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EFFECT OF GROWING SEASON AND GENOTYPE ON WINTER WHEAT QUALITY

Kristina LUKOVIĆ^{1*}, Veselinka ZEČEVIĆ², Slaven PRODANOVIĆ³, Jelena MILIVOJEVIĆ¹, Vera ĐEKIĆ¹

¹Centre for Small Grains, Kragujevac, Serbia

²Faculty of Biofarming, Bačka Topola, John Naisbitt University Belgrade, Serbia

³Faculty of Agriculture, University of Belgrade, Zemun, Serbia

*Corresponding author: kika@kg.ac.rs

Abstract

In this study, 11 winter wheat cultivars (KG-56S, Toplica, Perfekta, Takovčaka, Aleksandra, Vizija, Planeta, Kruna, Harmonija, Rujna and Premija) were investigated. The research was conducted in experimental field of the Centre for Small Grains Kragujevac (Serbia) during two growing seasons (2012/13, 2013/14). Variability of bread-making quality properties (sedimentation value and wet gluten content) was investigated. Quality components depended significantly upon genotype and environment factors. For a two-year average, sedimentation value varied from 23.33 ml (Premija) to 33.33 ml (Aleksandra, Planeta and Harmonija). The analyses of variance showed highly significant differences in sedimentation values between genotypes ($F=244.273^{**}$), investigated years ($F=717.176^{**}$), as well as their interaction ($F=50.767^{**}$). The highest wet gluten content on average was established at KG-56S cultivar (39.63 %) and the lowest at Kruna (27.92 %). There were highly significant differences in the wet gluten content among genotypes ($F=81.622^{**}$), investigated years ($F=816.569^{**}$), as well as their interaction ($F=25.974^{**}$). The analysis of phenotypic variance indicated that the highest impact of variance for sedimentation value belonged to genotype, while the highest impact of variance for wet gluten content belonged to year.

Key words: *wheat, cultivar, quality, sedimentation value, gluten content.*

Introduction

Grain quality is a complex character that depends on a number of traits, and the individual contribution of each trait varies depending on the specific reaction to environmental conditions (Mladenov *et al.*, 2001).

It is known that the quality of wheat depends, to a large extent, on the quantity and quality of gluten. Gluten proteins, consisting of gliadins and glutenins, play an important role in bread-making quality of wheat flour as gliadins mainly contribute to dough viscosity and extensibility, while glutenins affect dough strength and elasticity (Wieser, 2007). The composition of the stored proteins is a genotype characteristic and is independent of the conditions of the external environment. In recent years, a large number of papers have been published in which the emphasis of the positive effect of some gluten subunits on the technological quality of wheat (Li *et al.*, 2009; Kaya and Akcura, 2014; Mohan and Gupta, 2015).

However, the quantity of proteins depends to a great extent on the environmental factors. Thus, in a favorable regime of a mineral nutrition, soil moisture and air temperature, wheat genotypes achieve greater efficiency in pouring grains, accumulation of nitrogenous substances in the grain, and therefore increased protein content in grains. On the other hand, high temperatures in the filling phase, as well as prolonged harvest caused by abundant

precipitation, lead to changes in the quality of wheat and protein content (Đurić *et al.*, 2010; Hurkman and Wood, 2011).

Knowledge of the relative contributions of genotype and environment, as well as genotype and environment interaction effects on wheat quality, leads to more effective selection in breeding programs and segregation of more uniform parcels of grain better suited to the needs of customers (Williams *et al.*, 2008). It is desirable that wheat varieties maintain a good and stable grain quality in different environmental conditions. Stability of wheat quality characteristics over locations and years is important to the milling and baking industry, whose processing technology requires consistent raw materials in order to produce a quality end product (Grausgruber *et al.*, 2000).

The goal of this research is investigation of influence of the year, genotypes and their interactions on some wheat quality traits.

Materials and Methods

In this study, 11 winter wheat cultivars (KG-56S, Toplica, Perfekta, Takovčaka, Aleksandra, Vizija, Planeta, Kruna, Harmonija, Rujna and Premija) were investigated. The research was conducted in the experimental field of the Centre for Small Grains Kragujevac (Serbia) during two growing seasons (2012/2013 and 2013/2014). Experiment was carried out by the standard technology of scientific farming production of wheat. The period of the experiment is characterized by different meteorological conditions. During the growing period of wheat 2012/2013., 611.1 mm of precipitation fell in the area of Kragujevac. The average air temperature for the same period was 9.83°C. In the range from October 2013. to June 2014., 629.6 mm of precipitation fell in Kragujevac, while the average air temperature for the same period was 10.42°C (Republic Hydrometeorological Service of Serbia). The stem elongation period of wheat, during the month of April, started in similar temperature conditions in both vegetation seasons, with an amount of precipitation significantly higher in 2013/14. (129.1 mm compared to 41.2 in 2012/13.). During a May, when heading take a place and the process of grain filling starts, 2013/14 is characterized by extreme rainfall (227 mm) and slightly lower air temperature (15.4°C). However, in June, the air temperature was similar in both vegetation seasons but the amount of rainfall was higher in 2012/13. (85.4 mm compared with 66.9 mm in 2013/14.).

Variability of bread-making quality properties (sedimentation value and wet gluten content) was investigated. Grain samples were milled using a Brabender Quadrumat Junior laboratory mill. The quality analysis of Zeleny sedimentation test was carried out by ICC standard method No. 116/1 (1994), and wet gluten content was done by ICC standard method No. 106/2 (1984).

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) and using MSTAT-C statistical program. Evaluation of importance of the difference between average values of studied characteristics was tested by separate LSD test. Components of variance (genetic, interaction and environment) were calculated by Falconer (1981).

Results and Discussion

The genetically determined composition of gluten is the main determinant of genotypic differences in baking quality (Payne *et al.* 1987). Sedimentation value and wet gluten content are important quality components due to their positive correlation with other parameters of technological quality of wheat (Zečević *et al.*, 2004; Vázquez *et al.*, 2012; Laidig *et al.*, 2017). These quality parameters are both an indicator of the quality and quantity of proteins.

In these studies, it was found that sedimentation value in analyzed wheat cultivars varied, and on average it ranged from 23.33 ml (Premija) to 33.33 ml (Aleksandra, Planeta and Harmonija). In the first year of the research, the highest average value of the sedimentation had the cultivar Planeta (32.67 ml), and in the second year the cultivar Harmonija (38 ml). On average, the sedimentation value was higher in 2014 (31.76 ml) compared to 2013 year (28.03 ml), Table 1.

Analysis of variance showed highly significant differences among investigated genotypes ($F=244.273^{**}$), years ($F=717.176^{**}$) and their interactions ($F=50.767^{**}$). Components of variance for sedimentation volume have shown that the most variability belonged to genotype (46.07%), while the influence of the year (28.82%) and interactions genotype x year (23.68%) was lower (Table 2). This suggests that sedimentation depends predominantly on genetic factors, but the impact of environmental factors and their interaction (genotype x environment), that play a major role in the expressing of this property, should not be ignored (Zečević *et al.*, 2007; Kaya and Akcura, 2014; Abdipour *et al.*, 2016).

Table 1. Mean values for sedimentation volume of winter wheat cultivars

Genotype	Sedimentation volume (ml)		
	Year		Average
	2012/2013	2013/2014	
Kg-56S	28.67fg	32.67d	30.67c
Toplica	32.00de	34.00c	33.00a
Perfekta	28.67fg	29.33f	29.00d
Takovčanka	28.00g	31.00e	29.50d
Aleksandra	32.00de	34.67c	33.33a
Vizija	28.00g	36.00b	32.00b
Planeta	32.67d	34.00c	33.33a
Kruna	26.67h	25.33i	26.00e
Harmonija	28.67fg	38.00a	33.33.a
Rujna	21.67j	29.00fg	25.33e
Premija	21.33j	25.33i	23.33f
Average	28.03	31.76	29.89

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

Table 2. Analysis of variance for sedimentation volume of winter wheat cultivars

Source	DF	MS	F	LSD		Components of variance	
				0.05	0.01	σ^2	%
Genotype (A)	10	78.076	244.273**	0.728	1.035	10.31	46.07
Year (B)	1	229.227	717.176**	-	-	6.45	28.82
AB	10	16.227	50.767**	1.029	1.464	5.30	23.68
Error	42	0.320	-	-	-	0.32	1.43
Total	65	-	-	-	-	22.38	100

** Significant at P = 0.01 level

The quality of wheat products depends on the quantity and quality of gluten. It is known that the quality of gluten is one of the most important factors in breeding to improve the quality of grain wheat, which plays a decisive role in the quality of dough and bread.

The highest wet gluten content was established in average at Kg-56 s cultivar (39.63%), and the lowest at Kruna (27.92%). Looking at the years of research, in the first year the highest wet gluten content was established at Kruna cultivar (45.20 %), and in the second year at Planeta (35.25 %). On average, the wet gluten content was higher in 2013 (36.89%) compared to 2014 year (30.75%). All of the analyzed cultivars had wet gluten content above 30%, except at Kruna, what indicated good technological quality of flour and dough (Table 3).

Table 3. Mean values for wet gluten content of winter wheat cultivars

Genotype	Wet gluten content (%)		
	Year		Average
	2012/13	2013/14	
Kg-56S	45.20a	34.06fg	39.63a
Toplica	38.28bc	32.75gh	35.51bc
Perfekta	38.76b	30.20ijk	34.48cd
Takovčanka	33.96fg	29.93jk	31.94e
Aleksandra	39.03b	31.32hij	35.17bc
Vizija	39.59b	31.51hij	35.55bc
Planeta	36.99cd	35.25ef	36.12b
Kruna	33.64g	22.20l	27.92g
Harmonija	36.10de	31.53hi	33.81d
Rujna	34.28fg	29.48k	31.88e
Premija	29.99ijk	30.04ijk	30.01f
Average	36.89	30.75	33.82

Distinct letters in the row indicate significant differences according to LSD test (P ≤ 0.05).

Analysis of variance's components has shown that the biggest share in the wet gluten content have the year (56.30%), while the influence of variety and interactions variety x years was lower, Table 4.

Table 4. Analysis of variance for wet gluten content of winter wheat cultivars

Source	DF	MS	F	LSD		Components of variance	
				0.05	0.01	σ^2	%
Genotype (A)	10	62.206	81.622**	1.123	1.597	7.068	21.79
Year (B)	1	622.320	816.569**	-	-	18.258	56.30
AB	10	19.795	25.974**	1.588	2.259	6.344	19.56
Error	42	0.762	-	-	-	0.762	2.35
Total	65	-	-	-	-	32.432	100

** Significant at P = 0.01 level

These results were different from the results published by Zečević *et al.* (2007), who established that the largest impact of variances in the total variance for gluten content belongs to the genotype. Mladenov *et al.* (2001), on the other hand, found that the largest contribution of variance for wet gluten content belongs to the interaction cultivar x environment. These authors carried out research on a number of sites, which affected high components of the variance for the interaction cultivar x environment. The same authors pointed out that relatively high value of genotype x environment interaction for quality traits require multiple years and site testing to accurately assess the genetic potential of varieties.

Improvement of end-use quality in bread wheat depends on a complete understanding of current wheat quality and the influences of genotype, environment, and genotype x environment interactions on quality traits (Zhang *et al.*, 2004).

Conclusion

The investigation of wheat quality characteristics has shown that there are differences between wheat varieties indicating the specificity of the genotype. Different values of tested wheat properties in different cultivation years have also been established, which indicates the existence of different environmental factors in the years of research. On average, the highest sedimentation value was established at Premija cultivar. Components of variance for sedimentation volume were shown that the most variability belonged to genotype, while influence of the year and interactions genotype x year was approximately the same.

Cultivar KG-56S had the highest average value of wet gluten content. On average, the wet gluten content was higher in 2013 compared to 2014 year. Analysis of variance showed highly significant differences among investigated genotypes, years and their interactions for both analyzed traits of wheat quality.

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