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THE STABILITY PROPERTIES OF WHEAT PRODUCTION ON ACID SOIL

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Abstract

The investigation was carried out on the experimental field of Center for Small Grains, Kragujevac. This paper presents the results of winter wheat varieties (Takovčanka, KG 100, KG 56S, Ana Morava and Lazarica). Grain yield, 1000 kernel weight and test weight in grain the investigated wheat cultivars was determined in a two-year field experiment.
Average grain yield of wheat cultivars ranged from 2.151 t/ha to 4.206 t/ha. Grain yield differed significantly between years and the average of all cultivars was higher in 2006/07. compared to 2005/06. The study of physical properties of grain, cultivar KG 56S had the largest average grain yield in 2005/06th year (2.455 t/ha), while in the second year the highest yield was cultivar Ana Morava (4.206 t/ha). Average values of 1000 grain weight of wheat cultivars varied in the range from 36.26 to 42.58 g.
The difference found between the significance of the impact on the quality of grain and test weight of wheat cultivars were significant for grain yield. Analysis of the data revealed that the genotype is very significant impact on the 1000 grain weight.
Key words: 1000 grain weight, grain yield, wheat

Introduction

Winter wheat (*Triticum aestivum* L.) is one of the most important crops in Serbia, and sown on about 530,000 ha per year. The average yield of wheat last 10 years in the major production areas of Serbia ranging from 4.5 to 8.0 t/ha. For a successful and stable wheat production is necessary synergism high-yielding varieties, optimal growing conditions, application of modern agricultural practices and plant protection. Grain yield is a complex trait that depends on the genotype and the environmental conditions in which plants are grown (Đekić et al., 2010; Đurić et al., 2012, 2013; Perišić et al. 2011). Production of wheat with high grain yield and quality is appropriate only possible choice of high-quality varieties, but with the proper growing conditions and appropriate production technologies. However, wheat quality is a debatable point, which depends on whether it is viewed from the aspect of growers or users, but in any case it calls for continual improvement (Hristov et al., 2010).
Development of new genotypes, highly adapted to particular agroecological conditions, is crucial for obtaining high-quality end products (Milovanović et al., 2011). Success in breeding depends not only on the genotype but also on environmental factors. Successful wheat breeding of is based on the knowledge of characteristics of wheat genotypes, as well as their interactions with the environment (Zečević et al., 2009; Đekić at al., 2010). Understanding these relationships may serve to determine the breeding strategy, to identify favorable conditions for testing, as well as to zone the new genotypes for the different agroecological conditions.

Vegetation during the year (2005-2007) in field trials in the grounds of the Center for Small Grains, Kragujevac examined the five varieties of winter wheat, with the aim of determining the selection of the best varieties for the production requirements Serbia.

Materials and methods

Materials and field trials

During the 2005/06 and 2006/07 growing seasons, five cultivars of winter wheat were investigated, cultivated at the Center for Small Grains in Kragujevac. The cultivars Takovčanka, KG 100, KG 56S, Ana Morava and Lazarica had been investigated. Experiments have been conducted in randomized block systems, with a plot size of 10 m^2 in five replicates. The usual techniques for wheat production were applied, and it was done in the optimum sowing time in late October. 80 kg/ha N, 100 kg/ha P_2O_5 i 60 kg/ha K_2O of fertilizer NPK 8:24:16 was added in the fall on the investigated plots, while during the spring fertilization, AN (17% N) was supplemented.

The crop was harvested at full maturity. Grain yield (t/ha) was harvested and reported at 14% moisture. Two parameters of grain quality, namely test weight (kg/hl) and 1000-grain weight (g) were analyzed. Thousand grain weight was determined using an automatic seed counter. Test weight is the weight of a measured volume of grain expressed in kilograms per hectoliter.

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

Soil and weather conditions

Before the commencement of the experiment soil samples were taken from the sample surface and the chemical analysis of soil was performed. On the basis of obtained results it was revealed that the soil belongs to the vertisol soil type, with relatively high clay content, and unfavorable physical properties. The humus content in the surface layer of soil was low (2.22%), and a substitution and total hydrolytic acidity were quite high (pH H_2O=5.39, KCl=4.43). The soil was medium provided with total nitrogen (0.11-0.13% N) and easily accessible potassium (10-14 mg/100 g soil K_2O), while the available phosphorus content was low (under 10 mg/100 g of soil P_2O_5).

Table 1 *Middle monthly air temperature and precipitation amount (Kragujevac)*

Year	Months												Aver.
	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	
Mean monthly air temperature (^oC)													
2005-06	20.0	17.4	11.5	5.7	3.4	1.4	-1.7	4.7	11.6	16.5	19.3	21.7	11.0
2006-07	20.7	17.7	13.3	7.6	3.5	-1.7	1.5	5.6	12.7	16.4	19.7	23.0	11.7
Average 1961-90	21.0	16.9	11.8	5.6	1.9	0.6	2.0	6.2	11.2	16.2	19.4	21.3	11.2
The amount of rainfall (mm)													
2005-06	117.8	115.6	49.0	54.8	47.9	36.6	66.9	44.5	69.0	70.2	50.8	86.2	809.3
2006-07	141.9	57.4	16.7	13.7	51.9	27.9	38.1	116.1	86.3	29.6	84.8	22.4	686.8
Average 1961-90	49.1	42.0	47.5	50.0	49.5	36.8	33.9	43.5	51.5	64.8	79.3	62.5	610.4

Kragujevac area is characterized by a moderate continental climate, which general feature is uneven distribution of rainfall by month. The data in Table 1 for the investigated period (2005-2007) clearly indicate that the years in which the researches were conducted differed from the typical multi-year average of Kragujevac region regard the meteorological conditions. The average air temperature was 0.2°C lower in 2005/06 and 0.5°C higher in 2006/07, as compared to the long-term mean, whereas the sum of rainfall was 198.9 mm and 76.4 mm higher in respective years as compared to the long-term mean. Spring months April, May and June 2005/06 were with overly precipitation, which affected unfavorable on the crops. During the Mart in 2006/07 it was 116.1 mm of rainfall, what was 83.7 mm more compared with the perennial average. In May of 2005/06 it was 70.2 mm of rainfall, what was 12.6 mm more compared with the perennial average.

Results and discussion

Based on the analysis of variance, it can be concluded that there are very significant differences in grain yield regard the year of investigation (F_{exp}=31.365**) and very significant differences at grain test weight, relative while among the investigated wheat cultivars the differences were not significant. Very significant differences in 1000 grain weight at investigated wheat cultivars were found relative to the cultivar. In the dual interaction between the cultivar and year, significant effects were noted on grain test weight (Table 2). Our results are consistent with the results Đekić et al. (2010, 2012) and Jelić et al. (2013), where the authors state that the growing conditions in the observed years had a significant impact on yield.

Table 2 *Analysis of variance of the traits of wheat (ANOVA)*

Effect of year on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F(df1.2) 1. 48	p-level
Grain yield (t/ha)	24.5532	0.782830	31.365**	0.000001
1000 grain weight (g)	10.3968	5.358917	1.940	0.170076
Test weight (kg hl^{-1})	291.3698	9.497504	30.679**	0.000001
Effect of cultivars on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F(df1.2) 4. 45	p-level
Grain yield (t/ha)	0.58292	1.32883	0.439	0.779965
1000 grain weight (g)	35.91220	2.75502	13.035**	0.000000
Test weight (kg hl^{-1})	22.77950	14.58071	1.562	0.200728
Effect of the year x cultivars interaction on the traits analyzed				
Traits	Mean sqr Effect	Mean sqr Error	F(df1.2) 4. 40	p-level
Grain yield (t/ha)	0.92629	0.788475	1.175	0.336462
1000 grain weight (g)	4.60180	2.379300	1.934	0.123511
Test weight (kg hl^{-1})	22.08630	6.910425	3.196*	0.022793

**Statisticaly significant difference (P<0.05) **Statisticaly high significant difference (P<0.01)*

The grain yield of wheat significantly varied across years, from 2.313 t/ha in 2005/06 to 3.715 t/ha in 2006/07 (Table 3). Average grains yield observed in the two-year period was the highest at Ana Morava cultivar (3.229 t/ha), while the lowest yield was obtained by KG 100

cultivar (2.681 t/ha). The average grains yield over a two-year period was 3.014 t/ha. During the first year of investigations, cultivar KG 56S achieved the highest grains yield (2.455 t/ha), followed by Lazarica (2.404 t/ha), while the lowest yield was at Takovčanka cultivar (2.151 t/ha). During the second year of investigations, the yield of Ana Morava cultivar was the highest with 4.206 t/ha, while the slightly lower yield was realized by Takovčanka cultivar (4.123 t/ha).

The sufficient amounts of rainfall during the spring months (Table 1), particularly April, which are vital to successful wheat production, suggest that the distribution and total amount of rainfall during the growing season 2006/07 were considerably more favorable, resulting in an increased yield in this year as compared to the first year. The significantly lower yield in 2005/06 was due to a decline in total rainfall in the spring and its non-uniform distribution across months, accompanied by higher average air temperatures in these years. Đekić et al. (2012) in his research states that the air temperatures and the rainfall amount and distribution during the wheat growing season have the greatest impact on high yields and grain quality. Considerable variation in grain yield on years depending of research have established Đekić et al. (2010), Đurić et al. (2012, 2013) and Perišić et al. (2011).

Table 3 *Average values of the traits of wheat*

Cultivars	2005/06			2006//07			Average		
	$\bar{x}$	S	$S_{\bar{x}}$	$\bar{x}$	S	$S_{\bar{x}}$	$\bar{x}$	S	$S_{\bar{x}}$
Grain yield (t ha^{-1})									
Takovčanka	2.151	0.944	0.422	4.123	1.086	0.486	3.137	1.414	0.447
KG 100	2.304	0.814	0.364	3.058	0.996	0.445	2.681	0.945	0.299
KG 56S	2.455	0.686	0.307	3.220	0.809	0.362	2.838	0.814	0.257
Ana Morava	2.253	0.685	0.306	4.206	1.042	0.466	3.229	1.323	0.418
Lazarica	2.404	0.742	0.332	3.969	0.965	0.431	3.186	1.157	0.366
Average	2.313	0.721	0.144	3.715	1.023	0.205	3.014	1.126	0.159
1000 grain weight (g)									
Takovčanka	38.84	0.744	0.333	39.34	1.744	0.780	39.09	1.291	0.408
KG 100	38.98	0.726	0.325	37.08	2.051	0.917	38.03	1.763	0.557
KG 56S	42.12	1.746	0.781	42.58	2.314	1.035	42.35	1.948	0.616
Ana Morava	39.34	1.113	0.497	38.20	1.679	0.751	38.77	1.471	0.465
Lazarica	38.74	1.043	0.466	36.26	1.383	0.618	37.50	1.744	0.552
Average	39.60	1.663	0.333	38.69	2.820	0.564	39.15	2.337	0.330
Test weight (kg hl^{-1})									
Takovčanka	70.61	2.920	1.306	76.79	3.871	1.731	73.70	4.589	1.451
KG 100	66.91	1.684	0.753	74.45	1.960	0.876	70.68	4.331	1.370
KG 56S	71.41	2.128	0.952	77.75	1.952	0.873	74.58	3.856	1.219
Ana Morava	72.93	1.659	0.742	72.93	4.170	1.865	72.93	2.992	0.946
Lazarica	69.97	2.198	0.983	74.05	2.366	1.058	72.01	3.043	0.962
Average	70.37	2.836	0.567	75.19	3.309	0.662	72.78	3.905	0.552

Thousand grain weight in the test period was highest in 2005/06 (39.60 g), but decreased in 2006/07 by 0.91 g or 2.30%. Cultivars had a very significant effect on the 1000-grain weight ($p<0.01$). The wheat Lazarica cultivar achieved the lowest average 1000 grain weight during the both years of investigation (38.74 g and 36.26 g) compared with other tested wheat cultivars. During the both years of investigation the highest average value of 1000 grain weight achieved the KG 56S cultivar (42.12 g and 42.58 g). A number of authors (Đekić et

al. 2010, 2012; Đurić et al. 2012; Jelić et al. 2013) underline that 1000-grain weight is a cultivar-specific trait, with considerably higher variations being observed among genotypes than among treatments or environmental factors.
Test weight is an indicator of grain quality, particularly grain monetary value. Wheat grains having a higher test weight are generally considered to be of higher quality than those with a low test weight. During the first year achieved the highest test weight at Ana Morava cultivar (72.93 kg/hl), followed by KG 56S (71.41 kg/hl), while the lowest test weight was at KG 100 cultivar (66.91 kg/hl). During the second year of investigations, the test weight of KG 56S cultivar was the highest with 77.75 kg/hl, while the slightly lower test weight was realized by Takovčanka cultivar (76.79 kg/hl). The average two-year value of test weight at KG 56S cultivar was (74.58 kg/hl), while the lowest average two-year value was at KG 100 cultivar (70.68 kg/hl). Grain of investigated wheat cultivars was characterized by good physical characteristics; especially regard the test weight and 1000 grain weight. Realized average values of these characteristics in the study were slightly lower than the values obtained by Đekić et al. (2010, 2012).

Conclusion

Environmental conditions (weather and soil) have a significant effect on grain yield and quality in wheat. Grain yield shows a tendency to increase in the years having a higher total amount and better distribution of rainfall during critical plant development stages.
Based on the gain results during two-year investigation on five Kragujevac's wheat cultivars, it can be concluded that the highest yield achieved the cultivar Ana Morava. Takovčanka, KG 56S and Lazarica cultivars have achieved satisfactory results, while the poorest results were achieved by the cultivar KG 100.
Considering the average yields value and test weight in 2005/06 and 2006/07, it was evidently that the yields and test weight were highly statistically significantly different between the year ($p<0.01$). Interaction of the year and cultivars on the test weight were statistically significantly. Investigations on genotype and environment interaction present the basis for further refinement and wheat zoning.

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