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ECOLOGICAL AND GENETIC VARIABILITY OF WHEAT QUALITY COMPONENTS

Veselinka Zečević[1], Jelena Bošković[1], Desimir Knežević[2], Danica Mićanović[3] and Milomirka Madić[4]

[1] *Megatrend University- Belgrade, Faculty of Biofarming-Bačka Topola, Republic of Serbia*
e-mail: joca@kg.ac.rs
[2] *Faculty of Agriculture, Zubin Potok, Republic of Serbia*
[3] *Serbian Chamber of Commerce, Belgrade, Republic of Serbia*
[4] *Faculty of Agronomy, Čačak, Republic of Serbia*

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ABSTRACT. Variability of technological quality components (sedimentation value, wet gluten content and flour water absorption) in six winter wheat cultivars (KG-56S, KG-100, Studenica, Takovčanka, Toplica and Lazarica) created in the Small Grains Research Centre of Kragujevac were investigated. Quality components were analysed during seven years (1998-2004) in the cultivars that were present in the macro-trial of Small Grains Research Centre. Standard deviation and coefficient of variation were calculated as indicators of variability. The results showed that the sedimentation value greater variability expressed by years (Cv=19.4%) than by cultivars. (Cv=15.7%). On average sedimentation value had the largest variability, and the lowest water absorption (Cv=4.2%-years; Cv=5.1%-cultivars) of all investigated traits. Wet gluten content expressed high variability by years (Cv=10.3%) and cultivars (Cv=10.4%). Cultivar Lazarica showed the lowest variability for sedimentation value, Studenica for flour water absorption, and cultivar KG-56S for wet gluten content. In these investigations cultivar KG-56S had the largest values for sedimentation value and wet gluten content (55.8 ml and 33.3%, respectively). This cultivar has genetically excellent technological quality.

Key words: cultivar, gluten content, quality, sedimentation value, variability, wheat

INTRODUCTION

Breeding for improvement bread-making quality of wheat is an important breeding goal. Research of technological quality of new wheat cultivars in different ecological conditions is important for determining the stability of cultivars for specific characteristics.

The successful process of wheat breeding is based on the knowledge of characteristics of genotypes, environment and its interaction. The ideal cultivar for high grain yield or for any other desirable traits needs to express genetic potential with low value of variance in different environmental factors of growing.

Good baking quality has been one of the priorities in wheat breeding programes at Small Grains Research Centre Kragujevac. 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 quality characteristics of genotypes as well as interactions of genotypes and environments. The ideal cultivar for high technological quality and grain yield 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 & 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).

The aim of this paper was to study ecological and genetic variability of some technological properties in divergent wheat cultivars, which created at Small Grains Research Centre of Kragujevac.

MATERIAL AND METHODS

Six Kragujevac′s winter wheat cultivars (KG-56S, KG-100, Studenica, Takovčanka, Toplica and Lazarica) were grown at the macro trial at experimental field of Small Grains Research Centre of Kragujevac during seven years (1998-2004). Grain and flour quality traits (sedimentation value, wet gluten content and flour water absorption) 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 water absorption of flour. Gluten content was determined by standard method-hand washing (KALUĐERSKI & FILIPOVIĆ, 1998).

The analysis of standard deviation (σ) and analysis of coefficient of variation (Cv) were calculated according to HADŽIVUKOVIĆ (1991).

RESULTS AND DISCUSSION

Sedimentation volume. – It is 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; HORVAT *et al*., 2006). In these studies, cultivars showed a high variability of sedimentation values by years of study (Table 1). The average coefficient of variation for the cultivars ranged from 12.4% (Lazarica) to 18.4% (Studenica). Variability of sedimentation values by years of study was significantly higher. The average coefficient of variation by year of examination ranged from 10.5% (2004) to 26.9% (2000). On average of seven years, the highest value of sedimentation had a cultivar KG-56S (55.8 ml), and the smallest cultivar KG-100 (33.8 ml). On the average of examined years sedimentation value ranged from 37.0 ml (2004) to 50.5 ml (1999). Greater number of investigated cultivars belonged to the first quality class. Only KG-100 (33.8 ml) belonged to the second quality class. In addition to the cultivar KG-100, all other cultivars had an average sedimentation value of the level of 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.

Sedimentation depends predominantly of genetic factors (GRAUSGRUBER *et al*., 1998; KADAR & 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). Generally, sedimentation volume depends to genetic factors, but expression of this component highly depends to environmental factors (JOHANSSON *et al*., 2004; ZECEVIC *et al*., 2010), which is found in this study.

Table 1. Sedimentation value (ml)

Cultivar/Year	1998	1999	2000	2001	2002	2003	2004	Average	(σ)	Cv (%)
KG-56S	59	64	60	56	47	63	42	**55.8**	8.3	14.9
KG-100	32	41	34	34	26	38	32	**33.8**	4.8	14.2
Studenica	47	53	38	41	35	52	34	**42.8**	7.9	18.4
Takovčanka	43	54	32	41	40	41	35	**40.8**	7.0	17.1
Toplica	53	41	49	48	41	62	39	**47.6**	8.2	17.2
Lazarica	37	50	34	41	44	42	40	**41.1**	5.1	12.4
Average	**45.2**	**50.5**	**41.2**	**43.5**	**38.8**	**49.7**	**37.0**	**43.7**	**6.9**	**15.7**
σ	10.0	8.7	11.1	7.6	7.5	11.0	3.9	**8.5**	-	-
Cv (%)	22.1	17.2	26.9	17.5	19.3	22.1	10.5	**19.4**	-	-

Wet gluten content. – Variability of wet gluten content was lower compared with variability of sedimentation value by the years and cultivars. The average coefficient of variation for this property had a value in the range of 8.1% (KG-56S) to 12.1% (KG-100). By the years of research established higher variability of gluten content than by the tested cultivars. The average coefficient of variation by examination year ranged from 5.2% (2003) to 18.1% (2000). The highest average value of wet gluten had a cultivar KG-56S (33.3%), and the smallest cultivar KG-100 (25.6%). KG-56S cultivar had the highest value of both sedimentation volume and gluten content (Table 2). This cultivar has a high genetic potential for quality and belongs to the improver cultivars.

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 by protein type, but wheat quality largely depends on the nature of the gluten composition. 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 sedimentation value and gluten content although they grown in different climatic conditions. Results agree with previous obtained with ZEČEVIĆ *et al*. (2005) and MLADENOV *et al*. (2005).

Table 2. Wet gluten content (%)

Cultivar/Year	1998	1999	2000	2001	2002	2003	2004	Average	(σ)	Cv (%)
KG-56S	32.4	34.9	35.9	33.3	30.7	36.7	29.4	**33.3**	2.7	8.1
KG-100	24.8	27.7	21.6	25.6	24.3	31.4	23.8	**25.6**	3.2	12.5
Studenica	29.2	29.2	23.6	28.0	26.3	34.0	25.4	**28.0**	3.4	12.1
Takovčanka	33.9	28.0	29.2	30.3	27.4	35.8	27.5	**30.3**	3.3	10.9
Toplica	33.7	29.6	29.4	30.8	27.1	35.3	29.9	**30.8**	2.8	9.1
Lazarica	34.4	25.8	29.5	28.7	27.0	34.6	30.9	**30.6**	2.9	9.5
Average	**31.4**	**29.2**	**28.2**	**29.4**	**27.1**	**34.6**	**27.8**	**29.7**	**3.0**	**10.4**
σ	3.7	3.1	5.1	2.6	2.1	1.8	2.8	**3.0**	-	-
Cv (%)	11.8	10.6	18.1	8.8	7.7	5.2	10.1	**10.3**	-	-

Flour water absorption. – Water absorption is determined by protein content of the flour, the amount of starch damaged during milling and presence of non-starch carbohydrate. Water absorption of flour highly affected by the environment, what is in agreement with the results obtained previously (ZECEVIC *et al*., 2007; Ma *et al*., 2007). Water absorption on average was above 60%, what distinguish cultivars with strong flour and hard texture (Table 3). On average Toplica (63.8%) and KG-56S (63.2%) showed the highest water absorption, but the lowest water absorption established at Lazarica cultivar (59.1%). On the average years of research, values for the flour water absorption varied in the range from 57.8% (2004) to 64.2% (1998).

The coefficient of variation of water absorption of flour had an average value of 3.1% (Studenica) to 6.6% (KG-100). Lower variability was determined by year than by the cultivars. The average value of the coefficient of variation by year tested ranged from 1.7% (2004) to 6.2% (1999).

Table 3. Flour water absorption (%)

Cultivar/Year	1998	1999	2000	2001	2002	2003	2004	Average	(σ)	Cv (%)
KG-56S	64.8	68.3	59.6	63.2	60.2	67.2	58.8	**63.2**	3.8	6.0
KG-100	65.0	59.6	53.8	60.4	62.4	64.6	57.2	**60.4**	4.0	6.6
Studenica	60.2	62.8	62.4	61.6	63.8	62.2	58.1	**61.6**	1.9	3.1
Takovčanka	60.8	60.0	62.4	61.8	66.2	63.4	57.8	**61.8**	2.7	4.4
Toplica	69.4	60.8	62.6	63.8	65.3	66.0	58.6	**63.8**	3.6	5.6
Lazarica	64.8	57.4	57.6	59.1	57.8	61.0	56.2	**59.1**	2.9	4.9
Average	**64.2**	**61.5**	**59.7**	**61.6**	**62.6**	**63.3**	**57.8**	**61.6**	**3.2**	**5.1**
σ	3.3	3.8	3.5	1.7	3.2	1.8	1.0	**4.9**	-	-
Cv (%)	5.1	6.2	5.9	2.8	5.1	2.8	1.7	**4.2**	-	-

Environmental factors through different investigated years strongly influenced the sedimentation value, wet gluten content and flour water absorption, even though there was also a significant genotype effects shown by variability parameters. This strong influence of environment on quality traits of wheat is in agreement with results of previous investigations (JOHANSSON *et al*. 2004; DREZNER *et al*. 2007; ZECEVIC *et al*. 2007; ZECEVIC *et al*. 2010).

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