzima važno mjesto u proizvodnji voća i bitan je izvozni proizvod. Cilj istraživanja bio je usporediti kakvoću u vrijeme berbe pet sorata mandarine ('Chahara', 'Kawano Wase', 'Owari', 'Saigon' i 'Zorica') uzgajanih na području delte Neretve. Istraživani su plodovi ubrani prema standardima neretvanskih proizvođača. Kakvoća plodova utvrđena je praćenjem tvrdoće, topljive suhe tvari, ukupnih kiselina, odnosa topljive suhe tvari i ukupnih kiselina te boje. Najveću tvrdoću plodova imale su sorte 'Chahara' i 'Zorica' (4,28 kg cm<sup>-2</sup> i 3,98 kg cm<sup>-2</sup>). Sorte 'Chahara' i 'Zorica' u usporedbi s ostalim sortama imale su i više topljive suhe tvari (12,43 % i 13,02 %) i ukupnih kiselina (2,06 % i 2,38 %). Međutim te sorte su imale i najnepovoljniji odnos topljive suhe tvari i ukupnih kiselina (6,25 i 5,62) dok su najpovoljniji odnos imale sorte 'Kawano Wase' (9,20) i 'Owari' (11,47). Odnos topljive suhe tvari i ukupnih kiselina glavni je pokazatelj zrelosti mandarina i treba iznositi oko 10:1. Najranije promatrane sorte su 'Chahara' i 'Zorica', a najkasnije 'Owari' i 'Saigon'. Sorte 'Chahara' i 'Zorica' su slabije kakvoće plodova što je vjerojatno uzrokovano kraćom vegetacijom (rano dozrijevanje) i preranom berbom u želji da se što prije plodovi stave na tržište. Sorte 'Kawano Wase', 'Owari' i 'Saigon' prednjače po kakvoći ploda među promatranim sortama.

**Ključne riječi:** Unshiu, Satsuma, Citrus number, Citrus Color Index

## Comparison of fruit quality of five mandarin cultivars grown in the Neretva region

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### Summary

Mandarin (*Citrus reticulata* Blanco) has an important place in Croatia fruit production and is an important export product. The aim of the research was to compare the fruit quality at harvest of five varieties of mandarin ('Chahara', 'Kawano Wase', 'Owari', 'Saigon' and 'Zorica') grown in the Neretva Valley. The fruit were harvested according to the standards of Neretva producers. Fruit quality was determined by firmness, soluble solids content, total acids, the ratio of soluble solid content to total acids and color. The varieties 'Chahara' and 'Zorica' had the highest fruit firmness (4.28 kg cm<sup>-2</sup> and 3.98 kg cm<sup>-2</sup>). Varieties 'Chahara' and 'Zorica' in comparison with other varieties had more soluble solids content (12.43% and 13.02%) and total acids (2.06% and 2.38%). However, these cultivars also had the most unfavorable ratio of soluble solids content and total acids (6.25 and 5.62), while the cultivars 'Kawano Wase' (9.20) and 'Owari' (11.47) had the most favorable ratio. The ratio of soluble solids content to total acids is the main indicator of mandarin ripeness and should be around 10: 1. The earliest observed varieties are 'Chahara' and 'Zorica', and the latest are 'Owari' and 'Saigon'. Varieties 'Chahara' and 'Zorica' are of poorer fruit quality, which is probably caused by shorter vegetation (early ripening) and premature harvest in the desire to put the fruit on the market as soon as possible. The varieties 'Kawano Wase', 'Owari' and 'Saigon' are the leaders in terms of fruit quality among the observed varieties.

**Key words:** first, second, third, fourth, fifth

## The perspective of Croatian old apple cultivars for juice production

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### Summary

Recently, consumer demand for old apples and their products has been increasing as they follow the trend of consuming natural foods without added pesticides and additives. Unfortunately, old orchards are deteriorating lately, so more and older apple varieties are being lost. New knowledge and research on old apple varieties would strengthen the market for these fruits and their products, prevent the loss of this valuable genetic material, and contribute to greater biodiversity to promote health and overall well-being. Sweet and sour tastes are among the most important sensory characteristics that determine consumer preference for apples and apple juices. These depend largely on the content and compositional profile of soluble sugars and organic acids and, more importantly, on the balance between organic acids and sugars reflected in the sugar/acid ratio. In view of this, the objective of this study is to determine and compare the pH, total acids, individual sugars and sugar/acid ratio of five commercial and ten old apple varieties. The results obtained using chromatographic (HPLC) method showed that the main sugars in all apple varieties were fructose (56.14-101.43 g L<sup>-1</sup>), followed by sucrose (31.25-78.34 g L<sup>-1</sup>) and glucose (9.72-33.89 g L<sup>-1</sup>). The pH ranged from 3.04 to 3.31 for old and from 3.14 to 3.69 for commercial apple cultivars. ‘Wagener’ had the highest content (0.19 g mL<sup>-1</sup>) of total acids, while ‘Fuji’ had the lowest (0.07 g 100 mL<sup>-1</sup>). The sugar/acid ratio showed that all old apple cultivars had an optimal ratio for juice production, making them a desirable cultivar for juice production. Funding: This work has been supported by Croatian Science Foundation under the project “The possibility of exploiting old apple cultivars for the production of apples and apple juice with the reduced patulin content” (UIP-2020-02-8461).

**Key words:** old apple cultivars, fructose, glucose, sucrose, pH, total organic acids



## Učestalost pojave, djelomična molekularna karakterizacija te načini prijenosa G-virusa vinove loze

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### Sažetak

G-virus vinove loze (GVG) jedan je od osam vitivirusa otkrivenih u vinovoj lozi u posljednjem desetljeću. GVG je u Hrvatskoj detektiran 2018. god., a trenutna istraživanja ukazuju na njegovu proširenost u više vinogradarskih regija svijeta. Cilj istraživanja bio je utvrditi učestalost pojave GVG u Hrvatskoj, divergentnost dijela gena proteina omotača (CP), kao i načine prijenosa te eventualne alternativne domaćine. U tu svrhu u kolekcijskim nasadima te komercijalnim vinogradima prikupljena su 4302 uzorka peteljki vinove loze iz kojih je izolirana RNA. Korištenjem dostupnih podataka o genomu virusa razvijene su PCR metode detekcije (konvencionalni i u realnom vremenu). U testovima prijenosa korištene su četiri metode: prijenos lozinom štitastom uši (*Planococcus ficus*), mehanički prijenos, prijenos sjemenom te cijepljenjem. U kontinentalnom dijelu virus je potvrđen u kolekcijskom nasadu „Jazbina“ te zbirci virusa (Agronomski fakultet, Zagreb) u 7,1% te 10,7% uzoraka, ali ne i u uzorcima iz 16 komercijalnih vinograda. U priobalju GVG je detektiran u kolekcijskom nasadu u Splitu (4,8%) te u 22 od 72 testirana komercijalna vinograda (30,6%) s ukupnim postotkom zaraze od 10,6%. CP regija hrvatskih GVG izolata pokazala je heterogenost ovisno o lokaciji. Testovi prijenosa s loze na lozu korištenjem lozine štitaste uši pokazali su 15%-tnu uspješnost. Također, potvrđen je prijenos cijepljenjem, dok drugi tipovi prijenosa, kao ni alternativni domaćini, nisu potvrđeni.

**Ključne riječi:** RT-PCR, qPCR, sekvenciranje, filogenetika, *Planococcus ficus*

## Incidence, partial molecular characterization and transmission modes of grapevine virus G

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### Summary

Grapevine virus G (GVG) is one of eight vitiviruses discovered in grapevines in the last decade. GVG was detected in Croatia in 2018, and current research indicates its widespread in several wine-growing regions of the world. The aim of this study was to determine the incidence of GVG in Croatia, variability of the part of the coat protein gene (CP), as well as the modes of transmission and possible alternative hosts. For this purpose, 4302 samples of grapevine petioles were collected in the collection plantations and commercial vineyards and the RNA was extracted. PCR detection protocols (conventional and real-time) were developed using the available virus genome data. Four different methods in transmission trials were used: vine mealybug *Planococcus ficus*, mechanical transmission, transmission by seeds and grafting. In the Croatian continental part, the virus was confirmed in the collection plantation “Jazbina” and the collection of viruses (Faculty of Agriculture, Zagreb) in percentages of 7.1% and 10.7%, respectively, but not in samples from 16 tested commercial vineyards. In the coastal part, GVG was detected in the collection plantation located in Split (4.8%) and in 22 out of 72 (30,6%) commercial vineyards tested with a total occurrence rate of 10.6%. CP region of Croatian GVG isolates showed location dependent heterogeneity. Vine to vine transmission tests using vine mealybug showed 15% efficiency. Also, transmission by grafting has been confirmed, while other types of transmission, as well as alternative hosts, have not been confirmed.

**Key words:** RT-PCR, qPCR, sequencing, phylogenetics, *Planococcus ficus*

## Pomološke, fiziološke i fenološke karakteristike sedam sorti ribiza

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### Sažetak

U pokusnom voćnjaku Hrvatske agencije za poljoprivredu i hranu, Centra za voćarstvo u Donjoj Zelini posađen je pokusni nasad sa tri sorte crvenog ribiza: Jonkher van Teets, Losan i Detvan; dvije sorte crnog ribiza: Viola i Titania; te dvije sorte bijelog ribiza Werdavia i Primus. Sortni pokus postavljen je kao slučajni blokni raspored u tri repeticije koja čine dva grma starosti tri godine. Grmovi su posađeni na razmak od jednog metra. Cilj istraživanja je utvrditi kako se posađene sorte ponašaju u našim agro – ekološkim uvjetima. Bilježenjem fenofaza: C, D, F, I utvrdili smo da nema datumskih razlika između pojedinih sorti, a sukladno tome plodovi dozrijevaju od 65 do 70 dana nakon cvatnje. Nakon berbe mjerena su svojstva: prosječan urod po grmu, masu grozdica, visinu grozdica, broj bobica po grozdiću, duljinu peteljke, topivu suhu tvar refraktometrijski, pH soka, te smo odredili ukupne kiseline izražene kao jabučna kiselina. Prosječan prinos po grmu kretao se od 813,40 g (Viola) do 2040,00 g (Primus), težina grozdica od 4,10 g (Werdavia) do 10,26 g (Primus), visina grozdica od 44,69 mm (Titania) do 100,74 mm (Primus), broj bobica u grozdiću od 5 (Titania) do 21 (Primus), duljina peteljke od 12,28 mm (Losan) do 21,23 mm (Detvan). Topiva suha tvar izmjerena refraktometrijski iznosila je od 10,11 °Brixa (Jonkher van Teets) do 15,64 °Brixa (Titania), dok su se vrijednosti izmjerene pH-metrom kretale između 2,71 pH (Jonkher van Teets) i 2,96 pH (Viola). Ukupna kiselost izražena kao jabučna kretala se u rasponu od 22,17 g/l (Viola) do 43,35 g/l (Titania). Nakon provedenih kemijskih analiza na plodu provedeno je istraživanju tržišta o prihvaćanju obojenosti ploda. Na tržištu u Zagrebu proveli smo anketu u kojoj je sudjelovalo 183 slučajnih kupca (od ukupnog broja ispitanika sudjelovale su 142 ženske osobe). Ispitanici od 18 do 45 godina starosti preferiraju isključivo crvene sorte ribiza, dok starija populacija od 46 do 65 godina starosti podjednako preferira sorte crvenog i crnog ribiza. Za sorte bijele kožice ploda niti jedna od ispitanih dobnih skupina nije pokazivala interes za konzumacijom. Ispitanici plodove sorti crvenog ribiza uglavnom koriste za konzumaciju u svježem stanju ili kako dodatak raznim smoothe-ima dok plodove sorti crnog ribiza koriste za razne prerađevine (uglavnom sokove).

**Ključne riječi:** ribiz, sorta, fenofaze, pomologija

## Pomological, physiological and phenological characteristics of seven varieties currant

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### Summary

In the experimental orchard of the Croatian Agency for Agriculture and Food, Center for Fruit Growing in Donja Zelina, an experimental plantation with three varieties of red currant was planted: Jonkher van Teets, Losan and Detvan; two varieties of black currant: Viola and Titania; and two varieties of white ( gold ) currant :Werdavia and Primus. The variety experiment was set up as a random block layout in three rehearsals that make up two three-year-old shrubs. Shrubs are planted at a distance of one meter. The aim of the research is to determine how the planted varieties behave in our agro - ecological conditions. By recording phenophases: C, D, F, I, we found that there are no date differences between individual varieties, and accordingly the fruits ripen from 65 to 70 days after flowering. After harvest, the following properties were measured: average yield per bush, weight of grapes, height of grapes, number of berries per grape, length of stalk, soluble solids refractometrically, pH of juice, and we determined total acids expressed as malic acid. Average yield per bush ranged from 813.40 g (Viola) to 2040.00 g (Primus), weight of grapes from 4.10 g (Werdavia) to 10.26 g (Primus), height of grapes of 44.69 mm Titania up to 100.74 mm (Primus), number of berries in the bunch from 5 (Titania) to 21 (Primus), stem length from 12.28 mm (Losan) to 21.23 mm (Detvan). The soluble dry matter measured refractometrically ranged from 10.11 °Brix (Jonkher van Teets) to 15.64 °Brix (Titania), while the values measured by ph-meter ranged between 2.71 pH (Jonkher van Teets) and 2, 96 pH (Viola). Total acidity expressed as malic ranged from 22.17 g l<sup>-1</sup> (Viola) to 43.35 g l<sup>-1</sup> (Titania). After conducting chemical analyzes on the fruit, market research was conducted on the acceptance of fruit color. At the market in Zagreb, we conducted a survey in which 183 random customers participated (out of the total number of respondents, 142 women participated). Respondents from 18 to 45 years of age prefer exclusively red currant varieties, while the older population from 46 to 65 years of age equally prefers red and black currant varieties. For the varieties of white skin of the fruit, none of the examined age groups showed interest in consumption. Respondents mainly use the fruits of red currant varieties for fresh consumption or as an addition to various smoothies, while the fruits of black currant varieties are used for various processed products (mainly juices).

**Key words:** currant, variety, phenophases, pomology

## Utjecaj jestivog omotača kitozana na plod neretvanske mandarine

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### Sažetak

Plodovi mandarine su neklimakterijsko voće i ne mogu se dugo čuvati tijekom transporta i skladištenja. Odgovarajući tretman nakon berbe može dramatično smanjiti gubitak plodova, povećati kvalitetu ploda i rezultirati većom profitabilnosti. Jestivi omotači mogu pomoći da se produži rok trajanja voća smanjenjem migracije vlage i otopljenih tvari, izmjene plinova, disanja i reakcija, kao i minimiziranja ili suzbijanja fizioloških bolesti. Kitozan je jedan od najpopularnijih polisaharidnih omotača za različito voće zbog svoje sposobnosti da odgodi gubitak vode. Plodovi mandarine tretirani su kitozonom, te su određivani parametri kvalitete ploda. Gubitak težine, ukupne topljive krute tvari i ukupni fenoli određivani su u kontrolnom voću i voću tretiranom kitozonom. Uočen je značajno manji gubitak težine za tretirane mandarine nakon 10 dana skladištenja na sobnoj temperaturi. U mandarinama obloženim kitozonom nakon 10 dana skladištenja na sobnoj temperaturi pronađeno je povećanje od 50,04 % više ukupnih polifenola u odnosu na kontrolni uzorak.

**Ključne riječi:** kitozan, jestivi omotači, mandarine, tretmani poslije berbe, dolina Neretve

## Effect of edible coating chitosan on Neretva mandarin fruits

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### Summary

Mandarin fruits are non-climacteric, perishable fruit, and cannot be kept for a long time during transportation and storage. Appropriate postharvest treatment can minimize fruit loss dramatically, increase fruit quality, and result in higher profitability. Edible coatings may help to increase the shelf life of fruits by decreasing moisture and solute migration, gas exchange, respiration, and reaction rates, as well as minimizing or suppressing physiological diseases. Chitosan is one of the most popular polysaccharide coating for various fruits due to its capability to delay water loss. Mandarin fruits were treated with chitosan, and fruit quality parameters were determined. Weight loss, total soluble solids, and total phenolics were evaluated in control and chitosan-coated fruits. A significantly lower weight loss was observed for coated mandarins after 10 days of storage at room temperature. An increase in 50.04% more total polyphenols was found in chitosan-coated mandarins after 10 days of room temperature storage, relative to the control sample.

**Key words:** chitosan, edible coatings, mandarin fruits, postharvest treatments, Neretva valley

## Soil chemical composition within viticulture area of Fruška Gora

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### Summary

Grapevine has been grown in Fruška Gora for a long time. The earliest records are 1700 years old but it is reasonable to believe that vineyards had existed in that region before Roman Emperor Probus. The following soils of the Fruška Gora were found to be favorable for grape production: pararendzina soil on loesses, rendzina and regosol soils on loesses, ranker soils, different types of brown forest soil, and strongly eroded and brownized chernozem soils. This paper presents soil chemical composition of 22 plots within the Fruška gora wine region. The samples were taken from the soil layers of 0-30 cm, 30-60 cm and 60-90 cm. The soil analyses of the basic soil properties were done (pH value, content of  $\text{CaCO}_3$ , Total N, content of organic C, plant available P and K). Vineyard soils in Fruška Gora can be classified as carbonate soils (on average 9.4%  $\text{CaCO}_3$ ), while the soil pH was neutral (on average value 7.0). However, in the locality of Grabovo (north slope) pH values in some plots were below 7.0 (acidic). The soil organic matter was higher in the plots near the forest zone of the National Park (higher altitudes). The average content of phosphorus and potassium were 8.8 and 16.5 mg 100 g<sup>-1</sup>, respectively. Soil chemical composition in the Fruška Gora is almost optimal for grapevine growth and development, but high variations in water availability, both spatial and temporary, within the region, should be also considered in the future.

**Key words:** Fruška Gora, viticulture, plots, soil chemical composition

## Preliminarna karakterizacija smrdljike (*Pistacia terebinthus* L.) iz okolice Karina

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### Sažetak

Smrdljika (*Pistacia terebinthus* L.) je samonikla autohtona voćna vrsta rasprostranjena u mediteranskom i submediteranskom dijelu Hrvatske. Pripada porodici *Anacardiaceae*, rodu *Pistacia*, koji obuhvaća 20 vrsta među kojima je najpoznatija prava tršlja (*Pistacia vera* L.). Smrdljika se u rasadničarstvu često koristi kao podloga za uzgoj kuliviranih sorti tršlje. Preliminarni opis morfoloških svojstava smrdljike proveden je s ciljem utvrđivanja raznolikosti i potencijalne upotrebe u oplemenjivanju i rasadničarstvu. Prikupljeni su uzorci lista i ploda s osam (PT01 – PT08) stabala (grmova) prosječne visine 5,90 m i prosječnog promjera krošnje 5,48 m na području Karina i okolice. Morfološki opis listova i plodova proveden je prema UPOV deskriptorima za pravu tršlju. List smrdljike je perasto sastavljen, a najmanji broj utvrđenih liski u ovom istraživanju je pet (PT08) dok je najveći 11 (PT07). Zbog klimatološki iznimno nepovoljne godine, kod četiri od osam odabranih stabala utvrđen je dovoljan broj plodova za morfološku karakterizaciju. Najveće vrijednosti mase i dimenzija ploda zabilježene su za uzorak PT08 (0,13 g, visina ploda 8,32 mm i širina ploda 6,40 mm). Preliminarni rezultati ukazuju na varijabilnost morfoloških svojstava koje je neophodno nastaviti istraživati kako bi se procijenio oplemenjivački potencijal smrdljike.

**Ključne riječi:** tršlja, *Pistacia* sp., raznolikost, Dalmacija



## Preliminary characterization of terebinth (*Pistacia terebinthus* L.) from the Karin area

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### Summary

Terebinth (*Pistacia terebinthus* L.) is a wild autochthonous fruit species distributed in the Mediterranean and sub-Mediterranean part of Croatia. It belongs to the family *Anacardiaceae*, genus *Pistacia*, which includes 20 species, the best known of which is the pistachio (*Pistacia vera* L.). Terebinth is often used in nurseries as a rootstock for growing pistachio varieties. A preliminary description of the morphological characteristics of terebinth was carried out with the aim of determining its diversity and potential use in breeding and plant propagation. Leaf and fruit samples were collected from eight (PT01 - PT08) trees (shrubs) with an average height of 5.90 m and an average canopy diameter of 5.48 m in the Karin area. The morphological description of the leaves and fruits was done according to the UPOV descriptors for pistachio. The leaf of terebinth is pinnate. The smallest number of leaves found in this study is five (PT08), while the largest is 11 (PT07). Due to the extremely unfavorable climatic year, a sufficient number of fruits for morphological characterization was found in four of the eight selected trees. The highest values for fruit weight and size were obtained for sample PT08 (0.13 g, height 8.32 mm and width 6.40 mm). The preliminary results indicate the variability of morphological traits that need further investigation to evaluate the breeding potential of terebinth.

**Key words:** pistachio, *Pistacia* sp., diversity, Dalmatia

## Utjecaj prakse navodnjavanja na intenzitet latentne zaraze paunovim okom *Spilocaea oleagina* (Castagne) Hughes na sorti Coratina

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### Sažetak

Najdestruktivnija bolest na maslini (*Olea europaea* L.) je paunovo oko koju izaziva gljiva *Spilocaea oleagina*, (Castage). Prvi simptomi se pojavljuju na listu. Patogen je prisutan u masliniku tokom cijele godine. Tijek inkubacije od 15 dana pa do nekoliko mjeseci otežava nadzor bolesti zbog pojave latentne zaraze. Uzgoj stabla masline u mediteranskom podneblju je na plitkom skeletnom tlu koje ima niski kapacitet za vodu. Za postizanje zadovoljavajućeg prinosa i kvalitete ploda maslinu je potrebno navodnjavati. Cilj rada je odrediti intenzitet i jačinu zaraze paunovim okom na sorti Coratina u sklopu projekta „SAN – Smart Agriculture Network“ na 24 stabla po slučajnom bloknom rasporedu. Navodnjavanje je provedeno sustavom kap na kap. Varijante su: K (0%) - bez navodnjavanja, T1 (PP) - proizvođačka praksa, T2 (SAN) – 80 % od izračunate evapotranspiracije i T3 (100%) – od izračunate evapotranspiracije. Za određivanje latentne zaraze po pojedinim varijantama pokusa ubrani listovi tretirani su natrijevom lužinom. Ocjenjivan je postotak zaražene površine lista razvrstane u pet kategorija. Statističkom obradom podataka jednosmjernom analizom varijance (ANOVA) i povratnim testom (Duncan) određen je postotak zaraženih listova i postotak pokrivenosti lisne površine lezijama. Dobiveni rezultati ukazuju da bez obzira na obrok navodnjavanja sve varijante u istraživanju imaju jednak broj zaraženih listova. S druge strane sve istraživane varijante imaju jednak prosječni postotak zaražene površine lezijama, osim varijante T3 gdje je on značajno veći.

**Ključne riječi:** latentna zaraza, maslina, navodnjavanje, paunovo oko, SAN

## **Impact of irrigation practices on intensity of olive leaf spot *Spilocaea oleagina* (Castagne) Hughes on the Coratina variety**

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### **Summary**

Most destructive disease on olive trees (*Olea europaea* L.) is the olive leaf spot (OLS) caused by fungus *Spilocaea oleagina*, (Castagne). First symptoms appear on the leaf. Fungus is present in the olive grove throughout the year. Incubation time from 15 days to several months make difficult to control the disease due to the occurrence of latent infection. Cultivation of olive trees in the Mediterranean climate is on shallow skeletal soil that has a low water capacity. To achieve yield growth and fruit quality, olive tree need to be irrigated. In this study, aim is to determine the incidence and severity of OLS infestation on Coratina variety within project “SAN - Smart Agriculture Network” on 24 trees according to a random block layout. Irrigation was carried out with a drip system. Treatments are: K (0%) - without irrigation, T1 (MP) - manufacturing practice, T2 (SAN) - 80% of evapotranspiration and T3 (100%) - of evapotranspiration. To determine the latent infection by individual variants of the experiment, the harvested leaves were treated with sodium hydroxide. Percentage of infected leaf area were classified into five categories. Statistical analyses of data by one-way analysis of variance (ANOVA) and return test (Duncan) determined the percentage of infected leaves and the percentage of leaf surface coverage by lesions. Obtained results indicate that regardless of the irrigation, all treatments in the research have the same number of infected leaves. Moreover, all investigated treatments have the same average percentage infected leaf with lesions, except variant T3 where it is significantly higher.

**Key words:** irrigation, latent infection, olive leaf spot, olive tree, SAN

## Utječu li praksa navodnjavanja i svrdlaš (*Rhynchites cribripennis* Desbrocher 1869.) na indeks zrelosti Coratine?

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### Sažetak

Maslina (*Olea europaea* L.) je mediteranska voćna kultura koja zahtjeva navodnjavanje kako bi se postigao optimalni prinos i kvaliteta. Maslinin svrdlaš *Rhynchites cribripennis* Desbrocher 1869, je štetnik koji izgriza plod. Bitan čimbenik pri berbi je stupanj zrelosti ploda. Cilj rada je utvrditi kako različita praksa, kroz količinu i učestalost obroka navodnjavanja, uz prisutnost svrdlaša, utječe na indeks zrelosti masline, sorte Coratina. Istraživanje je provedeno kroz projekt „Smart Agriculture Network“ (KK.01.2.1.01.0100) na 24 stabla na dvije lokacije u Zadarskoj županiji: Žman (Dugi otok) i Novigrad. Navodnjavanje je provedeno sustavom kap na kap sa četiri varijante u tri ponavljanja: K(0%) bez navodnjavanja, T1(PP) proizvođač određivao obroke prema iskustvu, T2(SAN) obroci određivani obzirom na evapotranspiraciju i fenofazu razvoja, s do 80% poljskog kapaciteta tla i T3(100%) dodavanje vode do 100% od izračunate evapotranspiracije. Analizom tla određen je poljski kapacitet, a evapotranspiracija je očitavana s meteopostaje Pinova™. Berbe su obavljene u listopadu 2020. i 2021. Za određivanje štete od svrdlaša te indeksa zrelosti ubrano je 100 plodova po uzorku. Obradom podataka jednosmjernom analizom varijance (ANOVA) i povratnim testom (Tukey), utvrđen je utjecaj praksi navodnjavanja na indeks zrelosti ploda masline po tretmanima, godinama i lokacijama, jednostruko i u međuovisnosti. Nije ustanovljen utjecaj između prisutnosti svrdlaša i indeksa zrelosti.

**Ključne riječi:** indeks zrelosti, maslinin svrdlaš, navodnjavanje, SAN, Zadarska županija

## **Do irrigation practices and the weevil (*Rhynchites cribripennis* Desbrocher 1869) effect on the maturity index of Coratina?**

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### **Summary**

Olive (*Olea europaea* L.) is a Mediterranean fruit crop that requires irrigation to achieve optimal yield and quality. The olive weevil *Rhynchites cribripennis* Desbrocher 1869, is a pest that bites the fruit. An important factor in harvesting is the stage of fruit maturity. The aim of this paper is to determine how different practices, through the amount and frequency of irrigation, with presence of weevil, affect the maturity index of olives, cultivar Coratina. The research was conducted through the project “Smart Agriculture Network” (KK.01.2.1.01.0100) on 24 trees at two locations in Zadar County: Žman (Dugi otok) and Novigrad. Irrigation was carried out with a drip system with four variants in three replications: K (0%) without irrigation, T1 (PP) producer determined irrigation, according to experience, T2 (SAN) irrigation determined according to evapotranspiration and phenophase of development, with up to 80% of field capacity and T3 (100%) added 100% water of the calculated evapotranspiration. Soil analysis determined the field capacity, and evapotranspiration was observed from the Pinova™ meteorological station. Harvests was done in October 2020. and 2021. To determine the damage from weevil and the maturity index 100 fruits were harvested per sample. By processing the data with one-way analysis of variance (ANOVA) and return test (Tukey), the effect of irrigation practices on the olive fruit maturity index by treatments, years and locations, single and interdependent, was determined. No effect was found between the presence of weevil and the maturity index.

**Key words:** irrigation, maturity index, olive weevil, SAN, Zadar County

## Occurrence and presence of olive knot disease (*Pseudomonas savastanoi* pv. *savastanoi*) on Istrian peninsula

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### Summary

Olive knot disease or olive tuberculosis is caused by pathogenesis of gram-negative bacterium *Pseudomonas savastanoi* pv. *savastanoi* (*Pss*). *Pss* is a species that belongs to the complex of *Pseudomonas savastanoi*/*Pseudomonas syringae* along with some other economically significant pathovars. The mechanism of *Pss* pathogenesis includes synthesis of two growth hormones – auxins and cytokinins that causes the appearance of hypertrophic tissue on the different plant organs of olive tree (*Olea europaea* L.). Most often, these growths or knots forms on the branches and leaf stem, and when the infection is severe knots are present on the trunk, leaves and fruits. The presence of olive knot disease has been recorded in almost all olive growing regions in the world. Therefore, for the purpose of this study, field research and sampling of infected plant material from Istrian growing region was performed in year 2021. A total of 92 samples were collected from 39 different locations in Croatian Istria. Samples were collected from diverse olive varieties grown in different production systems. The presence of pathogen was determined by molecular method Real-Time PCR. Results shown that *Pss*, the causal agent of olive knot disease was detected in 24% of tested samples. The highest number of positive samples was determined on ‘Leccino’ variety (40%) followed by ‘Frantoio’ (22%).

**Key words:** field survey, Istria, olive knot, olive varieties, *Pseudomonas savastanoi* pv. *Savastanoi*

## Utjecaj različitih oblika zaštite vinove loze u suzbijanju *Botrytis cinerea* Pers. i utjecaj na urod te kakvoću grožđa i mošta kultivara Cabernet sauvignon

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### Sažetak

Istraživanje je provedeno na Vinogradarsko-vinarskome pokušalištu Mandićevac Fakulteta agrobiotehničkih znanosti Osijek u razdoblju od 2015. do 2017. godine. Korištena su kemijska sredstva *Teldor SC 500* i *Switch 62,5 WG*, a od bioloških preparata korišteni su *Trichodex WP* i *Serenade*. Jedan od tretmana uključivao je primjenu agroampelotehničkih mjera, koje su obuhvaćale uklanjanje bazalnih listova i zaperaka, propuhivanje grozdova i primjenu kalcijeva klorida. Cilj istraživanja bio je ispitati učinkovitost različitih oblika zaštite na pojavu i intenzitet zaraze gljivicom *Botrytis cinerea* na kultivaru Cabernet sauvignon u vinogorju Đakovo te utvrditi razlike u kvantitativnim i kvalitativnim karakteristikama grožđa i mošta koje se javljaju primjenom različitih oblika zaštite s obzirom na zarazu uzrokovanu sivom plijesni. Analizom varijance nije utvrđen statistički značajan utjecaj tretmana na ispitivane parametre niti je interakcija tretmana i godine bila značajna, osim u slučaju razlika u urodu kod tretmana „skup ampelotehničkih mjera i primjena kalcijeva klorida za 2016. i 2017. godinu“. Utvrđen je statistički značajan utjecaj godine na ispitivane parametre.

**Ključne riječi:** *Botrytis cinerea*, vinova loza, botricidi, biofungicidi

## The Influence of Different Forms of Grapevine Protection against *Botrytis cinerea* Pers. and Their Influence on the Grape Yield and Must Quality of Cabernet Sauvignon

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### Summary

Research was conducted at the Mandićevac Viticultural and Vinicultural Experimental Site of the Faculty of Agrobiotechnical Sciences Osijek during the 2015–17 period. The fungicides used were *Teldor SC 500* and *Switch 62.5 WG*, while the biofungicides were *Trichodex WP* and *Serenade*. The ampelotechnical measures included the removal of basal leaves and cotyledons, cluster blowing, and the application of calcium chloride. The study's objective was to examine the effectiveness of different protection forms concerning the occurrence and intensity of *B. cinerea* infection in the Cabernet Sauvignon cultivar in the Đakovo vineyards and to determine the differences in quantitative and qualitative characteristics of grape and must occurring in the application of different forms of protection against the gray mold. The ANOVA ( $p < 0.01$ ) revealed a statistically significant difference between the treatments with regard to a set of ampelotechnical measures and calcium chloride (for the years 2016 and 2017, respectively), whereas there was no significant difference in the grape yield or in an interaction among the treatments and a year between other treatments. A statistically significant influence of the year on all examined treatments was determined.

**Key words:** *Botrytis cinerea*, vine, botrycides, biofungicides



## Doprinos izotopnih analiza hrvatskih vina diferencijaciji vinogradarskih zona RH

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### Sažetak

U ovom su istraživanju prikazani omjeri izotopa kisika, ugljika i vodika u 30 uzoraka vina berbe 2019. Uzorci su proizvedeni mikrovinifikacijom prema Uredbi (EU) 2018/274 s ciljem sudjelovanja hrvatskih autentičnih vina u izotopnoj bazi podataka EU. Analize izotopnih omjera provedene su službenim metodama Međunarodne organizacije za lozu i vino (OIV): spektrometrija masa omjera izotopa (IRMS) za kisik i ugljik, te nuklearna magnetna rezonancija prirodne frakcionacije izotopa specifične za mjesto u molekuli etanola (SNIF-NMR) za omjere  $(D/H)_I$  i  $(D/H)_{II}$ . Izotopni podaci obrađeni su analizom glavnih komponenti (PCA) i algoritmom stroja potpornih vektora (SVM). Cilj ovog istraživanja bio je utvrditi doprinos izotopnih podataka hrvatskih vina diferencijaciji četiri vinogradarske zone (B, CI, CII i CIII) unutar Republike Hrvatske. PCA provedena za ispitane uzorke objasnila je 85 % ukupne varijabilnosti s prve dvije glavne komponente i omogućila razlikovanje vina iz različitih zona s najvećom razlikovnom snagom između kontinentalnih i primorskih vinogradarskih zona. Strojevi potpornih vektora (SMV) pokazali su točnu klasifikaciju 63,3 % uzoraka u validacijskoj matrici. Prikazani rezultati pokazali su da izotopni omjeri u kombinaciji s odgovarajućim statističkim modelom predstavljaju značajan doprinos razlikovanju vina iz hrvatskih vinogradarskih zona, što predstavlja dodanu vrijednost primjeni EU baze podataka.

**Ključne riječi:** hrvatska vina, IRMS, SNIF-NMR, stabilni izotopi, vinogradarske zone

## Contribution of isotope analyzes of Croatian wines to the differentiation of winegrowing zones within the Republic of Croatia

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### Summary

This study presents isotopic ratios of oxygen, carbon and hydrogen in 30 wine samples from the 2019 harvest, produced by microvinification in accordance with Regulation (EU) 2018/274, with the aim of participation of Croatian authentic wines in the EU wine data bank. Isotope ratio analyses were performed according to the official methods of the International Organization of Vine and Wine (OIV): Isotope Ratio Mass Spectrometry (IRMS) for oxygen and carbon, and Site-Specific Natural Isotope Fractionation studied by Nuclear Magnetic Resonance (SNIF-NMR) for the ratios of (D/H)I and (D/H) II. The isotopic data were processed using Principal Component Analysis (PCA) and the Support Vector Machines (SVM) algorithm. The objective of this study was to determine the contribution of isotopic data of Croatian wines to the differentiation of four wine-growing zones (B, CI, CII and CIII) within the Republic of Croatia. PCA performed for the tested samples explained 85% of the total variability with PC1 and PC2, and allowed separation of wines from different zones with the greatest discriminatory power between continental and coastal wine-growing zones. Support Vector Machines (SVM) showed a correct classification of 63.3% of the samples in the validation matrix.

The presented results show that the isotopic ratios, in combination with an appropriate statistical model, make a significant contribution to the discrimination of wines from Croatian winegrowing zones, which is an added value for the application of the EU database.

**Key words:** Croatian wines, IRMS, SNIF-NMR, stable isotopes, wine-growing zones

## Polyphenolic profile of organically grown traditional apple cultivars

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### Summary

The Republic of Croatia is a country with a long tradition of apple production and processing, and the cultivation of traditional apple cultivars in extensive farming occupies an important place for the economy, agronomy, and public health. Traditional fruit cultivars in Croatia are a valuable asset and natural heritage, which does not receive enough attention for popularization and processing. Some traditional apple cultivars possess great potential for organic and ecological fruit growing that is becoming increasingly popular. This is well aligned with increasing consumers' awareness about old cultivars with their specific morphological properties and valuable bioactive compounds, vitamins and minerals without the risks of harmful effects of applied pesticides. New knowledge and research on traditional apple cultivars would strengthen the market for these fruits and their products, prevent the loss of this valuable genetic material, and contribute to greater biodiversity to promote health and overall well-being. This research was conducted on organically grown traditional Croatian cultivars collected from OPG Horvatić, Cvetkovac, 48312 Rasinja, Croatia. For this purpose, polyphenol profile of five traditional Croatian cultivars ('Srčika', 'Mašanka', 'Kanadska reneta', 'Božićnica' and 'Ivandija') was determined by chromatographic (HPLC-DAD) method. Total of 16 polyphenols were identified with chlorogenic acid (CA) as the most prominent. The content of CA ranged from 929.77-3028.78 µg/kg. 'Božićnica' had the highest content of catechin and epicatechin (114.89 and 229.81 µg/kg, respectively) while 'Srčika' had the highest content of phloridzin and phloretin (117.75 and 48.23 µg/kg, respectively). The results showed that traditional apple cultivars are rich with polyphenols making them a desirable cultivar for a healthy snack. Funding: This work has been supported by Croatian Science Foundation under the project "The possibility of exploiting traditional apple cultivars for the production of apples and apple juice with the reduced patulin content" (UIP-2020-02-8461).

**Key words:** polyphenol profile, chlorogenic acid, phloridzin, phloretin

## Utjecaj vodnog deficita na izmjenu plinova lista i ekspresiju gena u četiri hrvatska kultivara vinove loze (*Vitis vinifera* L.) te jedne primke divlje loze (*Vitis vinifera* subsp. *sylvestris*)

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### Sažetak

Izvori vode na području Mediterana vrlo su ugroženi. Predviđaju se češće i intenzivnije suše te pojava ekstremnih vremenskih uvjeta. Vinova loza (*Vitis vinifera* L.) općenito dobro podnosi nedostatak vode te ima određeni mehanizam oporavka nakon suše, iako se kultivari međusobno razlikuju prema osjetljivosti na regulaciju vode u biljci. Kultivari koji pokazuju konzervativni odgovor tijekom suše klasificirani su kao „izohidrični”, dok oni koji imaju manje strogu stomatalnu regulaciju uz izraženiji negativni vodni potencijal tijekom suše su klasificirani kao „anizohidrični”. U ovom istraživanju, analizirana je izmjena plinova lista i transkriptomski odgovor na vodni deficit u četiri tradicionalna hrvatska kultivara *V. vinifera*: „Plavac mali”, „Malvazija istarska”, „Graševina” i „Tribidrag” te jednom genotipu *V. sylvestris*. Istraživanje je provedeno na jednogodišnjim biljkama ukorijenjenim na vlastitom korijenu u posudama za uzgoj biljaka pod kontroliranim uvjetima u stakleniku. Izmjena plinova lista mjerena je pomoću LICOR 6400 prije tretmana vodnim deficitom, dok su listovi iz navodnjavanih (kontrolnih) i nenavodnjavanih biljaka prikupljeni šestog i devetog dana tretmana vodnog deficita radi Real Time-qPCR analiza. Četiri gena, vezana uz biosintezu apscizinske kiseline, ABA (NCED1 i NCED2) i akvaporine (PIP2;1 i TIP2;1) analizirani su pomoću RT-qPCR. Svi analizirani parametri izmjene plinova lista, uključujući stomatalnu provodljivost, transpiraciju, fotosintezu i međustanični CO<sub>2</sub>, pokazali su značajne razlike među genotipovima. ‘Malvazija istarska’ pokazala je značajno nižu ekspresiju svih ispitivanih gena šestog dana tretmana suše, te su razine transkripata ispitivanih gena bile dva do pet puta niže od odgovarajuće kontrole. Samo su razine transkripata NCED1 bile povišene u kultivara ‘Plavac mali’ i primke *V. sylvestris*. Istraživani hrvatski kultivari vinove loze i *V. sylvestris* pokazali su različit odgovor na nedostatak vode, što upućuje na različitu regulaciju gena.

**Ključne riječi:** vinova loza, RT-qPCR, akvaporini, ABA, transkriptom

## The influence of water deficit to leaf gas exchange and gene expression in four Croatian grapevine cultivars (*Vitis vinifera* L.) and one wild accession (*Vitis vinifera* subsp. *sylvestris*)

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### Summary

Water sources are highly endangered in the Mediterranean region. Droughts are predicted to be more frequent, intense and with weather extremes. Grapevine (*Vitis vinifera* L.) has generally good tolerance to water deficit and recovery mechanism after severe drought although there are cultivar sensitivity to water regulation within plant. The cultivars that present conservative response under drought have been classified as “isohydric”, while cultivars that have a less strict stomatal control, exhibiting more negative water potentials under drought have been classified as “anisohydric”. In this study, leaf gas exchange and transcriptomic response to water deficit were determined in the four traditional Croatian *V. vinifera* cultivars: ‘Plavac mali’, ‘Malvazija istriana’, ‘Graševina’ and ‘Tribidrag’ and one *V. sylvestris* genotype. Experiment was set up on the one year own rooted young plants in pots under controlled greenhouse conditions. Leaf gas exchange was measured by LICOR 6400 before water deficit treatment while leaves from irrigated (control) and non-irrigated plants were collected upon six and nine days of water deficit treatment for Real Time-qPCR analyses. Four genes related to ABA (NCED1 and NCED2) and aquaporins (PIP2;1 and TIP2;1) were analysed by RT-qPCR. All studied leaf gas exchange parameters including stomatal conductance, transpiration, photosynthesis and intercellular CO<sub>2</sub> showed significant differences among genotypes. ‘Malvazija istriana’ showed significant downregulation of all studied genes at six days of drought treatment and transcript levels of studied genes were between two to five fold lower than corresponding control. Only transcript levels of NCED1 showed upregulation in cv. ‘Plavac mali’ and *V. sylvestris* accession. The studied local grapevine cultivars and *V. sylvestris* accession showed different pattern of response to water deficit suggesting their different gene regulation.

**Key words:** grapevine, RT-qPCR, aquaporins, ABA, transcriptome

## Utjecaj folijarne gnojidbe silicijem na morfološke karakteristike ploda masline (*Olea europaea* L.)

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### Sažetak

Silicij, iako ne spada u grupu esencijalnih biogenih elemenata, povećava otpornost masline na biotski i abiotski stres. Stoga je cilj ovog rada bio utvrditi utjecaj folijarnog tretmana silicijem na morfološke karakteristike ploda masline u uvjetima bez navodnjavanja. Na lokaciji Sikovo, u Zadarskoj županiji, proveden je dvofaktorijalni poljski pokus (gnojidba x sorta) po shemi potpuno slučajnog rasporeda. Nakon pune cvatnje primjenjena su četiri folijarna tretmana: netretirana kontrola, Si1 (425 mg L<sup>-1</sup> Si), Si2 (850 mg L<sup>-1</sup> Si), Si3 (1700 mg L<sup>-1</sup> Si). Tretmani su primijenjeni na 32 ujednačena stabla dvije sorte: 'Istarska bjelica' i 'Leccino'. Na 40 zdravih plodova, po svakom tretiranom stablu, provedena su morfološka mjerenja (masa, duljina i širina ploda te koštice). Plodovi su u tehnološkoj zriobi ubrani iz središnjeg obodnog djela krošnje ujednačeno sa svih strana svijeta. Sorta se pokazala kao značajan faktor koji je primarno utjecao na morfološke parametre ploda. Tako je sorta 'Istarska bjelica' imala značajno veću masu i širinu ploda kao i masu pulpe i udio pulpe ploda u odnosu na sortu 'Leccino'. Za duljinu ploda, duljinu, širinu i masu koštice te omjer duljine i širine ploda i koštice utvrđeno suprotno. Folijarni tretmani Si2 i Si3 utjecali su na povećanje svih morfoloških karakteristika ploda i koštice u odnosu na kontrolu, osim udjela pulpe. Pri tom, primjena tretmana Si1 rezultirala je najmanjim udjelom pulpe u odnosu na ostala tri tretmana.

**Ključne riječi:** Istarska bjelica, Leccino, maslinovo ulje, sorta, Zadarska županija

## The impact of silicon foliar fertilization on morphological characteristics of olive fruit (*Olea europaea* L.)

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### Summary

Despite the fact that it is not defined as an essential biogenic element, silicon has been found to increase olive resilience to biotic and abiotic stress. Based on the above, the aim of the study was to determine how silicon foliar fertilization affects morphological characteristics of the olive fruit in an environment without irrigation. A two-factor factorial field experiment (fertilization x cultivar) was carried out on the location Sikovo, Zadar County, using a completely randomized design. After anthesis four different foliar treatments were applied: Untreated control, Si1 (425 mg L<sup>-1</sup> Si), Si2 (850 mg L<sup>-1</sup> Si), Si3 (1700 mg L<sup>-1</sup> Si). The treatments were applied on 32 comparable olive trees of two cultivars: 'Istarska bjelica' and 'Leccino'. Morphological measurements were performed on 40 healthy fruits from each tree, in accordance with international method for morphological description of fruits and stones (the mass, length and width of the fruit and the stone). The fruits were harvested at the commercial maturity stage from the central peripheral part of the canopy, from all sides of the world evenly. The cultivar was found to be a significant factor affecting fruit parameters. All measured fruit parameters were significantly higher in 'Istarska bjelica' than in 'Leccino' cultivar, except for the morphological parameters of the stone which had the opposite trend, the length of the fruit and the ratio of the length and width of the fruit and the stone. Also, in fertilization as the second main factor, foliar treatments Si2 and Si3 also demonstrated a positive impact on the morphological characteristics of the fruit and the stone when compared to the control treatment, except for the proportion of the pulp. The application of Si1 treatment resulted in the lowest pulp content compared to the other three treatments.

**Key words:** 'Istarska bjelica', 'Leccino', olive oil, cultivar, Zadar County

## Morfometrijska varijabilnost grozda dalmatinskih autohtonih sorata vinove loze (*Vitis vinifera* L.)

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### Sažetak

S tehnološkog stajališta morfometrijske karakteristike grozda su važne i direktno utječu na kemijski sastav i urod grožđa. Zbijenost grozda je povezana s pojavom gljivičnih bolesti. Ovo istraživanje je provedeno kako bi se prikazala arhitektura grozdova i kemijski sastav 73 autohtone sorte vinove loze (*Vitis vinifera* L.) te njihova osjetljivost na *Botrytis* u poljskim uvjetima. Sorte su proučavane u kolekciji Instituta za jadranske kulture i melioraciju krša. Šest morfoloških varijabli izmjereno je tijekom berbe 2021. godine, uključujući dužinu, širinu, masu i volumen grozda te masu svježe peteljkovine i masu 100 bobica. Određen je osnovni kemijski sastav u moštu: sadržaj šećera ( $^{\circ}\text{Oe}$ ), ukupna kiselost (g/L) i pH. Morfometrijski podaci su analizirani univarijantnim i multivarijantnim statističkim metodama. Statistički značajna razlika između istraživanih sorti pronađena je kod svih istraživanih svojstava grozda i kemijskog sastava mošta ( $p < 0.05$ ). Analiza glavnih komponenata (PCA) urađena na osnovu 9 originalnih varijabli, pokazala je tendenciju grupiranja sorata u najmanje dvije grupe. Provedenom PCA analizom moguće je objasniti 66,28 % varijabilnosti u promatranom skupu podataka koja je definirana sa dvije glavne komponente PC1 i PC2. Klaster analiza otkrila je hijerarhijsku povezanost između promatranih sorti. Dobiveni rezultati sugeriraju morfometrijsku varijabilnost u pogledu strukture grozda. Rezultati će biti korisni u budućoj analizi otpornosti sorata prema *Botrytis*-u i ostalim gljivičnim bolestima, te analizi gena koji kontroliraju morfometrijske karakteristike grozda.

**Ključne riječi:** grozd, *Vitis vinifera*, gljivične bolesti, grupiranje, PCA



## **Bunch morphometric variability in Dalmatian autochthonous grapevine varieties (*Vitis vinifera* L.)**

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### **Summary**

From the technological point of view morphometric characteristics of bunch are very important traits which directly affect fruit chemical composition and yield. Bunch density is related with extent of presence of fungal diseases. This study was conducted to present the bunch structure and chemical composition of 73 autochthonous grapevine (*Vitis vinifera* L.) varieties and their susceptibility to fungal diseases under field conditions. Varieties were studied in germplasm field collection of Institute for Adriatic Crops and Karst Reclamation. Six morphological variables were quantified during harvest season 2021 including bunch length, width, weight, volume, fresh rachis weight and 100 berries weight. Basic must chemical composition was determined: sugar content (Oe), total acids (g/L) and pH. Morphometric data were analysed with univariate and multivariate statistical methods. Statistically significant difference between all bunch traits and must chemical composition ( $p < 0.05$ ) was confirmed for all studied varieties. Principal components analysis (PCA) based on 9 original variables showed a tendency to group varieties according to bunch size into at least two groups. The performed PCA analysis can explain the 66.28% variability in the observed data set, which is defined by two main components PC1 and PC2. Cluster analysis revealed a hierarchical relationship among the observed varieties. The obtained results suggest high morphometric variability in terms of bunch structure. The results will be useful in future analysis of resistance to *Botrytis* and other fungal diseases and analysis of genes that control the morphometric characteristics of bunch.

**Key words:** bunch, *Vitis vinifera*, fungal diseases, clustering, PCA

## Flavonoidi u kori i soku neretvanske mandarine

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### Sažetak

Neretvanska mandarina je zaštićeni izvorni hrvatski proizvod čiji je naziv registriran kao zaštićena oznaka izvornosti, a specifičan položaj uzgoja uz rijeku Neretvu čini je jedinstvenom. Plodovi mandarine dobar su izvor fenolnih spojeva, iako se količina uvelike razlikuje između sorti. Polimetoksilirani flavoni (PMF) učinkoviti su prirodni biokonzervansi koji se nalaze gotovo isključivo u rodu Citrus, osobito u korama mandarina. Određeni su tekućinskom kromatografijom (HPLC-DAD) pojedinačni fenolni spojevi u kori i soku u pet sorata (Zorica, Charara, Kawano Wase, Owari i Saigon) neretvanske mandarine. U soku su bili prisutni hesperidin (67,78-107,81 mg L<sup>-1</sup>), narirutin (117,12-278,73 mg L<sup>-1</sup>) i naringin (4,56-6,53 mg L<sup>-1</sup>), a kora je sadržavala i polimetoksi flavonoide, sinensetin (0,13-0,29 mg g<sup>-1</sup>), nobiletin (0,10-0,49 mg g<sup>-1</sup>) i tangeretin (0,06-0,21 mg g<sup>-1</sup>). Citrus peels had more abundant flavonoids and higher contents than pulps and juices.

**Ključne riječi:** neretvanska mandarina, kora, sok, flavonoidi, polimetoksilirani flavonoidi

## Flavonoids in peel and juice of mandarin fruits from Neretva valley

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### Summary

Neretva mandarin is a protected original Croatian product whose name is registered as a protected designation of origin, and the specific position along the Neretva river makes it unique. Mandarin fruits are a good source of phenolic compounds, although the amount varies greatly between varieties. Polymethoxylated flavones (PMF) are effective natural biopreservatives found almost exclusively in the genus *Citrus*, especially in mandarin peels. In this research, individual phenolic compounds in bark and juice were determined by liquid chromatography (HPLC-DAD) in five cultivars (Zorica, Charara, Kawano Wase, Owari and Saigon) of Neretva mandarins. Hesperidin (67.78-107.81 mg L<sup>-1</sup>), narirutin (117.12-278.73 mg L<sup>-1</sup>) and naringin (4.56-6.53 mg L<sup>-1</sup>) were present in the juice, and the peel also contained polymethoxy flavonoids; sinensetin (0.13-0.29 mg g<sup>-1</sup>), nobiletin (0.10-0.49 mg g<sup>-1</sup>) and tangeretin (0.06-0.21 mg g<sup>-1</sup>). Citrus peels had more flavonoids and higher content than pulps and juices.

**Key words:** Neretva mandarin, peel, juice, flavonoids, polymethoxy flavonoids

## Utjecaj različite pozicije vinograda unutar jednog položaja na kakvoću vina sorte Graševina

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### Sažetak

Kako je poznato vinogradarski položaji imaju značajan utjecaj na kakvoću grožđa i vina. Cilj istraživanja bio je utvrditi utjecaj različitih manjih lokaliteta unutar jednog vinogradarskog položaja na kakvoću grožđa i vina sorte Graševina (*Vitis vinifera* L.). Pokus je postavljen tijekom 2021. godine u vinogorju Kutjevo na položaju Podgorje. Istaživanje je provedeno na grožđu i vinu iz dva vinograda. Razlike između pozicija očitovale su se u različitom tipu tla, različitoj nadmorskoj visini i različitoj inklinaciji terena, te različitoj starosti nasada. Udaljenost između pozicija iznosi oko 1500 m. Pokus je postavljen po slučajnom bloknom rasporedu u 3 repeticije, a podatci su obrađeni statistički. Trenutak berbe određen je na osnovi ukupne kiselosti mošta koja je iznosila oko 6 g L<sup>-1</sup>. Fermentacija je obavljena u inox posudama pod istim uvjetima uz uporabu istih enoloških sredstava za oba tretmana. U trenutku berbe određen je urod po trsu pri čemu nisu utvrđene statistički značajne razlike. U moštu i vinu određeni su osnovni fizikalno kemijski parametri te je provedena organoleptička evaluacija vina, metodom 100 bodova te deskriptivnom metodom. Ocjenjivanje su proveli educirani ocjenjivači. Utvrđena je statistički opravdana razlika među tretmanima koja je iznosila 12 bodova, a vina različitik tretmana svrstana su u različite kategorije kakvoće sukladno važećim propisima.

**Ključne riječi:** vino, Graševina, vinogradarski položaj, Vinogorje Kutjevo,

## **Influence of different vineyard positions within one vineyard appellation on Graševina wine quality.**

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### **Summary**

As known, vineyard locations have a significant impact on the quality of grapes and wine. The aim of the research was to determine the influence of different smaller localities within one viticultural position on the quality of grapes and wine of the Graševina variety (*Vitis vinifera* L.). The experiment was set up in 2021 in the Kutjevo vineyards at the Podgorje appellation. The research was conducted on grapes and wine from two vineyards. Differences between positions were manifested in different soil types, heights, terrain inclinations, and different plantation ages. The distance between the positions of vineyards is about 1500 m. The experiment was set up according to a random block schedule in 3 repetitions, and the data were processed statistically. The time of harvest was determined on the basis of the total acidity of the must, which was about 6 g L<sup>-1</sup>. Fermentation was performed in stainless steel vessels under the same conditions using the same oenological agents for both treatments. At the time of harvest, the yield per vine was determined, and no statistically significant differences were found. Basic physicochemical parameters were determined in must and wine, and organoleptic evaluation of wine was performed using the 100-point method and the descriptive method. The evaluation was conducted by trained evaluators. A statistically justified difference of 12 points between treatments was found, and wines with different treatments were classified into different quality categories in accordance with applicable regulations.

**Key words:** wine, Graševina, vineyard position, Kutjevo vineyard

## Utjecaj duge maceracije na kakvoću vina sorte Graševina

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### Sažetak

Iako klasična proizvodnja bijelih vina podrazumijeva fermentaciju mošta, u posljednje vrijeme se primjećuje trend proizvodnje bijelih vina uz tzv. maceraciju odnosno fermentaciju izmuljanog ali ne i isprešanog grožđa. Cilj ovog rada je utvrditi utjecaj duge maceracije grožđa na kakvoću vina Graševina. Istraživanje je provedeno tijekom 2021. godine u vinogradima i vinskom podrumu Veleučilišta u Požegi u vinogorju Kutjevo. Nakon berbe, kontrolni uzorak vina proizveden je klasičnim postupkom proizvodnje bijelih vina, te je također proveden postupak duge maceracije u periodu od 3 mjeseca, u dva tretmana - jedan uz sumporenje tijekom primarne prerade a drugi bez sumporenja. U vinima su određeni slijedeći parametri: alkohol, reducirajući šećeri, ukupna kiselost, jabučna, mliječna kiselina, hlapiva kiselost, pH, apsorbanacija na 280 nm, ukupni polifenoli i antioksidativna aktivnost DPPH metodom. Statistički značajna razlika je u udjelu polifenola, kao i antioksidativnoj aktivnosti, s najvećim vrijednostima u maceriranom uzorku uz korištenje SO<sub>2</sub>. Organoleptičko ocjenjivanje uzoraka proveli su educirani ocjenjivači, metodom 100 bodova. Najveću prosječnu ocjenu od 87 bodova dobilo je vino proizvedeno dugom maceracijom grožđa uz redovito sumporenje u procesu primarne prerade. Kontrolni tretman slabije je ocjenjen, ocjenom od 78 bodova. Vino proizvedeno dugom maceracijom bez korištenja sumpora ocjenjeno je prosječnom ocjenom od 67 bodova uz napomenu pojedinih ocjenjivača da je kod ovog tretmana u mirisu izražena oksidacija.

**Ključne riječi:** Graševina, maceracija, sumporenje, polifenoli, antioksidativna aktivnost

## **Influence of long maceration on the quality of Graševina wine**

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### **Summary**

Although classical production of white wines involves the fermentation of must, recently there has been a trend in the production of white wines with the so-called maceration or fermentation of crushed but not pressed grapes. The aim of this paper is to determine the influence of long maceration of grapes on the quality of Graševina wine. The research was conducted in 2021 in the vineyards and wine cellar of the Polytechnic of Požega in the Kutjevo vineyards. After harvesting, a control sample of wine was produced by the classic white wine production process, and a long maceration process was carried out over a period of 3 months, in two treatments - one with sulfurization during primary processing and the other without sulfurization. The following parameters were determined in wines: alcohol, reducing sugars, total acidity, malic, lactic acid, volatile acidity, pH, absorbance at 280 nm, total polyphenols and antioxidant activity by DPPH method. There is a statistically significant difference in the content of polyphenols, as well as antioxidant activity, with the highest values in the macerated sample containing SO<sub>2</sub>. Organoleptic evaluation of samples was performed by trained evaluators, using the 100-point method. The highest average score of 87 points was given to wine produced by long maceration of grapes with regular sulfurization during primary processing. Control treatment was rated lower, 78 points. Wine produced by long maceration without the use of sulfur in the primary processing was evaluated with an average score of 67 points with a few remarks that in this treatment the oxidation is pronounced in the aroma.

**Key words:** Graševina, maceration, sulfurization, polyphenols, antioxidant activity

## Mogućnosti FTIR tehnike u razlikovanju voćnih vina obzirom na voćnu vrstu

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### Sažetak

Za kontrolu kvalitete voćnih vina pretežno se koriste tradicionalne metode za određivanje alkoholne jakosti, ukupnog suhog ekstrakta, šećera, kiselosti, pepela i sumporovog dioksida. Posljednjih je godina tehnika infracrvene spektroskopije s Fourierovom transformacijom (FTIR) našla svoje mjesto u rutinskoj kontroli kvalitete vina, ali je pokazala i veliki potencijal u području utvrđivanja autentičnosti prehrambenih proizvoda, kao što su to alkoholna pića, mlijeko i mliječni proizvodi, med i ulje. Omogućuje brzu i nedestruktivnu analizu te se može primijeniti i na voćna vina. Cilj ovog rada bio je istražiti mogućnosti FTIR tehnike u razlikovanju voćnih vina prema voćnim vrstama. Ukupno 28 uzoraka voćnih vina proizvedenih od jabuke, jagode, maline, tayberryja i višnje analizirano je klasičnim metodama i FTIR-om tijekom postupka stavljanja vina na hrvatsko tržište. Analiza glavnih komponenti (PCA) provedena je da bi se interpretirali dobiveni spektralni podatci i kako bi se utvrdilo da li voćna vina proizvedena od različitih voćnih vrsta čine odvojene skupine. PCA provedena za ispitane uzorke objasnila je 92 % ukupne varijabilnosti s prve dvije glavne komponente i pokazala jasno grupiranje svih voćnih vina prema voćnim vrstama sa PC1 kao dominantnom razdjelnom ravninom. Ovo istraživanje proširuje dosadašnje spoznaje o voćnim vinima proizvedenim od jabuke, jagode, maline, tayberryja i višnje te pridonosi definiranju njihovih karakteristika određenih klasičnim fizikalno kemijskim metodama.

**Ključne riječi:** FTIR, kemometrijske metode, PCA, voćna vina



## Possibilities of the FTIR technique in the differentiation of fruit wines according to fruit species

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### Summary

Traditional methods for determining alcohol content, total dry extract, sugar, acidity, ash, and sulfur dioxide have been used predominantly for quality control of fruit wines. In recent years, Fourier Transform Infra-Red spectroscopy (FTIR) has found its place in routine quality control of wine, but it has also shown great potential in the field of authenticity of foods such as alcoholic beverages, milk and dairy products, honey and oil. It allows rapid and non-destructive analysis and can also be applied to fruit wines. The aim of this work was to investigate the potential of the FTIR technique in distinguishing fruit wines according to plant species. A total of 28 fruit wine samples produced from apples, strawberries, raspberries, tayberries and sour cherries were analyzed by FTIR during the procedure of placing the wines on the Croatian market. Principal Component Analysis (PCA) was performed to interpret the spectral data obtained and to determine whether the fruit wines produced from different fruit species constitute distinctive groups. The PCA performed for the samples studied explained 92% of the total variability with PC1 and PC2 and showed a clear grouping of all fruit wines according to fruit species with PC1 as the dominant separating plane. This study extends the current knowledge on fruit wines from apples, strawberries, raspberries, tayberries, and sour cherries and contributes to the definition of their characteristics determined by classical physicochemical methods.

**Key words:** chemometric methods, FTIR, fruit wine, PCA

## **Influence of different wood barrel on aroma profile of Cabernet sauvignon and Merlot red wines from Kutjevo vineyard**

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### **Summary**

Wine aroma profile depends on various factors, including wine variety, viticulture and vinification techniques, fermentation and aging condition (time, temperature or vessel type, like wooden barrels or stainless steel tanks). The aim of this study was to investigate the influence of different wooden barrels (with light, medium and heavy toasting) on aroma profile of Cabernet Sauvignon and Merlot red wines from Kutjevo vineyard through 12 months of aging. As control sample, both wines also aged in stainless steel tank. The results showed that the total concentrations of acids, alcohols, esters and volatile phenols in both wines were higher after aging in wooden barrels than in stainless steel tanks, except for terpenes. Merlot wine aged in wooden barrel with heavy toasting had the highest total concentrations of acids, esters and volatile phenols, while Cabernet Sauvignon wine aged in wooden barrel with light toasting had the highest total concentration of alcohols, comparing to all other samples. The concentrations of volatile compounds with smoky and burnt aroma were higher in both wines aged in wooden barrels with heavy toasting, than in other samples. Both wines aged in wooden barrels with lighter toasting levels contained higher concentrations of aroma compounds with fruity and citrus aroma, than the ones aged in wooden barrels with heavy toasting. Heavier toasting levels of wooden barrels contributed to the higher concentrations of volatile compounds with fatty aroma.

**Key words:** Merlot, Cabernet Sauvignon, wooden barrel, toasting, aroma compounds

## Utjecaj folijarne primjene selena i silicija na koncentraciju oleuropeina u listu masline

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### Sažetak

List je središnji dio metabolizma masline ali povezanost folijarne aplikacije mineralnih hraniva i biosinteze fenola još uvijek nije dovoljno istražena. Fenolne komponente lista masline imaju dokazano pozitivan učinak na ljudsko zdravlje te se sve češće koriste kao nutraceutici ili prirodni aditivi u prehrambenoj industriji. Među fenolnim spojevima u lišću masline, dominira oleuropein. Stoga je cilj ovog rada bio utvrditi utjecaj folijalno primjenjenog selena (Se) i silicija (Si) na koncentraciju oleuropeina u listovima sorte 'Leccino' tijekom berbe. Pokus je postavljen po shemi slučajnog blokno rasporeda s dva glavna faktora: a) folijarna gnojidba (netretirana kontrola (C), selen (Se), silicij (Si) i tretman selenom i silicijem (Se+Si) i b) starost lista (ovo sezonski list masline (mladi list), prošlo sezonski list masline (stari list)). Svaki tretman činila su četiri stabla masline raspoređena u četiri ponavljanja. Kombinirani tretman Se i Si (Se+Si) kao i primjena Si (Si) rezultirali su većom koncentracijom oleuropeina (5850 mg 100 g<sup>-1</sup> DW odnosno 4899 mg 100 g<sup>-1</sup> DW) u usporedbi s netretiranom kontrolom (C) (3962 mg 100 g<sup>-1</sup> DW). Nadalje, koncentracija oleuropeina bila je veća u mladim (5721 mg 100 g<sup>-1</sup> DW) u usporedbi sa starim listovima masline (3962 mg 100 g<sup>-1</sup> DW), dok je suprotan učinak uočen za sadržaj silicija u lišću masline. U usporedbi s drugim tretmanima Se i Se+Si, kao i tretmani Si i Se+Si povećali su koncentraciju selena odnosno silicija u listu masline.

**Ključne riječi:** Leccino, fenoli, *Olea europaea* L., mladi list, stari list

## The impact of selenium and silicon foliar fertilization on olive leaf oleuropein concentration

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### Summary

Olive leaves are the central place of olive plant metabolism but the connection between foliar application of mineral nutrients and phenol biosynthesis still remains unclear. The phenolic components of olive leaves have a proven positive effect on human health and are increasingly used as nutraceuticals or natural additives in the food industry. Among phenolic compounds in olive leaf oleuropein is the most dominant one. Thus the aim of this work was to determine impact of foliarly applied Selenium (Se) and Silicon (Si) on 'Leccino' cv. leaf oleuropein concentration during harvest period. The trial was set up as random block design with two main factors: i) foliar fertilization (Untreated control (C), Selenium (Se), Silicon (Si) and Selenium and Silicon (Se&Si) treatment) and ii) leaf age (current season olive leaf (young leaf), previous season olive leaf (old leaf)). Each treatment was represented with four olive trees split in four replications. Combined Se and Si treatment (Se&Si) as well as Si application (Si) resulted in higher oleuropein concentration (5850 mg 100 g<sup>-1</sup> DW and 4899 mg/100 g DW, respectively) compared to untreated Control (C) (3962 mg 100 g<sup>-1</sup> DW). Furthermore oleuropein concentration was higher in young (5721 mg 100 g<sup>-1</sup> DW) compared to old olive leaves (3962 mg 100 g<sup>-1</sup> DW) while opposite effect was noticed for olive leaf Silicon concentrations. Compared to other treatments Se and Se&Si as well as Si and Se&Si treatments increased selenium and silicon olive leaf concentrations respectively.

**Key words:** Leccino cv., phenolic, *Olea europaea* L., young leaf, old leaf

## Effect of maceration duration, heat treatment, and barrel aging on water-soluble vitamin content in Teran wines

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### Summary

The objective of this study was to determine the effects of four winemaking techniques on water-soluble vitamin content and estimate the changes in their range during the barrel aging of Teran red wines. The study covered seven days of maceration as a control treatment (TM7), prolonged 10-day maceration (TM10), prolonged post-fermentative 21-day maceration (TM21), and 48-h pre-fermentative maceration heat treatment at 45 °C followed by eight-day standard maceration (TPHT). The fermentation of all treatments was conducted at 24 °C. Accordingly, all the wine samples were aged in oak barrels for six months. Vitamins were analyzed using high-performance liquid chromatography with UV-Vis diode array and single quadrupole mass detector equipped with electrospray ionization interface. The thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3), pyridoxine (vitamin B6), and ascorbic acid (vitamin C) were determined. Total B complex vitamin content of young Teran wines significantly increased with prolonged skin contact. Furthermore, the results showed that significantly the highest content of total B-complex vitamins was detected in TM21 wine, followed by TM10 treatment. Regarding the vitamin C concentration in young Teran wines, there were no statistical differences between TM7, TM10, TM21 treatments, while TPHT treatment showed a significantly lower concentration. Wine barrel aging significantly reduced the level of all investigated vitamins except vitamin B6, which remained stable in all treatments. This study showed that winemaking techniques could affect the vitamin concentrations in wine.

**Key words:** Teran wines, maceration duration, pre-fermentative heat treatment, barrel aging, vitamins

## Utjecaj rezidbe korijena na rast, rodnost i fizikalno – kemijska svojstva ploda jabuke ‘Cripps Pink’

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### Sažetak

Cilj rada bio je utvrditi utjecaj rezidbe korijena na rast, rodnost i fizikalno-kemijska svojstva ploda jabuke ‘Cripps Pink’. Istraživanje je provedeno tijekom 2019. godine u intenzivnom nasadu jabuke sorte ‘Cripps Pink’ u dolini rijeke Neretve. Rezidba korijena izvršena je strojno, rezačem za korijen u periodu mirovanja jabuke, u 4 tretmana koji su se razlikovali ovisno o rezidbi korijena na različitoj udaljenosti od debla: tretman A - 20 cm s jedne strane debla; B - 30 cm od debla s jedne strane; C - 40 cm s obje strane debla i D - kontrola (bez rezidbe korijena). Utvrđeno je značajno smanjenje vegetativnog rasta u tretmanima rezidbe korijena u odnosu na kontrolu. Kod tretmana C utvrđen je najveći utjecaj rezidbe korijena na smanjenje vegetativne aktivnosti, povećanje priroda i broja plodova po stablu, dok su najniže vrijednosti utvrđene kod tretmana D. Temeljem provedene fizikalno-kemijske analize plodova nakon berbe, utvrđeno je da je rezidba korijena značajno utjecala na smanjenje mase i visine ploda u odnosu na kontrolu. Značajno veća tvrdoća ploda utvrđena je kod plodova tretmana A, B i C u odnosu na tretman D. Viši udio topljive suhe tvari utvrđen je kod plodova iz tretmana C i D u odnosu na plodove iz tretmana A i B. Najviši indeks razgradnje škroba utvrđen kod plodova iz tretmana D. Rezidba korijena pozitivno je utjecala na smanjenje vegetativnog rasta, povećanje rodnosti te je utvrđen pozitivan učinak na pojedina fizikalno-kemijska svojstva ploda jabuke ‘Cripps Pink’.

**Ključne riječi:** *Malus domestica* Borkh., rezidba, vegetativni rast, analiza ploda

## **Influence of root pruning on the growth, yield and physico-chemical properties of ‘Cripps Pink’ apple**

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### **Summary**

The objective of this study was to determine the effect of root pruning on the growth, yield, and physicochemical properties of the apple cultivar ‘Cripps Pink’. The study was conducted in an intensive apple orchard of the cultivar ‘Cripps Pink’ in the valley of the Neretva River in 2019. Root pruning was performed mechanically with root pruner in the dormant period. It was carried out in 4 treatments, which differed in the distance of pruning from the apple trunk: Treatment A - pruning 20 cm from one side of the trunk, Treatment B - 30 cm from one side of the trunk, Treatment C - pruning 40 cm from both sides of the trunk and Treatment D - control treatment without root pruning. Monitoring of growth and yield indicators of apples showed a significant reduction in vegetative growth in treatments with root pruning compared to the control. In treatment C, the greatest effect on the reduction of vegetative activity was observed, the highest values for yield per tree, number of fruits per tree and yield efficiency were also observed in treatment C, and the lowest in treatment D. After harvest and based on fruit physicochemical analysis, it was found that root pruning significantly reduced fruit weight and height compared to the control treatment. Fruit firmness was significantly higher in treatments A, B, and C than in control treatment D. Soluble solids content was higher in fruits of treatments C and D than in fruits of treatments A and B. The highest starch degradation index was observed in the fruits of treatment D. Root pruning had a positive effect on reducing vegetative growth, increasing yield, and a positive effect on some physicochemical properties of ‘Cripps Pink’ apple fruit.

**Key words:** *Malus domestica* Borkh., pruning, vegetative growth, fruit analysis

## Rasprostranjenost, karakterizacija i prijenos badnavirusa vinove loze 1

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### Sažetak

Badnavirus vinove loze 1 (GBV-1) otkriven je 2018. godine u hrvatskim sortama vinove loze Ljutun i Vlaška s područja Kaštela sa simptomima zaostajanja u rastu. Cilj istraživanja bio je odrediti njegovu rasprostranjenost i učestalost pojave, karakteristike virusnih čestica, varijabilnost genoma u regiji reverzne transkriptaze (RT) te načine prijenosa. U periodu od 2018. do 2021. prikupljeno je 4302 uzorka vinove loze iz 88 vinograda te je izolirana DNA. Analizom postojećih podataka konstruirane su početnice i probe za detekciju metodom PCR (konvencionalni i u realnom vremenu). Morfološka karakterizacija virusnih čestica i citopatologija određena je transmisivnim elektronskim mikroskopom (TEM), dok je za prijenos korištena lozina štitasta uš (*Planococcus ficus*), mehanička inokulacija, a ispitana je i mogućnost prijenosa sjemenom i cijepljenjem. Prisutnost virusa potvrđena je u tri kolekcijska nasada te 29 vinograda u priobalnom području pri čemu je ukupna pojavnost virusa iznosila 13.4%. TEM analiza pokazala je štapičast izgled virusnih čestica te njihovu raspršenost u citoplazmi zaraženih stanica. Analiza dijela RT regije pokazala je sličnost hrvatskih izolata na nukleotidnoj razini u rasponu od 94.1 do 100% te na aminokiselinskoj razini od 92.6 do 100%. Lozina štitasta uš pokazala se kao vektor GBV-1 sa uspješnošću prijenosa sa loze na lozu od 55%. Također, dokazan je prijenos cijepljenjem, ali ne i mehaničkom inokulacijom ili sjemenom virusom zaraženih biljaka.

**Ključne riječi:** RT-PCR, qPCR, TEM, sekvenciranje, *Planococcus ficus*



## Incidence, characterization and transmission of grapevine badnavirus 1

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### Summary

Grapevine badnavirus 1 (GBV-1) was discovered in 2018 in Croatian autochthonous grapevine cultivars Ljutun and Vlaška, originating from the Kaštela region with symptoms of reduced growth. The aim of this study was to determine the distribution and abundance of the virus, virus particle characteristics, genome variability in the reverse transcriptase region (RT), and modes of transmission. During 2018 and 2021, 4302 samples were collected from 88 vineyards and DNA was isolated. Based on the analysis of existing data, primers and probes for the detection of GBV-1 by PCR (conventional and real-time) were developed. Morphological characterization of virus particles and cytopathology were determined by transmission electron microscope (TEM), while transmission experiments tested possibility of transmission by vine mealybug (*Planococcus ficus*), mechanical inoculation, and also by seeds and grafting. The presence of the virus was confirmed in the three collection plantations and in 29 vineyards in the coastal region, with an overall virus incidence of 13.4%. The TEM analysis showed the bacilliform shape of the virus particles and their distribution in the cytoplasm of the infected cells. The analysis of the part of RT genomic region showed the similarity of Croatian isolates at the nucleotide level ranging from 94.1 to 100% and at the amino acid level from 92.6 to 100%. Vine mealybug was found to be a vector of GBV-1 with a 55% vine-to-vine transmission rate. Transmission by grafting was also demonstrated, but not by mechanical inoculation or by seeds from virus-infected plants.

**Key words:** RT-PCR, qPCR, TEM, sequencing, *Planococcus ficus*

## Genetske specifičnosti fizikalnih i kemijskih svojstava plodova višnje (*Prunus cerasus L.*)

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### Sažetak

Plod višnje blagotvorno djeluje na ljudski organizam zbog kemijskog sastava koji obiluje polifenolnim spojevima, antocijanima te voćnim šećerima i kiselinama. Cilj ovog istraživanja bio je utvrditi genetske specifičnosti te dinamiku promjena fizikalnih i kemijskih svojstava plodova tijekom zrenja. Istraživanje je provedeno na sedam sorti višanja (Oblačinska, Haiman, Rexelle, Erdy Botermo, Debrecen Botermo, Ujfehertska i Erdy Jubileum) posadenih na pokusnom nasadu Poljoprivrednog instituta Osijek. Svojstva koja smo analizirali su: masa ploda i sjemenke, udio topljive suhe tvari, boja ploda, ukupne kiseline, šećeri, polifenoli i antocijani. Berba plodova je izvršena u tri roka sa razmakom od sedam dana. Najveću masu je imala sorta Erdy Botermo, a najmanju Oblačinska. Najmanju masu sjemenke je imala sorta Erdy Jubileum, a najveću Rexelle. Najvišu topljivu suhu tvar je imala sorta Erdy Botermo, a najmanju Erdy Jubileum. Sa dozrijevanjem vrijednost  $a^*(C)$  koja označava odnos crvene i zelene boje se smanjivala kod svih sorti. Ukupne kiseline su bile najviše kod Erdy Botermo, a najmanje kod Haiman. Najveći sadržaj polifenola je zabilježen kod sorte Haiman, a najmanji kod sorte Erdy Botermo. Sa kasnijim rokom berbe vidljiv je trend povećanja sadržaja antocijana kod svih sorti. Najveći sadržaj antocijana zabilježen je kod sorti Haiman i Rexelle dok je najmanji kod Erdy Botermo. Za određivanje optimalnog roka berbe vrlo je bitno pratiti fizikalne i kemijske promjene tijekom zrenja.

**Ključne riječi:** višnja, plod, svojstva, zrenje, sorta

## **Genetic specifics of physical and chemical properties of sour cherry fruits (*Prunus cerasus* L.)**

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### **Summary**

The sour cherry fruit has a beneficial effect on the human body due to its chemical composition, which is rich in polyphenolic compounds, anthocyanins and fruit sugars and acids. The aim of this study was to determine the genetic specifics and dynamics of changes in physical and chemical properties of fruits during ripening. The research was conducted on seven varieties of sour cherries (Oblacinska, Haiman, Rexelle, Erdy Botermo, Debrecen Botermo, Ujfehertoi furtos and Erdy Jubileum) planted on the experimental orchard at Agricultural Institute Osijek. The analyzed properties were: fruit and seed weight, soluble solid content, fruit color, total acids, sugars, polyphenols and anthocyanins. The fruits were harvested in three picking time with an interval of seven days. The Erdy Botermo variety had the largest weight, and Oblacinska the smallest. Erdi Jubileum had the lowest seed weight and Rexelle the highest. Erdy Botermo had the highest soluble solid content and Erdy Jubileum the lowest. During ripening the value of a \* (C), which indicates the ratio of red and green colour, decreased in all varieties. Total acids were highest in Erdy Botermo and lowest in Haiman. The highest polyphenol content was recorded in the Haiman, and the lowest in the Erdy Botermo. With the later harvest date, the trend of increasing the content of anthocyanins in all varieties is visible. The highest content of anthocyanins was recorded in the varieties Haiman and Rexelle, while the lowest was in Erdy Botermo. To determine the optimal harvest time, is very important to monitor physical and chemical changes during ripening.

**Key words:** sour cherry, fruit, properties, ripening, variety



**Poljoprivredna  
tehnika**

**09**

**Agricultural  
Technics**



## Utjecaj sustava obrade na prinos različitih sorata krumpira, utrošak goriva i vremena za obradu tla

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### Sažetak

U radu su prikazani rezultati jednogodišnjeg istraživanja primjene dvaju različitih sustava obrade tla, konvencionalnog (uključuje oranje, tanjuranje i završnu obradu sjetvospremačem) i konzervacijskog (uključuje obradu gruberom i rotodrljačom), u uzgoju krumpira na području Bjelovarsko-bilogorske županije. Cilj rada bio je utvrditi utjecaj sustava obrade tla na prinos četiri različite sorte krumpira (Arizona, Masai, Prada i Red Lady), kao i utrošak goriva te vremena potrebnog za obradu tla. Istraživanja su provedena u vegetacijskoj godini 2021. koja je bila izuzetno klimatski nepovoljna za uzgoj krumpira. Nepovoljan raspored oborina i niske temperature u nicanju krumpira uzrokovali su 40-70 % manje prinose od očekivanih. Primjenom konzervacijskog sustava obrade tla ostvareni su prosječno 511 kg ha<sup>-1</sup> viši prinosi krumpira, što čini oko 5 % razlike. Najmanja razlika bila je na sorti Masai (317 kg ha<sup>-1</sup>), koja je i najviše podbacila u prinosu, kod sorte Prada je razlika bila nešto veća (471 kg ha<sup>-1</sup>), a najveća razlika je bila kod sorti Arizona i Red Lady (628 kg ha<sup>-1</sup>). Kod konvencionalnog sustava obrade tla utrošak goriva je iznosio 56,25 l/ha, a za obradu je bilo potrebno 2,81 h/ha, dok je kod konzervacijskog sustava obrade utrošak goriva iznosio 43,75 l ha<sup>-1</sup>, a za obradu je bilo potrebno 1,88 h ha<sup>-1</sup>. Navedeni rezultati ukazuju na prednosti konzervacijskog načina obrade tla, kako u utrošku goriva (49,5 % uštede), tako i u vremenu potrebnom za obradu (28,6 % uštede), uz bolje prinose.

**Ključne riječi:** obrada tla, krumpir, prinos, utrošak goriva, vrijeme za obradu

## **Influence of tillage system on yield of different potato cultivars, fuel consumption and tillage time**

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### **Summary**

The paper presents the results of a one-year study of the application of two different tillage systems, conventional (including plowing, discharrowing and seedbed preparation) and conservation (including tillage with grubber and rotary harrow), in potato cultivation in Bjelovar-Bilogora County. The aim of this study was to determine the impact of tillage systems on the yield of four different potato cultivars (Arizona, Masai, Prada and Red Lady), as well as fuel consumption and time required for tillage. The research was conducted in the vegetation year 2021, which was extremely climatically unfavorable for potato cultivation. Unfavorable precipitation distribution and low temperatures in potato germination caused 40-70% lower yields than expected. By applying the conservation tillage system, on average 511 kg ha<sup>-1</sup> higher potato yields were achieved, which is difference of about 5%. The lowest difference was in the cultivar Masai (317 kg ha<sup>-1</sup>), which also failed the most in yield, in the cultivar Prada the difference was slightly higher (471 kg ha<sup>-1</sup>), and the largest difference was in the cultivars Arizona and Red Lady (628 kg ha<sup>-1</sup>). In the conventional tillage system fuel consumption was 56.25 l ha<sup>-1</sup> and required time for tillage was 2.81 h ha<sup>-1</sup> time, while in the conservation tillage system fuel consumption was 43.75 l ha<sup>-1</sup> and required time for tillage was 1.88 h ha<sup>-1</sup>. These results indicate the advantages of conservation tillage, both in fuel consumption (49.5% savings) and in the time required for tillage (28.6% savings), with better yields.

**Key words:** soil tillage, potato, yield, fuel consumption, tillage time

## Otpad od dorade sjemena kao izvor energije

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### Sažetak

Prilikom proizvodnje sjemena, u svrhu sprečavanja samozagrijavanja i propadanja sjemena, dorada predstavlja neizostavan korak. Dorada najčešće podrazumijeva posliježetveno čišćenje, sušenje i slično. Razlog tomu je činjenica kako prikupljeno sjeme sadrži, izuzev proizvedenog sjemena i korove te razne organske i anorganske primjese. Pri doradi sjemena, proizvode se znatne količine organskog otpada. Prema dosadašnjim istraživanjima, ta količina najčešće iznosi oko 5 %, dok ponekad dostiže 10 % ukupnog prinosa. Premda se spomenuti otpad može iskoristiti kao hrana za životinje, s obzirom na nisku kvalitetu takve hrane, ali i slabu prisutnost stočarske proizvodnje u blizini poljoprivrednog gospodarstva, ostatak od dorade sjemena predstavlja otpad koji je potrebno zbrinuti na odgovarajući način. U radu je istražena mogućnost iskorištenja otpada od dorade različitih sjemenskih kultura komercijalne proizvodnje (grašak, soja, pšenica, zob, pir, grah i uljana repica) u energetske svrhe, za potrebe vlastite proizvodnje električne energije.

Određivanjem energetske svojstava otpada pojedine kulture, kako i provedbom analize dostupnosti iz ukupne komercijalne proizvodnje, izračunat je energetski potencijal otpada od dorade sjemena. Statističkom obradom podataka utvrđeno je kako sav otpad iz dorade sjemena predstavlja značajan potencijal za iskorištenje u energetske svrhe, kako po jedinici mase, tako i po ukupnoj proizvodnji, dok kulture bogate uljem prednjače.

**Ključne riječi:** energetska svojstva, dorada sjemena, otpad



## Seed processing waste from as a source of energy

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### Summary

In seed production, in order to prevent self-heating and seed decay, final processing is an indispensable step. Final processing usually involves post-harvest cleaning, drying, etc. This is due to the fact that collected seeds contain weeds and various organic and inorganic impurities in addition to the seeds produced. During final processing, significant amounts of organic waste are produced. According to previous studies, it usually amounts to about 5%, sometimes even 10% of the total yield. Although this waste can be used as animal feed, it is often considered as a waste that must be properly disposed of because the quality of this feed is low, but also because the livestock production near the farm is insignificant. In this paper, the possibility of using waste from the final processing of different seed crops from commercial production (peas, soybeans, wheat, oats, spelt, beans and canola) for energy purposes for the needs of own heat production was investigated.

By determining the energy characteristics of the waste from each crop and analysing the availability of the entire commercial production, the energy potential of the waste from seed processing was calculated. Statistical data processing showed that all seed processing wastes represent significant potential for energy use, both per mass unit and in total production, with oleaginous crops predominating.

**Key words:** energy characteristics, final processing of seeds, waste

## Dostupnost i održivo iskorištenje ovčje vune u kružnom biogospodarstvu u Zadarskoj i Šibensko-kninskoj županiji

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### Sažetak

Održivo biogospodarstvo je obnovljivi segment kružnog gospodarstva, a podrazumijeva pretvorbu otpadnih organskih tvari u visokovrijedne proizvode. Valorizacija organskog ostatka, s ciljem daljnjeg iskorištenja, provodi se na lokalnoj razini. Stoga je važno utvrditi mogućnost korištenja lokalno dostupnih sirovina za daljnju proizvodnju proizvoda dodane vrijednosti, uz istovremeno poticanje ruralnog razvoja. Ovčja vuna je organski ostatak, koja je obnovljiv i ekološki prihvatljiv materijal, a zbog svojih prirodnih svojstava i sastava, vlakna ovčje vune se mogu koristiti za različite namjene u mnogim proizvodnim sektorima. Ovim istraživanjem obuhvaćene su tri proizvodne godine (2018.-2020.) u Zadarskoj i Šibensko-kninskoj županiji. Utvrđeno je da su broj ovaca i broj posjednika značajno viši u Zadarskoj županiji budući da ova županija ima bolji proizvodni potencijal, ali i zbog činjenice da su u toj županiji veće proizvodne površine, s obzirom da se županija proteže i u područje Like. Broj ovaca u Zadarskoj i Šibensko-kninskoj županiji u tri promatrane godine ima udjel od 23,77 % u ukupnom broju ovaca u Hrvatskoj. Procijenjena je količina vune od 265 t god<sup>-1</sup> do 270 t god<sup>-1</sup>, ovisno o istraživanoj godini, što ukazuje na visoki potencijal biomase koja je dostupna kao mogući izvor sirovine za daljnje iskorištenje u odabranim županijama.

**Ključne riječi:** kružno biogospodarstvo, održivost, ovčja vuna

## Availability and sustainable utilization of sheep wool in circular bioeconomy of the Zadar County and Šibenik-Knin County

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### Summary

Sustainable bioeconomy is a renewable segment of the circular economy, and it involves the conversion of organic waste into high-value products. Valorisation of the organic residues, with the aim of their further utilization, is carried out at the local level. In other words, it is important to determine the possibility of using locally available organic residues for further production of value-added products, while encouraging rural development. Sheep wool is an organic residue, which is a renewable and environmentally friendly material, and due to its natural properties and composition, wool fibres can be used for various purposes in many production sectors. This research covers three production years (2018-2020) in Zadar and Šibenik-Knin counties. It was found that the number of sheep and the number of owners is significantly higher in Zadar County since this county has higher production potential, but also since there are larger production areas in that county, given that the county extends to Lika area. The number of sheep in Zadar and Šibenik-Knin counties in the three observed years has a share of 23.77% in the total number of sheep in Croatia. The estimated amount of wool is from 265 t yr<sup>-1</sup> to 270 t yr<sup>-1</sup>, depending on the research year, which indicates the high potential of biomass available as a possible source of raw material for further use in the selected counties.

**Key words:** circular bioeconomy, sustainability, sheep wool

## Comparison of *Miscanthus x giganteus* and novel germplasm types commercial performance in Croatia.

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### Summary

Following INA's positive experiences with naturally occurring sterile clone, *Miscanthus x giganteus* in Croatia, INA was given an opportunity to test novel germplasm types of *Miscanthus*. The initiative for testing alternatives to *Miscanthus x giganteus* was possible through cooperation on EU funded GRACE "GRowing Advanced industrial Crops on marginal lands for bioRefineries" project. In total 6 ha of trial fields were established during 2019. at Ivanic Grad. The germplasm used in trials was prepared by Aberystwyth and Wageningen Universities. The selections included three interspecies hybrids of *M. sacchariflorus* × *M. sinensis* and one seed-based *M. sinensis*. On the same location as hybrids, the *Miscanthus x giganteus* trial field was established on 2 ha.

The aim of the paper is to quantify harvest data at the end of third growing season and assess viability of beforementioned types in commercial application. The results that we aim to obtain in this year's harvest will focus on yields obtained through commercial methods of harvest. Comparison of novel germplasm types with *Miscanthus x giganteus* will also be conducted. Quantity of biomass in both autumn and spring harvest scenario will be assessed and calculated by sampling method and compared with commercial harvest results.

Hopefully the results of the novel germplasm types will outline their potential in biomass production in Croatian climate and provide high and stable yielding alternatives to *Miscanthus x giganteus* that are more scalable in comparison to Mxg. The results may provide insight to maximizing biomass production and tackling the constraints of slow miscanthus establishment rates.

**Key words:** *Miscanthus*, Novel hybrids, yield, harvest, productivity



**Klima  
i poljoprivreda**

**10**

**Climate  
and Agriculture**



## Agroklimatski atlas Hrvatske u razdoblju 1991–2020

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### Sažetak

Agroklimatski atlas Hrvatske u razdoblju 1991–2020 prvi je hrvatski agroklimatski atlas u kojem su dani tablični i kartografski prikazi određenih agroklimatskih parametara i indeksa za dva klimatska razdoblja: 1981–2010 i 1991–2020. Atlas se sastoji od šest poglavlja, a nakon tekstualnog uvoda na početku svakog poglavlja slijede karte i tablice za novije razdoblje 1991–2020. Za starije razdoblje 1981–2010 na jednak način prikazane su tablice i karte ali samo u digitalnom obliku.

Za potrebe izrade atlasa korišteni su podaci sa 109 meteoroloških postaja. Nakon povijesnog pregleda u prvom poglavlju slijedi drugo poglavlje u kojem su prikazani agroklimatski indeksi koji se baziraju na temperaturi zraka te maksimalna duljina trajanja toplih i hladnih razdoblja u zraku. U trećem poglavlju analizirana je temperatura tla na različitim dubinama, maksimalna duljina trajanja toplih i hladnih razdoblja u tlu te maksimalna dubina smrzavanja. Tema četvrtog poglavlja su komponente vodne ravnoteže prema Palmerovom modelu (potencijalna i stvarna evapotranspiracija, sadržaj vode u tlu, gubitak vode iz tla, procjeđivanje i otjecanje) i maksimalna trajanja kišnih i sušnih razdoblja. Peto poglavlje bavi se indeksima meteorološke opasnosti od nastanka požara raslinja koji su određeni prema kanadskom modelu Fire Weather Index (FWI). U posljednjem poglavlju opisana je metoda prostorne interpolacije te je dan pregled mjera uspješnosti interpolacijskog modela.

**Ključne riječi:** Agroklimatski atlas, agroklimatski indeksi, temperatura tla, komponente vodne ravnoteže, FWI



## Agroclimatic Atlas of Croatia for the period 1991–2020

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### Summary

Agroclimatic Atlas of Croatia for the period 1991–2020 represents the first croatian agroclimatic atlas and contains tables and maps of certain agroclimatic parameters and indices for two climatological periods: 1981–2010 and 1991–2020. The atlas consists of six chapters. Textual introduction at the beginning of each chapter is followed by tables and maps for the newer period 1991–2020 while tables and maps for older period 1981–2010 are given only in digital form.

Data from 109 meteorological stations have been used for creation of the atlas. After the historical review in the first chapter, agroclimatic indices based on air temperature and maximum duration of hot and cold periods in the air were described in the second chapter. The third chapter deals with analysis of soil temperature at different depths, maximum duration of hot and cold periods in the soil and maximum frost line. Palmer model has been applied to estimate water balance components (potential and actual evapotranspiration, soil moisture content, soil moisture loss, recharge and runoff) which have been subject, alongside with maximum duration of dry and wet periods, of the fourth chapter. The fifth chapter of the atlas describes spatial distribution of fire indices which have been calculated according to Canadian model Fire Weather Index (FWI). Method of spatial interpolation and model validation were described in the last chapter.

**Key words:** Agroclimatic atlas, agroclimatic indices, soil temperature, water balance components, FWI

## Hrvatsko agrometeorološko društvo – agro i silvo meteorologija u službi korisnika

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### Sažetak

Hrvatsko agrometeorološko društvo (HAgMD) osnovano je 2012. godine s ciljem popularizacije, promicanja i promoviranja svih grana agrometeorološke znanosti preko seminara i radionica radi pomoći raznim korisnicima u agro i silvo meteorološkoj izobrazbi kako bi neposredni korisnici mogli ta znanja primijeniti u praksi. HAgMD je u suradnji s drugim javnim ustanovama poticao raspravu u svezi aktualnih tema kao što je odnos klime, tla, vode i poljoprivrede. Prvi koji reagira na vremenske i klimatske promjene u prirodi jest biljni svijet, stoga su iznimno važna agrometeorološka istraživanja koja povezuju utjecaj klimatskih i vremenskih uvjeta na uzgoj biljaka i praćenje pojedinih razvojnih faza biljaka. Danas agrometeorološki stručnjaci raspoložu rezultatima opaženih klimatskih promjena i na temelju njih procjenjuju prinose u izmijenjenim klimatskim uvjetima. Svrha tih istraživanja jest pomoći suvremenoj poljoprivredi u prilagodbi na novonastale klimatske uvjete i ublažavanju posljedica klimatskih promjena. Interes društva usmjeren je i na silvo meteorološka istraživanja jer sve učestalija pojava ekstremno suhih i vrućih ljeta izravno utječe na veći broj šumskih požara i sve više požarom zahvaćenih površina. Iz svih tih razloga jako je bitno provoditi preventivne mjere u zaštiti šuma od požara. Posljedice požara su od stradavanja biljnog i životinjskog svijeta, do pojačane eolske i vodene erozije tla te zahtjevne i skupe dugotrajne obnove šuma i šumskog zemljišta.

**Ključne riječi:** klima, poljoprivreda, šumarstvo, požari.

## **Croatian Agrometeorological Society – agro and silvo meteorology in the service of users**

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### **Summary**

The Croatian Agrometeorological Society (HAgMD) was founded in 2012 with the aim of popularizing, promoting and promoting all branches of agrometeorological science through seminars and workshops to help various users in agro and silvo meteorological training so that direct users can apply this knowledge in practice. HAgMD, in cooperation with other public institutions, encouraged discussion on current topics such as the relationship between climate, soil, water and agriculture. The first to react to weather and climate changes in nature is the plant world, so agrometeorological research is extremely important, which connects the impact of climatic and weather conditions on plant breeding and monitoring individual developmental stages of plants. The purpose of this research is to help modern agriculture adapt to emerging climatic conditions and mitigate the effects of climate change. The interest of the society is also focused on silvo meteorological research, because the increasingly frequent occurrence of extremely dry and hot summers directly affects a larger number of forest fires and more fire-affected areas. For all these reasons, it is very important to implement preventive measures to protect forests from fire. The consequences of fires range from the destruction of flora and fauna, to increased aeolian and aquatic soil erosion, and demanding and expensive long-term restoration of forests and forest land.

**Key words:** climate, agriculture, forestry, fires.

## Carbon and nitrogen gains and losses of soybean biomass

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### Summary

Agriculture can contribute significantly to climate change mitigation through biological carbon sequestration, i.e., the storage of atmospheric carbon in the plant pool through the process of photosynthesis. The objective of this study is to determine the carbon (C) and nitrogen (N) content in above- and below-ground biomass, as well as C and N balance of soybean biomass. Destructive harvest of aboveground (grain, stems, leaves, stubble) and belowground (root system) biomass of soybean (*Glycine max* L.) was conducted in Šašinovec, Croatia (45°50' N; 16°11' E; 120 m a.s.l.) in 2019. The C and N balance represents the difference between C and N gains (stems+leaves+stalks+root biomass) and losses (grain biomass) in the agroecosystem. The total dry matter yield is 16.53 t ha<sup>-1</sup> and is composed of 23.7% grain, 48.6% stem, 20.8% leaf, 2.1% stubble and 4.9% root biomass. The average C and N content ranged from 25-55% and 0.5-7%, respectively. The total C balance is positive and is 3,38 t ha<sup>-1</sup>, with total gains of 5,52 t ha<sup>-1</sup> and total losses of 2,14 t ha<sup>-1</sup>. The total N balance is negative and is -0.13 t ha<sup>-1</sup>, with total gains of 0.13 t ha<sup>-1</sup> and total losses of 0.26 t ha<sup>-1</sup>. The negative N balance indicates that soybean biomass negatively affects soil quality and results in N losses from the agroecosystem, while the positive C balance indicates that soybean biomass can contribute to climate change mitigation through biological carbon sequestration under the studied agroecological conditions.

**Key words:** climate change mitigation, carbon balance, aboveground biomass, belowground biomass, soybean

## Prilagodba poljoprivredne i ruralnog turizma klimatskim promjenama – projekcija na području Slavonije i Baranje

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### Sažetak

Klimatske promjene navode se kao jedna od najvećih prijetnji ovog stoljeća za prirodu i ljudsko društvo. Klima i okoliš važni su resursi za turizam i poljoprivrednu proizvodnju te se navedeni smatraju posebno ranjivim sektorima. Cilj istraživanja je provedba primijenjenog istraživanja o prilagođenosti turističke ponude u ruralnom području Slavonije i Baranje na klimatske promjene. U provedenoj fazi istraživanja sudjelovali su poduzetnici iz područje turizma, energetike i poljoprivredni proizvođači. Anketni rezultati ukazuju da je 76,2 % ispitanika privatnog sektora upoznato s problemima i dinamikom klimatskih promjena. Ispitanici su pokazali nisku razinu poznavanja zakonskih propisa Hrvatske (13,56 %) i Europske unije (30,51 %) o nadolazećim klimatskim promjenama. Zainteresiranost za edukacije u visoko obrazovnim institucijama i znanstveno-stručnim centrima pokazalo je 23,73 % ispitanika. Isto istraživanje je provedeno s ispitanicima iz javog sektora. Anketni rezultati ukazuju da je 68,85 % ispitanika upoznato s problemima i dinamikom klimatskih promjena. Sa zakonodavstvom Hrvatske o promjenama klime upoznato je 17,78 %, a Europske unije 31,11 % ispitanika. Interese za edukaciju u obrazovnim i stručnim centrima pokazalo je 24,44 % ispitanika. Provedeno istraživanje omogućuje dobivanje podataka za mjere prilagodbe gospodarsko ugrožavajućim klimatskim promjenama u području Slavonije i Baranje.

**Ključne riječi:** klimatske promjene, poljoprivredna proizvodnja, ruralni turizam

## The adaptation of agriculture and rural tourism to climate changes - projection in Slavonia and Baranja area

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### Summary

Climate change are one of the greatest threats to nature and human society in this century. Climate and the environment are important resources for tourism and agricultural production which are also considered as a particularly vulnerable sector. The aim of this study is adaptation possibility of agricultural production and tourist offer to climate change in the Slavonia and Baranja area. Participants from the field of tourism, energy and agricultural were included in research. Survey results indicate that 76.2% of private sector respondents are aware of the problems and dynamics of climate change. Respondents showed low knowledge of Croatian (13.56%) and European Union (30.51%) legislation on impending climate change. Only 23.73% of respondents showed interest in education in higher education institutions and scientific-professional centers. The same research with respondents from the public sector was conducted. Survey results indicate that 68.85% respondents were familiar with the problems of climate changes. 17.78% of respondents are familiar with Croatian and 31.11% with European Union legislation on upcoming climate change. 24.44% of respondents expressed interest in education in education institutions and professional centers. The research results enable obtaining data for measures of adaptation to climate change in economically endangered sectors in Slavonia and Baranja area.

**Key words:** climate change, agricultural production, rural tourism

## Prilagodba agrotehnike uzgoja kukuruza klimatskim promjenama

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### Sažetak

Primjena konzervacijskih sustava tla učinkovit je način u sprečavanju degradacije tla i prilagodbe biljne proizvodnje klimatskim promjenama uz osiguravanje produktivnosti i stabilnosti prinosa. Cilj istraživanja provedenog 2021. godine na pseugleju u Čačincima (17.86336 E, Lat. 45.61316 N) bio je utvrditi utjecaj konzervacijske obrade, gnojidbe i kondicioniranja tla na prinos i komponente prinosa kukuruza s glavnim tretmanom obrada tla: ST (konvencionalna s oranjem), CTD-konzervacijska duboka (rahljenje s 30 % biljnih ostataka) i CTS-konzervacijska plitka (uz 50 % biljnih ostataka) s podtretmanom kalcizacije i pod-podtretmanom gnojidbe. Tretmani gnojidbe bili su: FR (prema preporuci, NPK 170:150:225), FD (50 % od preporuke), GFR (prema preporuci + GeO<sub>2</sub> – biofiziološki aktivator tla), GFD (50 % od preporuke + GeO<sub>2</sub>). Obrada tla i gnojidba u prosjeku su statistički značajno utjecale na prinos, hektolitarsku masu i masu 1000 zrna. Najveći prosječni prinos (8,60 t ha<sup>-1</sup>), masa 1000 zrna (121,80 g) i hektolitar (70,15 kg hl<sup>-1</sup>) ostvareni su na ST tretmanu. Veći prinosi u prosjeku su zabilježeni su na svim kalciziranim tretmanima, a na tretmanu GFR ostvaren je najveći prinos kukuruza (9,75 t ha<sup>-1</sup>). Na tretmanima CTD i CTS najveća masa 1000 zrna u prosjeku je ostvarena na tretmanu GFR, a najveća hektolitarska masa zabilježena je na ST tretmanu uz kalcizaciju i gnojidbu GFD. U ovom istraživanju kondicioniranje tla rezultiralo je povećanjem prinosa i komponenti prinosa kukuruza.

**Ključne riječi:** klimatske promjene, *Zea mays* L, konzervacijska obrada tla, prinos, komponente prinosa

**Zahvala:** Ovaj je rad financirala Hrvatska zaklada za znanost projektom “Procjena konzervacijske obrade tla kao napredne metode uzgoja usjeva i prevencije degradacije tla – ACTIVEsoil” (IP-2020-02-2647)

## Adaptation of maize cultivation techniques to climate change

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### Summary

The implementation of conservation soil tillage systems is an effective way to prevent soil degradation and adapt crop production to climate change while ensuring productivity and yield stability. The aim of the research conducted in 2021 on stagnosol in Čačinci (17.86336 E, Lat. 45.61316 N) was to determine the impact of conservation tillage, fertilization and soil conditioning on yield and yield components of maize with the main treatment tillage: ST (conventional with plowing), CTD-conservation deep (loosening with 30% of crop residues on the surface) and CTS-conservation shallow (tillage with 50% of crop residues), sub-treatment of liming and sub-subtreatment of fertilization. Fertilization treatments were: FR (according to the recommendation, NPK 170:150:225), FD (50% of the recommendation), GFR (according to the recommendation + GeO<sub>2</sub> - biophysiological soil activator), GFD (50% of recommendation + GeO<sub>2</sub>). Tillage and fertilization on average had a statistically significant effect on yield, hectoliter weight and 1000 grain weight. The highest average yields (8.60 t ha<sup>-1</sup>), mass of 1000 grains (121.80 g) and hectoliters mass (70.15 kg hl<sup>-1</sup>) were achieved on the ST treatment. Higher yields were recorded on average in all liming treatments, and the highest yield of maize was achieved on the GFR treatment (9.75 t ha<sup>-1</sup>). In the CTD and CTS treatments, the highest mass of 1000 grains were achieved on average in the GFR treatment, and the highest hectoliter mass was recorded in the ST treatment with GFD fertilization and liming. In this study, soil conditioning resulted in an increase in yield and yield components of maize.

**Key words:** climate change, *Zea mays* L, conservation tillage, yield, yield components

**Acknowledgments:** This work has been fully supported by Croatian Science Foundation under the project “Assessment of conservation soil tillage as advanced methods for crop production and prevention of soil degradation – ACTIVEsoil (IP-2020-02-2647)



## Dynamics and intensity of climate change recorded in palaeosoils

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### Summary

A fundamental and multidisciplinary approach to investigate abrupt climate change enables us to obtain valuable data and interpret the dynamics of these changes. The aim of the CSF project ACCENT is the exploration of palaeosols intercalated in (i) loess (Baranja), (ii) the Đurđevac Sands in the Pannonian area (continental climate), (iii) fluvioglacial sediments in the Privlaka and (iv) lacustrine sediments of the Vrgorac Lake in the Dinaric area (Mediterranean climate). Investigations of loess-palaeosoil sequences enabled to reveal the warming intensity of archived interstadials (chernozem, brown forest soil or *terra rossa*), as well as postpedogenetic alterations (hydromorphy). Comparison with modern soils, developed from similar parent materials and on similar reliefs, indicate much longer and more intense warmings than in present climates. Additionally, loess-palaeosoil sequences revealed the existence of thick, uniform (cumulic) horizons, evolved just above well-developed palaeosoils. They are meaningful archives in the context of Late Pleistocene and Holocene climatic oscillations. Accordingly, this analytical approach will enable exploring the dynamics of the various facies transitions mentioned above and correlate them in other proposed sections. This research will improve our understanding of the spatial extent and differences in appearing of abrupt climate changes in the Pannonian and Dinaric areas, and correlation with the European Sand Belt and the Mediterranean.

**Key words:** Abrupt climate change, loess, dune, fluvioglacial sediment, karst lake

## Utjecaj navodnjavanja na globalne vodne resurse

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### Sažetak

Voda je nezamjenjiv prirodni resurs nužan za poljoprivrednu proizvodnju, no duga sušna razdoblja ili pojave ekstremnih količina oborina, sve su češća stvarnost s kojom se suočavaju poljoprivrednici diljem svijeta. Stoga znanost i struka svakodnevno traže rješenja kako ublažiti dramatične promjene u okolišu i održati dosadašnje načine poljoprivredne proizvodnje i proizvodnju hrane. Jedan od načina postizanja navedenog je i osiguravanje dostatnih količina vode za usjeve u sušnim dijelovima godine koji posljednjih desetljeća poprimaju do danas nikada ranije zabilježene vrijednosti. Navodnjavanje je osnovni i glavni alat kojim se ostvaruju uvjeti za dostatnu poljoprivrednu proizvodnju. Uspoređujući površinske i podzemne vode, u fizikalnom, kemijskom i mikrobiološkom smislu, za potrebe navodnjavanja pogodnije su podzemne vode zbog ujednačenih svojstava. No, dugogodišnje zahvaćanje podzemnih voda za navodnjavanje i ljudsku potrošnju, sve izraženije ostavlja posljedice na vodne resurse jer pri navodnjavanju, voda u najvećem udjelu evapotranspiracijom isparava u atmosferu umjesto da se procjeđuje nazad u podzemlje. Ovo zadiranje čovjeka u hidrološki ciklus već danas ima prepoznatljive dalekosežne negativne posljedice. U radu su prikazani primjeri posljedica crpljenja podzemnih voda za potrebe navodnjavanja te mjere europskog Zelenog plana kojima se nastoje ublažiti dramatične posljedice i smanjenje zaliha podzemnih voda za generacije koje dolaze.

**Ključne riječi:** navodnjavanje, hidrološki ciklus, podzemne vode

## Impact of irrigation on global water resources

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### Summary

Water is an indispensable natural resource necessary for agricultural production, but long droughts and occurrence of extreme rainfall become an increasingly common reality which farmers around the world are facing each day. Therefore, scientists and professionals are looking for solutions to minimize dramatic changes in the environment and maintain existing ways of agricultural and food production. Irrigation is the basic and main tool which can insure the basic conditions for sufficient agricultural production. Comparing the surface water and groundwater, in physical, chemical and microbiological aspects for agricultural production, groundwater is preferable due to the constant characteristics. However, long-term groundwater abstraction, for both, irrigation and human consumption, leaves negative consequences for groundwater reserves, because after irrigation, water evaporates into the atmosphere by evapotranspiration instead of leaking back in the underground. This human encroachment into the hydrological cycle already today has recognizable far-reaching negative consequences which, in addition to groundwater supplies, are increasingly affecting surface watercourses. In this paper, the negative examples of the groundwater abstraction for irrigation are described, as well as directions and measures incorporated in the European Green Deal intended to mitigate the dramatic consequences of climate change and preservation of the groundwaters for the future generations.

**Key words:** irrigation, hydrological cycle, groundwaters

## Micromorphological analysis of paleosols as a tool for identification of climate change

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### Summary

Paleosols are ancient soils formed in the landscapes of the past. They have preserved pedogenetic features that reflect the conditions of their formation and are therefore an excellent terrestrial archive for paleoenvironmental and paleoclimate reconstruction. Micromorphological analysis of the undisturbed samples of the soil gives information about the intensity and/or duration of soil-forming processes. Micromorphology contributes to the understanding of soil development that is directly affected by past climate conditions and environmental change. Moreover, it enables differentiation of the lithogenic and pedogenic origin of certain constituents and even traces eroded paleosols. The specific morphologies of the investigated soils indicate the climate dynamics records preserved within different Quaternary sediment-paleosol sequences in Croatia. The combination of micromorphological, chemical, physical and mineralogical characteristics of paleosols will enable the qualitative and quantitative estimation of the paleotemperatures and paleoprecipitation in the continental and coastal Croatia within the Late Pleistocene and Holocene time frame. The correlation of climate change intensities in continental and Mediterranean climates throughout the past will provide parameters for a proposal of the prognostic model of climate dynamics effect on the pedogenesis of these two regions.

**Key words:** micromorphology, paleosol, Quaternary, paleoclimate reconstruction, Croatia

**Acknowledgments:** This research is supported by the Croatian Science Foundation under the project ACCENT (3274).

## Procjena emisije CO<sub>2</sub> u požarima travnjaka vršne zone Dinare

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### Sažetak

Požari imaju brojne štetne utjecaje na živi svijet, uključujući i emisiju ugljikovog dioksida (CO<sub>2</sub>), stakleničkog plina koji značajno doprinosi globalnom zatopljenju. 2021. g. probijeni su rekordi u emisiji CO<sub>2</sub> izazvanoj požarima u brojnim regijama svijeta, između ostalog i na Mediteranu. Planina Dinara smještena je u Dalmatinskoj Zagori, na granici Republike Hrvatske i Bosne i Hercegovine. U proteklih nekoliko godina, Dinara je pretrpjela dva velika divlja požara – prvi u kolovozu 2018. g., a drugi u travnju 2020. g. Uzorci biomase s opožarenog područja sakupljeni u sklopu projekta Dinara back to LIFE (LIFE18 NAT/HR/000847), iskorišteni su kako bi se aproksimirala emisija CO<sub>2</sub> prilikom ova dva požara. Korištenjem tehnika daljinskog motrenja na satelitskim snimkama Sentinel-2 detektirane su opožarene površine u požarima 2018. i 2020. g. Prikupljanjem uzoraka na terenu procijenjena je biomasa i preračunata na ukupno područje. Pomoću emisijskog faktora CO<sub>2</sub> kod spaljivanja biomase izračunata je aproksimirana emisija. Procjena je da je tijekom požara 2018. g. emisija iznosila preko 11,5 milijuna kg, a 2020. g. oko 11 milijuna kg CO<sub>2</sub>. Rezultati predstavljaju prvu aproksimaciju za travnjake u Hrvatskoj te se u budućnosti očekuje usavršavanje metodologije.

**Ključne riječi:** požar, ugljikov dioksid, emisija, Dinara, daljinska istraživanja

## Estimated CO<sub>2</sub> emission by wildfires of the summit region of the Dinara mountain

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### Summary

Wildfires are one of the causes of carbon dioxide (CO<sub>2</sub>) emission and thus one of the factors contributing to global warming. In 2021 records of wildfire-produced CO<sub>2</sub> emissions were broken in multiple regions of the world (including the Mediterranean). Dinara is a mountain range located in the Dalmatian Hinterland, alongside the border between the Republic of Croatia and Bosnia and Herzegovina. In 2018 and 2020 the summit area of Dinara mountain was hit by wildfires. As a part of the “Dinara back to LIFE” project (LIFE18 NAT/HR/000847), biomass samples were collected in the same area. The samples were used to calculate the estimated CO<sub>2</sub> emission caused by these fires. Using remote monitoring techniques on Sentinel-2 satellite images, burned areas were detected in the 2018 and 2020 fires. Biomass was estimated by collecting samples in the field and calculated for total area. Using carbon dioxide’s emission factor for biomass burning, the emission caused by the fires was estimated. The estimated emission amounted to more than 11.5 million kg of CO<sub>2</sub> in 2018 and around 11 million kg of CO<sub>2</sub> in 2020. This study represents the first use of such approximations in Croatia. The results represent the first approximation for grasslands in Croatia and the methodology is expected to be improved in the future.

**Key words:** wildfires, CO<sub>2</sub> emission, Dinara, remote sensing

## **Preliminary study of the occurrence of Aflatoxin B1 and Ochratoxin A in the experimental field in Osijek**

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### **Summary**

Mycotoxins are toxic secondary metabolites produced by fungi toxic for humans and animals. They are generally considered to be unavoidable contaminants of food for humans and animals and pose a major problem worldwide. Environmental conditions conducive to mycotoxin production are humidity and temperature, oxygen concentration, physical damage, and the presence of mold spores. It is assumed that the increase in the average temperature on Earth could lead to the migration of mycotoxigenic fungi from tropical and subtropical areas where high temperatures and humid conditions prevail towards more northern areas with temperate climates. In the project “Food production of biocomposites and cereals in a circular economy”, the occurrence of conidia of afla and ochratoxigenic fungi during three-year in the experimental field in Osijek will be monitored. The occurrence of mycotoxigenic airborne molds in maize, wheat, and barley plantations, as well as in maize cobs will be analyzed. Preliminary results showed the presence of both aflatoxigenic and ochratoxigenic fungi in the field. About 10% of conidia isolated from the air belong to afla or ochratoxigenic species. The presence of these species was confirmed on swabs taken from damaged and contaminated maize cobs in the pre-harvest period. Analysis of the presence of aflatoxins and ochratoxin A in the harvested cereals is in the progress. The risk of contamination is present and the measures for prevention and control of aflatoxins and ochratoxin A should be applied.

**Key words:** mycotoxin, aflatoxin B1, ochratoxin A, food safety

## Utjecaj klimatskih promjena na početak nastupa fenoloških faza vinove loze u Hrvatskoj

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### Sažetak

Mnoga istraživanja u Hrvatskoj i svijetu pokazuju da je temperatura najznačajniji element za početak nastupa pojedinih fenofaza vinove loze. Posljednjih godina svjedočimo sve većim promjenama temperature, blažim zimama i ranijem početku vegetacije, a istraživanja pokazuju da će se takav trend nastaviti i u budućnosti. Cilj ovog rada je provesti analizu meteoroloških mjerenja i opažanja u vinogradima u dostupnom vremenskom razdoblju na području RH te pronaći najbolju metodu za povezivanje meteoroloških parametara i fenoloških faza. Proučavani su nastupi pupanja, cvatnje, šare i berbe za četiri sorte vinove loze (Graševina, Chardonnay, Merlot i Plavac mali) na području cijele Hrvatske. Analizirani su počeci nastupa pojedinih fenoloških faza te njihova korelacija s temp. zraka i temperaturnim sumama do trenutka nastupa pojedine fenofaze. Određeni su i temperaturni indeksi (Winklerov indeks, Huglinov indeks i srednja temp. zraka u vegetaciji) u dva 30-godišnja razdoblja (1961-1990, 1991-2020), kako bi se utvrdile temperaturne promjene u promatranom razdoblju. Rezultati pokazuju da uslijed povećanja prosječne temp. zraka dolazi i do promjena u nastupu fenofaza. Neovisno o sorti, pupanje počinje sve ranije, a i tehnološka zrelost nastupa sve ranije i ujednačenija je za sorte različite dobi dozrijevanja. Također, istraživanje pokazuje dobru povezanost između temperature zraka i početka pojedinih fenofaza te dobru korelaciju između prognoziranih i stvarnih nastupa pojedinih fenofaza.

**Ključne riječi:** vinova loza, klimatske promjene, agroklimatski indeksi, fenofaze



## Climate change impacts on beginning of viticulture phenological stages in Croatia

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### Summary

As numerous studies show, temperature is key element that affects grapevine growth. In a last few year, we are witnessing extreme temperature change, mild winters and earlier beginning of vegetation and studies show that this trend will continue in future. The aim of this paper is to conduct an analysis of meteorological measurements and observations in vineyard, in available time in Croatia, and finde most suitable method for connecting meteorological parameters and beginning of phenological stages. In this study, dates of beginning of 3 phenological phases (budburst, flowering and veraison), as well as harvest dates, collected from wineries across country, on 4 cultivars (Graševina, Chardonnay, Merlot and Plavac Mali) were analyzed. Also, 3 temperature agrometeorological indices (Growing degree day, Growing season temperature, Huglin index) were calculated in two 30 year long period (1961-1990, 1991-2020) from meteorological data so that they could serve as indicator of temperature changes in observed period. Results show earlier appearances of almost all phases, regardless of variety. With rise of temperature, the duration between two phases is shorted and that leads to an earlier harvest date. Harvest is more uniform for all varieties, regardless of the maturation. Results show a good correlation between dates and temperature, as well as observed and modeled dates of beginning of stages which can be valuable indicator for even more significant changes in vine growth in future.

**Key words:** vine, climate change, agrometeorological indicies, phenological stages

## Utjecaj konzervacijske obrade tla na pojavnost korova u kukuruzu u uvjetima klimatskih promjena

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### Sažetak

Konzervacijski sustavi na različite načine utječu na ublažavanja klimatskih promjena uz pozitivan utjecaj na produktivnost biljne proizvodnje. Istraživanje s konzervacijskim sustavima obrade tla i kalcizacijom provedeno je 2021. godine u Čačincima (17.86336 E, 45.61316 N, n.v. 111 m). Poljski pokus postavljen je po split plot eksperimentalnom dizajnu u tri ponavljanja s glavnim tretmanom obrade tla: ST (konvencionalna s oranjem), CTD (konzervacijska duboka, obrada rahljenjem do 30 cm s minimalno 30 % žetvenih ostataka na površini) i CTS (konzervacijska plitka, obrada do 10 cm s minimalno 50 % žetvenih ostataka na površini) s podtretmanom kalcizacija. Uzorkovanje korova provedeno je dva puta (fenofaza V10 i R5). Ocjena pokrovnosti vršila se metodom vizualne procjene, a brojnost i nadzemna biomasa korova utvrđivala se brojanjem pojedinačnih vrsta. Dominantne korovne vrste bile su *Ambrosia artemisiifolia* L., *Calystegia sepium* (L.) R. Br. i *Echinochloa crus-galli* (L.) PB. Svi istraživani parametri zakorovljenosti u prosjeku su bili najmanji na kalciziranim tretmanima, a statistički značajan utjecaj utvrđen je za broj korova u V10 i pokrovnost u fenofazi R5 na kalcizaciji. Obrada tla značajno je utjecala na pokrovnost korova u R5, a najmanja je bila na CTD (24,67 %). CTS tretman rezultirao je najvećim brojem korova (24 m<sup>-2</sup>), biomasom (134,43 g m<sup>-2</sup>) i pokrovnosti (69,84 %) ali bez statistički značajnih razlika u odnosu na ST i CTD te su se konzervacijski sustavi obrade u ovom istraživanju pokazali održivim u pogledu gospodarenja korovima.

**Ključne riječi:** konzervacijska obrada tla, zakorovljenost, *Zea mays* L., klimatske promjene

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## Influence of conservation tillage on weed occurrence in maize under climate change conditions

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### Summary

Conservation systems have different effects on climate change mitigation with a positive impact on crop production productivity. The research with conservation tillage systems and liming was conducted in 2021 in Čačinci (17.86336 E, 45.61316 N, n.v. 111 m). The field experiment was set up according to split plot experimental design in three replicates with the main tillage treatment: ST (conventional with plowing), CTD (conservation deep, loosening up to 30 cm with a minimum of 30% of crop residues on the surface) and CTS (conservation shallow, tillage up to 10 cm with a minimum 50% of crop residues on the surface) with sub-treatment liming (carbocalc, 10 t ha<sup>-1</sup>). Weed sampling was performed twice (phenophase V10 and R5). The assessment of weed coverage was performed by visual assessment and number and aboveground biomass of weeds were determined by counting individual weed species. The dominant weed species were *Ambrosia artemisiifolia* L., *Calystegia sepium* (L.) R. Br. and *Echinochloa crus-galli* (L.) PB. All investigated weed parameters were on average the lowest on liming treatments, and a statistically significant effect was found for the number of weeds in V10 and the coverage in phenophase R5 on liming. Tillage significantly affected weed cover in R5, and the lowest was on CTD (24.67%). CTS treatment resulted in the highest number of weeds (24 m<sup>-2</sup>), biomass (134.43 g m<sup>-2</sup>) and cover (69.84%), but without statistically significant differences in relation to ST and CTD, and conservation in this study proved to be sustainable in terms of weed management.

**Key words:** conservation tillage, weediness, *Zea mays* L., climate change

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## Primjena spektrometrije za vrednovanje biotskih i abiotskih čimbenika stresa u uzgoju ozime pšenice

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### Sažetak

U 2019. godini pšenica se u RH uzgajala na 141,602 ha, što je stavlja na drugo mjesto po zastupljenosti žitarica. Uspjeh uzgoja, osim prinosa, podrazumijeva i optimalnu kvalitetu zrna pšenice. Specifični učinci klimatskih promjena opažaju se u oscilaciji prinosa i kvalitete zrna i u onim područjima koja su tradicionalno omogućavala stabilnu proizvodnju. U tom su smislu nedostatna opskrbljenost usjeva vodom i napad štetnika, posebice u osjetljivim fenofazama, najizraženije prijetnje stabilnosti proizvodnje. Prilagođenost sortimenta prema osjetljivosti na sušu i štetočine, uz ranu detekciju pokazatelja stresa važna je prilagodba upravljanju proizvodnjom pšenice. Proksimalna i daljinska istraživanja alati su čiji se potencijal sve više koristi za ranu detekciju pokazatelja stresa u usjevima. Proksimalna snimanja spektrometrom u rasponu valnih duljina od 350 do 2500 nm provode se na pokusnim usjevima pet sorata pšenice u sklopu programa oplemenjivanja strnih žitarica na dvije lokacije u pojedinim fenofazama. Ovaj

Sažetak predstavlja istraživanje u tijeku gdje se korištenjem spektrometrijskih metoda nastoji detektirati i procijeniti utjecaj dva tipa stresa u usjevima o. pšenice. Kemometrijska analiza spektralnih snimaka poslužit će za izdvajanje specifičnih spektralnih vrpca koje upućuju na rane pokazatelje stresa. Spektrometrijskim snimanjima pokusnih polja omogućit će se testiranje razvijenih spektralnih i vegetacijskih indeksa kao indikatora stanja o. pšenice.

**Ključne riječi:** ozima pšenica, zaraza štetnicima, sušni stres, daljinska istraživanja, spektroskopija

## Ground-based remote sensing for estimating stress in winter wheat due to water deficit and insect pest infestation

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### Summary

In 2019, wheat was grown on 141,602 ha in the Republic of Croatia, making it the second most widely grown crop. The success of cultivation depends not only on the yield, but also on the quality of wheat grains. The specific effects of climate change can be seen in the variation of grain yields and quality even in growing areas that have traditionally had stable production. In this sense, insufficient crop water supply and pest infestations, especially in sensitive phenophases, are the most pronounced threats to production stability. Adapted varieties in terms of drought and pest sensitivity, as well as early detection of stress indicators, are important for wheat production management. Proximal and remote sensing are tools whose potential for early detection of stress indicators is increasingly being exploited in many crops. Proximal sensing using a spectroradiometer in the wavelength range of 350 to 2500 nm is being conducted on experimental crops of five wheat cultivars in the cereal breeding program at two locations in different phenophases. This

Summary represents an ongoing study using spectroradiometric methods to detect and evaluate the effects of two types of stress in w. wheat crops. Chemometric analysis of spectral response patterns is used to isolate specific spectral bands that indicate early signs of stress. The spectroradiometric method will allow the developed spectral vegetation indices to be tested as indicators of the condition of five w. wheat cultivars.

**Key words:** winter wheat, insect infestation, drought stress, remote sensing, spectroradiometer

## The prediction of grapevine phenophases in climate change conditions

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### Summary

Prediction of phenophases under future climate change scenarios is becoming a strategic tool for the adaptation to climate change. The aim of this research was to predict changes in the phenology of the grapevine variety (*cv. Panonia*) in the vineyard Plavinci (Serbia). Two future periods were analyzed: I (2021-2040); II (2041-2060) and compared with observed (2015-2021) and reference data (1986-2005). The scenario RCP 8.5 was selected to predict the future accompanied by a set of 8 regional climate models (RCMs) from the EURO-CORDEX project database. The results indicated that for the period I the budburst could be expected on April 14<sup>th</sup> (3 days later), flowering on May 29<sup>th</sup> (6 days later), veraison on July 25<sup>th</sup> (11 days later), harvest around September 8<sup>th</sup> (17 days later), and the end of vegetation around November 1<sup>st</sup> (1 week earlier) compared to the observed period. For the period II the date for the budburst, flowering, veraison, ripe for harvest, and end of vegetation are predicted for April 8<sup>th</sup> (3 days earlier), May 24<sup>th</sup> (1 day later), July 18<sup>th</sup> (4 days later), August 28<sup>th</sup> (6 days later), and November 11<sup>th</sup> (4 days later), respectively. Significant coincidences of the date of the beginning of phenophases for the observed period and the II period, while the period I indicates the later appearance of veraison (approximately 7 days). The harvest is expected about 10 days later in relation to these two periods. Comparing these three periods with the reference one, it can be concluded that in the past the vegetative period of the vine lasted shorter, the growing season began much later (April 18<sup>th</sup>) and ended earlier (October 28<sup>th</sup>), while the beginnings of other phenophases occurred later.

**Key words:** climate change, grapevine, climate models, phenology, adaptation measures

## Sezonsko prognoziranje u poljoprivredi

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### Sažetak

Sezonske prognoze od velike su važnosti za potporu donošenju odluka u različitim sektorima, kao što su poljoprivreda i energetika. Iako je uspješnost sezonskih prognoza općenito ograničena u Europi, ona se u nedavnoj prošlosti poboljšala kao rezultat boljeg predstavljanja različitih fizičkih procesa u modelima, veće prostorne rezolucije i prikaza početnih uvjeta. Posljedično tome, sezonske prognoze se sve više koriste u Europi, ali i diljem svijeta, kao alat koji pomaže poljoprivrednicima u donošenju odluka o odabiru odgovarajućih agrotehničkih mjera u poljoprivrednoj proizvodnji. Kako dosadašnja istraživanja sezonskih prognoza u Hrvatskoj nisu bila usmjerena na poljoprivredni sektor, pregledom literature i rezultata iz Europe i regije predstaviti će se koncept metodologije primjene ansambla sezonskih prognoza Europskog centra za srednjoročne vremenske prognoze (ECMWF) u agrometeorološkom modeliranju prinosa usjeva te kako se prinosi mogu povezati s izvorima predvidljivosti, kao što su EL Nino južna oscilacija i Sjeverno atlantska oscilacija na regionalnoj razini.

**Ključne riječi:** sezonska prognoza, agrometeorološko modeliranje usjeva, poljoprivreda

## Seasonal forecasting in agriculture

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### Summary

Seasonal climate forecasts are of high importance for supporting the decision making in various sectors, such as agriculture and energy. Although the skill of seasonal forecasts is generally limited in Europe, it has improved over in the recent past as a result of better representation of various physical processes in the models, higher spatial resolution and representation of initial conditions. Consequently, seasonal forecasts are increasingly being used in Europe as well as worldwide as a tool to help farmers make decisions about choosing the right agrotechnical measures in agricultural production. As previous research on seasonal forecasts in Croatia has not focused on the agricultural sector, a review of literature and results from Europe and the region will present the concept of methodology for applying the ensemble of seasonal forecasts of the European Center for Medium-Range Weather Forecasts (ECMWF) in agrometeorological modeling of crop yields. Likewise, how can yields connect with sources of predictability, such as the EL Nino Southern Oscillation and the North Atlantic Oscillation at the regional level.

**Key words:** seasonal forecast, agrometeorological modelling of yields, agriculture



