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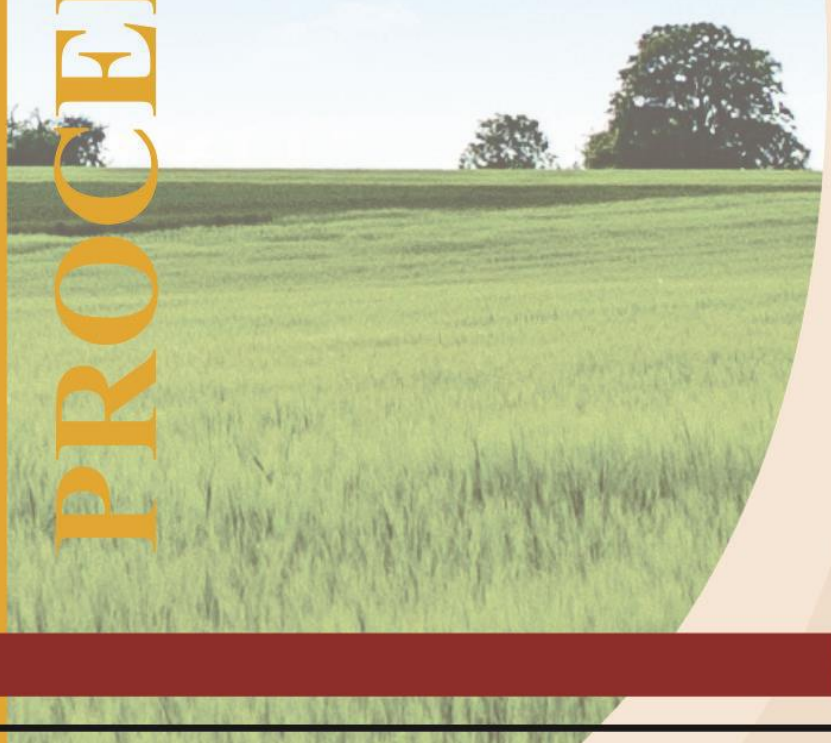

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VARIABILITY OF QUALITY AND RHEOLOGICAL PROPERTIES IN WINTER WHEAT UNDER THE INFLUENCE OF ECOLOGICAL FACTORS

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Abstract

This research involved analyses of six genotypes of the winter bread wheat (Toplica, Takovčanka, Perfekta, Vizija, KG-56S, and Aleksandra) on the experimental field of Centre for Small Grains in Kragujevac during two growing seasons (2011/2012 and 2012/2013). The most important parameters of bread-making quality were analysed (wet gluten content and rheological flour and dough properties). Grain samples were milled using a Brabender Quadrumat Junior laboratory mill. The gluten content was determined by the standard method and rheological flour and dough properties by Brabender Farinograph. Wet gluten content of analyzed wheat genotypes varied depending on the genotype and the year. The cultivar Aleksandra had the highest value of wet gluten content in both years of investigation (35.48% and 39.03%). The analyses of variance showed highly significant differences of wet gluten content between cultivars, investigated years as well as their interaction. The lowest water absorption in the first year of study was found in Takovčanka cultivar (59.2%), while in the second year in KG-56S (63.8%). The cultivar Vizija showed the highest water absorption in both years of studying (62.13% and 67.3%). According to the analysis of variance, highly significant differences for the water absorption were determined between genotypes, examined years and their interaction. Farinograph properties showed that flour of analyzed cultivars belonged to B_1 and C_1 quality groups in the first year, and B_1 and B_2 in the second year. The analysis of phenotypic variance indicated that the highest impact of variance for wet gluten content belonged to year, while for water absorption belonged to cultivar × year interaction.

Keywords: *wheat, quality, gluten, rheological properties.*

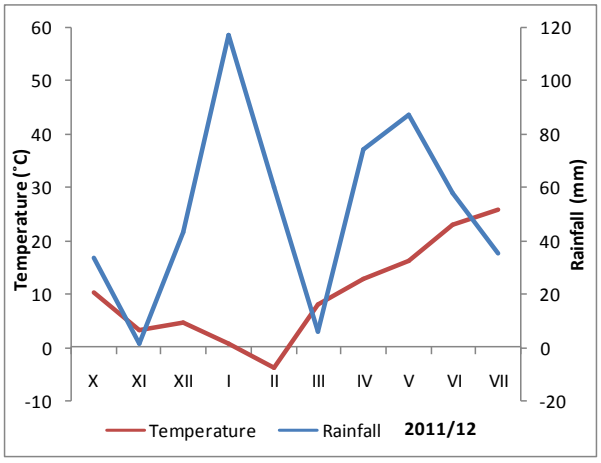
Introduction

The technological quality of wheat is primarily determined by the genetic potential of the variety, which is realized to a greater or lesser extent, depending on the agroecological conditions. The grain quality of wheat mostly depends on the quantity and quality of gluten. Gluten is formed in the early stages of ripening (milk) but its quality changes during maturity to the final characteristics (Lookhart et al., 2001). Temperature and precipitation in the filling phase and grain maturation has a great influence on the quality and content of the protein as well as on the rheological properties of the test (Đurićet al., 2010; Hurkman and Wood, 2011; Torbica et al., 2011). Water absorption is an important indicator of the quality of the flour, which is in a positive correlation with the protein content (Koppel and Ingver, 2010; Abbasi et al., 2011; Al-Saleh and Brennan, 2012). It represents one of the most important parameters in assessment of flour strength and it is directly related to the yield of finished bakery product (Dapčević et al., 2011). The quality properties associated with protein content are found under much greater influence of ecological factors and interaction of the genotype x environment, in contrast to the properties associated with the quality of the protein, the rheological characteristics of the test and the characteristics of the starch, where the influence genotype is significantly higher (Williams et al., 2008). It is known that one and the same genotype

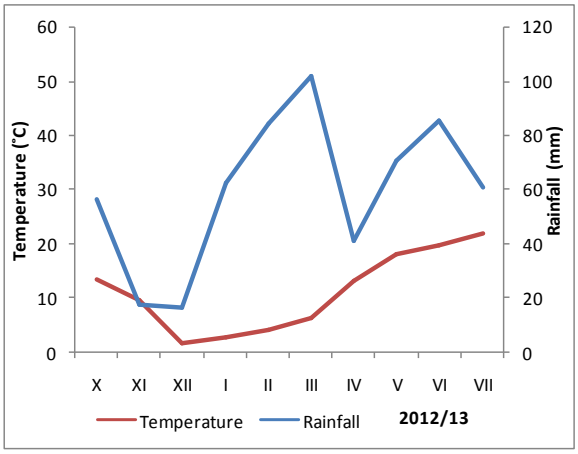
cultivated in different environmental conditions can belong to different quality classes and quality groups (Zečević et al., 2007). The cause of the variation in quality traits wheat is the consequence of genetic differences in cultivars, ecological factors, as well as their interactions, that are determined in research by a large number of authors (Zhang et al., 2004; Finlay et al., 2007; Vázquez et al., 2012; Zečević et al., 2013; Laidiget al., 2017).
The goal of this research is to investigate the influence of the ecological factors, genotypes and their interactions on some quality and rheological properties in winter wheat.

Material and Methods

In these studies, six wheat varieties (Toplica, Takovčaka, Perfekta, Vizija, KG-56S and Aleksandra) were analyzed. Varieties were grown in the experimental field of the Center for Small Grains Kragujevac (Serbia) during two vegetation season (2011/12 and 2012/13).
The rheological properties of grain quality were analyzed: wet gluten content, water absorption, quality number and quality group. Grain samples were milled using a Brabender Quadrumat Junior laboratory mill. The gluten content was determined by standard method (ICC standard methods 106/2, 1992). Farinograph was used to determine rheological properties of flour and dough. The results of the research were studied by Analysis of Variance (ANOVA) according to completely randomized block design with two main factors (genotype and year) using SPSS Statistics 22 statistical program. Evaluation of the importance of difference between average values of studied characteristics was tested by *Duncan* test. Components of variance (genetic, environment and interaction) were calculated by FALCONER (1981).
The average values of mean monthly air temperatures and precipitation amounts per month are shown on the graph1 and 2 (Republic Hydrometeorological Service of Serbia).



Graph. 1. Average monthly air temperatures and total amount of precipitation in production 2011/12 year



Graph. 2. Average monthly air temperatures and total amount of precipitation in production 2012/13 year

The first year of research, in November, was characterized by a dry period with extremely low precipitation. The average air temperature as well as total precipitation during October and November in the second year, was higher compared to the same months in the first year, which had a more favorable effect on seed germination and plant growing. Winter was mild with significantly lower precipitation in December and January in the second year compared to the first (78.8 mm compared to 160.5 mm). The stem elongation period and heading of wheat, during April and May, took place in both vegetation season in similar temperature conditions, with the amount of rainfall being higher in 2011/12 (74.5 mm, 87.3 mm compared to 41.2mm, 70.8 mm). However, in June, the filling phase of the grain was carried out at a higher air temperature (23 ˚C compared to 19.8 ˚C) and a lower amount of precipitation in 2012 compared to 2013 (85.4 mm compared to 66.9 mm), which affected the accelerated maturation of cereals.

Results and Discussion

In the first year of the research, the highest value of wet gluten content had the cultivar Aleksandra (35.48%) and KG-56S (34.6%), and in the second year the cultivar KG-56S variety (45.2%). On average, the wet gluten content was higher in 2012/2013 (39.14%) compared to 2011/12 year (31.56%), Table 1.

Table 1. Mean values for wet gluten content of wheat cultivars

Genotype	Wet gluten content (%)		
	2011/12	2012/13	Average
Toplica	31.75ab	38.28b	35.02
Takovčanka	29.49a	33.96a	31.72
Perfekta	29.05a	38.76b	33.91
Vizija	28.99a	39.59b	34.29
KG-56S	34.6bc	45.2c	39.9
Aleksandra	35.48c	39.03b	37.26
Average	31.56	39.14	35.35

Distinct letters in the row indicate significant differences according to Duncan test ($P \leq 0.05$).

Analysis of variance showed highly significant differences among investigated genotypes ($F=18.337$; $p<0.01$), years ($F=193.563$; $p<0.01$) and their interactions G × Y ($F=5.606$; $p<0.01$). Components of variance for wet gluten content have shown that the most variability belonged to year (69.16%), and a significantly smaller genotype (14.05%) and interactions genotype x year (10.17%), Table 2.

Table 2. Analysis of variance for wet gluten content of wheat cultivars

Source	DF	MS	F	Components of variance	
				σ^2	%
Repetition	2	5.892	2.206^{ns}	-	-
Genotype (G)	5	48.974	18.337^{**}	5.667	**14.05**
Year (Y)	1	516.956	193.563^{**}	27.89	**69.16**
G×Y	5	14.971	5.606^{**}	4.1	**10.17**
Error	22	2.671	-	2.671	**6.623**
Total	**35**	-	-	**40.328**	**100**

** Significant at P = 0.01 level; ^{ns} Non significant

The results of these studies are consistent with the results of Kaya et al. (2014) and Luković et al. (2017) who found that quality traits were largely dependent on environmental factors while the impact of the genotype was lower, suggesting that breeders' quality objectives should be adapted to the targeted environments.

Water absorption is the amount of water that needs to be added to the flour to obtain the dough with optimum consistency. This indicator depends primarily on the content of damaged starch grains, the content of protein and non-polysaccharide arabinoxylane (Rakszegiet al., 2014). In both years of research, the highest water absorption was established at cultivar Vizija (62.3%, 67.3%, respectively), with all varieties on average having a higher water absorption capacity in the second year compared to the first year of testing. Using the Farinograph the quality number and quality group for analyzed cultivars was determined. In 2011/2012, the best quality, expressed through a quality number, showed Aleksandra (61.3/B_1). The analyzed genotypes, in 2012/2013, showed the quality of the flour at the level of the B_1 quality group, except for the cultivar Vizija (B_2), Table 3.

Table 3.Mean values for water absorption (%), quality number and quality group of wheat cultivars

Genotype	Water absorption (%)			Quality number/ quality group	
	2011/12	2012/13	Average	2011/12	2012/13
Toplica	60.33b	65.47bc	62.9	47.6/B2	66.2/B1
Takovčanka	59.2a	66.2c	62.7	21.5/C1	62.2/B1
Perfekta	60b	64.33a	62.17	21.8/C1	63.3/B1
Vizija	62.13c	67.3d	64.72	31.9/C1	54.4/B2
KG-56S	61.07bc	63.8ab	62.43	46.8/B2	65.2/B1
Aleksandra	61.27bc	65.37bc	63.32	61.3/B1	61.5/B1
Average	60.67	65.41	63.04	-	-

Distinct letters in the row indicate significant differences according to Duncan test ($P \leq 0.05$)

The analysis of variance showed a significant influence of all sources of variation on the expression of the water absorption of the of studied wheat varieties.

Table 4. Analysis of variance for water absorption (%) of wheat cultivars

Source	DF	MS	F	Components of variance	
				σ^2	%
Repetition	2	0.081	0.071^{ns}	-	-
Genotype (G)	5	10.631	9.336^{**}	0.651	**12.01**
Year (Y)	1	175.563	154.176^{**}	1.771	**32.66**
G×Y	5	6.723	5.904^{**}	1.861	**34.32**
Error	22	1.139	-	1.139	**21.01**
Total	**35**	-	-	**5.422**	**100**

** Significant at P = 0.01 level, ^{ns} Non significant

By performing analysis of variance it was determined that the most significant contirbution of variance belongs to the interaciton G × Y (34.32%) as well as the year of (32.66%), while substanitally lower for the genotype (12.01%), Table 4. The results of these investigations agree with the results of Zečević et al. (2007) and Rozbicki et al. (2014) who emphasize that water absorption was more affected by the environment than by the genotype. Also, Laiding et al. (2017), studying the genetic improvement in quality of winter wheat varieties in the last

32 years in Germany, found that traits influencing baking quality (protein sedimentation, water absorption and bread volume), most impact of genetic factors (more than 60% of total variability belongs to the genotype), emphasizing that the years are more important than locations to explain variation.

Conclusion

In these studies, a significant influence of ecological factors on the quality of analyzed wheat varieties was established. The analysis of phenotypic variance indicated that the highest impact of variance for wet gluten content belonged to year, while for water absorption belonged to cultivar × year interaction. The year of 2012/2013 was a milder winter with more accurate rainfall during the wheat growing season. The period of heading and blooming in the month of May lasted with enough rainfall in both years. However, the grain filling phase in the second year of study was carried out at a slightly lower air temperature and higher precipitation compared to the first year, which caused the wheat varieties to be studied to achieve better quality of grain and flour.

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