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Yield components and yield of winter wheat in different years of research

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***Abstract*:**

Terzić, D., Đekić, V., Milivojević, J., Branković, S., Perišić, V., Perišić, V., Đokić, D.: *Yield components and yield of winter wheat in different years of research. Biologica Nyssana, 9 (2). December, 2018: 119-131.*

Field trial with wheat varieties Perfekta, KG 56S, Aleksandra and Vizija was set on vertisol-type soil during the vegetation season 2010/11 and 2011/12. The aim of the research was to analyse the yield and grain yield components in four varieties of wheat cultivated on acid soil. The highest values of yield components and grain quality were established in the year with moderate temperatures and high precipitation in the vegetation year 2010/11. The KG 56S and Vizija varieties had the highest yield of grain, the highest number of plants and spikes per m^2. The Perfekta variety showed the highest 1000 grain weight and grain weight per spike. The highest number of grains in the spike and the lowest average yield of grain during the research were recorded for the variety Aleksandra. A significant positive correlation between grain yield and grain weight per spike, the number of grains in the spike and the number of plants per m^2 were established, as well as between the 1000 grain weight and the number of grains in the spike and the grain weight per spike.

Key words: yield components, grain yield, wheat

***Apstrakt*:**

Terzić, D., Đekić, V., Milivojević, J., Branković, S., Perišić, V., Perišić, V., Đokić, D.: *Komponente prinosa i prinos ozime pšenice u različitim godinama istraživanja. Biologica Nyssana, 9 (2). Decembar, 2018: 119-131.*

Poljski ogled sa sortama pšenice Perfekta, Kg 56S, Aleksandra i Vizija postavljen je na zemljištu tipa vertisol tokom vegetacionih sezona 2010/11 i 2011/12 godine. Cilj istraživanja je bio da se kod četiri sorte pšenice gajene na kiselom zemljištu analizira prinos i komponente prinosa zrna. Najveće vrednosti komponenti prinosa i kvaliteta zrna ustanovljene su u godini sa umerenim temperaturama i velikom količinom padavina u vegetacionoj 2010/11 godini. Sorte KG 56S i Vizija imale su najveći prinos zrna, najveći broj biljaka i klasova po m^2. Sorta Perfekta odlikovala se najvećom masom 1000 zrna i masom zrna po klasu. Najveći broj zrna u klasu i najmanji prosečan prinos zrna tokom istraživanja imala je sorta Aleksandra. Ustanovljena je značajno pozitivna korelacija između prinosa zrna i mase zrna po klasu, broja zrna po klasu i broja biljaka po m2, kao i između mase 1000 zrna i broja zrna po klasu i mase zrna po klasu.

Ključne reči: komponente prinosa, prinos zrna, pšenica

Introduction

Winter wheat (*Triticum aestivum* L.) is one of the most important field crops in Serbia, and it is cultivated on about 530,000 ha per year. Average yields of wheat for the last 10 years in the main production areas of Serbia have ranged from 4.5-8.0 t/ha. Wheat production in Serbia depends to a large extent on the environmental factors. The average grain yield of winter wheat and the potential of fertility of cultivated varieties are significantly different, especially in mountainous areas of Serbia. Hristov et al. (2011) and Jocković et al. (2014) state that the yield and grain yield components of winter wheat vary considerably depending on the cultivation system, the applied doses of nitrogen, variety and conditions during the growing year, as well as their complex interactions. In addition to the genotype, the grain yield of winter wheat is largely influenced by the fertilization system, which is one of the key factors affecting the formed yield and its quality, but it must be harmonized with the climatic and soil conditions as well as the requirements of the variety (Malešević et al., 2008; Jaćimović et al., 2011; Popović et al., 2011; Đekić et al., 2014; Jelic et al., 2015; Terzić et al., 2018). Research has shown that the yield of wheat depends on a number of components: the number of plants i.e. spikes per unit area, the number of grains in the spike, the weight of the grains in the spike and the absolute grain weight. There are complex interactions between these indicators, because in increasing the value of one parameter, the value of another is often reduced (Borojević and Williams, 1992; Denčić et al., 2000; Kandić et al., 2009; Dimitrijević et al., 2011; Laghari et al., 2011; Perišić et al., 2011; Đekić et al., 2012; Hristov et al., 2012; Milovanović et al., 2012; Đurić et al., 2013; Hagos and Abay, 2013; Mohamed et al., 2013).

The variety as an autonomous genetic, biological and agronomic entity is one of the crucial factors both on quantitative and qualitative production levels (Denčić and Kobiljski, 2007). The increase in the yield of wheat depends primarily on cultivated variety, climatic conditions and applied cultivation technology (Dodig et al., 2008; Milovanović et al., 2011; Đekić et al., 2012; Hristov et al., 2014). The introduction into the production of varieties with increased genetic potential for yield and improved agronomic and technological traits represents the contribution of breeding to achieve higher production per unit area (Mladenov et al., 2007; Milovanović et al., 2008; Luković et al., 2014; Przulj et al., 2014; Đurić et al., 2018). The genetic potential for yield can be increased in different ways: better use of genetic variability, better utilization of solar energy, increase in number and weight of grain, increase in total biomass of the plant, using heterosis, i.e. wheat hybrid (Denčić et al., 2010).

Choosing the appropriate site/location, i.e. reonization of varieties, will contribute to a less variation in the yields achieved and to achieving better average results (Biberdžić et al., 2005; Williams et al., 2008; Madić et al., 2010; Dimitrijević et al., 2011; Hristov et al., 2014; Perišić, 2016; Stevanović et al., 2018; Đurić et al., 2018; Djuric et al., 2018). Bearing all this in mind, it is necessary that climatic conditions are in accordance with the biological requirements of the plants. In the last ten years, extreme temperatures and disturbances in the amount and distribution of precipitation have significantly affected the reduction in overall production of organic matter and yield reduction (Hristov et al., 2013; Popović et al., 2014).

Production of winter wheat with high grain yield and appropriate quality is possible only by choosing varieties of good quality with appropriate cultivation conditions and appropriate production technology. During the vegetation years (2010-2012), in the field trials, four winter wheat varieties were examined in order to determine the selection/breeding of the better varieties for the production conditions of Central Serbia.

Material and methods

Experimental design and soil conditions

This study was conducted over a two-year period in the Šumadija region, Central Serbia, on a vertisol soil, at Kragujevac location, 173-220 m a. s. l. (44°00′51″ N and 20°54′42″ E), in a temperate continental climate having an average annual temperature of 11.5 °C, typical of Šumadija districts in Serbia and a rainfall amount of about 550 mm. The basic type of soil on which the trial was carried out in Kragujevac was characterized as smonitsa in degradation. The physical properties of this soil are very unfavourable making it the type of heavy clay soil. According to the analysis, this soil was of a medium acid reaction (pH_{KCl} = 4.8) and poor in

Table 1. Mean monthly air temperature and precipitation amount (Kragujevac)

	Months									
Interval	X	XI	XII	I	II	III	IV	V	VI	Average
Mean monthly air temperature (ºC)										
2010/11	10.2	11.4	2.4	0.9	0.5	7.2	12.0	15.8	20.9	9.0
2011/12	10.4	3.1	4.6	0.7	-3.7	8.1	12.9	16.1	23.0	8.4
Average	12.5	6.9	1.9	0.5	2.4	7.1	11.6	16.9	20.0	10.5
The amount of precipitation (mm)										
2010/11	86.9	27.9	50.1	29.1	48.5	20.4	20.8	65.8	32.3	381.8
2011/12	33.3	1.3	43.3	117.2	60.1	5.7	74.5	87.3	57.8	480.5
Average	45.4	48.9	56.6	58.2	46.6	32.4	51.9	57.6	70.4	468.0

humus (2.65%). It was very poorly provided with accessible phosphorus (1-2 mg/100 g of soil) and provided with easily accessible potassium (20 mg/100 g of soil).

During the 2010/11 and 2011/12 growing seasons, four varieties of winter wheat were investigated (Perfekta, Kg 56S, Aleksandra and Vizija) at the Small Grains Research Centre in Kragujevac (in central Serbia). The experiments were conducted in randomized block systems, with a plot size of 50 m^2 (5 m x 10 m) in five replications. The sowing was carried out using a machine with row spacing of 12 cm. The soil on which the trial was conducted was uniform and well prepared. The amount of seed per square meter amounted to 400-450 viable seeds, depending on the traits of varieties. It was sown in the third decade of October, with 400 kg/ha of fertilizer NPK 15:15:15, which was added in the fall, while during the spring fertilization soil was supplemented with 300 kg/ha (KAN 27% N).

During the trial, the influence of variety and year on productive yield elements was monitored (number of grains by spike, grain weight per spike, number of plants and spikes per m^2 and yield of grain) and grain quality. Determination of the number of spikes per m² was done by numbering them in the period of ripening from the surface of 1 m². The analysis of the fertility factors of the spikes (number of grains in the spike and the grain weight per spike) was done by measuring, counting and processing the obtained results. As a material, by random sample, 20 spikes in full maturity were taken from each variant and from all repetitions. After harvest, the yield from each elementary parcel was measured and expressed in kg/ha. The yield was corrected for grain moisture content of 14%.

Agroecologial conditions

Data in **Tab. 1** for the investigated period (2010-2012) clearly indicate that the years in which the research were conducted differed from the typical multi-annual average for Kragujevac region, regarding the meteorological conditions.

The average air temperature in 2010/11 was lower by 1.5 °C and 2011/12 was lower by 2.1 °C as compared to the long-term mean. The sum of rainfall precipitation in 2010/11 was lower by 86.2 mm, where the sum of rainfall in 2011/12 was by 12.5 mm higher than the average of many years and with a very uneven distribution of precipitation per months. Compared to the long-term mean, total rainfall values, especially in the first year, second and third year, were considerably higher in February, April and May, whereas total rainfall in April 2010/11 decreased by 31.1 mm. Given the high importance of sufficient rainfall amount during the spring months, particularly April and May, for wheat production, the distribution and amount of rainfall over the growing season 2010/11 were considerably more favourable, resulting in increased yields in this year. Apart from the rainfall deficiency during the spring months and the non-uniform distribution of rainfall across months, an increase in average air temperatures was also observed. Larger precipitation amounts during the spring months (March-May) caused rising groundwater levels and flooding of agricultural land. The excessive amount of moisture influenced the poorer heading and filling of grain, lodging of crops, the abundance of the weeds and the intense occurrence of the disease in the examined wheat and other winter grains.

Significant deviation of precipitation and temperature from the multi annual average is becoming more pronounced (Dodig, 2010; Đekić et al., 2015). It was found that newly-produced high-yielding wheat varieties are less susceptible to temperature deviation (except for extreme) compared to precipitation (Hodson and White, 2009; Hristov et al., 2013). Namely, the total amount of precipitation is reflected on the multi annual average, but the distribution, especially at critical stages of development, is significantly disturbed. It was found that winter precipitation significantly influences the realization of the production potential of wheat (Malešević et al., 2011). In addition to the necessary reserve for the spring part of the vegetation, winter precipitation greatly influences the distribution of easily accessible nitrogen in the soil (Đekić et al., 2014; Jelic et al., 2015; Terzić et al., 2018).

Statistical Analysis

On the basis of achieved research results the usual variation statistical indicators were calculated: average values. Experimental data were analysed by descriptive and analytical statistics using the statistics module Analyst Program SAS/STAT (SAS Institute, 2000) for Windows. All evaluations of significance were made on the basis of the ANOVA test at 5% and 1% significance levels. Relative dependence was defined through correlation analysis (Pearson's correlation coefficient), and the coefficients that were obtained were tested at the 5% and 1% levels of significance.

Results and discussion

Productive elements of wheat grain yield and quality

The average values of productive grain yield and quality traits of the investigated winter wheat varieties grown in the Centre for Small Grains - Kragujevac are shown in **Tab. 2**.

In regard to grain yield, differences were established in the tested varieties. The average yield of wheat in the experiment was 5.091 t/ha, with a variation of 4.630 t/ha in the second year to 5.553 t/ha in the first year of the study. The highest grain yield in the vegetation year 2010/11 was established for the variety Vizija (6.127 t/ha) and variety KG 56S (5.863 t/ha). In the second study year, cultivation, the highest average grain yield (5.159 t/ha) was recorded for the variety KG 56S. The highest average grain yield in the two-year period was recorded for KG 56S (5.511 t/ha) and Vizija (5.485 t/ha), and the lowest for the variety Aleksandra (4.628 t/ha).

The weight of 1000 grains in the vegetation year 2010/11 year was significantly higher than in 2011/12 (**Tab. 2**). The average weight of 1000 grains in the study was 43.13 g, with a variation of 42.05 g in the vegetation year 2011/12 to 44.21 g in the vegetation year 2010/11. The highest weight of 1000 grains in the first year was recorded for KG 56S (47.76 g) and Perfekta (46.40 g) varieties. In the second year of the study, the highest weight of 1000 grains were achieved by the variety Aleksandra (45.80 g). The variety Perfekta had the highest average two-year value of the 1000 grain weight (45.00 g) and the lowest the variety Vizija (41.98 g).

The variety Perfekta had the highest number of grains in the spike (45) in the vegetation year 2010/11 year, while in 2011/12 the highest value of the number of grains in the spike was recorded for the variety Aleksandra (41). The average two-year value for number of grains in the spike in all wheat varieties examined was 39.65, with a variation of 37.50 in the vegetation year 2011/12 to 41.80 in the vegetation year 2010/11.

The data on grain weight per spike, independent of the year, showed that there was a significant difference between the genotypes, with the variety Perfekta (1.908 g) showing the highest average weight of grain per spike for the examined years. The average grain weight per spike in the study was 1.725 g, with a variation of 1.423 g to 2.026 g. The highest grain weight per spike in both years was recorded for the varieties Perfekta and KG 56S.

In regard to the number of plants per m^2, significant differences were found in the studied wheat varieties (**Tab. 2**). The average two-year plant count per m^2 was 386.9, while the same ranged from 414.6 per m^2 in the first year of research to 359.2 per m^2 in the second vegetation season. The highest number of plants in vegetation year 2010/11 was established for the varieties Vizija (437.2) and KG 56S (426.8). In the second year of testing, the highest number of plants per m^2 was found in KG 56S (376.0).

The average two-year value of number of spikes per m^2 was 518.2, while the same ranged from 564.5 in the first year of research to 472.0 in the second vegetation season. The highest number of spikes in the vegetation year 2010/11 was recorded for the varieties Vizija (604.0) and KG 56S (583.6). In the second year of the study, the highest number of spikes was recorded in the variety KG 56S (500.8).

Analysis of variance between observed traits of wheat

The analysis of the variance of productive grain yield and quality traits in the examined Kragujevac cultivars of winter wheat, grown in the Centre for small Grains in Kragujevac during the two vegetation seasons, is shown in **Tab. 3**.

The estimation of the significance of the obtained results shows that there are statistically highly significant differences between the examined vegetation seasons and grain yield (F_{exp}=14.5689), the number of grains in the spike (F_{exp}=16.0342), the grain weight per spike (F_{exp}=101.1208) and significant for the number of plants per m^2 (F_{exp}=8.9838). The statistically significant

Table 2. Average values of investigated triticale varieties traits

Varieties	2010/11			2011/12			Average		
	x	S	Sx	x	S	Sx	x	S	Sx
Yield, (t/ha)									
Perfekta	5.099	1.001	0.448	4.385	0.678	0.303	4.742	0.890	0.281
KG 56S	5.863	0.537	0.240	5.159	0.956	0.427	5.511	0.820	0.259
Aleksandra	5.121	0.421	0.188	4.135	0.256	0.114	4.628	0.615	0.194
Vizija	6.127	0.633	0.283	4.843	0.654	0.292	5.485	0.909	0.287
Average	5.553	0.780	0.174	4.630	0.747	0.167	5.091	0.887	0.140
1000 grain weight, g									
Perfekta	46.40	2.266	1.013	43.60	1.475	0.660	45.00	2.329	0.737
KG 56S	47.76	0.713	0.319	38.20	1.204	0.538	42.98	5.124	1.620
Aleksandra	39.34	3.265	1.460	45.80	2.168	0.969	42.57	4.292	1.36
Vizija	43.36	2.611	1.168	40.60	1.673	0.748	41.98	2.528	0.799
Average	44.21	3.985	0.891	42.05	3.336	0.746	43.13	3.789	0.599
Number of grains per spike									
Perfekta	45.00	0.707	0.316	35.00	4.062	1.817	40.00	5.944	1.880
KG 56S	41.20	1.304	0.583	38.20	2.588	1.158	39.70	2.497	0.789
Aleksandra	39.20	2.049	0.916	41.00	3.162	1.414	40.10	2.685	0.849
Vizija	41.80	1.923	0.860	35.80	4.147	1.855	38.80	4.392	1.389
Average	41.80	2.587	0.579	37.50	4.046	0.905	39.65	3.997	0.632
Grain weight per spike, g									
Perfekta	2.186	0.055	0.025	1.630	0.097	0.044	1.908	0.302	0.096
KG 56S	2.138	0.063	0.028	1.500	0.071	0.032	1.819	0.342	0.108
Aleksandra	1.810	0.093	0.042	1.287	0.071	0.032	1.548	0.287	0.091
Vizija	1.970	0.084	0.037	1.278	0.279	0.125	1.624	0.413	0.131
Average	2.026	0.167	0.037	1.423	0.209	0.047	1.725	0.358	0.057
Number of plants per m^2									
Perfekta	390.8	44.623	19.956	368.0	88.136	39.416	379.4	66.946	21.170
KG 56S	426.8	65.629	29.350	376.0	49.639	22.199	401.4	61.043	19.303
Aleksandra	403.6	81.761	36.564	331.2	39.233	17.545	367.4	71.492	22.608
Vizija	437.2	46.981	21.010	361.6	48.711	21.784	399.4	60.193	19.035
Average	414.6	59.602	13.327	359.2	57.273	12.807	386.9	64.154	10.144
Number of spikes per m^2									
Perfekta	522.0	46.217	20.669	460.8	18.199	8.139	491.4	46.227	14.618
KG 56S	583.6	65.106	29.116	500.8	41.415	18.521	542.2	67.458	21.332
Aleksandra	548.4	85.725	38.337	456.0	14.491	6.481	502.2	75.704	23.940
Vizija	604.0	22.935	10.257	470.4	32.354	14.469	537.2	75.213	23.785
Average	564.5	63.640	14.230	472.0	31.855	7.123	518.2	68.274	10.795

differences were established between the wheat varieties examined and grain yield (F_{exp}=3.3398). The influence of the interaction of agro-climatic conditions and genotypes has had a significant influence on grain yield and grain weight per spike, as well as on the weight of 1000 grains between the tested winter wheat varieties.

Correlation dependence between tested wheat traits

The average values of the Pearson's coefficient of correlation (*r*) of investigated winter wheat traits are shown in **Tab. 4**.

The established correlation coefficients between the yield of grain and the weight of 1000 grains, grain weight per spike and the number of plants and spikes per m^2 in both vegetation seasons as well as during the two-year research were positive, except between the yield and the weight of 1000 grains in the second year of research in which significantly negative coefficient of correlation (r=-0.480*) was established. Highly significant and weak correlation was established between grain yield and grain weight per spike (r=0.479**) and medium with number of spikes per m^2 (r=0.639*), while significant and weak correlations were established between grain yield and number (r=0.345*) of grains in the spike and number of plants per m^2 (r=0.360*).

The highest value of the positive and highly significant strong correlation, in the first year of the study, was established between the weight of 1000 grains and the grain weight per spike (r=0.754**), as well as between the number of grains in the spike and grain weight per spike (r=0.770**). The lowest value of the negative correlation in the same year of the study was established between the number of grains per spike and the number of plants per m^2 (r=-0.190). Negative, weak and statistically significant correlation in the second year of the study was determined between grain yield and 1000 grain weight (r=-0.480*). Positive and statistically highly significant correlation during the two-year investigation period was established between the grain weight per spike and the yield of grain, the weight of 1000 grains and the number of grains in the spike. Positive, weak and significant correlations were found between the number of grains in the spike and the yield (r=0.345*) and the weight of 1000 grains (r=0.372*), as well as between the number of plants per m^2 and yield (r=0.360*) and the grain weight per spike (r=0.390*) during the duration of the research. The weight of 1000 grains and the number of plants per m^2 in both vegetation seasons, as well as during the duration of the experiment, had a negative coefficient of correlation.

Correlative dependence between traits showed a large variation depending on the test years which results from the interaction between the properties within each genotype and genotype interactions with environmental factors. This suggests that the selection of genotypes with longer spike (hence higher number of grains per spike) with good resistance to biotic and abiotic stresses contributed to

Table 3. Analysis of variance of the tested parameters (ANOVA)

		Effect of year on the traits analysed		
Traits	Mean sqr Effect	Mean sqr Error	F (df 1, 38)	p-level
Grain yield, t/ha	8.50	0.584	14.5689**	0.000484
1000 grain weight, g	46.87	13.503	3.4712	0.070187
Number of grains per spike	184.90	11.532	16.0342**	0.000279
Grain weight per spike, g	3.63	.036	101.1208**	0.000000
Number of plants per m^2	30691.60	3416.316	8.9838*	0.004780
Number of spikes per m^2	85562.50	2532.395	33.7872**	0.000001
		Effect of cultivar on the traits analysed		
Traits	Mean sqr Effect	Mean sqr Error	F (df 3, 36)	p-level
Grain yield, t/ha	2.227	0.667	3.3398*	0.029847
1000 grain weight, g	17.185	14.123	1.2168	0.317626
Number of grains per spike	3.500	17.017	0.2057	0.891792
Grain weight per spike, g	0.280	0.115	2.4214	0.081864
Number of plants per m^2	2676.667	4235.600	0.6319	0.599209
Number of spikes per m^2	6370.767	4518.922	1.4098	0.25577
		Effect of the year x cultivar interaction		
Traits	Mean sqr Effect	Mean sqr Error	F (df 3, 32)	p-level
Grain yield, t/ha	2.227	0.467	4.7713**	0.007358
1000 grain weight, g	17.185	4.280	4.0147*	0.015626
Number of grains per spike	3.500	7.563	0.4628	0.710220
Grain weight per spike, g	0.280	0.015	18.5725**	0.000000
Number of plants per m^2	2676.667	3666.800	0.7300	0.541718
Number of spikes per m^2	2302.500	2194.100	1.0494	0.384167

*Statistically significant difference (P<0.05); **Statistically high significant difference (P<0.01)

Table 4. Correlation coefficients by studied environments in winter wheat

	GY	GW	NGS	GWS	NP	NS
Correlations between the traits analysed in the 2010/11						
Grain yield, GY	1.00	0.093	0.041	0.137	0.308	0.528*
1000 grain weight, GW		1.00	0.397	0.754**	-0.118	-0.094
Number of grains per spike, NGS			1.00	0.770**	-0.190	-0.190
Grain weight per spike, GWS				1.00	-0.104	-0.178
Number of plants per m^2, NP					1.00	0.675**
Number of spikes per m^2, NS						1.00
Correlations between the traits analysed in the 2011/12						
Grain yield, GY	1.00	-0.480*	0.113	0.011	0.020	0.350
1000 grain weight, GW		1.00	0.191	0.042	-0.288	-0.316
Number of grains per spike, NGS			1.00	-0.356	-0.207	-0.037
Grain weight per spike, GWS				1.00	0.155	0.276
Number of plants per m^2, NP					1.00	0.348
Number of spikes per m^2, NS						1.00
Correlations between the traits analysed in the 2010-2012						
Grain yield, GY	1.00	0.022	0.345*	0.479**	0.360*	0.639**
1000 grain weight, GW		1.00	0.372*	0.433**	-0.040	0.090
Number of grains per spike, NGS			1.00	0.475**	0.091	0.309
Grain weight per spike, GWS				1.00	0.390*	0.584**
Number of plants per m^2, NP					1.00	0.655**
Number of spikes per m^2, NS						1.00

*Statistically significant (P<0.05); **Statistically high significant (P<0.01)

**Grain yield, t/ha - GY; 1000 grain weight, g - GW; Number of grains per spike -NGS; Grain weight per spike, g - GWS; Number of plants per m^2 - NP; Number of spikes per m^2 - NS.

the increase in production and yield stability of wheat in our agroecological conditions.

Discussion

The highest average grain yield of 5.553 t/ha of studied wheat varieties was recorded in vegetation season 2010/11 and it was significantly higher than the yield in 2011/12 (4.630 t/ha), which can mostly be associated with higher precipitation during the first vegetation period. Hassan et al. (2013) and Perišić et al. (2016) have indicated similar results. After the formation of the number of spikes and the number of grains per spike during the vegetation stage, the yield becomes mainly determined by the weight of the grain (Zafaranaderi et al., 2013). The yield of wheat grain, according to many authors, depends on several components: the number of spikes per unit area, the number of grains per spike, the weight of the grains per spike and the plant, as well as the weight of 1000 grains (Hristov et al., 2008; Petrović et al., 2010; Perišić, 2016; Djuric et al., 2018). Varying of yield below 10% in exceptionally yielding years is not considered a serious problem in intensive wheat production. If these deviations are conditioned solely by the action of climatic factors (without loss during harvest or transport), using varietal agro-technology, it is possible to significantly reduce the disturbance of total grain production in one production area (Malešević et al., 2011; Jaćimović et al., 2012; Đekić et al., 2014; Jelić et al., 2015; Terzić et al., 2018).

In the production of wheat, the correct reonization (regional distribution) of varieties is very important, and it can contribute to a lesser variation in realized yields and achieving better average results (Donmez et al., 2001; Zečević et al., 2004; Dencic and Kobiljski, 2007; Dodig et al., 2008; Madić et al., 2010; Dimitrijević et al., 2011; Đekić et al., 2012, 2013). Bearing all this in mind, it is necessary that climatic conditions are in accordance with the biological requirements of the plants. In the last few years, extreme temperatures and disturbances in the amount and distribution of precipitation have significantly affected the reduction in the total production of organic matter and yield reduction (Hodson and White, 2009; Đurić et al., 2013; Hristov et al., 2013; Popović et al., 2013; Đekić et al., 2015; Jelic et al., 2015). In the continental climate, winter wheat has long been exposed to the influence of weather conditions, and hence the climate extremes. According to the forecasts of the European Commission for Agriculture, global climate change will cause significant deviations from the average values of climatic factors in the field crop areas of Serbia (Vojvodina, Mačva, Stig), which is related to the increase in winter and reduction of summer precipitation, increased risk of drought and soil erosion, and to a certain extension of the vegetation period (which would lead to an increase in yield, but with higher variability). Temperatures will increase slightly, which will impose changes in the sowing structure and a more careful selection of the variety, i.e. hybrid. According to this scenario, the biggest concern is the increase of winter precipitation (November-March), which will often cause flooding of lower terrains as well as greater possibility of soil erosion. In Serbia, there are about 30 percent of the soil with a heavier mechanical composition that is susceptible to compaction and formation of the plow pan. Frequent passing of machines and conventional tillage at low depths (due to weaker tractors) leads to the formation of a poorly permeable layer - “plow pan” at a small depth and rapid saturation of the surface layer of the soil with water. The soil acidification process has been strengthened in recent times and tackling this problem is an important issue in order to reduce the impact from natural hazards in Serbia. Decrease of the acidity in acid soils contributes to the improvement of chemical, physical and biological properties of the soil. Improvement of these soil properties contributes to better infiltration and water storage and reduction of damage and losses from natural hazards, including floods and droughts. These facts impose the need to change the system of crop fertilization and processing systems as well as land management in general. Higher air temperatures in June and July of year 2012, compared to the first year of the study, caused a shortening of the period of filling of the grain, accelerated ripening and reduction of yield. The dependence of the yield on the conditions of the year was also emphasized by other authors (Biberdžić et al., 2005; Zecevic et al., 2010; Perišić et al., 2016). A certain contribution to the continuous increase in grain yield is also interpreted by the increased use of nitrogen fertilizers, pesticide use, improved agro-technology (especially earlier sowing), as well as the positive interaction of these factors (Jelić et al., 2012; Đekić et al., 2014; Terzić et al. 2018). The best genetic predispositions for yield were found in the KG 56S and Vizija varieties, while the lowest yield in our study was recorded in the Aleksandra variety and it was significantly lower in comparison to the other varieties tested. Our results are in agreement with the results of Milovanovic et al. (2008), who, based on their research, state the variety Vizija as a variety of high genetic potential for yield with the possibility of its manifestation at different sites/locations. The differences in the yields that were observed in the tested varieties in our experiment are the result of varietal specificities, which are mostly genetically conditioned. Thus, by analysing the obtained results we can conclude that there is a significant dependence of grain quality components on the genotype, which is in agreement with the results of Laghari et al. (2011) and Perišić (2016).

The weight of 1000 grains in year 2010/11 was significantly higher compared to 2011/12 (44.21 g and 42.05 g). The highest value of the 1000 grain weight was established for the Perfekta variety, the variety with the lowest number of grains per spike, and the lowest value for the variety Vizija, which had the highest number of grains per spike. Vegetation period in year 2011/12, at the time of grain filling, was marked by drought and high temperatures. Climatic conditions are especially important during the filling of the grain, since the lack of moisture and high temperature during this period affects the decrease in the weight of 1000 grains (Przulj et al., 2014), as confirmed by the results of these studies. Perišić (2016) points to significant differences in grain weight between years, irrespective of the genotype. Jaćimovic et al. (2012) find that the application of mineral fertilizers has a significant impact on the weight of 1000 grains, i.e. the grain weight is significantly higher in more intensively fertilized variants especially fertilized with nitrogen.

The number of grains per spike is a very variable trait of the spike, because it depends on other components of the spike and factors of the external environment. The results of these investigations are in agreement with the previously performed studies by Đurić et al. (2018) and established a high variability of the number of grains per spike and grain weight per spike Djuric et al., (2018). These spike characteristics have a direct impact on the overall yield of wheat grain. The number of grains per spike is quite variable trait, which largely depends on the agroecological conditions of the year and the applied agro-technology (Zecevic et al., 2004). The number of grains per spike is a yield component that is directly dependent on the number of spikelets per spike, the number of flowers per spikelet and the success of pollination and grain formation (Borojević and Williams, 1992). Since these parameters significantly depend on the agroecological conditions of the year and the applied agro-technology, the number of grains per spike is quite variable trait. Hristov et al. (2008) point out that the increase in the yield of grain per plant is directly determined by the number of grains per spike and the weight of 1000 grains, which is confirmed by the results of our research. Milovanović et al. (2011), based on their research, suggest that better lines of triticale have 75-95 grains per spike compared to 40-50 grains in wheat. The number of grains per spike for all investigated wheat genotypes ranged from 35 to 45 grains. In the first year of the research, which was more favourable, the number of grains per spike was 42, and in the second year of the research it was 37. The highest number of grains in the spike in the vegetation year 2010/11 was recorded for the Perfekta variety (45), while in 2011/12 for the variety Aleksandra (41). The average value of the number of grains per spike of 44.80 is established by Perišić (2016). The same author states that the number of grains per spike has ranged from 38.61 to 47.76. The number of grains per spike or plant is the result of the number of spikelets and the number of flowers per spikelet, on the one hand, and the success of polination and formating of grains in these flowers, on the other hand, so that the number of grains depends to a large extent on the genetic basis of the variety, i.e. the gene with additive and non-additive effect (Perišić et al., 2011; Deletić et al., 2012; Luković et al., 2014; Đurić et al., 2018) and external factors (Dodig, 2010; Hassan et al., 2013). In the case of wheat genotypes, the increase in the number of grains in the spike was observed during the study in the case of a reduced number of spikes per m^2, which is in agreement with the results of Perišić (2016). According to Garcia del Moral et al. (2003), the yield stability under the influence of different environmental conditions is closely related to the number of grains per spike, because a large number of grains per spike allows the achievement of a large number of grains per unit area also in conditions of a smaller number of spikes. Donmez et al. (2001) find that significant genetic progress is achieved by improving the yield components formed during the vegetative phase of wheat development (the number of spikes per surface area and the number of grains per spike), compared to the grain weight, a component formed at unfavourable temperature and humidity conditions.

The number of spikes per unit area depends on the sowing density, the number of seedlings, the number of plants that managed to survive winter and the number of productive stems. The number of spikes is greatly affected by the conditions of cultivation, which is confirmed by our research. In our study, the highest number of spikes per m^2 in the period 2010-2012 was realized by the varieties KG 56S and Vizija. The highest number of spikes in the vegetation year 2010/11 was established for the varieties Vizija (604.0) and KG 56S (583.6), while in the second year of the study, KG 56S (500.8) had the highest number of spikes. Our results are in agreement with Perišić (2016), who states that the number of spikes has ranged from 544.4 to 671.1 per m^2 and that it was statistically significant among the wheat genotypes examined. Biberdžic et al. (2005) pointed out that the number of spikes/m^2, the number of grains per spike and the length of spike are important factors that influence grain yield. There are complex interactions between these indicators, as by increasing the value of one parameter, the value of another is often reduced (Hristov et al., 2008), which is confirmed by the results of our research. Also, it was noticed that in year 2010/11, due to favourable climatic conditions (at the time of emergence and tillering), in almost all genotypes, on average, statistically significantly higher number of spikes per m^2 (564.5) was achieved compared to the second year (472.0). Obviously, weather conditions (precipitation and temperature) were the least favourable in the second year of testing. It has been confirmed earlier by other authors that meteorological factors, and especially the moisture regime, can influence this property (Joshi et al., 2002; Janušauskaite and Šidlauskas, 2004; Erekul and Köhn, 2006).

In order to be able to perceive which traits have most influenced the formation of the grain yield, as well as the relationship between them, the correlation coefficients between the tested properties have been determined. The correlative dependence of the yield and the weight of the 1000 grains, depending on the investigated vegetation season in wheat, ranged from -0.480* (2011/12) to 0.093 (2010/11). Grain yield depends directly on the number of grains per spike and the weight of 1000 grains (Hristov, 2008). Knowledge of correlation relations between yield components is of practical importance in the breeding process. Correlation analysis is the most commonly used method for this purpose (Hristov et al., 2011). Since yield components directly or indirectly affect the yield, it is necessary to determine their correlation relations. These authors have established a highly significant correlation between the height of the plant and the length of the spike, the number of grains/ spike, the weight of the 1000 grains and the grain weight per plant, the highly significant correlation between the harvest index and plant height and the length of the spike. The weight of the grains per spike was in significant correlation with the yield ($r=0.479^{**}$), the weight of 1000 grains ($r=0.433^{**}$) and the number of grains in the spike ($r=0.475^{**}$). Many researchers are of the opinion that an increase in the number of grains per spike leads to an increase in the yield of wheat (Zafarnaderi et al., 2013; Đurić et al., 2016). Many authors consider the number of grains per spike the most important component of the yield. In wheat, the coefficient of correlation showed values from non-significantly positive in 2010/11 (r=0.041) to significantly positive in the two-year investigation period ($r=0.345^{*}$). Many authors cite weak positive (Mohammadi et al., 2013) to very positive correlations (Djuric et al., 2018). According to the majority of researchers, the number of spikes per unit area is in significant positive correlation with the yield of grain (Zecevic et al., 2004). Iftikhar et al. (2012) find that the number of grains per spike and mass of 1000 grains are in a positive and statistically significant correlation with grain yield and point out that the number of grains per spike and weight of 1000 grains have a direct effect on yield and, therefore, can be used as direct selection criteria.

New varieties are characterized by a higher number of spikes per unit area, but their relationship to yield is not always in a positive correlation (Deletić et al., 2012). The same authors point out that in the determination of yield, the weight of the grain has the crucial role, and then the number of spikes and the number of grains per spike. Perišić (2016) states that a higher number of productive trees cannot guarantee high yields. There are complex interdependent relations between all components of yield. The importance of these components in the formation of grain yield depends on the climatic conditions in critical phases of growth and development, applied agro-technology and various combinations and relationships of NPK nutrients (Popović et al., 2013; Đekić et al., 2014; Jelić et al., 2014; Terzic et al., 2018). Therefore, it is important to know the effect of these properties, i.e. yield components, as well as their interdependence on grain yield. It should be noted that the grain weight per plant or the yield per plant is a direct indicator of total yield, as well as all components of spikes that are in significant positive correlation with this parameter (Hristov et al., 2008; Đekić et al., 2013). The presence of phenotypic and genotypic correlations between fertility components and fertility itself were studied by Kashif and Khaliq (2004). They find that at the genotypic level there is a significant positive correlation of the height of the plant, the length of the spike, the number of spikelets per spike, the number of grains per spike, and the weight of 1000 grains with grain yield, while phenotypically there is a very significant association of these properties. Due to this association of quantitative properties, it is necessary to select genotypes with a genetic basis in which a balance is achieved between the most important components (number of spikes per unit area, number of grains per spike and grain weight per spike).

Conclusion

In the highest yield of grain, weight of 1000 grains, number of grains per spike, grain weight per spike and number of spikes per m^2 in all wheat varieties were in the vegetation period with moderate temperatures at the time of grain filling and large amount of precipitation in the first vegetation period. Grain yields in wheat cultivars ranged from 4.628 t/ha (Aleksandra) to 5.511 t/ha (KG 56S). The average weight of 1000 grains in the study was 43.13 g, with a variation of 42.05 g in the vegetation year 2011/12 to 44.21 g in the vegetation year 2010/11. The number of grains per spike for all examined wheat genotypes varied from 35 to 45 grains.

The coefficient of correlation between grain yield and grain weight per spike, number of grains per spike and number of plants per m^2 showed significant positive values over the examined period, while the coefficient between 1000 grain weight and number of grains per spike and grain weight per spike had significant positive values. Also, there were significant positive coefficients of correlation between the grain weight per spike with the number of grains per spike and the number of plants per m^2.

Based on the results of the research it can be concluded that a greater number of traits have a decisive role in the formation of grain yield. The contribution of each individual trait may be different in various genotypes and in various environmental conditions so that the correlation between two quantitative traits is not fixed. This suggests that the selection of genotypes with longer spike with good resistance to biotic and abiotic stresses contributed to the increase in production and yield stability of wheat.

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