THE EFFECT OF FERTILIZATION SYSTEM ON WEED INFESTATION AND GRAIN YIELD OF SMALL GRAINS ON ACID SOILS

M. BIBERDŽIĆ[1], M. JELIĆ[1], N. DELETIĆ[1], S. BARAĆ[1], S. STOJKOVIĆ[1], S STANKOVIĆ[2], S. STAMENKOVIĆ[1]

[1]University of Priština, Faculty of Agriculture Kosovska Mitrovica –Lešak
Kopaonička bb, 38232 Lešak, Serbia
[2]Center for Agricultural and Technological Research Zaječar
Grljanski put bb, 19000 Zaječar, Serbia
E-mail: mbiberdzic@gmail.com

Abstract: *This paper deals with the effect of fertilization systems on weed infestation degree and grain yield of some small grains on the vertisol soil type. The trial was set in random complete block design with three replications. The trial included control variant and three variants fertilized by mineral fertilizers, lime and manure (1. NP_1K, 2. NP_2K, and 3. $NP_1K + CaCO_3$ + manure). Small grain crops involved in the trial were wheat, barley, triticale and rye. Results of the study showed significant effect of fertilization on decreasing weed infestation degree of the all investigated small grain crops. The highest degree of infestation by weeds (average 2.2) was observed at the variant without fertilization, while the lowest one (1.2) was found at the variant fertilized by the combination of mineral fertilizers, lime and manure. The highest degree of infestation by weeds was observed in wheat, and the lowest one in rye.*

Grain yield at fertilized variants was significantly higher comparing with the control variant. The highest average grain yield of the all small grains (3961 kg ha^{-1}) was reached at the variant with combined application of mineral fertilizers, lime and manure, while the lowest one was observed at the unfertilized variant (1378 kg ha^{-1}). Combined application of mineral fertilizers, lime and manure gave high-significantly greater grain yield in regard to mineral fertilizers alone with lower phosphorus dose. The difference between the variant with combined NPK, lime and manure and the variant NP_2K was not statistically significant. The highest average grain yield in the all variants of 3884 kg ha^{-1} was given by wheat, and it was high-significantly greater than in the other crops, while the lowest one (2290 kg ha^{-1}) was observed in rye. The difference between grain yields of barley and triticale was not significant. The highest grain yield of 4770 kg ha^{-1} was given by wheat at the variant with combination of NPK, lime and manure. The lowest grain yield was observed in rye and it was significantly lower than in other crops at every variant, which was expected. Triticale had greater grain yield than barley at the all variants, but the difference at the variant with combination of NPK, lime and manure was not significant.

Key words**:** *small grains, fertilization, weed infestation, grain yield*

INTRODUCTION

Vertisols are soils with bad air-water and physico-mechanical properties. Plant production is unstable on such soils. According to ANIOL and MADEJ (1996), the highest tolerance to soil acidity is expressed by rye, than triticale and wheat, and the most sensitive crop is barley. Weeds are permanent companions of grown crops expressing a negative effect of grain yield and quality. Crops of lower density are much more infested by weeds than crops of high density (ŽIVANOVIĆ-KATIĆ, 2004). The most of weed species can be found on soils with moderate pH value, while on extremely acid soils weeds are rarely present (KOJIĆ and ŠINŽAR, 1985). BARBERI et al. (1997) stated that weeds were sensitive to the all agrotechnique measures, and they were good indicators for intensity of the applied agrotechnique.

Type and amount of fertilizers show a great effect on wheat infestation by weeds, so on its grain yield too (OGNJANOVIĆ et al., 1994). Application of nitrogen fertilizers increases ability of small grains to compete with weeds, causing drop of weed species number, weed

density and biomass (WELLS, 1979; GRUNDY et. al, 1993). Some researchers, such as Kirkland and BECKIE (1998), found that application of nitrogen was favorable for some weeds.

Numerous studies in our country and throughout the world show that adequate application of lime combined with organic and mineral fertilizers is the most efficient way to remediate bad production properties of acid soils causing increase of grain yield manyfold (JOVANOVIĆ et al., 2006; KOVAČEVIĆ et al., 2006; JELIĆ et al., 2006).

Our study was aimed to determine degree of weed infestation and grain yield of some small grain crops as affected by doses and types of the applied fertilizers.

MATERIAL AND METHODS

The investigation was carried out through the field trial set in the Center for Agricultural and Technological Research at Zaječar, during the production season 2009/10. The trial was set in random complete block design with three replications. The trial included control variant and three variants fertilized by mineral fertilizers, lime and manure (1. NP_1K, 2. NP_2K, and 3. $NP_1K + CaCO_3$ + manure). Small grain crops involved in the trial were wheat, barley, triticale and rye. Amounts of pure nutrients used in the experiment are given in table 1.

Table 1

Amounts of pure nutrients used in the experiment

Fertilization variants	Amount of nutrients (kg ha^{-1})				
	N	P_2O_5	K_2O	$CaCO_3$	Manure
Control	0	0	0	0	0
NP_1K	120	80	53	0	0
NP_2K	120	160	53	0	0
NP_1K + lime + manure	120	80	53	5,000	20,000

Area of each elementary experimental plot was 50 m^2. The total amount of phosphorus and potassium fertilizers together with one third of nitrogen was dispersed manually, before fine cultivation of soil. At the liming variant, lime fertilizer "Njival Ca" was dispersed together with manure and mineral fertilizers. Mineral fertilizers used were complex NPK fertilizer (8:24:16) and superphosphate (17% P_2O_5), while for additional nutrition (side dressing) ammonium nitrate (AN) with 34.4% N was used.

Plowing and fine cultivation of soil were done in classic way (down to 25 cm of depth) immediately after maize harvest and removal of harvest remains. The rest of the applied production technology in the trial was standard.

The following small grain crops were included in the trial: wheat (cultivar Pobeda), barley (cultivar Jagodinac), triticale (cultivar KG-20) and rye (cultivar Raša).

Estimation of small grains infestation by weeds was carried out by the method according to BRAUN-BLANQUET (1964), by grading from 1-5, during stem elongation stage. Weed determination was done according to KOJIĆ (1981).

Small grain crops harvest was carried out during full ripeness. Grain yield was recalculated to 14% of moisture and processed by analysis of variance.

Soil and climatic conditions

Table 2

Chemical properties of the soil

Depth (cm)	pH		Humus	Available (mg/100g of soil)	
	H_2O	nKCl		P_2O_5	K_2O
0-20	5.23	4.84	0.12	16.68	29.53
20-40	5.54	5.15	0.11	12.34	27.22

This soil belongs to the type carbonate-free vertisol and is characterized by high soil acidity (pH in nKCl 4.84-5.15). Humus content in the layer down to 20 cm was 0.12% and decreasing by depth. Available phosphorus content of the layer to 20 cm was 16.68 mg/100g of soil, and 12.34 mg in deeper layers. This soil is well-supplied by available potassium (29.53 mg/100g of soil in cultivated layer). Such soils are prone to volume change, to imbibition and contraction, so they are very hard to cultivate. They belong to the category of soils characterized by a short optimal term for cultivation. Remediation of these soils is necessary in order to reach satisfactory grain yields on them.

Table 3

Meteorological conditions during the trial (2009/10)

Months	Mean monthly air temperature (ºC)	Monthly sum of precipitation (mm)	Air humidity (%)
X	12	104	75
XI	9	94	74
XII	1	124	79
I	-2	53	81
II	1	100	74
III	7	59	73
IV	12	72	70
V	17	57	71
VI	20	94	71
VII	23	88	67
Average	10	845	73.5

October was characterized by a large amount of precipitation, which had favorable effect on sowing and emerging of small grains.

During March and April there were favorable conditions for growth and development of plants, especially for tillering, rooting and increasing of plant leaf mass. Vegetative development of plants in the spring was followed by favorable thermal conditions and enough precipitation, which had a positive effect on plants development. During final stages of growth and development, in June and July, daily temperatures were optimal, but abundant rainfall delayed harvest causing partial loss of grain yield and quality.

RESULTS AND DISCUSSIONS

Estimation of weed infestation

Estimation of crop infestation by weeds was conducted during stem elongation stage, at the all fertilization variants. The following weed species were observed as predominant and most frequent: *Cirsium arvense*, *Lamium purpureum*, *Veronica pollita*, *Stelaria media* and *Capsella bursa-pastoris*. Table 4 shows degree of small grain crops infestation by weeds as affected by fertilization variants.

Table 4

Degree of small grains infestation by weeds

Fertilization variants	Small grains				
	Wheat	Barley	Triticale	Rye	**Average**
Control	2.8	2.3	2.3	1.7	2.2
NP_1K	1.7	1.5	1.3	1.3	1.4
NP_2K	1.5	1.4	1.0	1.3	1.3
NP_1K + lime + manure	1.4	1.4	1.0	1.0	1.2
Average	1.8	1.6	1.4	1.3	--

The average crop infestation by weeds of the all studied small grain crops at unfertilized variants amounted 2.2. At fertilized variants weed infestation degree significantly decreased in the all studied small grain crops. So the lowest degree of infestation by weeds was observed at the variant with combined NPK, manure and lime applied, and at the variant with increased phosphorus dose (average 1.2 and 1.3 respectively). The lowest weed infestation degree was found in rye and barley, which pointed to a good competing ability of those crops. Unlike them, wheat and barley showed weed infestation degree of 1.8 and 1.6, respectively. These results are in accordance with the data of ŽIVANOVIĆ-KATIĆ et al. (2008) also pointing to a decrease of weed infestation caused by application of fertilizers, lime and manure. Furthermore, KNEŽEVIĆ et al. (2007) also report a decrease of weeds number per square unit caused by higher doses of nitrogen fertilizers.

Grain yield of small grains

The highest average grain yield of the all small grains (3961 kg ha^{-1}) was reached at the variant with combined application of mineral fertilizers, lime and manure, while the lowest one was observed at the unfertilized variant (1378 kg ha^{-1}). Combined application of mineral fertilizers, lime and manure gave high-significantly greater grain yield in regard to mineral fertilizers alone with lower phosphorus dose. The difference between the variant with combined NPK, lime and manure and the variant NP_2K was not statistically significant. The highest average grain yield in the all variants of 3884 kg ha^{-1} was given by wheat, and it was high-significantly greater than in the other crops, while the lowest one (2290 kg ha^{-1}) was observed in rye. The difference between grain yields of barley and triticale was not significant.

Table 5

Grain yield of small grains as affected by fertilization (kg ha^{-1})

Fertilization variants (A)	Small grains (B)				
	Wheat	Barley	Triticale	Rye	**Average**
Control	1607	1197	1630	1077	1378
NP_1K	4440	3183	3577	2443	3411
NP_2K	4720	3470	4007	2913	3778
NP_1K + lime + manure	4770	4293	4053	2727	3961
Average	3884	3036	3317	2290	--
LSD values	A		B		AxB
0.05 (5%)	325.23		357.55		380.40
0.01 (1%)	392.05		404.86		411.77

The highest grain yield of 4770 kg ha^{-1} was given by wheat at the variant with combination of NPK, lime and manure. The lowest grain yield was observed in rye and it was significantly lower than in other crops at every variant. This was expected, having in mind genetic potential of that crop. Triticale had greater grain yield than barley at the all variants, but the difference at the variant with combination of NPK, lime and manure was not significant.

Numerous previous reports showed that wheat is a crop sensitive to low soil pH values, so on acid soils full application of NPK, lime and manure gave a high effect on wheat grain yield (OGNJANOVIĆ et al., 1994; JELIĆ et al., 1995; Jelić et al., 2004).

Relatively good wether conditions during vegetation period, with enough precipitation present from the earliest developmental stages of wheat plants to ripeness, enabled achieving a satisfactory grain yield. Numerous reports showed the effect of weather conditions on nutrients utilization (JELIĆ, 1995; ŽIVANOVIĆ-KATIĆ et al., 2000; JELIĆ et al., 2006; JELIĆ et al., 2007).

The effect of NPK application with the increased phosphorus dose, which was also observed, was the result of high soil acidity and low content of available phosphorus. Positive influence of the increased doses of phosphorus on winter wheat grain yield, as well as on yields of other small grain crops, was shown in the previous reports (JELIĆ et al., 1998; JOVANOVIĆ et al., 2006; KOVAČEVIĆ et al., 2006).

So the degree of infestation by weeds reduced under influence of fertilizers, especially higher doses of phosphorus, lime and manure, as grain yield was rising. It was the result of fertilizers' action giving denser crops and better development of plants. Positive effects of fertilization, especially by nitrogen, on decrease of weed species number and reaching of higher wheat grain yields were also reported by other researchers (JORNSGARD et al., 1996; ANDERSON et al., 1998; JELIĆ et al., 2007; ŽIVANOVIĆ-KATIĆ, 2008).

CONCLUSIONS

On the basis of the study, dealing with influence of fertilization on infestation by weeds and grain yield of some small grains, we can conclude the following:

- Application of fertilizers had a positive influence on weed infestation decrease and increased grain yield of small grain crops;
- The highest degree of infestation by weeds was observed at the variant without fertilization, while the lowest one was found at the variant fertilized by mineral fertilizers, lime and manure;
- The greatest weed infestation degree was noticed in wheat, and the lowest one in rye and triticale;
- Grain yield at fertilized variants was significantly higher comparing with the control variant;
- The highest grain yield of the all studied small grain crops was achieved at the variant fertilized by the combination of mineral fertilizers, lime and manure;
- The greatest average grain yield was noticed in wheat, the lowest one in rye, while between barley and triticale there was not any significant difference;
- Because of its positive effect on increase of fertility level and improvement of physical, chemical and biological soil properties, as well as for a high efficiency in grain yield increasing on acid soils such as vertisol, application of lime together with manure and mineral fertilizers is the most important measure which ought to be regularly conducted in future, in order to remediate these degraded soils.

ACKNOWLEDGEMENT

The investigation published in this paper is a part of the project "The development of new technologies of small grains cultivation on acid soils using contemporary biotechnology" financed by the Ministry of Science and Technological Development of the Republic of Serbia, grant No TR-31054.

BIBLIOGRAFY

1. ANDERSON, T.N., MILBERG, P. (1998): Weed flora and the relative importance of site, crop, crop rotation, and nitrogen. Weed. Sci., 46:30-38.
2. ANIOL, A., MADEJ, J. (1996): Genetic variation for aluminium tolerance in rye. Vortr. Pflanzenz, 35:201-211.
3. BARBERI, P., SILVESTRI, N., BONARI, B. (1997): Weed communities of winter wheat as influenced by input evel and rotation. Weed Res., 37:301-313.
4. BRAUN-BLANQUET, J. (1964): Pflanzensoziologie: grundzüge der vegetationskunde. Zweite,

umgearbeitete und vermehrte Auflage. Springer-Verlag: Wien : New York. 865 pp.
5. GRUNDY, A.C., FROUD-WILLIAMS, R.J., BOATMAN, N.D. (1993): The use of cultivar, crop seed rate and nitrogen level for the suppression of weeds of winter wheat. Proc. Brit. Crop. Protec. Conf. Weeds., Brighton, UK, 997-1002.
6. JELIĆ, M., OGNJANOVIĆ, R., LOMOVIĆ, S., MILIVOJEVIĆ, J. (1995): Promena nekih pokazatelja plodnosti zemljišta tipa vertisol posle višegodišnje primene "Njival Ca". Zbornik radova sa Savetovanja "Popravka kiselih zemljišta Srbije primenom krečnog đubriva "Njival Ca", Paraćin, 138-145.
7. JELIĆ, M., LOMOVIĆ, S., MILIVOJEVIĆ, J. (1998): Effect of nitrogen and phosphorus fertilizers on the mineral nutrition of wheat plants on acid vertisol. In: S. Stamenković (ed.). Proceedings of 2nd Balkan Symposium on Field Crops, Novi Sad, 2:83-86.
8. JELIĆ, M., ŽIVANOVIĆ-KATIĆ, S., DUGALIĆ, G., MILIVOJEVIĆ, J. (2004): Kalcifikacija kiselih zemljišta kao faktor povećanja plodnosti zemljišta i prinosa strnih žita. Tematski zbornik radova "Poljoprivreda između suša i poplava", Novi Sad, 52-59.
9. JELIĆ, M., MILIVOJEVIĆ, J., DUGALIĆ, G. (2006): Dosadašnji rezultati i perspektive primene krečnog đubriva "Njival Ca" u popravci kiselih zemljišta na području Šumadije. In: Ž. Gajić (ed.). U Monografiji "Prirodne mineralne sirovine i mogućnosti njihove upotrebe u poljoprivrednoj proizvodnji i prehrambenoj industriji". Društvo poljoprivrednih inženjera i tehničara Srbije, Beograd, 125-133.
10. JELIĆ, M., ŽIVANOVIĆ-KATIĆ, S., MILIVOJEVIĆ, J., NIKOLIĆ, O. (2007): Uticaj kalcifikacije na produktivne osobine strnih žita. Zbornik radova sa XII Savetovanja o biotehnologiji, 12(13):339-345.
11. JORNSGARD, B., RASMUNSEN, K., HILL, J., CHRISTIANSEN, J.L. (1996): Influence of nitrogen on competition between cereals and their natural weed populations. Weed. Res., 36:461-470.
12. JOVANOVIĆ, Ž., ĐALOVIĆ, I., KOMLJENOVIĆ, I., KOVAČEVIĆ, V., CVIJOVIĆ, M. (2006): Influences of liming on vertisol properties and yields of the field crops. Cereal Research Communations 34(1):517-520.
13. KIRKLAND, K.J., BECKIE, H, J. (1998): Contribution of nitrogen fertiliser placement to weed menagment in spring wheat (*Triticum aestivum*). Weed. Technol., 2:507-514.
14. KNEŽEVIĆ MIRA, STIPEŠEVIĆ, B., KNEŽEVIĆ, I., LONČARIĆ, Z. (2007): Weed populations of winter wheat as affested by tillage and nitrogen. Ecologia, Bratislava, 26(2):190-203.
15. KOJIĆ M., ŠINŽAR B. (1985): Korovi. Naučna knjiga. Beograd.
16. KOJIĆ M. (1981): Određivanje korova. Nolit. Beograd.
17. KOVAČEVIĆ, V., BANAJ, D., KOVAČEVIĆ, J., LALIĆ, A., JURKOVIĆ, Z., KRIZMANIĆ, M. (2006): Influences of liming on maize, sunflower and barley. Cereal Research Communations 34(1):553-556.
18. OGNJANOVIĆ, R., KOSTIĆ, M., ĐOKIĆ, D., JELIĆ, M., JELENKOVIĆ, R. (1994): Changes of certain soil properties after application of calcium fertilizer "Njival Ca" and cropping agricultural species. Zemljište i biljka, 43(3):195-202.
19. ŽIVANOVIĆ-KATIĆ, S., JELIĆ, M., STOJANOVIĆ, J. (2000): Uticaj meliorativne primene đubriva na prinos i kvalitet semena jarih strnih žita na kiselom zemljištu. Zbornik izvoda sa III JUSEM, Zlatibor, 105.
20. ŽIVANOVIĆ-KATIĆ SNEŽANA (2004): Uticaj kalcizacije na floristički sastav korovske zajednice i prinos strnih žita. Doktorska disertacija. Univerzitet u Beogradu, Poljoprivredni fakultet, 1-166.
21. ŽIVANOVIĆ-KATIĆ SNEŽANA, JELIĆ, M., ĐALOVIĆ, I. (2008): Uticaj kalcizacije na floristički sastav i građu korovske zajednice u usevu ječma. Acta herbologica, 17(2):105-111.
22. WELS, G.J. (1979): Annual weeds competition in wheat crops the effects of weed density and applied nitrogen. Weed. Res., 19:185-191.