BIOLOGICA NYSSANA
13 (2) December 2022: 129-139
DOI: 10.5281/zenodo.7437258

Genetic potential of Novi Sad winter wheat varieties on smonica-type soil

Original Article

Dragan Terzić
Faculty of Agriculture, University of Niš, Kosančićeva 4, 37000 Kruševac, Republic of Serbia

Vera Rajičić
Faculty of Agriculture, University of Niš, Kosančićeva 4, 37000 Kruševac, Republic of Serbia
verarajicic@yahoo.com (corresponding author)

Milan Biberdžić
Faculty of Agriculture, University of Priština-Kosovska Mitrovica, Kopaonička bb, 38228 Lešak, Serbia

Vesna Perišić
Faculty of Agriculture, University of Niš, Kosančićeva 4, 37000 Kruševac, Republic of Serbia

Marijana Dugalić
Faculty of Agriculture, University of Niš, Kosančićeva 4, 37000 Kruševac, Republic of Serbia

Dragoslav Đokić
Faculty of Agriculture, University of Niš, Kosančićeva 4, 37000 Kruševac, Republic of Serbia

Snežana Branković
University of Kragujevac, Faculty of Science, Department of Biology and Ecology, Radoja Domanovića 12, Kragujevac, Republic of Serbia

Abstract:

The field experiment with the wheat varieties Simonida, NS 40 S, Zvezdana, NS Ilina, NS Futura, NS Mila and NS Obala was set up on the smonica-type soil during the 2016/17 and 2017/18 growing seasons. The aim of the research was to analyse the yield, weight of 1000 grains and hectolitre weight of seven Novi Sad wheat varieties grown on slightly acidic soil. The highest values of the observed properties were established in the 2017/18 vegetation year with moderate temperatures and a higher amount of precipitation. Varieties NS Futura, NS Obala and NS 40 S had the highest grain yield during the two-year study. The Simonida variety was characterized by the highest hectolitre weight. The highest values of hectolitre weight were found in the Zvezdana variety in both study years. The analysis of variance established a highly significant influence of the interaction of agro climatic conditions and genotype on the weight of 1000 grains and the hectolitre weight of the tested varieties of winter wheat.

Key words:
grain yield, hectolitre weight, variety, wheat

Apstrakt:

Genetski potencijal novosadskih sorti ozime pšenice na zemljištu tipa smonice

Poljski ogled sa sortama pšenice Simonida, NS 40 S, Zvezdana, Ilina, Futura, Mila i Obala postavljen je na zemljištu tipa smonica tokom vegetacionih sezona 2016/17 i 2017/18 godine. Cilj istraživanja je bio da se kod sedam novosadskih sorti pšenice gajene na slabo kiselom zemljištu analizira prinos, masa 1000 zrna i hektolitarska masa. Najveće vrednosti ispitivanih osobina ustanovljene su u godini sa umerenim temperaturama i većom količinom padavina u vegetacionoj 2017/18 godini. Sorte NS Futura, NS Obala i NS 40 S imale su najveći prinos zrna tokom dvogodišnjeg istraživanja. Sorta Simonida odlikovala se najvećom hektolitarskom masom. Najveće vrednosti hektolitarske mase ustanovljene su kod sorte Zvezdana u obe ispitivane godine. Analizom varijanse ustanovljen je visoko značajan uticaj interakcije agroklimatskih uslova i genotipa na masu 1000 zrna i hektolitarsku masu kod ispitivanih sorti ozime pšenice.

Ključne reči:
hektolitarska masa, prinos zrna, pšenica, sorta

Received: *September 01, 2022*
Revised: *October 27, 2022*
Accepted: *November 04, 2022*

Introduction

Winter wheat (*Triticum aestivum* L.) is one of the most important agricultural crops in Serbia. According to FAO data, in year 2017 in the Republic of Serbia, wheat was harvested from 556,115 hectares with an average yield of 4.092 t/ha, while in 2018 it was harvested from 643,083 hectares with an average yield of 4.574 t/ha. Statistical data show that in the past two-year period, wheat in the world has been grown on over 216,120,193 hectares with an average yield of 3,480 t/ha, while in the Republic of Serbia in the same period, the area under wheat has amounted to 599,599 ha with an average yield of 4,333 t/ha (FAO, 2021).

The 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 largely depends on external environmental factors. The average grain yields of winter wheat in our country and the fertility potential of cultivated varieties differ significantly, especially in the mountainous regions of Serbia (Jelić et al., 2015, 2016; Jevtić & Đekić, 2018). The yield and yield components of

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winter wheat vary significantly depending on the cultivation system, applied nitrogen doses, variety and conditions present during growing season, as well as their complex interactions (Đekić et al., 2012; Tmušić et al., 2021; Rajičić et al., 2021). In addition to the genotype, the grain yield of winter wheat is greatly influenced by the fertilization system, as one of the key factors that affects the formed yield and its quality, but it should be harmonized with climatic and soil conditions, as well as the requirements of the variety (Đekić et al., 2014; Terzić et al., 2018; Rajičić et al., 2019; Biberdžić et al., 2020b; Đurić et al., 2020; Luković et al., 2020).

In the production of wheat, proper zoning of varieties is very important, and it can contribute to less variation in realized yields and achieving better average results (Đurić et al., 2018; Terzić et al., 2018; Rajičić et al., 2020; Grčak et al., 2020). With all that in mind, it is necessary that the 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 influenced the reduction of the total production of organic matter and the reduction of yields (Đurić et al., 2016; Luković et al., 2017; Grčak et al., 2018; Đekić et al., 2019; Popović et al., 2020; Biberdžić et al., 2021b).

The aim of the study was to analyse grain yield and some yield traits and examine the influence of varieties and ecological and environmental factors on the differences in stability and adaptability of the tested winter wheat genotypes. During two growing seasons, in field trials, seven winter wheat genotypes were examined in order to determine the selection of better varieties for production conditions in Western Serbia.

Materials and Methods

Materials and field trials

The trial was carried out on the experimental field of the Secondary Agricultural School with the student home "Ljubo Mićić" in Požega (43°50´41´´N latitude, 20°02´11´´E longitude, 310 m above sea level), town and municipality in the Zlatibor district of Western Serbia. During two growing seasons (2016/17 and 2017/18), in conditions of dry crop production, tests were carried out with the aim to analyse the yield and quality of winter wheat grains and determine and choose better varieties for production conditions in Western Serbia.

The experiment was set up according to the random block system in four repetitions, with the size of the elementary plot 100 m^2 (10 x 10 m). The soil on which the experiment was set up was the smonica-type soil. The main crop (preceding crop) in both years was corn. Sowing was done with a small mechanical seeder in both years in the middle of the third decade of October, at an inter-row distance of 12.5 cm and 3 cm in a row. The amount of seeds per square meter was 400-450 germinated seeds, depending on the characteristics of the variety. The total amount of fertilizer 300 kg/ha NPK 15:15:15, where one third of nitrogen was distributed by hand on the ploughing surface before the pre-sowing soil preparation. At the beginning of intensive plant growth, in the 2-3 leaf phase, at the beginning of March, 200 kg/ha of KAN (CAN-calcium-ammonium-nitrate, 27% N) was applied.

Wheat varieties Simonida, NS 40 S, Zvezdana, NS Ilina, NS Futura, NS Mila and NS Obala of the Institute of Field and Vegetable Crops, Novi Sad, were selected as material for the trial. The following properties were analysed: grain yield (t/ha), weight of 1000 grains (g) and hectolitre weight (kg/hl). At the stage of full maturity, a sample of 30 plants from five plots was taken to determine the weight of 1000 grains. After harvesting, the grain yield from each plot was measured and converted to yield in t/ha based on 14% grain moisture, after which a sample was taken for analysis of the hectolitre weight of wheat.

Soil conditions

The trial was carried out on the experimental field of the Secondary Agricultural School with the student home "Ljubo Mićić" in Požega, on a plot of smonica-type soil. The soil on which the research was carried out has unfavourable physical properties, poor water-air regime with frequent water deficiency. The soil is slightly acidic (pH<6.5), compact, with a high content of silt and clay particles and slow percolation of water. The soil is well supplied with humus (3.1%) and has good microbiological activity, due to the introduction of manure. It is characterized by a low content of available phosphorus (10.7 mg/100 g of soil) and an optimal content of potassium (20 mg/100 g of soil).

Meteorological conditions

The Požega area is characterized by a moderately continental climate, with an uneven monthly distribution of precipitation. The latitude of the meteorological station in Požega is 43°50´41´´N, the longitude is 20°02´11´´E, and the altitude is 310 m above sea level. On the basis of the data provided by the meteorological station, the years in which the surveys were conducted differed from the multi-annual average for the given area. The average air temperature in 2016/17 was lower by 0.33 ºC, while in 2017/18 it was higher by 0.91 ºC compared to the multi-annual average (**Tab. 1**).

The data presented in **Tab. 1** for the studied vegetation period (2016-2018) clearly indicate that the years in which the tests were performed differed in terms of meteorological conditions from the multi-annual average characteristic of this area. The total amount of precipitation during the trial was below the multi-annual average in the 2016/17 vegetation season, with a rather uneven distribution by month (501.1 mm), while in the same period during the second vegetation season years 2017/18, the amount of precipitation was higher and amounted to 605.9 mm, with an even monthly distribution (**Tab. 1**). Weather conditions in the growing season in 2016 and 2017 were marked by a high amount of precipitation in October, while in May 2016 and 2017 there was less precipitation compared to the multi-annual average. May 2017 and 2018 and June 2017 were characterized by changeable and moderately warm weather with less precipitation than average.

The vegetation period 2016/17 was rainy, especially from the beginning of heading until harvest (May–June). In the same year, precipitation was lower than the multi-annual average from December to March. During the tillering period, which took place during March, the applied amounts of nitrogen fertilizers in the soil were not sufficiently used due to insufficient moisture, as the nitrogen fertilizer did not change into easily accessible forms for the plant and was not used by the plants. Nitrogen, due to insufficient moisture, did not play the role of yield builder, which resulted in a decrease in yield in year 2017. In April, precipitation was above the multi-annual average. The total amount of precipitation was 39.4 mm less than the multi-annual average (**Tab. 1**).

Conditions for germination and initial growth of plants in the first year (2017/18) were significantly more favourable. The period from November to February was favourable for germination, sprouting and tillering of wheat. The continuation of tillering and the beginning of stem elongation during the month of March was with a slightly higher amount of precipitation compared to the multi-annual average. In the month of March, the precipitation was above the multi-annual average, which had a favourable effect on the period of fertilization and filling of grains (**Tab. 1**). Changeable and moderately warm weather with more precipitation than average marked June 2018. In the growing season 2017/18, the sum of precipitation was higher than the multi-annual average by 65.4 mm. Based on the fact that the amount of precipitation and temperature in the period March–June are very important for the development of wheat, the second year can be characterized as more favourable in terms of the distribution and amount of precipitation.

Temperature variations on average were greater in the first compared to the second growing season. Vegetation period of wheat during testing in 2017/18 mostly took place in conditions of higher temperatures compared to the multi-annual average (**Tab. 1**). Relatively warm weather during the entire vegetation period with a relatively sufficient amount of precipitation enabled intensive germination, sprouting/shooting and normal development of all phases of winter wheat plant development. In the final stages of growth and development, during the month of June, high temperatures contributed to the early drying of leaves and accelerated ripening.

Statistical analysis

Experimental data were analysed by descriptive and analytical statistics using the statistics module Analyst Program GenStat (2013) for PC/Windows 7. The usual variational statistical indicator was calculated, average value (x), as well as standard deviation (S) and standard error (Sx). Evaluation of significance was made on the basis of the ANOVA test at 5% and 1% significance levels. Relative

Table 1. Mean monthly air temperatures and precipitations in Požega, Serbia

	Months									
Interval	X	XI	XII	I	II	III	IV	V	VI	Average
Mean monthly air temperature (^{o}C)										
2016/17	9.7	4.6	-1.5	-6.6	2.9	8.3	9.4	15.3	20.4	6.94
2017/18	10.1	4.5	2.1	0.4	0.8	4.4	14.5	17.5	19.3	8.18
Average	10.4	4.9	-0.1	-1.3	1.0	5.7	10.6	15.2	19.0	7.27
The amount of precipitation (mm)										
2016/17	81.0	85.9	9.1	20.6	30.9	35.9	76.7	76.8	84.2	501.1
2017/18	108.1	29.8	68.9	48.5	76.7	109.6	20.4	48.5	95.4	605.9
Average	60.6	54.3	54.3	41.1	46.1	52.7	60.1	82.2	89.1	540.5

dependence was defined through correlation analysis (Pearson's coefficient), and the values of coefficient that were obtained were tested at the 5% and 1% levels of significance.

Results

Grain yield and yield components

The average values of the yield, weight of 1000 grains and hectolitre weight of the tested wheat varieties of the Institute of Field and Vegetable crops from Novi Sad are shown in **Tab. 2**.

Grain yield: In regard to grain yield, differences were observed between the tested varieties. The average yield of wheat for all tested genotypes in the experiment was 5.188 t/ha. The higher average grain yield of 5.585 t/ha of the tested wheat varieties was achieved in the 2017/18 growing season and was higher by 793 kg/ha compared to the yield in vegetation season 2016/17 (4.792 t/ha), which can mainly be related to the adequate distribution of precipitation during the second vegetation period (**Tab. 2**). The highest grain yield in the 2016/17 vegetation season was realized with the NS Futura variety (5.175 t/ha), but a good yield was also achieved with the NS Obala variety (5.025 t/ha). In the second study year, the NS Futura variety had the highest average grain yield (6.087 t/ha), but a good yield was also achieved with the NS Obala (5.802 t/ha) and NS 40 S (5.697 t/ha) varieties. The variety NS Fu-

Table 2. Average values of investigated winter wheat varieties traits (**x**-average value, **S**-standard deviation and **Sx**-standard error)

Varieties	2016/17			2017/18			Average		
	x	S	Sx	x	S	Sx	x	S	Sx
				Yield, t/ha					
Simonida	4.253	0.251	0.126	5.447	0.329	0.165	4.850	0.693	0.245
NS 40 S	4.876	0.517	0.259	5.697	0.517	0.259	5.286	0.650	0.230
Zvezdana	4.523	0.468	0.234	5.556	0.444	0.222	5.040	0.695	0.246
NS Ilina	4.892	0.450	0.225	5.326	0.540	0.270	5.109	0.515	0.182
NS Futura	5.175	0.192	0.096	6.087	0.580	0.290	5.631	0.631	0.223
NS Mila	4.799	0.502	0.251	5.178	0.319	0.160	4.989	0.439	0.155
NS Obala	5.025	0.126	0.063	5.802	0.580	0.290	5.414	0.569	0.201
Average	4.792	0.451	0.085	5.585	0.516	0.097	5.188	0.625	0.083
				1000 grain weight, g					
Simonida	43.45	1.072	0.536	50.73	0.348	0.174	47.09	3.965	1.402
NS 40 S	42.72	0.644	0.322	44.96	1.173	0.586	43.84	1.485	0.525
Zvezdana	41.03	1.757	0.879	43.52	1.683	0.841	42.28	2.076	0.734
NS Ilina	36.72	0.769	0.384	43.22	1.408	0.704	39.97	3.632	1.284
NS Futura	42.54	0.853	0.426	44.36	0.844	0.422	43.45	1.251	0.442
NS Mila	42.03	0.755	0.378	41.44	0.779	0.390	41.73	0.778	0.275
NS Obala	41.64	1.134	0.567	44.77	0.505	0.253	43.20	1.860	0.658
Average	41.44	2.296	0.434	44.71	2.899	0.548	43.08	3.072	0.410
				Hectolitre weight, kg/hl					
Simonida	75.05	0.816	0.408	77.00	0.252	0.126	76.03	1.183	0.418
NS 40 S	74.50	0.443	0.222	78.16	0.278	0.139	76.33	1.987	0.703
Zvezdana	77.35	0.476	0.238	79.00	0.503	0.252	78.18	0.992	0.351
NS Ilina	71.90	2.253	1.127	78.18	0.708	0.354	75.04	3.693	1.306
NS Futura	74.60	0.755	0.378	77.55	0.258	0.129	76.08	1.661	0.587
NS Mila	70.90	1.969	0.984	76.70	1.112	0.556	73.80	3.435	1.215
NS Obala	73.65	0.231	0.115	73.80	0.252	0.126	73.73	0.237	0.084
Average	73.99	2.280	0.431	77.20	1.668	0.315	75.60	2.556	0.341

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

Effect of year on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F (1.54)	p-level
Grain yield (t/ha)	8.801	0.234	37.524	0.000**
1000 grain weight (g)	149.635	6.839	21.879	0.000**
Hectolitre weight (kg/hl)	143.840	3.990	36.052	0.000**
Effect of genotype on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F (6.49)	p-level
Grain yield (t/ha)	0.585	0.366	1.597	0.168 ns
1000 grain weight (g)	38.595	5.865	6.581	0.000**
Hectolitre weight (kg/hl)	19.525	4.942	3.951	0.003**
Effect of the year x genotype interaction				
Traits	Mean sqr Effect	Mean sqr Error	F (6.42)	p-level
Grain yield (t/ha)	0.178	0.192	0.924	0.488 ns
1000 grain weight (g)	15.101	1.122	13.456	0.000**
Hectolitre weight (kg/hl)	9.920	0.923	10.742	0.000**

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

tura had the highest average grain yield during the two-year study (5.631 t/ha), and varieties Simonida (4.850 t/ha) and NS Mila (4.989 t/ha) the lowest.

1000 grain weight: The grain of the tested wheat varieties had good physical properties, especially the 1000 grain weight. The weight of 1000 grains in 2017/18 was significantly higher than in 2016/17 (**Tab. 2**). The vegetation period in year 2017, at the time of grain filling, was marked by drought and high temperatures, which affected the reduction of 1000 grain weight. The highest 1000 grain weight during the two-year research period was recorded for the Simonida variety (47.09 g), and the lowest for the NS Ilina variety (39.97 g). The Simonida variety had the highest 1000 grain weight in the 2017 vegetation year (43.45 g), and the NS Ilina variety had the lowest (36.72 g). In the second year of research, the Simonida variety had the highest 1000 grain weight (50.73 g), and the lowest was recorded for the NS Mila variety (41.44 g).

Test weight: Hectolitre weight is an indicator of grain quality, especially its monetary value. The obtained data on the hectolitre weight, regardless of the year, showed that there was a significant difference between the genotypes, with the Zvezdana variety having the highest hectolitre weight (78.18 kg/hl) on average for the trial years. The average value of hectolitre weight during the two-year research was 75.60 kg/hl. The higher average value of hectolitre weight was achieved in the 2017/18 growing season (77.20 kg/hl) compared to the in-vegetation season 2016/17 (73.99 kg/hl), (**Tab. 2**). In the first research year, the Zvezdana variety had the highest hectolitre weight (77.35 kg/hl), while in the second year, the highest hectolitre weight was observed for the Zvezdana variety (79.00 kg/hl) and with a slightly lower value for the varieties NS Ilina (78.18 kg/hl) and NS 40 S (78.16 kg/hl).

Analysis of variance between observed traits of wheat

The analysis of yield variance, weight of 1000 grains and hectolitre weight of the tested winter wheat varieties from Novi Sad during two vegetation seasons are shown in **Tab. 3**.

The influence of year and variety and their interactions on the tested properties of winter wheat are shown in **Tab 3**. Based on the analysis of variance, it can be concluded that the interaction of variety and year in tested wheat varieties did not significantly affect the grain yield, while it had a very significant effect on 1000 grain weight (F_{exp}=13.456**) and hectolitre weight (F_{exp}=10.742**) in tested varieties of winter wheat.

The influence of year on the yield, 1000 grain weight and hectolitre weight of tested winter wheat varieties was highly significant. No significant influence of the variety on grain yield was found, among the tested wheat genotypes, while highly significant differences were found in the weight of 1000 grains and hectolitre weight.

Correlation dependence between tested wheat traits

The average values of Pearson's correlation coef-

Table 4. Correlation coefficients by studied environments in winter wheat

	Grain yield, GY	1000 grain weight, GW	Hectolitre weight, HW
Correlations between the traits analysed in the 2016/17			
Grain yield, GY	1.00	-0.037	-0.232
1000 grain weight, GW			0.295
Hectolitre weight, HW			1.00
Correlations between the traits analysed in the 2017/18			
Grain yield, GY	1.00	0.045	-0.129
1000 grain weight, GW			-0.066
Hectolitre weight, HW			1.00
Correlations between the traits analysed in the 2016-2018			
Grain yield, GY	1.00	0.351**	0.297*
1000 grain weight, GW			0.416**
Hectolitre weight, HW			1.00

*Statistically significant ($p<0.05$); **Statistically high significant ($p<0.01$)

ficient (r) of the tested traits of winter wheat are shown in **Tab. 4**.

Correlations between grain yield and hectolitre weight of the tested genotypes of winter wheat at the Požega location show a negative value in both investigated vegetation seasons. Correlations between grain yield and 1000 grain weight show a negative value in the first year of research (2016/17), while correlations between 1000 grain weight and hectolitre weight show a negative value in the vegetation year 2017/18.

Correlations between grain yield and 1000 grain weight and between the 1000 grain weight and hectolitre weight of winter wheat genotypes tested at the Požega location during the two-year study show a positive and highly significant value. Correlations between grain yield and hectolitreweight, during the two-year study, show a positive and significant value.

Discussion

Adverse weather conditions such as frost and temperature stress, and short periods with high temperatures, have a strong negative impact on plant production and represent a great risk (Rajičić et al., 2020; Biberdžić et al., 2021a; Ljubičić et al., 2021). According to Lalić et al. (2014), the negative impact of high temperatures on winter wheat is reflected in a reduced number of grains, an increase in the intensity of grain filling (up to a certain limit), as well as a shortening of the duration of the filling period, which results in a decrease in yield when temperatures exceed the critical level above 35 °C. In numerous studies, soil drying or shortening of phenophases during the growing season are reported as the cause of winter wheat yield reduction with increasing temperatures (Mohamed et al., 2013). In their research, Ottman et al. (2012), report that wheat yield decreased by 6.9% with each degree increase in temperature during the season when it exceeded 16.3 °C. A 2.5 °C increase in night-time temperatures in northern China resulted in a 27% drop in wheat yields (Fang et al., 2010).

The significant deviation of precipitation and temperature from the multi-annual average is becoming more pronounced (Dimitrijević et al., 2011; Jocković et al., 2014). It has been established that the newly created high-yielding varieties of wheat react less to temperature deviations (except for extremes), compared to precipitation (Milovanović et al., 2012; Đekić et al., 2015, 2017). Namely, the total amount of precipitation is maintained at the multi-annual average, but the distribution, especially in critical stages of development, is significantly disturbed (Đekić et al., 2013; Zafaranaderi et al., 2013). It has been established that winter precipitation significantly affects the realization of the production potential of wheat (Laghari et al., 2011; Luković et al., 2016). In addition to the necessary reserve for the spring part of the vegetation, winter precipitation greatly affects the distribution of easily accessible nitrogen in the soil (Biberdžić et al., 2014; Terzić et al., 2018; Rajičić et al., 2019).

The variety, as an autonomous genetic, biological, and agronomic entity, is one of the decisive factors on both the quantitative and qualitative level of production (Đurić et al., 2020). The increase in wheat yield primarily depends on the cultivated variety, climatic conditions and applied cultivation technology (Jelić et al., 2015; Đekić et al., 2018). The introduction into production of varieties with increased genetic potential for yield and improved agronomic and technological properties represents the contribution of breeding to achieving higher production per unit area (Perišić et al., 2016; Branković et al., 2018; Đurić et al., 2018). The genetic potential for yield can be increased in different ways: better use of genetic variability, better use of solar energy, increasing the number and weight of grains, increasing the total biomass of the plant, using heterosis, i.e., wheat hybrid (Đurić et al., 2016).

Grain yield: Grain yield is a complex property because it depends on several factors, primarily: genotype, external environment, and their interaction. A high and stable yield, first of all, must be economically justified, which can be achieved, by respecting varietal agrotechnics and with favourable agro climatic conditions.

The results of our two-year study show that the grain yield of the tested wheat varieties was 5.188 t/ha (**Tab. 2**). The 2018 production year had a higher average grain yield compared to the 2017 production year, which was mostly contributed by favorable weather conditions. The yield of winter wheat in 2018 was 5.585 t/ha and varied in the range from 5.178 t/ha to 6.087 t/ha. The lower quality and quantity of the yield in the 2017 production year was influenced by unfavourable temperature conditions and uneven distribution of precipitation in periods of the year that coincided with the sensitive stages of wheat development, which affected the yield, which was 4.792 t/ha (**Tab. 2**). Temperature, precipitation, and sufficient amount of water in the soil are the three most important reasons for yield instability in our area. In the ecological conditions of Serbia, high temperatures and water deficit during the May-June period led to a reduction in yield and a deterioration in the technological properties of grain, which is why by extending the total vegetation period the period of grain filling for the purpose of yield increase cannot be extended.

Živanović et al. (2017), show slightly lower wheat yields on vertisol-type land in Šumadija (from 4.31 t/ha to 4.44 t/ha), obtained during year 2017. Đurić et al. (2013), state that the yields in the trial were very high and ranged from 8.00 t/ha of grain in case of the variety Esperia to 9.60 t/ha in Pobeda and Talas varieties. However, in the first three varieties Talas, Victory and NS 40 S, difference in yield was about 400 kg and that is negligible considering the total yield. Hristov et al. (2013) state that in a three-year period, all varieties, except Pobeda, achieved a higher yield at a higher density. The lower yield of the Pobeda variety was primarily the result of long-standing water on the plot. Also, with the exception of the problematic year 2010, varieties Pobeda (10.76 t/ha) and Renesansa (11.05 t/ha) achieved higher yields in 2011, indicating that in order to make correct conclusions, it is necessary to analyse a larger number of localities over a longer period of time. Đekić et al. (2013), examined five winter wheat varieties (Takovčanka, KG 100, KG 56S, Ana Morava and Lazarica). The average grain yield of the tested wheat varieties ranged from 3.011 t/ha to 3.774 t/ha. In regard to the physical characteristics of the grain, the Ana Morava variety achieved the highest average yield in both growing seasons (4.499 t/ha and 3.049 t/ha). Terzić et al. (2018) point out that the average yield of wheat in the trial was 5.091 t/ha, ranging from 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 2010/11 vegetation year was established with the Vizija variety (6.127 t/ha), but a good yield was also achieved with the KG 56S variety (5.863 t/ha). In the second year of research, the variety KG 56S had the highest average grain yield (5.159 t/ha). The highest average grain yield in the two-year period was observed for the varieties KG 56S (5.511 t/ha) and Vizija (5.485 t/ha), and the lowest for the variety Aleksandra (4.628 t/ha). Đurić et al. (2016) point out that the PKB Vizantija variety achieved an average grain yield of 8.356 t/ha. Rajičić et al. (2021) have found that the highest winter wheat yield of 4.673 t/ha was obtained with the Renesansa variety. Analysis of variance showed a very significant influence of vegetation on wheat yield.

1000 grain weight: The 1000 grain weight is a direct component of yield and at the same time an important indicator of grain quality. It represents a highly variable property which depends to a high degree on the conditions of the external environment. Numerous authors (Milovanović et al., 2011; Đekić et al., 2012; Đurić et al., 2013) have pointed out that the 1000 grain weight is a varietal characteristic and that there is a significantly greater variation between different genotypes than between applied treatments or external environmental factors.

During the two-year trial, the grain of the tested wheat varieties was characterized by good physical properties, especially the 1000 grain weight. The 1000 grain weight during the two-year research period was 43.08 g, ranging from 39.97 g to 47.09 g. The obtained values are close to the values obtained by Jevtić and Đekić (2018) and Terzić et al. (2018), and slightly higher than the results obtained by Biberdžić et al. (2020a). Đurić et al. (2013) state that the weight of 1000 grains ranged from 38.80

g in the variety NS 40 S to 46.50 g in the variety Pobeda. Đekić et al. (2013) point out that the average value of the 1000 grain weight in the tested wheat varieties ranged from 36.23 to 42.70 g. Examining different variants of fertilization in the wheat variety Takovčanka, Đekić et al. (2014) have found that the weight of 1000 grains was the highest with balanced fertilization with all three nutrients in the variant $N_{80}P_{60}K_{60}$ (44.46 g) and variant $N_{80}P_{100}K_{60}$ (43.38 g). Đekić et al. (2015a), point out that in the first year of research, the Vizija variety had the highest weight of 1000 grains (42.65 g), while the Kruna variety had a slightly lower value (41.63 g). In the second year of research, the weight of 1000 grains of the Vizija variety was by 1.036 g higher than the Kruna variety. Đekić et al. (2015b), have examined six winter wheat varieties from Kragujevac, with the aim of determining and choosing the best varieties for Serbia's production conditions. Based on a two-year study, they concluded that the highest two-year average value of the weight of 1000 grains was observed in the variety Planeta (44.22 g), while the lowest was reported for the variety Vizija (37.53 g). The results of the research by Jelic et al. (2015), show that the highest 1000 grain weight of 47.06 g was achieved with the complete application of mineral NPK, lime and manure with a higher dose of $CaCO_3$ of 5 t/ha and phosphorus of 100 kg/ha P_2O_5. Terzić et al. (2018) point out that the average weight of 1000 grains was 43.13 g, ranging from 42.05 g to 44.21 g. In the study of five varieties of wheat (Kruna, Renesansa, Pobeda, NS 40 S and Takovčanka) during two growing seasons in the agro ecological conditions of western Serbia, Rajičić et al. (2021) have found that the highest weight of 1000 grains was obtained in case of the variety Renesansa (43.72 g). By analysis of variance, the same authors have found a highly significant influence of genotype on the weight of 1000 grains.

Hectolitre weight: Hectolitre weight is a complex quantitative trait that is determined by the action of a large number of genes under the strong influence of the external environment (Đurić et al., 2013). The average value of hectolitre weight during the two-year research was 75.60 kg/hl, ranging from 73.73 kg/hl to 78.18 kg/hl. The highest value of hectolitre weight in both examined years was achieved by the variety Zvezdana (77.35 kg/hl and 79.00 kg/hl). The obtained hectolitre weight values were slightly higher than the values obtained by Jelic et al. (2015), Jevtić and Đekić (2018) and Biberdžić et al. (2020a), and lower than the results obtained by Đurić et al. (2013). It is generally considered that grain with a higher hectolitre weight is of better quality compared to that with lower values (Đurić et al., 2013; Đekić et al., 2015b; Rajičić et al., 2021).

Đurić et al. (2013) state that the obtained hectolitre weight values are relatively high, which indicates a good marketable quality, ranging from 78.9 kg/hl for the NS 40 S variety to 84.4 kg/hl for the Merkur variety. Đekić et al. (2014) have found the highest value of hectolitre weight in the variant with individual fertilization with 60 kg/ha of phosphorus (71.57 kg/hl) and in the variant that was fertilized with 80 kg/ha of nitrogen, 60 kg/ha of phosphorus and 60 kg/ha of potassium (71.49 kg/hl). By evaluating the significance, they have found statistically very significant differences for the hectolitre weight between the tested fertilization variants. Đekić et al. (2015b) by using the analysis of variance, have established highly significant differences for the hectolitre weight values between the tested wheat varieties. According to the results of Jelić et al. (2015), observed by fertilization variants, the highest hectolitre weight of grain was recorded for variant F5 (70.91 kg/hl), which was fertilized with 120 kg/ha N, 100 kg/ha P_2O_5, 60 kg/ha K_2O, 5.0 t/ha of $CaCO_3$ and with 20 t/ha of manure. Jevtić and Đekić (2018) point out that the hectolitre grain weight of the tested wheat varieties, during the two-year study, ranged from 69.5 to 71.03 kg/hl. Regarding the optimal wheat sowing date, Biberdžić et al. (2020a) have found that the hectolitre weight of grain was 71.42 kg/hl, while in the case of later sowing it was 69.96 kg/hl, which does not represent a statistically significant difference. Rajičić et al. (2021) have found that the highest two-year average value of hectolitre weight was observed for varieties Kruna and Pobeda (77.52 kg/hl and 77.31 kg/hl, respectively). They established a very significant influence of vegetation and genotype on the hectolitre weight of wheat.

Conclusions

Based on the obtained results, it can be concluded that the winter wheat variety NS Futura achieved the best results in terms of grain yield, while the Simonida variety had the highest of 1000 grain weight, and the variety Zvezdana had the highest hectolitre weight in the observed two-year period. The highest values for yield of wheat grains, 1000 grain weight and hectolitre weight, were observed in the 2017/18 vegetation season with moderate temperatures at the time of grain filling and a large amount of precipitation evenly distributed in the second part of the vegetation season. The grain yield of the tested wheat varieties in the two-year period ranged from 4.850 t/ha (Simonida) to 5.631 t/ha (NS Futura). The average hectolitre weight during the two-year research was 75.60 kg/hl, with 73.99 kg/hl in the 2016/17 growing season and 77.20 kg/hl in the

2017/18 vegetation season.

Grain yield showed a tendency to increase in years with higher sum of precipitation and better distribution of rainfall during critical stages of plant development. The analysis of variance established a very significant influence of the interaction of year x variety on the weight of 1000 grains and the hectolitre weight of the examined wheat varieties, while the influence of the vegetation season on all the examined traits was statistically justified.

Many traits play a decisive role in the formation of grain yield. The contribution of each individual trait can be different in different genotypes and in different environmental conditions. Based on the obtained results, it can be concluded that the sowing structure should be based on more than one variety, in order to reduce the risk of the unpredictability of each individual vegetation, regardless of the reliability of the criteria for selection of variety for sowing in a particular research year.

Acknowledgements. Ph.D. Dragan Terzić and authors sincerely thanks to the secondary agricultural school with the student dormitory "Ljubo Mićić" in Požega in Serbia, which has enabled the use and analysis of traits of the wheat. Investigations necessary for this paper are part of the Projects agreement number 451-03-09/2021-14/200383 financed by the Ministry of Education, Science and Technology Development of Republic of Serbia.

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