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COMPONENTS OF VARIANCE AND HERITABILITY OF QUALITY PARAMETERS IN WHEAT CULTIVARS

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Fifty wheat genotypes from different selection centers of Yugoslavia and world were analyzed. The experiment for this investigation was performed in a randomized block design in three replications on the experimental field of the Center for Small Grains, Kragujevac and during two year which differed in climate conditions. The 60 plants of each cultivar were analyzed. The protein content was analyzed by Kjeldahl method, and sedimentation value by Zeleny method. The results were calculated by analysis of variance, and components of variance (genetic, interaction, environment, phenotypic) were calculated from analysis of variance. Heritability was calculated as a ratio of genetic/phenotypic variance. High significant differences for grain protein content and sedimentation value at all investigated cultivars were established. High values for grain protein content from 14.4 % in Jugoslavija cultivar to 18.1 % in Hart cv., and sedimentation value from 25.5 ml in Brock cv. and Florida cv. to 70.5 ml in Bankut 1205 cv. were established. The broad-sense heritability of grain protein content was low (h^2=33.2%), and of sedimentation value was high (h^2=90.0%). The highest percentage of the whole phenotypic variability, was assigned to the

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cultivar/year interaction (58.54 %), while only 16.46 % were assigned to genetic factors. Higher impact of genotype (81.5 %) than environment (17.9 %) for the sedimentation value was found by phenotypic variance analysis.

Key words: protein content, sedimentation value, analysis of variance, components of variance, heritability, wheat

INTRODUCTION

Increasing of grain quality stability in wheat cultivar represents one of main breeding task today. For the bread production the most important is cultivar characteristics, but for maximal expression of genetic potential for quality, in medium and high quality cultivars is necessity supply desirable environmental conditions, wet and nutrition (GOTSOVA and RACHINSKA, 1988). One of the important quality parameters of wheat is grain protein content. Protein molecules consist of aminoacids and have complex chemical structure. Flour proteins include gluten and nongluten proteins. The nongluten proteins are essential, because they greatly enhance the functionality of the gluten proteins (FINNEY *et al.*, 1987).

Except the grain protein content, very important quality component of wheat is protein sedimentation value, which use as a parameter of protein quality estimation. Nevertheless high grain protein content need to follow its quality. The sedimentation test described by ZELENY (1947), and later modified by PINCKNEY *et al.* (1957) is one which, if proved to give an accurate evaluation of quality, could be of great value to a breeder. Protein sedimentation value is important quality components, which are in positive correlation with other quality parameters as gluten quality and loaf volume.

MATERIAL AND METHODS

Fifty wheat genotypes from different selection centers in Yugoslavia and other countries (Russia, Italy, Great Britain, SAD, Japan, Hungary, Bulgaria, China, Poland, Belgium, Brazil, Rumania, France, Macedonia and Croatia) were examined.

The experiment was performed in a randomized block design in three replications on the experimental field of the Center for Small Grains, Kragujevac. The seeds were sown in 1 m long rows, with 0.20 m space between the rows and a 0.10 m space between each seed in a row. A total number of 60 plants were analyzed in the stage of full maturity (20 plants per replication). The grain protein content was analyzed by a Kjeldahl method, and the sedimentation value by a Zeleny method.

The following parameters were calculated: the average value ($\bar{x}$); the coefficient of variation (V) as an index of the relative variability of the trait; heritability (h^2) as the ratio between genetic and phenotypic variance; analysis of variance. The significant differences between the average values were estimated by the LSD test.

Table 1. Grain protein content and sedimentation value in wheat

Cultivar	Grain protein content (%)			Sedimentation value (ml)			Quality class
	1st year	2nd year	Average	1st year	2nd year	Average	
Kavkaz	18.1	16.5	17.3	38.3	36.3	37.3	II
Bezostaya 1	16.7	16.1	16.4	61.7	59.3	60.5	I
Mironovskaya 808	15.8	14.4	15.1	61.3	51.0	56.2	I
San Pastore	16.7	15.2	16.0	32.7	24.0	28.3	III
Mara	19.1	16.7	17.9	38.3	41.3	39.8	II
Brimstone	16.2	13.9	15.0	55.3	54.3	54.8	I
Pernel	15.5	14.1	14.8	51.3	44.0	47.7	I
Brock	16.1	15.9	16.0	24.7	26.3	25.5	III
Phenix	15.5	16.0	15.7	62.3	69.3	65.8	I
Blue Boy	15.6	15.4	15.5	47.0	36.0	41.5	I
Seneca	14.8	15.0	14.9	46.7	43.0	44.8	I
Pike	16.2	15.1	15.7	58.0	52.3	55.2	I
Florida	18.1	16.8	17.5	27.0	24.0	25.5	III
Hart	18.2	18.1	18.1	50.3	71.0	60.7	I
Norin 10	18.0	16.8	17.4	44.7	41.0	42.8	I
Akakomugi	15.8	17.0	16.4	41.0	42.0	41.5	I
Bankut 1205	17.1	14.7	15.9	69.7	71.3	70.5	I
Szegedi 7610	15.7	16.6	16.1	36.3	39.3	37.8	II
Szegedi 768	17.7	14.4	16.0	60.0	70.0	65.0	I
Pobeda	16.7	17.5	17.1	32.7	30.0	31.3	II
Katya	15.4	16.1	15.8	53.0	51.0	52.0	I
Rubin	15.1	15.5	15.3	23.3	32.0	27.7	III
Dobrudja 1	17.9	15.7	16.8	60.3	68.0	64.2	I
Peking 8	15.4	15.0	15.2	59.3	60.0	59.7	I
Pai Yu Pao	14.8	18.1	16.5	61.0	71.0	66.0	I
Jawa	16.5	16.3	16.4	55.3	39.0	47.2	I
Minister Dwarf	15.2	14.9	15.0	32.3	41.3	36.8	II
Frontana	16.6	17.8	17.2	38.7	57.0	47.8	I
Fundulea 262	16.1	15.9	16.0	34.3	33.0	33.7	II
Etoille de Choisy	18.0	16.2	17.1	32.0	26.0	29.0	III
KG-56	16.2	16.4	16.3	59.7	64.3	62.0	I
Lepenica	16.7	15.8	16.3	44.7	35.0	39.8	II
Srbijanka	15.5	16.4	16.0	39.3	41.3	40.3	I
Levčanka	14.6	16.4	15.5	46.0	50.3	48.2	I
Sava	14.3	16.6	15.4	45.3	43.0	44.2	I
Partizanka	13.9	16.1	15.0	68.7	67.3	68.0	I
Jugoslavija	13.6	15.2	14.4	44.3	49.0	46.7	I
Evropa	15.3	14.4	14.8	49.7	59.0	54.3	I
Lasta	17.3	15.0	16.2	61.7	62.3	62.0	I
Polimka	15.0	15.9	15.5	34.7	37.3	36.0	II
Zemunka	15.5	17.6	16.5	28.7	42.3	35.5	II
Krajinka	15.0	16.0	15.5	31.7	35.0	33.3	II
Kraljevica	14.4	15.8	15.1	54.0	50.0	52.0	I
ZA-149	16.5	17.5	17.0	55.3	59.0	57.2	I
Skopjanka	14.2	15.1	14.7	40.7	31.0	35.8	II
Radika	16.4	16.4	16.4	54.3	52.3	53.3	I
Baranjka	17.0	17.5	17.3	54.3	47.3	50.8	I
Zlatna Dolina	16.6	17.8	17.2	39.7	48.3	44.0	I
Njivka	14.7	17.3	16.0	51.7	52.0	51.8	I
Poljarka	17.2	16.8	17.0	50.3	68.0	59.2	I
Average	16.1	16.1	16.1	46.9	48.0	47.4	I

The analysis of variance was performed according to a random block system with two factors, allowing the calculation of the components of variance (σ_g^2 - genetic; σ_{gl}^2 - interaction; σ_E^2 - environment; σ_f^2 - phenotypic).

RESULTS AND DISCUSSION

Grain protein content - The grain protein content was very high in all wheat cultivars, on average it was 16.1%. The highest grain protein content was found in the first year in cultivar Mara (19.1 %). In the second year, cultivars Hart (18.1 %) and Pai Yu Pao (18.1 %) had the highest value of this trait. The lowest grain protein content was established in the first year in cv. Jugoslavija (13.6 %), but cultivar Brimstone (13.9 %) had the lowest value for this trait in the second year. In both years, the highest grain protein content was found in cultivar Hart (18.1 %), and the lowest in cv. Jugoslavija (14.4 %), on average. All the cultivars averaged the same values of grain protein content (16.1 %), in both years (Table 1). High grain protein content in wheat had been found in earlier investigations (MUNGOVA and STANKOV, 1987; MIHALJEV and KRALJEVIĆ-BALALIĆ, 1988; DIMITROV *et al.*, 1990; IVANOSKI *et al.*, 1996).

The broad-sense heritability of grain protein content was low (h^2=33.2 %), what indicated low inheritance of this trait and high dependence of environmental factors (Table 2). Earlier investigations indicated high heritability for grain protein content (9-89 %) in dependence of cross combination (FOWLER and DE LA ROCHE, 1975; KNOTT and KUMAR, 1975; SHARMA *et al.*, 1975; COX *et al.*, 1985).

The analysis of phenotypic variance established significant differences in the average value of grain protein content in the cultivars and years. Interaction of a cultivar/year was also very significant. The highest percentage of the whole phenotypic variability, was assigned to the cultivar/year interaction (58.54 %), while only 16.46 % were assigned to genetic factors (Table 2). Other researchers also discovered a high impact of the genotype/environment interaction on the entire phenotypic variance of grain protein content (BAKER and KOSMOLAK, 1977; MIHALJEV, 1981; NOAMAN *et al.*, 1990; LUKOW and MC VETTY, 1991; KADAR and MOLDOVAN, 1999).

Table 2. Components of phenotypic variance for grain protein content in wheat

Source of Variation	DF	MS	F_t	Components of variance		LSD	0.01	0.05
				δ^2	%	Cultivar	0.96	0.73
Replication	2	1.248	-	-	-	Year	0.19	0.15
Cultivar	49	4.941	12.06**	0.27	16.46	Cultivar x Year	1.36	1.03
Year	1	0.025	0.06**	-	-			
Cultivar x Year	49	3.304	8.06**	0.96	58.54			
Error	198	0.410	-	0.41	25.00	h^2=33.2 %		
Total	299			1.64	100.0	V= 4.0 %		

Sedimentation value - The sedimentation value was shown that cultivars differed in grain protein quality. The highest value of sedimentation was found in the second year in cultivar Bankut 1205 (71.3 ml). This cv. had also the highest sedimentation value in the first year (69.7 ml). The lowest value of sedimentation was found for cv. Rubin (23.3 ml) in the first year, but in the second year the lowest value of sedimentation was found in cultivars San Pastore (24.0 ml) and Florida (24.0 ml). On an average for both years, the highest sedimentation value was discovered in cv. Bankut 1205 (70.5 ml), and the lowest in cv. Brock (25.5 ml). On an average, the sedimentation value was higher in the second (48.0 ml) than in the first (46.9 ml) year (Table 1). Those results are in agreement with other (KUBUROVIĆ *et al.*, 1994; PAVLOVIĆ *et al.*, 1994; IVANOSKI *et al.*, 1996).

The broad sense heritability of sedimentation value was high (h^2=90.0 %), what indicated high inheritance of this trait (Table 3). High heritability of sedimentation value had been found in earlier investigations (FOWLER and DE LA ROCHE, 1975; KNOTT and KUMAR, 1975; KONECHNIY and LOMAKINA, 1982; MATUZ, 1998; BRANLARD *et al.*, 2000).

Table 3. Components of phenotypic variance for sedimentation value in wheat

Source of Variation	DF	MS	F_t	Components of variance		LSD	0.01	0.05
				δ^2	%	Cultivar	1.52	1.15
Replication	2	11.561	-	-	-	Year	0.30	0.23
Cultivar	49	910.097	886.03**	136.55	81.53	Cultivar x Year	1.36	1.03
Year	1	0.025	88.35**	-	-			
Cultivar x Year	49	3.304	88.37**	29.91	17.86	h^2=90.0 %		
Error	198	0.410	-	1.03	0.61	V= 2.1 %		
Total	299			167.49	100.0			

The analysis of phenotypic variance established significant differences in the average of sedimentation value in the cultivars and years. Interaction of a cultivar/year was also very significant. The highest percentage of the whole phenotypic variability, was assigned to genetic factors (81.53 %), while only 17.86 % were assigned to the cultivar/year interaction (Table 3). High impact of genetic factors in exspression of sedimentation value had been found in earlier investigation (BAKER and KOSMOLAK, 1977; KAZARCEVA *et al.*, 1991; LUKOW and MC VETTY, 1991; KADAR and MOLDOVAN, 1999).

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KOMPONENTE VARIJANSE I HERITABILNOST PARAMETARA KVALITETA KOD SORTI PŠENICE

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Izvod

U ovom radu su izučavane osobine kvaliteta (sadržaj proteina i sedimentaciona vrednost) kod 50 sorti pšenice poreklom iz selekcionih centara Jugoslavije i sveta. Sorte su gajene na eksperimentalnom polju Centra za strna žita u Kragujevcu u ogledu dizajniranom po slučajnom blok sistemu u tri ponavljanja, u toku dve godine. Za analize osobina kvaliteta korišćeno je 60 biljka (20 biljaka po ponavljanju). Sadržaj proteina odredjen je po *Kjeldahl* metodi, a sedimentaciona vrednost po *Zeleny* metodi. Dobijeni rezultati su statistički obradjeni analizom varijanse. Izračunate su komponente varijanse (genetička, fenotipska, ekološka i interakcija) i heritabilnost u širem smislu za ispitivana svojstva. U ovim istraživanjima su ustanovljene visoko signifikantne razlike u srednjim vrednostima za sadržaj proteina i sedimentacionu vrednost kod svih ispitivanih sorti pšenice. Prosečne vrednosti sadržaja proteina bile su različite kod ispitivanih sorti i varirale su od 14,4 % (Jugoslavija) do 18,1 % (Hart), dok su prosečne vrednosti sedimentacije varirale od 25,5 ml (Brock i Florida) do 70,5 ml (Bankut 1205). Dobijeni rezultati za sadržaj proteina i sedimentacionu vrednost pokazuju da od 50 analiziranih sorti, 35 su pripadale prvoj kvalitetnoj klasi, 5 trećoj a ostale drugoj kvalitetnoj klasi. Ustanovljena je niska heritabilnost u širem smislu za sadržaj proteina (h^2=33,2 %), a visoka za sedimentacionu vrednost (h^2=90.0 %). Analizom komponenti fenotipske varijanse utvrdjeno je da u ispoljavanju sadržaja proteina u zrnu najveći udeo pripada interakciji sorta/godina (58,54 %) dok je udeo genetičkih faktora bio nizak (16,46 %), a kod sedimentacione vrednosti je ustanovljen znatno veći udeo genetičkih (81,53 %) od ekoloških faktora (17.86 %).

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