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EFFECTS OF ORGANIC AND MICROBIOLOGICAL FERTILIZERS ON MORPHOLOGICAL AND PRODUCTIVE CHARACTERISTICS OF TRITICALE IN THE ORGANIC FARMING SYSTEM

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Abstract: The aim of the study was to examine the impact of microbiological and organic fertilizers on morphological and productive characteristics of triticale during a three-year period (2009/10–2011/12). A two-factorial field experiment was arranged using a randomized block design with four replications. The object of the study was the triticale winter cultivar Odisej, and the following treatments were applied: a control variant without fertilization, microbiological fertilizer “Slavol” (Agrounik Serbia) 5.0 l ha^{-1}, organic fertilizer “Biohumus Royal offert” (Altamed RS) 3.0 t ha^{-1} + microbiological fertilizer “Slavol” (Agrounik Serbia) 5.0 l ha^{-1}. The results showed that the expression of the characteristics was significantly affected by the environment. The lowest values were obtained in the first year when the most unfavourable meteorological conditions were observed. The application of microbiological fertilizer had no impact on the stem length and grain weight per spike, but it significantly increased the number of fertile spikelets (3.7%), spike length (7.7%) and grain yield (18.6%). The combined application of fertilizers provided better results for all the examined characteristics, while in comparison with the control, the differences ranged from 4.3% for the number of fertile spikelets to 46.5% for grain yield. The strongest correlation was determined between the spike length and the number of fertile spikelets (r = 0.939**). The obtained results lead to the conclusion that under variable environmental

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conditions, the application of fertilizers has a significant impact on morphological and productive characteristics of triticale, and consequently on the stability of this crop production in the organic farming system.

Key words: triticale, stem height, spike length, grain weight, fertile spikelets, grain number, yield, microbiological fertilizer, organic fertilizer.

Introduction

Triticale (*x Triticosecale* Wittmack) is the first artificial type of cereals obtained by crossing wheat (*Triticum spp*.) as the mother plant and rye (*Secale cerale*) as the pollinator. Triticale possesses the genetic yield potential of wheat and the efficient use of nutritive matter of rye (Ayalew et al., 2018; Wójcik-Gront and Studnicki, 2021). It is resistant to abiotic stress (Deng et al., 2020), very modest in its soil requirements (Łysoń and Biel, 2016; Kavanagh and Hall, 2015), resistant to diseases (Góral et al., 2021), has a higher yield potential of grain (Roques et al., 2017) and forage mass (Estrada-Campuzano et al., 2012) than common wheat, especially on low-quality soils (Belović et al., 2020). Its high crop coverage enables intercepting sunlight, shading and controlling weeds (Ayalew et al., 2018), as well as protecting soil from unfavorable meteorological conditions. The strong root and the ability to efficiently absorb nitrogen enable the cultivation of triticale after the crops that leave great quantities of this macroelement in the soil, thus decreasing its leaching and running off from agricultural land (Ketterings et al., 2015).

Triticale is grown on 3,807,661 ha worldwide, with an average grain yield of 3.7 t ha^{-1}. The primary world producer is Poland (34.5% of world area) (FAO, 2019). It is mainly used as animal feed, forage crop as well as for biogas production (Randhawa et al., 2015). It is not substantially present in the human diet, although its nutritive value is significantly higher than that of common wheat (Doxastakis et al., 2002). The high presence of albumins and globulins and simultaneously a lower content of the prolamin protein (gliadin) improve the digestibility of triticale-based products (Burešová et al., 2010). Triticale has around 20% higher content of essential amino acid lysine compared to common wheat, while its aleurone layer contains a large amount of minerals and fibre (Burešová et al., 2010). Some studies have proved the presence of lunasine in the triticale grain. Lunasine is a peptide that is reported to have cancer-preventive and anti-inflammatory properties and to prevent a high level of cholesterol in the blood (Nakurte et al., 2012). In the food industry, it is very important in preparing special bread types containing different kinds of cereal grains, while it is more appropriate than common wheat in the production of cakes, muffins, tortillas and pancakes. Triticale flour obtained by complex grinding contains 14–15% of proteins (Tohver et al., 2005). However, due to the lower gluten content, triticale-based bread characteristics are estimated to be poorer than those of common wheat bread.

Triticale grain yield and quality are impacted by the genotype, agroecological conditions and growing technology, primarily the application of fertilizers. Results of previous examinations showed that the application of nitrogen (Lalević and Biberdžić, 2016), as well as the application of mineral fertilizers with the increased content of phosphorus and potassium (Lalević et al., 2019), had a positive effect on the yield and yield components of winter triticale. In addition, it was determined that the nitrogen application had a significant impact on the technological quality of this cereal grain, while the highest gluten content was recorded in the variant with the highest dose of nitrogen fertilizer (Zečević et al., 2010). From the point of view of sustainable agriculture, there are significant positive effects of organic fertilizers on morphological and productive characteristics of triticale (Roljević Nikolić et al., 2020). Parvin et al. (2020) concluded that the foliar application of 200 mg l^{-1} humic acid in the flag leaf stage led to the maximum triticale grain yield, while Kheirizadeh Arough et al. (2016) recommended the application of biofertilizers for the profitable production of triticale, particularly under water-limitation conditions. The four-year research by Sautkina and Cheverdin (2020) showed that the pre-sowing nitrogen application at a dose of 30 kg ha^{-1} could be replaced by biofertilizer application in the production technology of winter triticale.

Owing to its modest requirements regarding climatic and soil conditions and agricultural practices, triticale can be grown in marginal areas. Consequently, farmers, particularly those engaged in the organic farming system, find it increasingly popular (Feledyn-Szewczyk et al., 2020). Under low-investment conditions, triticale provides a 100% higher yield than common wheat, durum wheat and barley (Benbelkacem, 2004). Studies have shown that in the years with favorable meteorological conditions, it provides almost the identical yield in the organic and conventional field farming systems, while in the years with poorer conditions, triticale yield is slightly lower in organic farming (Kronberga, 2008). Kronberga (2008) claims that in the years with favorable meteorological conditions, the selection of the appropriate cultivar provides the possibility of obtaining a higher yield, greater protein content in the grain and higher 1,000-grain weight in organic farming than in conventional farming.

The aim of the paper is to examine the impact of microbiological and organic fertilizers on morphological and productive characteristics of triticale depending on weather conditions during three vegetation seasons in the organic farming system. Examining the relationship between morphological and productive characteristics can contribute to creating more adaptable and productive triticale cultivars in low input systems.

Material and Methods

Site description. The examination of the impact of microbiological and organic fertilizers on morphological and productive characteristics of winter triticale was conducted at “Radmilovac” (44°45′21.18″ N, 20°34′43.27″ E; 130 m a.m.s.l.) on the leached chernozem soil type of the following properties: pH (in H_2O) 8.04, N 0.13%, P_2O_5 22.18 mg, K_2O 19.10 mg, average humus content in the plow-layer 2.45%. The experiment was realized using the method of a randomized complete block design with four replications during three years (2009/10–2011/12). The elementary plot area was 6 m^2. Sowing was done manually with the sowing density of 550 germinating seeds per m^{-2}.

The weather conditions during the three-year period (Figure 1) showed certain deviations from the usual characteristics of climate in the production regions. The average annual temperatures during the examinations were significantly higher than the long-term average (10.8°C).

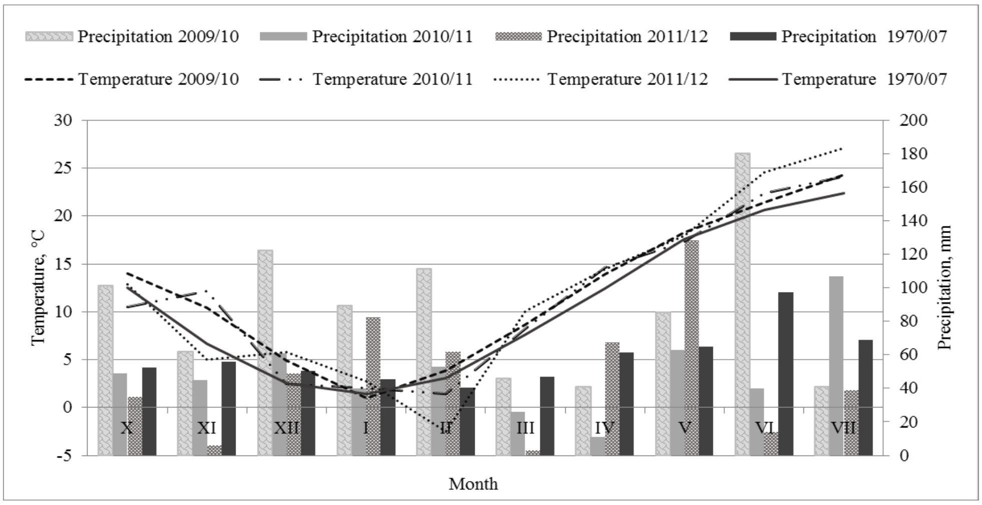

Figure 1. Average monthly air temperatures (°C) and precipitation sums (mm). Source: Republic Hydro-meteorological Service of Serbia.

Regarding the weather conditions, the 2009/10 season was very unfavorable (12.1°C, 878 mm). The pronounced water excess in the soil during the sowing period, abundant precipitation in sensitive developmental phases (heading), as well as high temperatures in the grain ripening phases, had an unfavorable impact on the growth and development, as well on total crop productivity.

During the research year of 2010/11, the average annual temperature was higher by 0.7°C than the long-term average, with the greatest deviation in November (+5.2°C), April (+2.1°C) and June (+1.7°C), while the lower average temperatures were recorded in October (-2.0°C), February (-1.8°C) and May (-0.4°C). The precipitation sum (495 mm) was lower than the long-term average (588 mm), particularly in April (47.8 mm) and June (59.5 mm).

Although in the third year (2011/12), the precipitation sum (485 mm) was lower than the long-term average, the abundant snowfall in February and retention of snow cover slowed down the vegetation in spring. Consequently, the heading and flowering phases occurred later. In addition, higher air temperatures in June and July 2012 reduced the period of grain filling and induced accelerated maturity.

Materials. The object of the study was the triticale winter cultivar Odisej. The Odisej cultivar has an excellent resistance to cold and lodging and a very good resistance to diseases. Regarding its maturity time, it belongs to the group of very early cultivars. Its 1,000-grain weight ranges from 47 to 49 g, its hectolitre weight from 75 to 79 kg, while its protein content is at the level of 12–14%.

The experiment comprised the following treatments:

T_1 – control – without the application of microbiological and organic fertilizers;

T_2 – microbiological fertilizer (5.0 l ha^{-1});

T_3 – organic fertilizer (3.0 t ha^{-1}) + microbiological fertilizer (5.0 l ha^{-1}).

For crop nutrition in spring in the BBCH 31-33 phase, a microbiological fertilizer “Slavol” (“Agrounik” Serbia) – the liquid foliar microbiological fertilizer was used of the following content: *Bacillus megaterium* 10^{-6} cm^3, *Bacillus licheniformis* 10^{-6} cm^3, *Bacillus suptilis* 10^{-6} cm^3, *Azotobacter chroococcum* 10^{-6} cm^3, *Azotobacter vinelandii* 10^{-6} cm^3, *Derxia* sp. 10^{-6} cm^3.

To improve and maintain the soil fertility, organic fertilizer “Biohumus Royal offert” (“Altamed,” Serbia) was used as the organic fertilizer, certified for use in organic farming, plowed in the autumn with the primary tillage in order to improve the content of nutritive matter, primarily phosphorus. The chemical characteristics were: pH in H_2O 8.63, N 2.2%; P_2O_5 4.8% and K_2O 2.8%.

Triticale was grown in four crop rotations: maize → winter triticale → spring barley+red clover → red clover. Tillage was done with moldboard plow in September, while the presowing preparation of soil was done with a disc harrow and a harrow in the second half of October. Crop protection was not conducted except for the mechanical weed control on the paths between the plots. The harvest was conducted by a combine harvester for experiments in the full crop maturity phase. The grain yield was measured based on the whole elementary plot, calculated at 14% moisture content and expressed in kg ha^{-1}.

Sample collection. In all three years, immediately prior to the harvest, 10 whole plants from each elementary plot were collected by random sampling.

The examined morphological characteristics were: the stem height (cm) and spike length (cm), while the following productive characteristics were determined: spike weight (g), grain weight per spike (g), number of fertile spikelets, grain number per spike and grain yield (kg ha^{-1}).

Statistical analysis. Data on the yield were analyzed using the analysis of variance (ANOVA) procedure of the Statistical Package for Social Sciences (SPSS software, 19.0). The comparisons among the different fertilization treatments were made with the least significant difference (LSD) test. The correlation analysis was performed to examine the relationship between the examined characteristics. Statistical significance was determined at the level of $p < 0.05$.

Results and Discussion

Stem height, which is a quantitative characteristic and an indirect component of grain yield, is greatly influenced not only by the genotype but by the environment as well (Đekić et al., 2019). The results of the analysis of the variance of this research showed a significant impact of the year and fertilization on the stem height (Table 1). The greatest average stem height was recorded in the third year (82.89 cm), which was significantly higher than in the first year (17%). The differences were also influenced by the fertilization treatments (Tables 2 3). The average stem height recorded in the treatment with the combined application of microbiological and organic fertilizers (80.83 cm) was significantly higher than the one in the control treatment (by 9.7%). In contrast, the independent use of microbiological fertilizer did not significantly impact the increase in the stem height (by 3.2%). The interaction of the examined factors (Y x T) did not have a significant impact on the triticale stem height, and similar results were also registered in other studies (Roljević Nikolić et al., 2020).

A spike has an important role not only as a direct holder of yield and grain, but owing to its large surface area, it also participates in photosynthesis, organic matter production and grain filling (Đekić et al., 2012). A longer spike has a greater ability to photosynthesis, which, along with mineral nutrition, directly affects the intensity of organic matter production and a larger number of fertile florets in a spikelet (Miralles and Slafer, 2007). In addition, a spike of greater length is most commonly correlated with a higher grain number per spike (Roljević Nikolić et al., 2020). Spike length was found to be significantly affected by year and fertilization (Table 1). During the three-year research, the average spike length of the cv. Odisej amounted to 10.01 cm. The greatest average spike length was recorded in the third year (11.49 cm), which was higher by 46.7% and 7.2% than in the first and the second year, respectively. There were significant differences between the fertilization treatments (Tables 2 and 3). Namely, the spike length of the cv. Odisej recorded in the treatment using the combined application of microbiological and organic fertilizers (10.60 cm) and in the treatment using only the microbiological fertilizer (10.08 cm) was higher by 13.4% and 7.7%, respectively, than in the control variant (Table 2).

Table 1. Results of the analysis of variance.

Source	Traits	Type III Sum of squares	Mean square	F	Sig.
Year	Stem height	680.217	340.109	11.138	0.001
	Spike length	67.022	33.511	70.785	0.000
	Spike weight	10.714	5.357	23.622	0.000
	Grain weight per spike	2.789	1.395	60.773	0.000
	No. of fertile spikelets	240.090	120.045	153.758	0.000
	No. of grains per spike	7129.023	3564.511	74.551	0.000
	Yield	9593706.936	4796853.468	23.001	0.000
Treatment	Stem height	234.876	117.438	3.846	0.041
	Spike length	7.043	3.522	7.439	0.004
	Spike weight	1.295	0.648	2.856	0.084
	Grain weight per spike	0.376	0.188	8.191	0.003
	No. of fertile spikelets	5.587	2.794	3.578	0.049
	No. of grains per spike	207.481	103.740	2.170	0.143
	Yield	8955456.080	4477728.040	21.471	0.000
Year x Tretment	Stem height	24.984	6.246	0.205	0.933
	Spike length	0.559	0.140	0.295	0.877
	Spike weight	0.175	0.044	0.193	0.939
	Grain weight per spike	0.011	0.003	0.115	0.976
	No. of fertile spikelets	0.261	0.065	0.084	0.986
	No. of grains per spike	129.281	32.320	0.676	0.617
	Yield	1123869.358	280967.339	1.347	0.291

The impact of the years on the spike weight was primarily expressed in the differences regarding the amount and distribution of precipitation, as well as the air temperature fluctuations. Greater soil moisture in the first year favoured weed growth, which had an additional impact on the total above-ground weight of the cultivated plants (previous research by Roljević Nikolić et al., 2017; 2020). Therefore, the average spike weight in the first year (1.67 g) was significantly lower than in the second (3.14 g) and the third year (2.8 g), i.e. by 46.8% and 40.6%, respectively. Although the impact of fertilization, as well as the interaction of the examined factors, was not significant (Table 1), it can be noticed that the spike weight in the control variant was lower than in the variants where fertilizers were applied in all years. On average, this difference amounted to 9.9% in treatment T_2, and 23.4% in treatment T_3 in comparison to the control (Table 2).

On the other hand, the grain weight per spike was significantly impacted by the fertilizer application (Table 1). The recorded average value in the T_3 treatment was greater by 19.1% and 12.1% than in T_1 and T_2, representing significant differences (Tables 2 and 3). During the research, the average grain weight per spike ranged from 1.16 g in the first research year to 1.90 g in the third year, which also represents a significant difference. Although the interaction of the studied factors (Y x T) did not significantly affect this productive characteristic, the obtained results showed that the greatest differences between the control and the variants with the applied fertilizers were registered in the first research year (T_1 – 9.8% and T_2 – 22.2%). In addition, it was determined that, in the variants with the applied fertilizers, the grain weight per spike had a smaller coefficient of variation (T_2 7.6% and T_3 6.6%) in comparison to the control (T_1 8.3%), which highlights the significance of fertilizer application from the aspect of production stability as well.

One of the most important components of cereal yield is the grain number per spike. The grain number per spike results from several parameters (spike length, number of spikelets, number of florets per spikelet), which may vary significantly depending on agro-ecological conditions. The average grain number per spike recorded for the cv. Odisej amounted to 50.86, with significant differences between the years (Tables 2 and 3). The greatest average grain number per spike was recorded in the second year (70.35), which was greater by 130.2% and 36.2% than in the first and third year, respectively. The application of fertilizers did not show a significant impact on this characteristic, but the values obtained in the control were smaller by 6.0% and 12.5% on average than in the fertilization treatments T_2 and T_3, respectively (Table 2). Examining the impact of mineral fertilizers on the productive and morphological characteristics of spelt wheat, Glamočlija et al. (2012) concluded that adding mineral fertilizers had a statistically significant impact on the stem length and spike length, while no statistical significance was recorded for the number of spikelets per spike, grain number per spike and 1,000-grain weight, although the values of these characteristics were greater in the treatment including fertilizers than in the control. These findings are in accordance with our research results.

Heading and flowering phases represent a very important determinant of seasonal and regional adaptation of cereal cultivars (Trkulja et al., 2011). The adaptations are reflected in avoiding low air temperatures in flowering time (which can cause male sterility), as well as avoiding high temperatures and droughts during the grain filling phase. The significant impact of the year was determined on the number of fertile spikelets per spike (Table 1). The average number in the third year (27.14) was significantly greater in comparison to the first (20.20) and the second year (25.63) (Tables 2 and 3). The application of microbiological fertilizer had an impact on the increase in the number of fertile spikelets by 3.7%, while the application of microbiological and organic fertilizers increased the number of fertile spikelets by 4.3%. This represents a significant difference in comparison to the control. The analysis of the data presented in Table 1 indicates that the best result of the application of microbiological fertilizer was recorded in the third year (4.0%), while the best result of the combined application of microbiological and organic fertilizers was registered in the first research year (5.8%). During the research, variation in the number of fertile spikelets was the lowest in the T_3 treatment (11.7%).

Table 2. Morphological and productive traits of the cv. Odisej in the three-year period.

Year	Treatment			Average
	T_1	T_2	T_3	
		Stem height (cm)		
2009/2010	66.82	71.73	74.03	70.86
2010/2011	73.58	80.32	83.29	79.06
2011/2012	80.70	82.82	85.16	82.89
Average	73.70	78.29	80.83	
		Spike length (cm)		
2009/2010	6.99	7.88	8.62	7.83
2010/2011	10.00	10.90	11.26	10.72
2011/2012	11.08	11.46	11.93	11.49
Average	9.36	10.08	10.60	
		Spike weight (g)		
2009/2010	15.20	16.93	18.00	16.71
2010/2011	28.00	30.97	35.27	31.41
2011/2012	25.43	27.53	31.40	28.12
Average	22.88	25.14	28.22	
		Grain weight per spike (g)		
2009/2010	1.05	1.15	1.28	1.16
2010/2011	1.64	1.72	1.96	1.77
2011/2012	1.77	1.86	2.07	1.90
Average	1.49	1.58	1.77	
		Number of fertile spikelets		
2009/2010	19.60	20.27	20.73	20.20
2010/2011	25.00	25.90	26.00	25.63
2011/2012	26.47	27.53	27.43	27.14
Average	23.69	24.57	24.72	
		Number of grains per spike		
2009/2010	29.90	30.60	31.20	30.57
2010/2011	64.15	69.03	77.87	70.35
2011/2012	48.73	52.23	54.03	51.67
Average	47.59	50.62	54.37	
		Yield (kg ha^{-1})		
2009/2010	2,429.00	2,938.17	3,393.17	2,920.11
2010/2011	2,691.50	3,667.00	4,708.70	3,689.07
2011/2012	3,909.20	4,108.33	5,127.02	4,381.52
Average	3,009.90	3,571.17	4,409.63	

In the applied organic farming technology, the three-year average yield of the Odisej cultivar amounted to 3,664 kg ha^{-1}, which is by 40–60% lower in comparison to the yields stated by Glamočlija (2004) obtained under conventional farming conditions. The impact of the year on yield was significant and the greatest grain yield was recorded in the third year (4,381.52 kg ha^{-1}), while the significantly lower was registered in the first research year (2,920.11 kg ha^{-1}) (Tables 1 and 2). In terms of weather conditions, the vegetation season of 2009/10 was very unfavorable. Greater soil moisture had a negative impact on the mineralization of the organic fertilizer and the availability of nutritive matter. In addition, abundant precipitation occurred in the periods of the sensitive development phases, which had an unfavorable effect on the productivity of the cv. Odisej in the first year. Some other studies also underlined that the moisture excess in autumn had a negative effect on the growth and development of triticale (Wójcik-Gront and Studnicki, 2021).

Table 3. The least significant difference (LSD) test.

Traits		2009/2010–2011/2012		
	a level	Y	T	Y*T
Stem height	0.05	4.74	4.74	-
	0.01	6.50	6.50	-
Spike length	0.05	0.59	0.59	-
	0.01	0.81	0.81	-
Spike weight	0.05	0.41	-	-
	0.01	0.56	-	-
Grain weight per spike	0.05	0.13	0.13	-
	0.01	0.18	0.18	-
Number of fertile spikelets	0.05	0.76	0.76	-
	0.01	1.04	1.04	-
Number of grains per spike	0.05	5.93	5.93	
	0.01	8.13	8.13	
Yield	0.05	391.51	391.51	-
	0.01	536.93	536.93	-

Y – year; T – treatment.

The analysis of variance determined a significant impact of the examined fertilization treatments on the grain yield (Tables 1 and 3). The best result was recorded in the T_3 treatment, where the grain yield was greater by 46.5% than in the control (Table 2). The effect of fertilizer application was somewhat weaker since the recorded increase in the yield amounted to 18.6%. The positive impact of the fertilizer application on the grain yield of the Odisej cultivar in conventional farming was noticed by Lalević et al. (2019). They stated that the variant with the lowest nitrogen amount had a significantly lower yield than the other fertilization variants. The results of the descriptive analysis showed that the grain yield variations in the control (21.4%) were greater than in the variants with the applied fertilizers (T_1 – 13.5% and T_2 – 16.8%), which indicates that the application of fertilizers in the organic production of triticale was significant not only from the aspect of grain yield but also from the aspect of the stability of grain yield.

The results of the correlation analysis show that there was a positive and significant correlation between the studied traits of the Odisej cultivar (Table 4). The stem height has a positive and significant correlation with all the studied characteristics: spike length (r = 0.742**) and spike weight (r = 0.609**), number of fertile spikelets (r = 0.754**), grain number per spike (r = 0.545**) and grain weight per spike (r = 0.666**), and grain yield (r = 0.800**) (Table 3). However, the strongest correlation was determined between the spike length and the number of fertile spikelets ($r = 0.939^{**}$), where a 1-cm increase in the spike length increased the number of fertile spikelets by 0.3 ($y = -0.106 + 0.315x_i$). Also, the grain weight per spike had a significant correlation with the spike length (r = 0.904**).

Table 4. The coefficient of correlation between analyzed morphological and productive characteristics of the triticale cv. Odisej cultivated in the system of organic production in the three-year period.

Traits	Stem height	Spike length	Spike weight	Grain weight per spike	Number of fertile spikelets	Number of grains per spike	Yield
Stem height	1	.742**	.609**	.666**	.754**	.545**	.800**
Spike length		1	.847**	.904**	.939**	.725**	.697**
Spike weight			1	.814**	.828**	.907**	.555**
Grain weight per spike				1	.915**	.723**	.680**
Number of fertile spikelets					1	.749**	.667**
Number of grains per spike						1	.443*
Yield							1

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level.

Grain formation and yield production occur primarily at the expense of decomposition and translocation of reserve compounds from older and photosynthetically inactive plant parts, such as the stem and older leaves, into the spike. It has been estimated that reserves of carbohydrates in the stem contribute to the total wheat yield by approximately 10–12% under optimal agro-ecological conditions and by more than 40% during droughts and heat stress conditions

(Evans and Wardlaw, 2017). Therefore, the determined strong positive correlation between the stem height and grain yield (r = 0.800**) needs attention in breeding Otherwise, a drastic decrease of stem height can significantly decrease the complete biomass, and consequently the grain yield (Madić et al., 2016).

Conclusion

Organic farming of winter triticale is characterized by a great impact of weather conditions on all the studied morphological and productive characteristics. The lowest values of all characteristics were recorded in the first year, which was characterized by the greatest amount of precipitation and the highest average air temperatures. Although fertilization had a positive impact on the examined characteristics, there were no significant effects regarding the spike weight and grain number per spike. The application of biofertilizer significantly increased the number of fertile spikelets (3.7%), spike length (7.7%) and grain yield (18.6%), while the combined application of biohumus and biofertilizer significantly increased the stem length (9.7%), spike length (13.3%), grain weight per spike (19.1%), number of fertile spikelets (4.3%), as well as the grain yield (46.5%) in comparison with the control. It was determined that the characteristics such as stem length and spike length, grain weight per spike and grain weight had the greatest coefficient of variation in the control, which highlights the significance of the organic fertilizer application not only from the aspect of the grain yield but also from the aspect of yield stability. There was a positive and significant correlation between the examined characteristics, particularly between the spike length and the number of fertile spikelets. The obtained results show that, within low input systems such as organic farming, even under very changeable agro-ecological conditions during a season, the selection of well-balanced formulas of organic and microbiological fertilizers can have a positive impact on the expression of the genetic potential of the triticale.

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UTICAJ ORGANSKOG I MIKROBIOLOŠKOG ĐUBRIVA NA MORFOLOŠKE I PRODUKTIVNE OSOBINE TRITIKALEA U SISTEMU ORGANSKE PROIZVODNJE

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R e z i m e

Cilj istraživanja bio je ispitivanje uticaja biohumusa i biofertilizatora na morfološke i produktivne osobine tritikalea u trogodišnjem periodu (2009/10–2011/12). Poljski ogled je postavljen kao dvofaktorijalni, po metodi blok sistema sa slučajnim rasporedom tretmana u četiri ponavljanja. Predmet ispitivanja bila je ozima sorta tritikalea, Odisej, a ispitivan je uticaj sledećih tretmana: kontrola bez đubrenja, biofertilizator (5,0 l ha^{-1}), biohumus (3,0 t ha^{-1}) + biofertilizator (5,0 l ha^{-1}). Rezultati su pokazali da spoljašnja sredina ima značajan uticaj na ekspresiju ispitivanih osobina. Najmanje vrednosti dobijene su u prvoj godini, koja je imala i najnepovoljnije meteorološke uslove. Đubrenje je imalo statistički značajan uticaj na većinu ispitivanih osobina. Primena biofertilizatora nije uticala na dužinu stabla i masu zrna u klasu, ali je značajno povećala broj plodnih klasića (3,7%), dužinu klasa (7,7%) i prinos zrna (18,6%). Kombinovanom primenom đubriva postignuti su bolji rezultati za sve ispitivane osobine, a razlike u odnosu na kontrolu bez đubrenja kretale su se u nivou od 4,3% za broj plodnih klasića do 46,5% kod prinosa zrna. Najjača korelaciona povezanost ustanovljena je između dužine klasa i broja plodnih klasića (r = 0,939**). Dobijeni rezultati upućuju na zaključak da, u promenljivim uslovima spoljašnje sredine, primena dobro izbalansiranih formula organskih i mikrobioloških đubriva ima značajan uticaj na morfološke i produktivne osobine tritikalea, a samim tim na stabilnost proizvodnje ovog useva u sistemu organskog gajenja.

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Ključne reči: tritikale, visina stabla, dužina klasa, masa zrna, plodni klasići, broj zrna, prinos, mikrobiološko đubrivo, organsko đubrivo.

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