

The effect of ameliorative tillage on some important soil physical properties and grain yield of sunflower, maize and winter wheat

Dušan KOVAČEVIĆ¹, Snežana OLJAČA¹, Željko DOLIJANOVIĆ¹, Života JOVANOVIĆ², Irena JUG³, Danijel JUG³, Bojan STIPESEVIĆ³, Vesna MILIĆ⁴

¹University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Zemun, Serbia (e-mail: dulekov@agrif.bg.ac.rs)

²Maize Research Institute Zemun Polje, Serbia

³Josip Juraj Strossmayer University of Osijek, Faculty of Agriculture, Kralja Petra Svačića 1d, 31000 Osijek, Croatia

⁴University of East Sarajevo, Faculty of Agriculture, Bosnia and Herzegovina

Abstract

The paper deals with the effects of ameliorative tillage on some important properties of soil and grain yield sunflower, maize and winter wheat. The trial was carried out at the Maize Research Institute "Zemun Polje" experimental fields in village Krnješevci near Belgrade on meadows chernozem soil type. The following ameliorative and conventional tillage systems were included in investigations:

1. Ameliorative tillage system - (ATS) – includes new types machines for field systematisation-scrappers (USM 5) in autumn, drainage plow on the depth 60-80 cm, and subsoiling with heavy vibratory subsoiler (VR 5) on 30-35 cm depth. After basic tillage soil was prepared for seeding with preparation by disking and harrowing
2. Conventional tillage - (CT) - in this case control includes ploughing to the depth of 30-35 cm + presowing preparation by disking and harrowing.

After those ameliorative measures first crops in 2008 yr were maize and sunflower. Third crop in 2009/2010 were winter wheat.

The following soil properties were studied: bulk density, total porosity, moisture weight and volume percent, and total water content in different layers in m³, in tillering stage of winter wheat on the different depth 0-10cm; 10-10cm; 20-30cm.

Ameliorative tillage systems have aftereffect for all investigated properties of soil on this heavy soil type compared with control. This tillage system increase significantly grain yield sunflower, maize and winter wheat compared with conventional tillage systems.

Key words: ameliorative tillage, conventional tillage, physical properties of soil, grain yield, sunflower, maize, winter wheat

Utjecaj meliorativne obrade na važnija fizikalna svojstva tla i urod suncokreta, kukuruza i ozime pšenice

Sažetak

Ispitivanje utjecaja sustava meliorativne obrade tla zasnovanog na novim konstrukcijskim rješenjima i tehnologiji (ravnanje tla + podrivanje krtičnim plugom + vibracijsko podrivačko oruđe) na fizikalna svojstva tla i urod suncokreta, kukuruza i ozime pšenice obavljeno je na površinama Instituta za kukuruz "Zemun Polje" u Krnješevcima tijekom 2007., 2008., i 2009.

godine. Nasuprot melioriranoj površini, na kontrolnoj površini na istom tlu s dva ista usjeva s konvencionalnom obradom, nije obavljena meliorativna obrada tla.

Praćen je utjecaj meliorativnog sustava obrade tla na važnija fizikalna svojstva tla, prije prve međuredne kultivacije kod suncokreta i kukuruza i utjecaj produženog djelovanja u narednom usjevu, ozimoj pšenici, u fazi punog busanja.

Ostvareni rezultati ukazali su na postojanje brojnih statistički signifikantnih razlika fizikalnih svojstava na melioriranom tlu u usporedbi s kontrolnom varijantom. Gornji dijelovi oraničnog sloja tla su rastresitiji na melioriranoj varijanti, što omogućuje lakše prihvaćanje veće količine vode i njen brži transport u dublje slojeve.

Primijenjene mjere imale su pozitivan utjecaj na urod usjeva suncokreta i kukuruza u drugoj i ozime pšenice u trećoj godini ispitivanja.

Ključne riječi: meliorativna obrada tla, konvencionalna obrada, fizikalna svojstva tla, urod, suncokret, kukuruz, ozima pšenica

Introduction

Soils with heavy mechanical texture require processing system that ensures conservation of natural resources of fertility and prevents soil degradation processes, especially in terms of optimization of energy use, action and water. A large number of researchers who have studied this type of soil, point out that soil heavy texture possess a number of specific characteristics, especially the unfavorable physical and water-air properties. Bearing in mind that in Serbia we have more than 400.000 ha of soil heavy mechanical texture and approximately 1 million hectares of degraded soil in different ways, this kind of researches are important and useful from the standpoint of science, and even more from the point of using this research into practice (Hadas, 1997; Kovačević et al., 2009; Ercegović et al., 2010). In the researched areas, an important and limiting factor for the successful production is over-wetting of the soil. This fact does not allow the respect optimum time for application cultural measures like tillage, seeding, and normal conditions for growth and development of plants or crop-harvesting. Poor infiltration or permeability of soil is the reason of waterlogging, which leads to suppression of crops, lack of normal operation of machinery (jamming and deterioration of the tractor up to the height of the wheels on some depressions).

Materials and methods

Investigation of the effect of new types of machines and tools were made in the production areas of the Maize Research Institute, Zemun Polje, O.D. Krnjesevci in Krnješevci, on meadow loamy chernozem soil type. The experiment was conducted during 2008, 2009 and 2010 on the experimental plot, area 45.68 ha, was set experimental and control plots.

Two variations of soil tillage were examined:

Variant 1 – Ameliorative tillage system (ATS) by using the new types of machines – leveling with soil leveling scraper, then for manufacture of drainage channels was used drainage plough DP-4 at a depth of 60-80 cm. The distance between the drainage channels was 5 m, processing by using vibrating subsoiler VR-5 at a depth of 50 cm and at the end seedbed preparation of the soil with disc harrowing and harrowing.

Variant 2 - Control. Conventional tillage system (CTS). Basic tillage with mouldboard plough and seedbed preparation of the soil with disk harrow and harrowing.

This type of soil preparation was done in the second year of investigation (2009, while on the third year (2010) were applied conventional basic (mouldboard plough) and seedbed tillage methods (disc harrow and harrow) on the experimental and on the control plot. The effects of prolonged application of ameliorative tillage methods were examined in this way, by using the new types of machines.

For production year 2009 the experimental plots were set up for two crops: sunflower - hybrid Albatre, and maize - hybrid ZP SC 360 Ultra. For production year 2010 experimental and control plot was set up for one culture winter wheat - NS cultivar Dragana.

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Undisturbed soil samples were taken with cylinders Kopecky (100 cm³) after the first inter-row cultivation maize and sunflowers in 2009 yr and in third investigated year (2010) in full tillering of winter wheat. Samples were taken from three depths: 0-10 cm, 10-20 cm, 20-30 cm in four replications for each depth.

During the testing following standard methods JDPZ were used (Bosnjak et al., 1997): bulk density with cylinders of 100 cm³ and Kopecky method; Specific mass with Albert-Bogs method; Total porosity - is calculated from the Bulk and Specific mass; and the Amount of water according to the formula

$$W = \frac{(10.000 \cdot h \cdot v \cdot b)}{100}$$

W – Water content in soil, m³ ha⁻¹,

h – Thickness of soil, m,

v – Bulk density, g cm³,

b – Soil moisture, wt %.

The grain yield of the sunflower, corn and winter wheat was used for analysis in four replications.

All data for soil properties and grain yield were analyzed using the statistic method - analysis of variance. For individual comparisons it was used the LSD test.

Results and discussion

The data shows at the end of beginning year less amounts of precipitation in autumn and winter months. Good distribution of rainfall in spring and early summer followed the same time a relatively high average monthly air temperature at all growth stages of sunflower and maize but after that we can see two short dry periods. High precipitation in autumn, winter and early spring 2010 were a reason to waterlogging on the control variant (Fig.1).

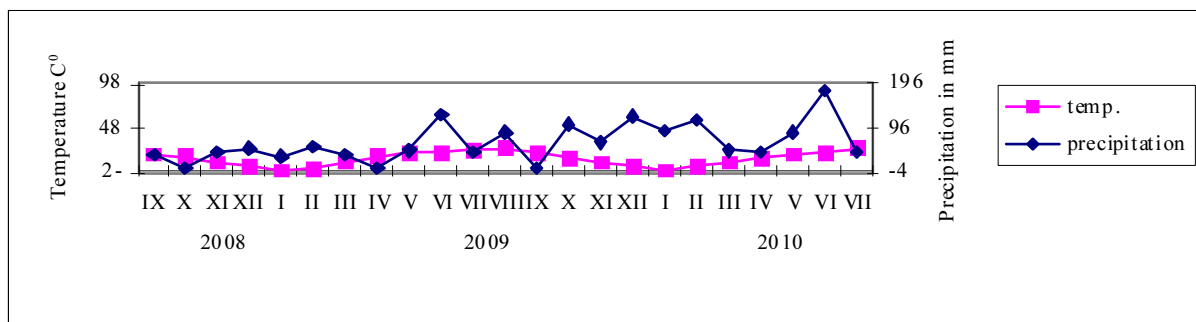


Figure 1. Climatediagram for meteorological conditions in Krnjesevci near Belgrade

The results of the effect of ameliorative tillage on some important properties of soil are shown in Table1.

Ameliorative tillage with new types of machines was obtained a significantly lower bulk density in compared with control. In the first period of research there is a significant difference between the two examined variations and the examined depth, except the third (20-30 cm). Greater soil loosening in the experimental area can be seen from the higher porosity. Higher porosity allows better air flow and rapid infiltration of water. This can be seen from the moisture content. Higher moisture content on the control variants is a result of higher density of individual layers. The total amount of water has significantly contributed to this. It can be seen that the control variation at all depths has higher amount of water. In loam soils it does not mean and higher availability of water. This circumstance at higher rainfall could be the limit for fast water flow. Tillage system that was used, was consisted of leveling of the field, of undermining with the drainage plough and of tillage with vibrating subsoiler, has resulted in an increased soil loosening as we can see from significantly lower values of bulk density, higher total porosity and a better connection between the solid, liquid and gaseous phases.

Table 1. Effects of tillage system on physical properties of soil after first interrow cultivation in maize and sunflower

Variants (A)	Depth in cm (B)	Bulk density g cm ³	Total porosity %	Max. water Content, % vol.	% moisture		Amount of water m ³ ha ⁻¹
					vol.	weight	
ATS	(b) 0-10	1.08	57.8	40.6	27.1	21.9	714
(a)	(b) 10-20	1.34	48.5	41.2	27.8	20.9	837
	(b) 20-30	1.35	48.7	36.6	29.7	21.9	892
Average	0-30	1.26	51.6	39.5	28.2	21.6	814
CTS	(b) 0-10	1.44	43.9	34.4	29.6	20.6	888
(a)	(b) 10-20	1.42	45.6	37.1	34.9	24.5	1042
	(b) 20-30	1.42	45.6	36.1	28.4	20.0	851
Average	0-30	1.43	45.0	35.8	31.3	21.9	927
LSD A	0.05	0.038	1.476	1.980	4.736	0.724	32.376
	0.01	0.053	2.069	2.775	6.641	1.014	45.393
LSD B	0.05	0.054	2.087	2.780	6.698	1.023	45.787
	0.01	0.076	2.926	3.925	9.391	1.435	64.195
LSD AB	0.05	0.076	2.952	3.959	9.473	1.447	64.754
	0.01	0.108	4.139	5.551	13.281	2.289	90.786

Table 2. Effects of different tillage system on soil properties in full tillering of winter wheat

Variants (A)	Depth in cm (B)	Bulk density g cm ³	Total porosity %	Max. water content, % vol.	moisture % vol.	Amount of water m ³ ha ⁻¹
ATS	(b) 0-10	1.31	51.4	40.5	36.7	482.9
(a)	(b) 10-20	1.36	48.1	38.7	34.1	984.2
	(b3) 20-30	1.37	51.2	38.4	32.5	1336.2
Average	0-30	1.35	50.2	39.2	34.4	∑ 2803.3
CTS	(b) 0-10	1.32	50.2	39.5	34.9	459.0
(a)	(b) 10-20	1.43	48.7	38.2	35.6	1015.6
	(b3) 20-30	1.42	49.2	37.5	33.6	1439.3
Average	0-30	1.39	49.4	38.4	34.7	∑ 2913.9
LSD A	0.05	0.068	2.514	1.971	0.984	84.456
	0.01	0.096	3.525	2.763	1.379	118.409
LSD B	0.05	0.097	3.556	2.787	1.391	119.439
	0.01	0.136	4.985	3.907	1.951	167.456
LSD AB	0.05	0.138	5.029	3.942	1.967	168.912
	0.01	0.193	7.050	5.526	2.758	236.818

Table 3. Effects of different tillage system on grain yield sunflower, maize and winter wheat

Sunflower (t ha ⁻¹)		Maize (t ha ⁻¹)		Winter wheat (t ha ⁻¹)	
Conventional tillage system	Ameliorative tillage system	Conventional tillage system	Ameliorative tillage system	Conventional tillage system	Ameliorative tillage system
3.716	3.990	7.998	8.627	3.550	4.170
LSD 0.05	0.143		0.359		0.365
LSD 0.01	0.217		0.544		0.606

The soil properties were repaired in the first year and it became more favorable habitat for growing crops, also, it should be noted and the prolonged effect on the other crops (winter wheat in third year of investigations 2010 (Table 2).

Ameliorative tillage systems have aftereffect for all investigated properties of soil on this heavy soil type compared with control. This tillage system increase significantly grain yield sunflower 0.274 t ha⁻¹ and maize 0.629 t ha⁻¹ in the second year of investigated period and also too grain yield of winter wheat 0.620 t ha⁻¹ compared with control. (Table 3).

Conclusion

All the investigated soil physical and water characteristics have been significantly repaired. This ameliorative tillage system (ATS) had beneficial effect on soil loosening. Repaired soil characteristics, reduced

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compaction, in the first year are more favorable habitat for grown crops of sunflower and maize and for winter wheat in the second year.

The results of our investigation show that yield grain of sunflower, maize and winter wheat on ameliorative tillage was higher compared with conventional tillage (CT) as a control on the same soil type.

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