THE IMPACT OF INTEGRATED GROWING SYSTEM AND TOP DRESSING IN PRODUCTIVITY OF WINTER WHEAT

Željko DOLIJANOVIĆ[1], Snežana OLJAČA[1], Dušan Kovačević[1], Milena SIMIĆ[2], Srđan ŠEREMEŠIĆ[3], Nemanja GRŠIĆ[1]

[1]University of Belgrade, Faculty of Agriculture, Belgrade-Zemun, Serbia
[2]Maize Research Institute, Zemun Polje, Belgrade-Zemun, Serbia
[3]University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia
*Corresponding author: dolijan@agrif.bg.ac.rs

Abstract

The examination of the effects of sustainable growing systems on the grain yield of winter wheat was conducted at the research and study field "Radmilovac" of Faculty of Agriculture (44°45' N, 20°35' E Serbia, 130 m above mean see level). Investigations was conducted in 2016/17 and 2017/18 on the luvic chernozem soil type, in completely randomized blocks. In intergrated growing system (IGS), based on low inputs, tillage was performed using a chisel plough at 25 cm with ≥30% of maize crop residues retaining on the soil surface and the pre-sowing tillage using a disc harrow and a harrow, basic fertilization in autumn with 600 kg ha^{-1} NPK and top dressing in spring with 60, 120 kg ha^{-1} N and control treatment, without top dressing. Two common winter wheat cultivars (*Triticum aestivum* ssp. *vulgare*) Ilina and Zvezdana grew in this growing system. Statistical analysis confirmed that year, variety and top dressing had a significantly greater impact on grain yield and year and top dressing on weight of 1000 grains. Interaction of year*cultivar and year*top dressing had a significant effect on investigation parameters. More favorable meteorological conditions in the first year led to obtaining statistically significantly higher grain yields (5885.56:5585.56 kg ha^{-1}). A higher yield per unit area was found in the Ilina variety (6012.22 kg ha^{-1}) compared to the Zvezdana variety (5458.89 kg ha^{-1}). With increasing N dose in top dressing, the weight of 1000 grains and the grain yield of winter wheat increased in both tested varieties (5437.5; 5704.17; 6065.00 kg ha^{-1}). An integrated cultivation system on heavier soils has less positive effects than on soils with more favorable characteristics, especially in the higher dose of N.

Key words: *integrated management, winter wheat, grain yield, top dressing.*

Introduction

Wheat (*Triticum aestivum* L.) is one of the most significant cultivated species and the staple food for more than 50% of the global population (Rizwan et al., 2016) and special attention must be paid to the farming system of this species. Integrated farming system is sustainability and it combine the best practices from organic and conventional systems have potential to reduce negative environmental impacts while maintaining yield levels. Special attention in this growing system is paid to soil tillage, selection of genotypes, fertilization and application of chemical protection means. The main trend in tillage for winter wheat growing the past 3-4 decades has been the introduction and increased use of pot-powered harrows for secondary tillage. A comprehensive survey of soil characteristics in many countries winter wheat fields showed that the use of rotary harrows significantly affects soil structure. At present, new technologies for the cultivation of grain crops based on the use of minimum tillage are becoming more widespread (Korchagin and Chudanov, 2002).

With different reductions in soil tillage in our country, there are numerous results that are related, mainly, to better soils such as chernozem, but also to something more difficult such as eutric cambisol. According to some results, with the application of herbicides and special planters on chernozem, intensive production of wheat without plowing and pre-sowing preparation is possible (Konstantinović, 1997), while on heavier soils the advantage is mainly related to soil moisture preservation and soil protection from erosion. Compared to the conventional one, the conservation system of tillage achieved lower grain yields of winter wheat (25–35%), spring barley (5.72–51.85%), maize (24.90–24.62%) and soybeans (34.95–39.41%) as stated by Kovačević et al. (2020). Conservation technologies are more rational, however, since they give lower biomass yields than the conventional system, there is a need to examine their economic efficiency from the energy and soil protection point from degradation. Insisted conservation tillage systems are far more rational, but since they have resulted in slightly lower yields, there is a need to test their economic efficiency based on the ratio of additional energy input and the degree of soil conservation in each individual case. The introduction of a system of conservation tillage in the future must be in line with changes, both in crop rotation and in plant breeding (Momirović et al., 2021).

In addition to soil tillage systems, the optimal application of fertilizers is an important factor for obtaining high yield and high quality products. Tillage system and level of nitrogen fertilization in top dressing, as well as interaction between these two factors have important influence on grain yield of winter wheat (Dolijanović et al., 2019). Among the elements of mineral nutrition, nitrogen has the most important role in forming the yield (Litke et al., 2018), quality and utilizable value of the wheat grain (Blandino et al., 2016).

The objective of this study was to evaluate an effect of conservation tillage system and level of nitrogen top dressing on 1000 grain weight and grain yield of winter wheat in agroecological condition in Belgrade (Radmilovac research field).

Material and methods

Study site

The field experiment was conducted at the research field "Radmilovac" of Faculty of Agriculture ($44^o45'$ N, $20^o35'$ E Serbia, 130 m above mean see level). Since 1990 up to now, this experimental field has witnessed decades-long examinations of the impact of conventional, integrated and organic growing systems crop properties. The soil type is a luvic chernozem.

Experimental design

A three-factor field experiment (year, top dressing and variety) was designed as a randomised block with three replications, with the elementary plot of 6 m^2. The crop rotation was included four crops (maize → winter wheat → spring barley + red clover → red clover). In intergrated cropping system (ICS), based on low-inputs, tillage was performed using a chisel plough at 25 cm with ≥30% of maize crop residues retaining on the soil surface and the pre-sowing tillage, using a disc harrow and a harrow, basic fertilization in autumn with 600 kg ha^{-1} NPK and top dressing in spring with 0, 60 and 120 kg ha^{-1} N. Two common winter wheat cultivars 'Ilina' and 'Zvezdana' were used with 550 seeds m^{-2}. Cv. 'Ilina' is an excellent winter hardiness cultivar of medium-late maturity, which belongs to the B1 quality group. Cv. 'Zvezdana' is a very good winter hardiness cultivar of medium early maturity, which belongs belongs to the A1 - A2 quality group. Both varieties are very resistant to *Erysiphe graminis* DC. and well-resistant to *Puccinia striiformisf.* sp. *tritici* (Pst). All used varieties are winter resistant

and morphologically very similar, produced in the same seed company (Institute of Field and Vegetable Crops, Novi Sad, Serbia).

Sowing was conducted on October 22th and 25th, 2016 and 2017 and harvest was done on July 03rd, and June 28th. For weed control in the studied cropping systems used the preparation Maton (2,4D) for treating from the middle of tillering to the beginning of jointing (stages 25-30 of the BBCH scale) in the amount of 0.5 l ha^{-1}.

Statistical analysis

Sampling of wheat grains was performed in June, at the stage of full maturity and measuring 1000 grain weight and grain yield. The data were statistically processed using statistical package, IBM SPSS Statistics Version 25 (ANOVA). The level of significance was set at $P < 0.05$.

Results and discussion

The long-term mean precipitation in this area is on average 531.2 mm and the mean annual temperature is 10.3°C. However, in the research years (2016/17 and 2017/18), significant differences in meteorological conditions could be noticed, particularly regarding precipitation (Table 1). The annual precipitation in the first year was lower than the long-term average, with the extreme values in December (as low as 2.6 mm). Smaller amounts of precipitation were recorded in January, February, March and June compared to long-term averages. In this year, the average air temperature was also lower than the long-term average by 0.5°C. Higher temperature deviations from the long-term average were registered in October, November, December, January, February and May. On the other hand, significantly higher temperatures than the long-term average were recorded in June (+ 2.4°C). In the second year, precipitation was on level long-term average with more favourable precipitation schedule by months. The average months and annual temperatures were very higher than first year investigation (Table 1). In general, in terms of meteorological conditions, the second year of investigation was less favourable, primarily due to higher precipitation in June and higher air temperatures during April and May, which affected the 1000 grain weight and grain yield, especially in the Zvezdana variety.

Table 1. Mean monthly air temperatures and precipitation sums from October to June in Belgrade

Months	Temperature (°C)			Precipitation (mm)		
	2016/17	2017/18	1991-2016	2016/17	2017/18	1991-2016
October	11.1	13.9	13.3	76.8	65.9	56.2
November	7.7	8.4	8.4	71.8	41.2	46.6
December	0.9	5.1	3.1	2.6	45.2	53.9
January	-3.3	5.3	2.3	23.4	39.3	52.8
February	5.4	2.3	3.8	23.5	58.1	48.6
March	11.5	6.9	8.2	27	64.8	54.1
April	12.7	18.2	13.8	51.8	39.7	48.2
May	18.4	21.5	18.1	86.1	56.2	84.0
June	24.3	22.3	21.9	53	121.6	86.8
Average/Sum	9.9	11.5	10.3	416	532	531.2

The results of the study of the influence of the observed factors on the weight of 1000 grains and the grain yield of winter wheat are shown in Table 2. The weight of 1000 grains was statistically significantly influenced by the year of investigating and the level of top dressing (individual

factors), and interaction of all investigation factors. The grain yield of the examined winter wheat cultivars changed statistically significantly under the influence of all examined individual factors, as well as under the influence of the year * variety interaction (Table 2).

When we look at the obtained yield of winter wheat by years, it can be seen that the lower yields were obtained in 2017/18, which was with more unfavorable meteorological conditions. By growing the Zvezdana variety, lower grain yields and a weight of 1000 grains were achieved in relation to the Ilina variety. The absolute highest grain yields in both cultivars were recorded in conservation cultivation technology with protective treatment and intensive top-dressing of 120 kg ha^{-1} nitrogen (6597 and 6080 kg ha^{-1}). When it comes to the interaction between the year and top-dressing, it is interesting that with the increased amount of nitrogen in top-dressing, the negative effects of weaker meteorological conditions can be eliminated.

The results show that top-dressing in the first and second year of investigating, with the amount of 60 kg ha^{-1} nitrogen in the cultivar Ilina increased the yield by 6.5 and 4.6%, and with 120 kg ha^{-1} by 11.5 and 11.3% compared to the control. The increases in the variety Zvezdana were smaller, ie they were 1.7 and 6.7% for the dose of 60, respectively 9.0 and 14.5% for the second dose of nitrogen compared to the control. The relatively smaller increase in yield observed by the years of testing is the result of the weak effect of nitrogen in the first year of testing, primarily caused by bad meteorological conditions. However, the small difference between the two fertilization levels examined suggests that the Ilina and Zvezdana cultivars we used in these studies were cultivars with relatively lower nitrogen requirements. This fact recommends them as suitable for rational cultivation technologies based on reduced investments. It should be noted that increased nitrogen doses in top dressing are most justified in intensive winter wheat gay systems, especially in the case of intensive varieties (high input) (Kovačević et al., 2009).

Table 2. Yield and 1000-grain weight of the studied wheat cultivars in integrated cropping systems

Top dressing (kg ha^{-1} N) (C)	Variety (B)/ Year (A)	1000-grain weight (g)		Yield kg ha^{-1}	
		2016/17	2017/18	2016/17	2017/18
0	'Ilina'	41.2	39.8	5917	5463
	'Zvezdana'	41.4	39.4	5310	5060
	Average	41.3	39.6	5614	5262
60	'Ilina'	40.9	40.3	6300	5717
	'Zvezdana'	41.4	40.4	5400	5400
	Average	41.2	40.3	5850	5559
120	Ilina	40.7	40.9	6597	6080
	Zvezdana	42.1	40.7	5790	5793
	Average	41.4	40.8	6194	5937

ANOVA - LSD (0.05) 1000-grain weight				Yield			
A	0.249	AC	0.431	A	156.3	AC	270.7
B	0.249	BC	0.431	B	156.3	BC	270.7
C	0.305	ABC	0.610	C	191.4	ABC	382.9
AB	0.352			AB	221.1		

Conclusions

Based on the results of examining the impact of important agro-technical measures as elements of growing technology based on the basic postulates of sustainable agriculture on the weight of 1000 grains and the grain yield of winter wheat, it can be concluded:

The examined parameters had higher values in the first, meteorologically more favorable, year of investigating.

Top dressing with a higher dose of nitrogen was more efficient than the rational dose in both years.

The choice of variety is extremely important for rational (low-input) technology of growing winter wheat. The chosen degree of reduction in soil tillage, mineral nutrition and protection corresponded to the selected varieties, which showed increased adaptability to reduced tillage conditions, achieving optimal grain yields and a more modest mineral diet.

Acknowledgement

This paper is the result of research under the "Contract on the scientific research work realization and financing in 2021 between the Faculty of Agriculture in Belgrade and the Ministry of Education, Science and Technological Development of the Republic of Serbia", Ref. No: 451-03-9/2021-14/.

References

Blandino, M., Marinaccio, F., Reyneri, A. (2016): Effect of late-season nitrogen fertilization on grain yield and on flour rheological quality and stability in common wheat, under different production situations. - Italian Journal of Agronomy. 11(745): 107-113.

Dolijanović, Ž., Roljević-Nikolić S., Kovačević, D., Djurdjić S., Miodragović, R., Jovanović-Todorović M., Popović-Djordjević, J. (2019): Mineral profile of the winter wheat grain: effects of soil tillage systems and nitrogen fertilization. Applied ecology and environmental research 17 (5): 11757-11771.

Korchagin, V.A., Chudanov, I.A. (2002): Modern technological complexes for the cultivation of grain crops in adaptive farming systems Samara Research Institute of Agriculture Volga MIS 28–39.

Litke, L., Gaile, Z., Ruža, A. (2018): Effect of nitrogen fertilization on winter wheat yield and yield quality. - Agronomy Research. 16(2): 500-509.

Rizwan, M., Ali, S., Abbas, T., Zia-ur-Rehman, M., Hannan, F., Keller, C., Ok, Y. S. (2016): Cadmium minimization in wheat: a critical review. - Ecotoxicology and environmental safety, 130: 43-53.

Kovačević, D., Dolijanović, Ž., Oljača, S. (2009): Influence of tillage system, nitrogen supplementation and cultivars on winter wheat yield. Agricultural Engineering, Year XXXIV, No. 2, 9-13.

Kovačević, D., Oljača, S., Momirović, N., Broćić, Z., Dolijanović, Ž., Milić, V. (2020): Systems of conventional, integral and organic production of cultivated plants. In: Janjić V, Pržulj N (editors) Limitations and challenges in plant production. Academy of Sciences and Arts of the Republic of Srpska, Banja Luka, Monograph LXII: 91-133.

Konstantinović, J. (1997): Soil tillage in field science production. Institute of Field and Vegetable Crops Novi Sad, Novi Sad.

Momirović, N., Kovačević, D., Dolijanović, Ž. (2021): Technology of plant production in field and vegetable science production from the humanistic aspect of protection of man and nature. Scientific-professional gathering: Djordje Radic - the founder of modern agriculture in Serbia, 180 years since the birth of the first doctor of agricultural sciences among Serbs. SANU, Belgrade. Book CXSIV, Department of Chemical and Biological Sciences Book 18. Proceedings, 127-165.