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GRAIN YIELD AND QUALITY OF WINTER WHEAT CULTIVARS

Vera RAJIČIĆ[1, 2*], Vesna PERIŠIĆ[1, 2], Milomirka MADIĆ[3], Vera POPOVIĆ[4], Vladimir PERIŠIĆ[1], Kristina LUKOVIĆ[1], Dragan TERZIĆ[2, 5]

[1]Small Grains Research Centre, Save Kovačevića 31, Kragujevac, Serbia
[2]University of Niš, Faculty of Agriculture, Kosančićeva 4, Kruševac, Serbia
[3]University of Kragujevac, Faculty of Agronomy Čačak, Cara Dušana 34, Čačak, Serbia
[4]Institute of Field and Vegetable Crops, Maxim Gorky St. 30, Novi Sad, Serbia
[5]Institute for forage crops, Globoder bb, Kruševac, Serbia
*corresponding author: verarajicic@yahoo.com

Abstract

The experiment was established at the experimental field of the Small Grains Research Centre in Kragujevac (Serbia) during the two growing seasons. The objective of the research was to evaluate the effect of genotype and the environment on the grain yield of winter wheat cultivars (Takovčanka, Kruna, Planeta and Vizija). The following characteristics were analysed: grain yield, 1000 grain weight and test weight. The average grain yield of all cultivars in the 2010/11 growing season was significantly greater than in the 2009/10 year, mostly as the result of highly favourable weather conditions at major stages of plant development. Takovčanka and Kruna gave significantly higher grain yields in all years compared to Planeta. Averaged across years, significantly higher values for 1.000 grain weight were found in Planeta and test weight was found in Takovčanka. Different responses of cultivars to variable agroenvironmental conditions in terms of grain yield and 1.000 grain weight and test weight require the use of a number of cultivars in the crop structure.

Keywords: *cultivars, grain yield, wheat, quality characteristics*

Introduction

Wheat productivity and grain quality in Central Serbia are governed by a range of factors, notably climate, soil, genetics and crop nutrition. Soil acidity in wheat fields in Central Serbia has become a severe problem that leads to a significant decline in grain yield and quality of wheat (Đekić *et al*., 2013, Jelic *et al*., 2015). The yield per unit area is the result of the action of factors of genotypic factors and their interaction with environmental factors. Therefore, yield is a relative term and is determined by the variety, environmental conditions and the level of applied technology. Yield is largely dependent on the genetic potential, which could be defined the yield of variety which was grown in conditions on which it had been adapted, with adequately amounts of water and nutrients and efficient control of pests, diseases, weeds and other stresses (Đekić *et al*., 2014; 2019). Yields considerably vary primarily as a result of agro-ecological conditions during the growing season (Hristov *et al*., 2011; Đekić *et al*., 2012; Jelić *et al*., 2014; Djuric *et al*., 2018; Jordanovska *et al*., 2018; Terzić *et al*., 2018b).
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 (Dodig *et al*., 2008; Luković *et al*., 2014; Jordanovska *et al*., 2018; Terzić *et al*., 2018b; Đekić *et al*., 2019). 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 (Jelic *et al*., 2015; Perišić *et al.* (2016). In the continental climate, winter wheat has long been exposed to the influence of weather conditions, and hence the climate extremes.
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. The aim of this study was to determine the cultivars and the influence of ecological environmental factors on differences in stability and adaptability of cultivars regarding the grain yield, 1.000 grain weight and test weight of tested winter wheat cultivars, for the production conditions of Serbia.

Material and methods

Meteorological conditions

Kragujevac area is characterized by a moderate continental climate, which general feature is uneven distribution of rainfall by month. Data in Table 1 for the investigated period (2009-2011) clearly indicate that the years in which the researches were conducted differed from the typical multi-year average for Kragujevac region, regarding the meteorological conditions.

Table 1 *Precipitation sum and average monthly temperature in Kragujevac, Serbia*

Months	Mean monthly air temperature (^{o}C)			The amount of rainfall (mm)		
	2009/10	2010/11	Average	2009/10	2010/11	Average
X	11.7	10.2	12.5	102.6	86.9	45.4
XI	8.8	11.4	6.9	77.5	27.9	48.9
XII	2.6	2.4	1.9	194.2	50.1	56.6
I	0.9	0.9	0.5	57.0	29.1	58.2
II	3.2	0.5	2.4	150.5	48.5	46.6
III	7.2	7.2	7.1	43.3	20.4	32.4
IV	12.1	12.0	11.6	142.2	20.8	51.9
V	16.5	15.8	16.9	116.7	65.8	57.6
VI	20.2	20.9	20.0	196.7	32.3	70.4
Average	9.24	9.03	8.87	1080.1	381.8	468.0

The average air temperature in 2009/10 was higher by 0.37°C and 2010/11 was higher by 0.16°C than the average of many years. The amount sum of rainfall precipitation in 2009/10 was higher by 612.1 mm, whereas the respective rainfall in 2010/11 was 86.2 mm lower than the average of many years and with a very uneven distribution of precipitation per months. During the April and May in 2009/10 there were 142.2 mm and 116.7 mm of rainfall, and this was 90.3 mm and 59.1 mm higher compared to the perennial average. During June in 2009/10 it was 196.7 mm of rainfall, and this was 126.3 mm higher compared to the perennial average.

The total amount of precipitation is reflected on the multi annual average, but the distribution, especially at critical stages of development, is significantly disturbed in the 2009/10 year. 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; Grčak *et al.*, 2018; Milivojević *et al.*, 2018; Terzić *et al.*, 2018a).

Experimental design and statistical analysis

During the 2009/10 and 2010/11 cropping seasons, four cultivars of winter wheat (Takovčanka, Kruna, Planeta and Vizija) grown at the experimental field of the Small Grains Research Centre in Kragujevac (Serbia) were studied.

The soil used in the trial was vertisol having a very acid reaction (pH in KCI: 3.92-4.27), the content of total nitrogen was medium (0.12-0.15%), the content of affordable phosphorus was high (26.9 mg P_2O_5/100 g soil), and the content of affordable potassium was high ranging from 19.5 to 21.0 mg of K_2O/100 g of soil. The climate of the region was characterised by variable precipitation and an uneven distribution across months. A randomised block design with three replications and the plot size was 10 m^2 (5 m x 2 m) was used. In all years, winter wheat was sown in the second half of October at a row spacing of 12.5 cm. Along with primary tillage, 400 kg/ha complex NPK (15:15:15) was incorporated into the soil, while during the spring fertilization the soil was supplemented with 300 kg/ha (KAN 27%N). During the growing season, common cultural operations were applied, without irrigation. The following traits were analysed: grain yield, 1000 grain weight and test weight. Grain yield was measured for each plot and calculated as grain yield in t/ha at 14% grain moisture. Then, a sample was taken for 1000 grain weight and test weight determination.

On the basis of achieved research results the usual variation statistical indicators were calculated: average values, standard error and standard deviation. Statistical analysis was made in the module Analyst Program SAS/STAT (SAS Institute, 2000).

Results and discussion

Table 2 shows the impact of the year, cultivar and interaction of year x cultivar on yield, 1.000-grain weight and test weight. The analysis of variance revealded a highly significant effect of year on the grain yield ($F=17.913^{**}$) and 1.000-grain weight ($F=60.540^{**}$). Based on the analysis of variance, it can be concluded that there are very significant differences in grain yield and 1.000-grain weight regarding the year of investigation, while among the investigated wheat cultivars the differences were not significant (Table 2).

Table 2 *Analysis of variance of the tested parameters*

Sources of variation	df	Mean squares		
		Grain yield, t/ha	1.000-grain weight, g	Test weight, kg/hl
Year	1	17.913^{**}	60.540^{**}	0.0002^{ns}
Cultivar	3	0.787^{ns}	0.132^{ns}	0.989^{ns}
Year x Cultivar	3	9.340^{**}	1.216^{ns}	0.440^{ns}

** F –test significant at 0.01; * F –test significant at 0.05; ^{ns} –non-significant

As the result of favourable weather conditions i.e. sufficient amounts of precipitation at major stages of plant development and moderate temperatures at the end of the growing season, the average grain yield of all cultivars was significantly higher in 2010/11. Significantly lower yields were obtained in 2009/10 (Table 3).

Table 3 *Mean values for the tested parameters at winter wheat cultivars*

		GY (t/ha)	TW (kg/hl)	1.000GW (g)
Years	2009/10	3.897^{b}	71.20^{b}	37.63^{a}
	2010/11	4.602^{a}	77.36^{a}	37.64^{a}
Cultivar	Takovčanka	4.347^{a}	75.10^{a}	36.93^{a}
	Kruna	4.480^{a}	74.02^{a}	37.50^{a}
	Planeta	4.075^{a}	73.76^{a}	38.25^{a}
	Vizija	4.095^{a}	74.23^{a}	37.87^{a}

*Means within columns followed by different lowercase letters are significantly different according to the LSD test

The average grain yield of wheat cultivars ranged from 3.897 t/ha in 2009/10 to 4.602 t/ha in 2010/11. In all years, Takovčanka and Kruna produced significantly higher grain yields compared to Planeta. The average two-year value of test weight in Takovčanka cultivars was 75.10 kg/hl. The 1.000-grain weight of winter wheat varied across cultivars, from 36.93 g in cultivar Takovčanka to 38.25 g in cultivar Planeta. Thousand grain weight and test weight were significantly greater in 2010/11 than in the previous year.

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 it can be concluded that there is a significant dependence of grain quality components on the genotype, and this is in agreement with the results of Đekić *et al*., (2014), Perišić *et al*. (2016) and Terzić *et al*. (2018b).

Table 4 *Mean values for the tested parameters at winter wheat cultivars in two vegetation seasons*

		Grain yield (t/ha)	Test weight (kg/hl)	1.000-grain weight (g)
2009/10	Takovčanka	4.273[b]	72.52[a]	36.63[a]
	Kruna	4.007[a]	71.38[a]	37.10[a]
	Planeta	3.967[a]	71.08[a]	38.57[a]
	Vizija	3.340[a]	69.82[a]	38.23[a]
2010/11	Takovčanka	4.420[bc]	77.68[a]	37.23[a]
	Kruna	4.953[a]	76.67[a]	37.90[a]
	Planeta	4.183[c]	76.44[a]	37.93[a]
	Vizija	4.850[ab]	78.64[a]	37.50[a]

*Means within columns followed by different lowercase letters are significantly different according to the LSD test

Averaged across years grain yield was higher in Kruna and Takovčanka than in the other cultivars (Table 4). In two cropping seasons the average grain yield of the wheat cultivars ranged from 4.273 t/ha to 4.420 t/ha in Takovčanka, 4.007 t/ha to 4.953 t/ha in Kruna, 3.967 t/ha to 4.183 t/ha in Planeta and 3.340 t/ha to 4.850 t/ha in Vizija. Regardless of year, Takovčanka had higher values for test weight compared to the other cultivars. The 1.000 grain weight was higher at Planeta than in the other cultivars.

Table 5 *Correlation coefficients by studied environments in wheat*

	Grain yield	Test weight	1.000 grain weight
Correlations between the traits analysed in the 2009/10			
Grain yield	1.00	0.487	-0.366
Test weight		1.00	-0.073
1.000 grain weight			1.00
Correlations between the traits analysed in the 2010/11			
Grain yield	1.00	0.127	0.179
Test weight		1.00	0.202
1.000 grain weight			1.00
Correlations between the traits analysed in the 2009/11			
Grain yield	1.00	0. 708**	-0.121
Test weight		1.00	0.001
1.000 grain weight			1.00

* $p<0.05$; ** $p<0.01$

The average values of the Pearson's coefficient of correlation (*r*) of investigated winter wheat traits are presented in Table 5. The established correlation coefficients between the grain yield and test weight in both vegetation seasons as well as during the two-year research were positive. The established correlation coefficients between the grain yield and the 1000 grains weight in both vegetation seasons as well as during the two-year research were negative, except in the second year of research in which a positive coefficient of correlation was noticed. The importance of these components in the formation of grain yield depends on the climatic conditions during the critical phases of growth and development, the applied agro-technology and the various combinations and relationships of NPK nutrients (Hristov *et al*., 2011; Đekić *et al*., 2014; Jelić *et a*l., 2014; Djuric *et al*., 2018; Terzic *et al*., 2018a). Therefore, it is important to know the effect of these properties, i.e. yield components, as well as their interdependence on grain yield.

Conclusion

Based on the results during the two-year investigation in four Kragujevac's winter wheat cultivars, it can be concluded that the grain yield of wheat ranged from 4.075 t/ha (Planeta) to 4.480 t/ha (Kruna). The highest two-year average value of test weight was found in the cultivars Takovčanka (75.10 kg/hl). Winter wheat cultivars had test weight greater than 70 kg/hl. The highest 1.000 grain weight of investigation in winter wheat Planeta cultivar (38.25 g). During 2010/11 cropping season, statistically significantly higher grain yield per area unit, as well as 1.000 grain weight was obtained, compared to the 2009/10 cropping season.

On the base of studied parameters the wheat cultivars Takovčanka and Kruna were more tolerant to adverse chemical soil characteristics (low pH) and can be recommended as a suitable genotypes for wheat production on acid soils, especially after liming of soil. Different responses of cultivars to variable agroenvironmental conditions, particularly in terms of major grain quality indicators, require the use of a number of cultivars in the crop structure.

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