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VARIABILITY OF TECHNOLOGICAL QUALITY COMPONENTS IN WINTER WHEAT

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Ten winter wheat cultivars created in Small Grains Research Centre of Kragujevac (KG-56, Srbijanka, Studenica, Takovčanka, KG-56S, KG-100, Toplica, Levčanka, Gruža, and Tara) were grown at experimental field during four years. Variability of bread-making quality properties (sedimentation value, gluten content and quality, and rheological flour and dough properties) was investigated. The sedimentation value was determined by *Zeleny* method, gluten content by standard method, and rheological flour and dough properties by Farinograph. Quality components depended significantly of genotype and environment factors. Obtained results have shown that the highest value of sedimentation in average was at KG-56S cultivar (61.8ml). Sedimentation in all investigated cultivars was at the level of the first quality class. Wet gluten are characterized by good physical properties, and on average ranged from

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25.6% (KG-100) to 36.3% (Gruža). Wheat technological quality depended predominantly of genetic potential of cultivar, and it was on the level of A_2-B_2 quality group. The highest impact of phenotypic variance belonged to genotype for sedimentation value, wet gluten content and rheological flour and dough properties, while for water absorption belonged to genotype-year interaction.

Key word: gluten, quality, rheological properties, sedimentation, variability, wheat

INTRODUCTION

The major aim of each wheat breeding program is to increase yield and improve quality. Therefore good baking quality has been one of the priorities in wheat breeding at Small Grains Research Centre Kragujevac. There are significant phenotypic differences between wheat genotypes regarding grain and flour quality. Modern cultivars are much better adapted and much productive in agriculture environments than their wild ancestors. Adaptedness and productivity are however both complexly inherited traits and much affected by environment (ALARD, 1997). The successful process of wheat breeding based on the knowledge of characteristics of genotypes as well as interactions of genotypes and environments. The ideal cultivar for high grain yield and technological quality need to express genetic potential in different environmental factors of growing.

Understanding of the causes of genotypic-environment interaction can be used to establish breeding objectives, identify ideal test conditions, and formulate recommendations for areas of optimal cultivar adaptation (WEIKAI and HUNT, 2001). The presence of genotype-environment interaction complicates selection of superior genotypes and understanding of environmental and genotypic causes of significant genotype-environment interaction is important in all stages of plant breeding (DHUNGANA *et al*., 2007).

Wheat breeding programs developed at Small Grains Research Centre of Kragujevac have created high yielding and quality wheat cultivars. This study investigates the effects of genotype and environment, and their interactions on the milling and rheological quality of winter wheat cultivars.

MATERIAL AND METHODS

Ten Kragujevac′s winter wheat cultivars (KG-56, Srbijanka, Studenica, Takovčanka, KG-56S, KG-100, Toplica, Levčanka, Gruža, and Tara) were grown at the macro trial at experimental field of Small Grains Research Centre of Kragujevac during four years. Grain and flour quality traits (sedimentation value, wet gluten content, rheological flour and dough properties) were investigated. Grain was milled to flour on the Brabender Quadrumat Junior laboratory mill. Sedimentation was measured by *Zeleny* method. Farinograph was used to determine rheological properties of flour and dough. Gluten content was determined by standard method-hand washing (KALUĐERSKI and FILIPOVIĆ, 1998).

The analysis of variance was performed according to a random block design with two factors, and the significant differences between the averages values were evaluated by least significance difference test (LSD), HADŽIVUKOVIĆ (1991). Components of variance (genetic, interaction, environment, and phenotypic) were calculated by FALCONER (1981).

RESULTS AND DISCUSSION

Sedimentation volume. - Sedimentation volume differed between genotypes and years and on average ranged from 35.2 ml (KG-100) to 61.8ml (KG-56S), and from 42.2ml in 2000 year to 50.4ml in 1999 year. Cultivar KG-56S had the highest sedimentation in three years, except in 2000 year, when Gruža had the highest value of sedimentation (64.0ml). Greater number of investigated cultivars belonged to first quality class. Only KG-100 (35.2ml) and Srbijanka (37.5ml) belonged to second quality class. Sedimentation volume on average for all cultivars and years was at the first quality class, what indicated high quality of proteins and possibility for good bread-making quality (Table 1). High values of sedimentation indicate to good protein quality and other traits necessary to production high quality bread. It well-know that sedimentation and gluten content are important quality traits because of their positive correlations with other bred-making quality parameters of wheat (ZEČEVIĆ *et al*., 2004; MLADENOV *et al*., 2005).

Table 1. - Sedimentation volume of winter wheat cultivars

Cultivar	Sedimentation volume (ml)				
	1997	1998	1999	2000	Average
KG-56	38	55	60	31	46.0
Srbijanka	38	33	43	36	37.5
Studenica	37	47	49	33	41.5
Takovčanka	51	43	56	38	47.0
KG-56S	64	59	64	60	61.8
KG-100	37	32	42	30	35.2
Toplica	61	53	41	49	51.0
Levčanka	33	55	45	43	44.0
Gruža	55	41	60	64	55.0
Tara	42	40	44	38	41.0
Average	45.6	45.8	50.4	42.2	46.0

The relative effects of genotype, environment and genotype-environment interaction to wheat quality components were studied using the components of phenotypic variance. Components of variance for sedimentation volume (Table 2) were shown that the most variability belonged to genotype (47.35%), than cultivar-year interaction (46.72%), and the lowest variability belonged to year (5.21%). It means that sedimentation depends predominantly of genetic factors (GRAUSGRUBER *et al*., 1998; KADAR and MOLDOVAN, 1999; ZEČEVIĆ *et al*., 2001), but approximately the same as that of the genotype (LEMELIN *et al*., 2005; MLADENOV *et al*., 2005) and growing technology (ANDERSON *et al*., 1998; BOEHM *et al*., 2004; ZEČEVIĆ *et al*., 2005). Earlier investigations have shown that genotype was consistently the most important determinate of quality traits (SOUZA *et al*., 2004).

Table 2. - Components of phenotypic variance for sedimentation volume in winter wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				δ^2	%			
Replication	2	30.833	-	-	-	Cultivar	0.984	0.742
Cultivar	9	810.333	972.40**	54.11	47.35	Year	0.622	0.469
Year	3	339.500	407.40**	5.95	5.21	Cultivar x year	1.968	1.484
Cultivar x year	27	161.000	193.20**	53.39	46.72	V=1.98 %		
Error	78	0.833	-	0.83	0.73			
Total	119	-	-	114.28	100.0			

Gluten content. - Analysis of variance showed highly significant differences among the genotypes and years for wet gluten content, indicating the presence of variability among the genotype as well as environment. The highest wet gluten content was established in average at Gruža cultivar (36.3%), and the lowest at KG-100 (25.6%). On average gluten content was the highest in 1997 year (34.3%), and the lowest in 2000 year (30.2%). Gluten content was above 30% in greater number of cultivars, except at KG-100 and Studenica, what indicated good technological quality of flour and dough (Table 3).

The analysis of phenotypic variance indicated that wet gluten content was more affected by the genotype than by the environment. The highest variance of whole variability belonged to genetic factors (53.39%). Variability for year (20.54%) and interaction cultivar-year (25.81%) was approximately the same (Table 4). The composition of proteins and protein subunits is genetically

determined (JOHNSSON *et al*., 1993; MACRITCHIE, 1999). There is a strong correlation between flour protein content and large monomeric proteins (LABUSCHAGNE *et al*., 2006). Improvement of the loaf volume will be due to a higher amount of gluten, and gluten quality highly depends of different protein fractions content and size distribution of glutenin polymers. Thus, in breeding for improved bread-making quality, it might be better to breed for improved protein composition than to breed for higher protein concentration (LABUSCHAGNE *et al*., 2006). The bread-making quality of flour is influenced both by protein content and protein type but wheat quality largely depends on the nature of the gluten composition.

Table 3. - Wet gluten content of winter wheat cultivars

Cultivar	Wet gluten content (%)				
	1997	1998	1999	2000	Average
KG-56	33.5	33.7	31.2	28.2	31.6
Srbijanka	34.0	35.1	31.5	33.6	33.6
Studenica	31.7	29.2	29.2	23.6	28.4
Takovčanka	34.9	33.9	28.0	29.2	31.5
KG-56S	35.0	32.4	34.9	35.9	34.6
KG-100	28.4	24.8	27.7	21.6	25.6
Toplica	35.2	33.7	29.6	29.4	32.0
Levčanka	38.1	33.3	29.0	33.0	33.4
Gruža	38.8	36.2	34.9	35.2	36.3
Tara	33.1	32.1	30.1	31.8	31.8
Average	34.3	32.41	30.6	30.2	31.9

Likewise, glutenin fraction was found to be almost totally genotype dependent (GRAYBOSCH *et al*., 1996). In this investigation the cultivars held its genetic potential for gluten content and quality although they grown in different climatic conditions. Results are agreed with previous obtained with ZEČEVIĆ *et al*. (2005) and MLADENOV *et al*. (2005).

Table 4. - Components of phenotypic variance of wet gluten content in winter wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				δ^2	%			
Replication	2	36.519	-	-	-	Cultivar	0.216	0.162
Cultivar	9	110.229	2789.13**	8.19	53.39	Year	0.136	0.103
Year	3	106.342	2690.78**	3.15	20.54	Cultivar x year	0.431	0.325
Cultivar x year	27	11.927	301.78**	3.96	25.81	V=0.62 %		
Error	78	0.040	-	0.04	0.26			
Total	119	-	-	15.34	100.0			

Rheological flour and dough properties. - The flour and dough rheological properties, as water absorption, dough development time, dough stability, and degree of softening were determined by 10-g Brabender Farinograph. Water absorption on average was above 60%, what distinguish cultivars with strong flour and hard texture (Table 5). On average Levčanka (65.8%) showed the highest water absorption, but the lowest water absorption established at Toplica cultivar (60.4%).

Table 5. - Rheological flour and dough properties of winter wheat cultivars

Cultivar	Water absorption (%)				
	1997	1998	1999	2000	Average
KG-56	61.6	62.1	61.5	66.6	63.0
Srbijanka	63.0	60.6	62.4	66.6	63.2
Studenica	63.9	60.2	62.8	62.4	62.3
Takovčanka	62.2	60.8	60.0	62.4	61.4
KG-56S	68.3	64.8	68.3	59.6	65.2
KG-100	66.2	65.0	59.6	53.8	61.2
Toplica	60.8	60.0	60.0	61.0	60.4
Levčanka	65.2	64.4	65.2	68.2	65.8
Gruža	66.3	60.8	66.3	61.8	63.8
Tara	60.4	63.5	59.8	60.6	61.1
Average	63.8	62.2	62.6	62.3	62.7

Table 6. Components of phenotypic variance for water absorption in winter wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				δ^2	%			
Replication	2	43.075	-	-	-	Cultivar	0.295	0.222
Cultivar	9	38.098	507.98**	1.14	11.95	Year	0.187	0.141
Year	3	18.086	241.15**	0.21	2.20	Cultivar x year	0.590	0.445
Cultivar x year	27	24.431	325.75**	8.12	85.12	V=0.44%		
Error	78	0.075	-	0.075	0.79			
Total	119	-	-	9.54	100.0			

Phenotypic variability for water absorption showed that cultivar-year interaction had the highest influence to water absorption variability (85.12%). The lowest impact of variability for this trait had year (2.20%). Water absorption was more affected by the environment than by the genotype (Table 6), what is in agreement with the results obtained by BAKER and KOSMOLAK (1977).

Table 7. Rheological flour and dough properties of winter wheat cultivars

Cultivar	Quality number/quality group				Average
	1997	1998	1999	2000	
KG-56	60.4/B_1	76.7/A_2	85.9/A_1	76.7/A_2	74.9/A2
Srbijanka	66.7/B_1	46.2/B_2	56.2/B_1	67.5/B_1	59.2/B1
Studenica	71.6/A_2	49.4/B_2	65.0/B_1	62.6/B_1	62.2/B1
Takovčanka	71.9/A_2	48.6/B_2	63.1/B_1	53.3/B_2	59.2/B1
KG-56S	94.5/A_1	86.4/A_1	94.5/A_1	74.6/A_2	87.5/A1
KG-100	57.7/B_1	55.4/B_1	64.0/B_1	68.5/B_1	61.4/B1
Toplica	78.4/A_2	71.3/A_2	71.3/A_2	78.4/A_2	74.8/A2
Levčanka	81.7/A_2	76.0/A_2	81.7/A_2	77.1/A_2	79.1/A2
Gruža	76.0/A_2	76.7/A_2	76.0/B_1	68.8/B_1	74.4/A2
Tara	70.2/A_2	74.6/A_2	68.5/B_1	76.7/A_2	72.5/A2
Average	72.9/A_2	66.1/B_1	72.6/A_2	70.4/A_2	70.8/A2

On the base of farinogram determined quality number and quality group for analyzed cultivars. The rheological flour and dough quality was very good. The best dough quality showed KG-56S, which belonged to A_1 quality group. Six of ten investigated cultivars belonged to A quality group and four belonged to B quality group. Because of good gluten quality which has high influence to dough properties, cultivars showed very good rheological flour and dough quality (Table 7). Gluten content and protein quality have fundamental impact on rheological flour and dough properties.

Phenotypic variance analysis established significant differences in the average value of quality number in the cultivars, years and cultivar-year interaction (Table 8). The highest percentage of the whole phenotypic variability was assigned to genotype (57.26%), while only 3.16% was assigned to year.

Table 8. Components of phenotypic variance for quality number in wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				δ^2	%			
Replication	2	38.220	-	-	-	Cultivar	0.152	0.115
Cultivar	9	1108.552	54743.57**	78.77	57.26	Year	9.641	7.269
Year	3	293.923	14514.78**	4.35	3.16	Cultivar x year	0.305	0.300
Cultivar x year	27	163.302	8064.35**	54.43	39.57	V=0.20 %		
Error	78	0.020	-	0.02	0.01			
Total	119	-	-	137.57	100.0			

Generally the genetic components represented the largest amount of total variation for sedimentation volume, wet gluten content and quality number. Variation due to genotype-year interaction was higher only for water absorption. These results are in agreement with other authors (BAKER and KOSMOLAK, 1977) who found that genotype-environment interaction was important for rheological flour and dough properties.

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VARIJABILNOST KOMPONENTI TEHNOLOŠKOG KVALITETA OZIME PŠENICE

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I z v o d

U radu je ispitivana varijabilnost parametara tehnološkog kvaliteta (sedimentacija, sadržaj i kvalitet glutena i reološke osobine testa) kod deset kragujevačkih sorti pšenice (KG-56, Srbijanka, Studenica, Takovčanka, KG-56S, KG-100, Toplica, Levčanka, Gruža i Tara). Sorte su gajene na oglednom polju Centra za strna žita, Kragujevac tokom četiri vegetacione sezone. Sedimentacija je urađena po metodi *Zeleny*, sadržaj i kvalitet glutena po standardnoj metodi, a reološke osobine testa su određene na farinografu. Analizom varijanse je utvrđena značajna zavisnost ispitivanih komponenti kvaliteta od genotipa i ekoloških faktora. Ustanovljeno je da su sve sorte imale sedimentaciju na nivou prve kvalitetne klase, a najveća prosečna vrednost utvrđena je kod sorte KG-56S (61,8 ml). Sadržaj vlažnog glutena se kretao u rasponu od 25,6 % (KG-100) do 36,3 % (Gruža). Sorte su ispoljile vrlo dobar i stabilan reološki kvalitet brašna i testa, koji je bio na nivou A_2, B_1 i B_2 kvalitene grupe. Analizom komponenti fenotipske varijanse ustanovljeno je da, za sve ispitivane osobine kvaliteta, najmanji udeo varijanse pripada godini, a znatno veća varijansa pripada sorti i interakciji sorta-godina, što ukazuje da na ispoljavanje kvaliteta pšenice veći uticaj ima genotip, a znatno manji ekološki faktori.

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