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Original scientific paper

EFFECT OF FARMING SYSTEMS ON SOIL COMPACTION, WEED SYNUZIA AND YIELD OF WINTER WHEAT

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The paper deals with effects of different farming systems on some important soil physical properties, floristic composition of weeds and yield of some winter wheat cultivars. The following farming systems were included in this investigation: Conventional Farming System (CFS) with high inputs, and Sustainable Agriculture (SA) with low inputs. The following physical soil properties were studied: bulk density, total porosity, air field capacity and penetration resistance. Higher differences were found between three investigated layers, and for interactions between farming system and layer. Significant increase in compaction during the waxy stage was found in CFS on the layer 10-20 cm (1.51g/cm^3) which was a result of multiple passes of mechanization in basic and pre-sowing tillage.

Increased total number of individuals and biomass of weeds, especially annuals, was found in SA plots.

The yield of wheat cultivars reacts differently under the two agricultural farming systems. The semi-dwarf cultivars Pobeda, Fundulea 4, Bezostay 1 and Siete Cerros show higher differences in yield than the tall cultivars Odeskay 51 and Flamnik.

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Key words: conventional farming system, sustainable agriculture, soil physical properties, weed synuzia, cultivar, winter wheat

INTRODUCTION

Numerous researches have shows that the future of agricultural development in the 21st century is in sustainable agriculture as an alternative to conventional system. It is considered that future in agriculture will be in flexible cultural practices, developing of biotechnology and appreciation of basic ecological principles in soil usage. Crop production systems are influenced by a complex array of factors combining various crops, soil, water, climate and management parameters. Cultivars created in Serbia have genetic potential for grain yields exceeding 11 t ha^{-1}, different technological qualities, resistance to lodging, diseases and winter killing, various maturing periods and good adaptability to the climate and soil conditions existing in this and other regions of winter wheat growing in Southern and Central Europe. Generally, the characteristic of new cultivars is that they have top yield under favorable environments, but suffer the greatest absolute loss under a given reduction in available resources. Choice of cultivar has a significant role in determination of competitive ability KORRES and FROUD-WILLIAMS (2002). Cultural practices enable maximum utilization of the genetic potential for grain yield under specific agroecological conditions. Today we have important changes in the application of some cultural practices, primarily: soil tillage, fertilization, weed control, crop rotation etc. (BIRKÁS *et al.*, 1995; KOVAČEVIĆ, 1997). Influence of these practices on soil properties is very important, both individual or in interaction (synergistic). Some of them could be a source of stress (mechanical, drought) and that is why we have to create a new ideotype of certain tolerance to the limited use of resources in such conditions. Plant breeders need to recognize all changes in the farming system at the beginning of this new millenium and adapt their breeding programs toward greater productivity and sustainability (DENČIĆ, 1996).

Conventional farming system (CFS) that includes intensive mechanization and high inputs of fertilizers, pesticides etc. has achieved a rapid growth of production (KOVAČEVIĆ *et al.*, 1997). This system is very expensive because of increased inputs (energy, pesticides, fertilizers etc.). In the last decade of the second millenium a concept known as sustainable agriculture (SA) consolidated. With regard to economic rationality and a role in the protection of natural resources and soil conservation, the new production trends have defined the concept of sustainable agriculture development. In Serbia, conventional high-input growing practices predominated, with cultivars mostly adapted to such conditions.

The main objective of this paper was to examine the influence of different agricultural systems (CFS and SA) on soil physical condition, weed infestation and grain yield of wheat; and to estimate differences among chosen cultivars.

MATERIALS AND METHODS

The effect of farming systems on soil physical properties, weed control and grain yield of winter wheat were examined on a chernozem soil type in experimental fields of the Scientific Institute of Field and Vegetable crops in Rimski Sancevi-Novi Sad (Vojvodina province) during vegetation seasons 1995/96-1996/97.

Two agricultural farming systems with extremely different inputs were applied:

I - Conventional farming system (CFS) - which implies classical moldboard ploughing to the depth of 25 cm, pre-sowing preparation with combine tools and optimal inputs of fertilizers and full protection against prevalent pathogens, weeds and pests (prep. Starane 0.5 l ha^{-1} (fluroxypir)+ 20 g ha^{-1} prep. Granstar 75-DF (75% tribenuron-methyl) and 0.3 l ha^{-1} prep. Karate 2,5 EC (lambda-cymalothrin).

II - Sustainable agriculture (SA) - Low-input technology involving no tillage with 100% mulch cover of land surface by chopped maize residues, which may be termed conservation tillage practice, without fertilizers and pesticides.

A number of wheat cultivars originating from regions worldwide were tested, namely: 1) Eastern Europe - Pobeda (Yugoslavia) and Fundulea 4 (Romania); 2) Russia and the Ukraine - Bezostay 1 (Russia) and Odeskay 51 (Ukraine); 3) Central America - Siete Cerros (Mexico); 4) South Africa - Flamnik (Lesotho). These cultivars were selected with a purpose of estimating individual abilities of different wheat types under high and low-input conditions.

The following physical soil properties were studied: bulk density, total porosity and field capacity.

Undisturbed samples were collected with Kopetzky cylinders (100 cm^3) from layers: 0-10, 10-20 and 20-30 cm in five replicates. The compaction of soil layers was measured by Ejkelkamp hand penetrometar. For monitoring soil physical properties samples were taken in in the waxy stage. Standard methods (YUSSS, 1997) were applied in the laboratory.

Number and biomass of weeds were analyzed at the heading stage of winter wheat growth.

After the harvest plant material was measured and then analysed for morphological characteristics and yield component. All data were subjected to analysis of variance.

RESULTS AND DISCUSSION

The main objective of these studies was to determine the effect of two farming systems (CFS and SA) on changes in soil physical properties as an important form of interaction with the environment. The obtained results of our investigations showed that cropping system had different effects on the soil physical properties (Table 1).

Table 1. - Effect of farming system on soil physical properties on chernozem in the waxy stage of winter wheat (average 1995/96-1996/97)

Farming system (A)	Depth (B)	Bulk density g/cm³	Total porosity %	Field capacity %
CFS	0-10	1.41	45.83	12.42
	10-20	1.51	42.01	9.14
	20-30	1.44	45.18	9.38
Average (a_1)	0-30	1.45	44.34	10.31
SA	0-10	1.43	44.84	9.35
	10-20	1.43	45.08	7.94
	20-30	1.45	44.53	7.68
Average (a_2)	0-30	1.44	44.82	8.32
LSD A	0.05	0.035	1.375	1.785
	0.01	0.149	1.930	2.505
B	0.05	0.041	1.591	2.066
	0.01	0.055	2.163	2.808
AB	0.05	0.058	2.251	2.921
	0.01	0.078	3.060	3.971

Bulk density. Tillage is a powerful management tool under direct human control that is used to modify the crop environment. Those values were very high for the chernozem soil type. DRAGOVIĆ *et al.* (1977) reported degradation of water-physical and other properties of the chernozem soil type (first of all bulk densities from 1.40 to 1.50 g/cm³) under long-term mineral fertilization without organic fertilizers and legumes included in crop rotation.

The relationships between CFS and SA were significant for bulk density between layers. Bulk density was highest in layer 10-20 cm, and the relationship did not significantly differ in other investigated layers. SA farming practice resulted in higher values of bulk density (1.43 g/cm³) than tilled soil under CFS practice (1.41g/cm³) in the surface layer. Differences in bulk density values between the farming systems and between the analyzed soil layers were lower in the waxy growth stage, but not significantly (CFS 1.45; SA 144). Greater compaction was only found in soil layer 10-20 cm. Regarding the significance of analyzed interactions, a certain deviation was found under CFS in layer 10-20 cm with values 1.51 g/cm³ .

Total porosity. In the waxy stage of winter wheat total porosity was significantly higher in layer 0-10 cm than in the other two layers.

Field capacity. Farming systems differ significantly in the waxy stage growth of winter wheat. Field capacities were significantly higher in CFS (10.31%) than in SA (8.32). Field capacity permanently decreased with soil depth.

Penetrometar resistance. The results of investigations (Figure 1) show significant differences between farming systems and soil layers in penetrometar resistance, especially at 0-30 cm depth in the waxy stage. Regarding the interaction farming systems x soil layer significantly greater value (3.62 MPa) was found in the soil layer at 10-20 cm depth under CFS practice. This compaction is a result of intensive soil loading by heavy agricultural machinery during basic and pre-sowing tillage (SOANE *et al.*, 1980/81; CANARACHE *et al.*, 1984). In the two

investigated years, soil compaction was not greater under no-tillage production in SA than when conventional tillage in CFS was practiced. Correlation analyses revealed a high positive correlation between bulk density and penetration resistance (r =0.69 in waxy stage).

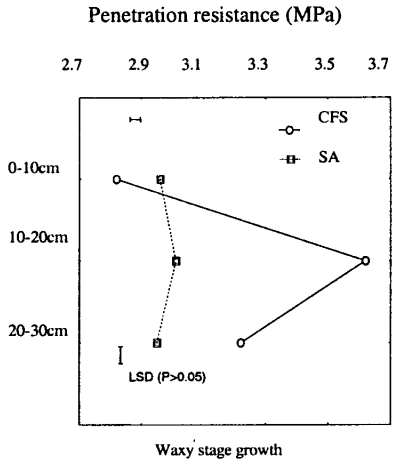

Fig.. 1. - Effect of farming system on penetrometer resistance

Weed populations were a result of applied farming systems and crop competition. (Table 2). SA farming system increased total weed number, especially annual species. Dominant species in the weed flora composition were: *Anagallis arvensis* L. and *Chenopodium album* L. among annuals and *Convolvulus arvensis* L. among perennial weeds.

The effect of cultural practices on yield was very significant (Table 3). It was obvious that CFS provided significantly higher yield on the average (7.58 t ha^{-1}), compared with SA, which yielded only 2.26 t ha^{-1}. Looking from the cultivar standpoint, it is evident that the semi-dwarf cultivars developed in Eastern Europe (Pobeda, Fundulea 4, and Bezostay 1) yielded significantly better than the cultivar Siete Cerros, which had been developed very far from Europe (Mexico), or the tall cultivars Odeskay 51 (Ukraine) and Flamnik (Lesotho, South Africa). The cultivars reached different yields depending on the two tested agricultural farming systems. Generally, two tall cultivars, Odeskay 51 and Flamnik, achieved lower difference between CFS and SA compared to other modern semi-dwarf cultivars.

Serbia's leading cultivar Pobeda gave the highest grain yield in both agricultural farming systems. The reason for such result is probably the fact that the cultivar had been developed precisely under the environmental conditions in which the experiment was carried out.

Table 2. - Effect of Farming Systems on the floristic composition of weed synuzia in the waxy stage of winter wheat per m² (Average 1995/96-1996/97)

Life form	Weed species	Conventional Farming System	Sustainable agriculture
T4	*Amaranthus blitoides* Wats.	-	1.62
T4	*Amaranthus retroflexus* L.	-	0.12
T4	*Ambrosia artemisifolia* L.	0.12	0.37
T4	*Anagallis arvensis* L.	-	7.37
T4	*Anthemis arvensis* L.	-	0.25
t1	*Capsella bursa pastoris* (L.) Med.	-	0.12
T4	*Chenopodium album* L.	-	0.62
T4	*Chenopodium hybridum* L.	-	0.62
T2	*Consolida regalis* Gray	-	0.37
G4	*Convolvulus arvensis* L.	0.62	7.37
T4	*Erigeron canadensis* L.	-	1.75
T1	*Lamium purpureum* L.	-	0.12
T2	*Papaver rhoeas* L.	-	0.12
H5	*Plantago major* L.	0.12	0.12
T4	*Portulaca oleracea* L.	-	0.12
T3	*Sinapis arvensis* L.	1.75	-
T4	*Solanum nigrum* L.	-	0.12
T4	*Sonchus oleraceus* L.	-	0.25
G1	*Sorghum halepense* (L.) Pers.	0.12	0.12
T1	*Veronica persica* Poir.	0.12	0.37
Number of annual weeds		1.99	23.87
Number of perennial weeds		0.86	7.87
Total weeds number		2.85	31.75
Weeds above-ground mass g/m²		12.3	96.8

Table 3. - Effect of cultural practices in different farming systems on grain yield of different winter wheat cultivars (t ha⁻¹)

Farming systems (A)	Cultivars (B)						Average
	Pobeda (Yugoslavia)	Fundulea 4 (Romania)	Bezostay 1 (Russia)	Siete Cerros (Mexico)	Odeskay 51 (Ukraina)	Flamnik (Lesotho)	
CFS	8.44	8.33	7.67	7.07	7.02	6.93	7.58
SA	3.18	2.19	2.40	1.49	2.19	2.09	2.26
Average	5.81	5.26	5.04	4.28	4.61	4.51	4.92
d	5.26	6.14	5.27	5.58	4.83	4.84	5.32

* d - differences between CFS and SA

LSD		0.05	0.01		0.05	0.01
	A	0.206	0.280	AxB	0.505	0.687
	B	0.357	0.486			

CONCLUSION

The results obtained during investigations of the effects of CFS and SA systems on soil physical properties, floristic composition of weeds and yield of

some renowned international genotypes of winter wheat suggest the following conclusions:

Soil physical properties (bulk density, total porosity, field capacity, penetration resistance) changed through the vegetative season of winter wheat.

Higher differences were found between three analyzed layers of soil and for interactions between farming system and soil layers. In the waxy stage of winter wheat under SA, soil profile reverted back to a more natural condition. Significant differences between CFS and SA were found regarding penetrometar resistance for all samplings, and for field capacity during early summer in that growth stage. On CFS plots, significant compaction was recorded in the layer 10-20 cm (1.51g/cm^3), which resulted from multiple passes of mechanization in basic and pre-sowing tillage.

An increased total number of individuals and biomass of weeds, especially annuals, was found on the plots practicing SA system.

Wheat cultivars achieved different yields in the two agricultural farming system. The semi-dwarf cultivars Pobeda, Fundulea 4, Bezostay 1 and Siete Cerros showed higher differences in yield, compared with tall cultivars Odeskay 51 and Flamnik. The reason is probably that the genetic potential for yield in tall cultivars is generally low compared to semi-dwarf genotypes, so that those cultivars had low level yields even under favorable conditions.

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UTICAJ SISTEMA ZEMLJORADNJE NA ZBIJENOST ZEMLJIŠTA, KOROVSKU SINUZIJU I PRINOS OZIME PŠENICE

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U radu je prikazan uticaj različitih sistema zemljoradnje na neke važnije fizičke osobine, floristički sastav korova i prinos nekih sorti ozime pšenice. U ispitivanje su bili uključeni sledeći sistemi zemljoradnje: konvencionalni sistem zemljoradnje (KSZ) sa velikim ulaganjima i održivi sistem zemljoradnje (OSZ) sa malim ulaganjima. Od fizičkih osobina zemljišta ispitivane su sledeće: zapreminska masa, ukupna poroznost, vazdušni kapacitet i kompakcija.

Veća razlika između u pogledu fizičkih osobina zemljišta dobijena je kod interakcija sistema zemljoradnje i ispitivanih dubina. U fazi voštane zrelosti ozime pšenice zemljišni sloj do dubine od 30 cm vraća se u prirodno stanje u OSZ. Signifikantno veća kompakcija zemljišta prisutna je u sloju 10-20cm (1.51g/cm^3), što je rezultat višestrukih prohoda mehanizacije prilikom osnovne i dopunske obrade.

Održivi sistem zemljoradnje povećava broj i masu korova, posebno jednogodišnjih.

Sorte pšenice različito reaguju na uslove u oba sistema zemljoradnje. Sorte stabla srednje visine, Pobeda, Fundulea 4, Bezostaja 1 i Siete Cerros, pokazuju veće razlike od sorata visokog stabla Odeska 51 i Flamnik. Razlog za to je u činjenici da je genetski potencijal visokih sorata generalno posmatrano niži u poređenju sa genotipovima stabla srednje visine. Tako su te sorte prinosnije u lošijim uslovima uspevanja.

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