UDC 575.21; 633.11
Original scientific paper

GENETIC AND PHENOTYPIC VARIABILITY OF YIELD COMPONENTS IN WHEAT (*TRITICUM AESTIVUM* L.)

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Zečević V., D. Knežević, M. Kraljević-Balalić, and D. Mićanović (2004): *Genetic and phenotypic variability of yield components in wheat (Triticum aestivum L.).* – Genetika, Vol. 36, No. 2, 151-159.

The heritability, phenotypic variability and components of variance for spike length and number of spikelets per spike have been studied in 50 cultivars from different selection centers all over the world. The experiment was performed in randomized block design in three replications on the experimental field in two years. A total number of 60 plants have been analyzed in the full maturity stage. Average estimated values of spike length and number of spikelets per spike differed significantly among years and among cultivars. The highest average value of spike length had Mironovskaya 808 cultivar ($\bar{x}$ =14.5 cm), and the lowest value was found in Etoille de Choisy ($\bar{x}$ =8.1 cm) and San Pastore cultivar ($\bar{x}$ =8.2). During investigated periods the highest average value for number of spikelets/spike had Sava cultivar ($\bar{x}$ =28.2), and the lowest value expressed Frontana cultivar ($\bar{x}$ =19.2). The average variation coefficient for spike length was 8.0%, and for number of spikelets per spike was 7.5%. The lowest variability for spike length was established in Pernel cultivar (V=4.8%) and the highest in Lepenica cultivar (V=12.9%). The coefficient of variation for number of spikelets per spike ranged from 4.7% in Bankut 1205 to 12.4% in Norin 10 cultivar. The obtained herita-

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bility values in broad sense were fairly high for spike length (96.4%) and number of spikelets per spike (79.1%). Phenotypic analysis of variance indicated that genetic variance took a larger portion of the total phenotypic variability for spike length (81.82%) and for number of spikelets per spike (57.36%) than influence of environmental factors on expressing of analyzed yield components.

Key words: wheat, cultivar, spike length, number of spikelets/spike, variability, phenotypic variance, heritability

INTRODUCTION

Wheat breeding programs have been directed towards such factors as seed yield and quality. The successful process of wheat breeding 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 need to express genetic potential with low value of variance in different environmental factors of growing. The wheat grain yield is a result of contribution many traits. The characters as spike length and number of spikelets per spike are in positive correlation with grain yield, and have played a great role in increasing the yield potential. The grain yield of wheat is variable trait that depends on numerous yield components and environmental factors (KRALJEVIĆ-BALALIĆ *et al*., 1995). The variability of yield components is less studied than yield itself. The investigation of variability, heritability and components of phenotypic variance for spike length and number of spikelets per spike are very important for the cultivar creation. This two traits are quantitative characters, and learning about the influence of genetic and environmental variability in genetically different wheat cultivars to be necessary for good selection of parents in breeding programs. Little information is available as to the nature and importance of interaction between genotype and environment in determining grain yield in wheat.

The object of this study was to investigate variability, heritability and components of phenotypic variance for spike length and number of spikelets per spike in genetically divergent wheat cultivars which can be used as parent cultivars in breeding programs for improvement grain yield and quality in wheat.

MATERIAL AND METHODS

Fifty wheat cultivars originated from different world selection centers and countries (Brazil, Belgium, Bulgaria, China, Croatia, France, Great Britain, Hungary, Italy, Japan, Macedonia, Poland, Rumania, Russia, USA and Serbia and Montenegro) were selected for this study. The experiment was performed in randomized block design in three replication on the experimental field of Center for Small Grains, Kragujevac in two years. The seeds were sown in 1 m long rows, with 0.20 m space between the rows and 0.10 m distance between each seed in a row. For analysis of spike length and number of spikelets/spike were used 60 plants in full maturity stage (20 plants/replication).

The following parameters were computed: the average value ($\bar{x}$); the variance (σ^2); the coefficient of variation (V) as an index of relative variability of the trait; heritability in broad sense as ratio of genetic/phenotypic variance ($h^2 = \sigma^2_g / \sigma^2_f \times 100$) and analysis of variance. The significant differences between the average values were estimated by LSD-test values (HADŽIVUKOVIĆ, 1991).

The analysis of variance was performed according to a random block system with two factors, allowing the calculation of the components of variance (σ^2_g -genetic, σ^2_{gl} -interaction; σ^2_E -environment; σ^2_f -phenotypic), FALCONER (1981).

RESULTS AND DISCUSSION

Spike length - Spike length has influence on grain yield through number of spikelets per spike. High spike length increases photosynthetic active area and become important source and acceptor of assimilates and has influence to plant production (BOROJEVIĆ *et al*., 1994; DENČIĆ, 1990; DENČIĆ and BOROJEVIĆ, 1992). High variability of spike length in wheat depends on investigated cultivars and years. The very significant differences among the analyzed cultivars and average values of spike length were found, what indicated that divergent genetic material was investigated. Significant differences between years indicated that spike length depended on the environmental conditions during the year of growing.

During investigated period the highest average value of spike length had Mironovskaya 808 cultivar ($\bar{x}$ = 14.5 cm) and Bankut 1205 cultivar ($\bar{x}$ = 14.4 cm). The lowest average value of spike length was found in Etoille de Choisy cultivar ($\bar{x}$ = 8.1 cm) and San Pastore cultivar ($\bar{x}$ = 8.2). The spike length need to be 15 cm combine with high value of grain mass to achieving maximal grain yield in wheat (BOROJEVIĆ, 1990). In this study only Bankut 1205 cultivar had length of spike 15 cm in the first year and several cultivars over the 13 cm (Mironovskaya 808, Blue Boy, Minister Dwarf, Kraljevica, Skopjanka and Radika) what indicated their potential for high grain yield. The results for remain cultivars agree with the results of JOVANOVIĆ *et al*. (1992); RONČEVIĆ *et al*. (1998) and DIMITRIJEVIĆ *et al*. (1996; 2000).

The lowest variability, in average, for spike length was in Pernel cultivar (V = 4.8%) as well as in the first year (V = 4.6%) and in the second (V = 5.0 %). The highest variability of spike length, in average, was established in Lepenica cultivar (V = 12.9%) as well as in the first year (V = 14.4%) and in the second year of investigation (V = 11.5%). Hart cultivar (V = 8.0%) was the most stable of all in both years of investigation. These results are in agreement with obtained values by KOBILJSKI *et al*. (1996). Variability of spike length is controlled by high number of genes which expression highly influenced by environment (JOVANOVIĆ *et al*. 1992). Results are displayed in Table 1.

Heritability in broad sense of spike length has been high (h^2 = 96.4%) what indicated that genetic factors have higher influence than environment on the spike length expression (Table 2). High heritability value of this trait was established in other investigation (PRODANOVIĆ, 1992; ŽIVANOVIĆ *et al*., 1995; MLADENOV, 1996; PETROVIĆ, 2000).

Table 1. Two years average of mean values and variability for spike length and number of spikelets per spike in wheat

Cultivar	Spike length (cm)			Number o spikelets/spike		
	$\bar{x} \pm s\bar{x}$	S	V(%)	$\bar{x} \pm s\bar{x}$	S	V(%)
Kavkaz	11.9±0.11	0.82	6.9	22.4±0.30	2.31	10.4
Bezostaja 1	11.2±0.11	0.83	7.5	24.7±0.22	1.64	6.6
Mironovskaya 808	14.5±0.15	1.12	7.8	25.8±0.21	1.63	6.3
San Pastore	8.2±0.11	0.81	9.8	21.7±0.22	1.70	7.9
Mara	10.8±0.11	0.80	7.3	22.9±0.31	2.40	10.2
Brimstone	11.0±0.09	0.66	6.0	26.8±0.19	1.47	5.4
Pernel	9.6±0.06	0.46	4.8	21.6±0.16	1.22	5.6
Brock	11.7±0.10	0.74	6.4	26.4±0.22	1.73	6.6
Phenix	10.8±0.11	0.81	7.5	23.7±0.22	1.73	7.2
Blue Boy	13.4±0.14	1.03	7.7	23.8±0.16	1.22	5.2
Seneca	11.2±0.12	0.90	8.0	23.2±0.18	1.36	5.9
Pike	11.4±0.13	0.97	8.4	22.4±0.23	1.78	8.0
Florida	11.9±0.14	1.08	9.2	25.4±0.26	2.06	8.0
Hart	10.0±0.11	0.80	8.0	21.2±0.17	1.35	6.4
Norin 10	8.4±0.11	0.80	9.6	22.0±0.36	2.72	12.4
Akakomugi	9.0 ±0.11	0.68	7.6	20.4±0.19	1.48	7.3
Bankut 1205	14.4±0.12	0.91	6.3	25.4±0.16	1.20	4.7
Szegedi 7610	12.2±0.11	0.86	7.0	23.4±0.21	1.63	6.8
Szegedi 768	10.3±0.07	0.52	5.0	23.7±0.16	1.22	5.2
Pobeda	11.0±0.11	0.88	8.0	22.9±0.22	1.64	7.2
Katya	11.4±0.12	0.89	7.8	25.2±0.26	2.07	8.2
Rubin	10.1±0.10	0.78	7.8	25.0±0.20	1.62	6.4
Dobrudža 1	10.0±0.08	0.62	6.2	22.9±0.20	1.52	6.6
Peking 8	12.0±0.11	0.89	7.4	21.0±0.20	1.56	7.5
Pai Yu Pao	8.8±0.14	1.04	11.8	20.3±0.30	2.36	11.6
Jawa	12.4±0.12	0.90	7.2	27.0±0.20	1.52	5.6
Minister Dwarf	13.4±0.13	0.96	7.3	25.0±0.18	1.36	5.5
Frontana	11.3±0.10	0.80	7.1	19.2±0.18	1.38	7.2
Fundulea 262	11.2±0.08	0.63	5.6	21.4±0.15	1.18	5.5
Etoille de Choisy	8.1±0.07	0.52	6.4	21.5±0.20	1.58	7.4
KG-56	10.7±0.11	0.85	8.0	24.0±0.26	1.97	8.2
Lepenica	10.8±0.18	1.40	12.9	22.6±0.24	1.82	8.0
Srbijanka	11.3±0.11	0.86	7.7	24.3±0.24	1.88	7.8
Levčanka	10.8±0.11	0.86	8.0	24.2±0.24	1.80	7.6
Sava	11.2±0.13	0.98	8.8	28.2±0.28	2.21	8.0
Partizanka	10.8±0.17	1.28	11.9	24.2±0.35	2.72	11.1
Jugoslavija	11.0±0.13	1.13	10.2	23.4±0.22	1.67	7.1
Evropa	11.2±0.10	0.73	6.5	22.2±0.19	1.50	6.8
Lasta	11.9±0.12	0.92	7.6	23.4±0.22	1.74	7.4
Polimka	10.0±0.13	1.02	10.2	23.4±0.24	1.82	7.8

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Cultivar	Spike length (cm)			Number o spikelets/spike		
	$\bar{x} \pm s\bar{x}$	S	V(%)	$\bar{x} \pm s\bar{x}$	S	V(%)
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Zemunka	11.2±0.10	0.78	6.9	26.2±0.23	1.96	7.5
Krajinka	10.0±0.10	0.78	7.8	24.4±0.22	1.70	7.1
Kraljevica	13.0±0.14	1.05	8.1	22.8±0.22	1.64	7.2
ZA-149	10.6±0.14	1.10	10.2	22.4±0.25	1.94	8.8
Skopjanka	13.6±0.13	1.00	7.0	24.6±0.24	1.84	7.5
Radika	12.8±0.11	0.88	7.0	23.8±0.22	1.69	7.2
Baranjka	10.2±0.14	1.03	10.0	23.4±0.24	1.90	8.2
Zlatna Dolina	9.4±0.11	0.87	9.2	22.1±0.30	2.28	10.5
Njivka	8.8±0.11	0.80	9.0	21.1±0.22	1.70	8.0
Poljarka	9.3±0.12	0.86	10.0	21.2±0.19	1.46	7.0
Average	11.0±0.11	0.87	8.0	23.4±0.22	1.75	7.47

By the analysis of phenotypic variance established significant differences in average values of spike length in the cultivars and years (Table 2). The highest percentage of the whole phenotypic variability was assigned to genetic factors (81.8%) and to environment (10.6%) while only 5.3% were assigned to the cultivar/year interaction. In total phenotypic variability was established higher impact of genetic factors than environment in investigation by DIMITRIJEVIĆ *et al*. (1996), PETROVIĆ *et al*. (1999).

Table 2. Components of phenotypic variance for spike length in wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				σ^2	%			
Replication	2	0.084	-	-	-	Cultivar	0.37	0.28
Cultivar	49	13.421	216.32**	2.16	81.82	Year	0.08	0.06
Year	1	42.907	691.58**	0.28	10.61	Cultivar x year	0.53	0.40
Cultivar x year	49	0.481	7.75**	0.14	5.30	h2=96.4%		
Error	198	0.062	-	0.06	2.27	V=8.0 %		
Total	299	-	-	2.64	100.00			

Number of spikelets per spike - Number of spikelets/spike depends from spike length and compactness of spike. The analyzed wheat cultivars showed significant phenotypic variability for number of spikelets per spike in wheat. All values are highly significant, and agree with previous studies (PETROVIĆ *et al*., 1996). High variability of number of spikelets per spike in wheat depended on investigated cultivars and years. Significant differences between years indicated that spike length depended on the environmental conditions during the year of growing.

During investigated periods the highest average value of number of spikelets/spike had Sava cultivar ($\bar{x}$ = 28.2) that was the highest in first (29.4) and second year (27.0). The lowest average value of number of spikelets/spike expressed Frontana cultivar ($\bar{x}$ = 19.2) that had the lowest number of spikelets/spike in first ($\bar{x}$ = 19.8) and in the second year ($\bar{x}$ = 18.7). For expression of high yield in wheat it is desirable more than 18 spikelets/spike and in average 3 kernels/spikelets (BOROJEVIĆ, 1972). In this study all cultivars had more than 18 spikelets because of low density of planting. Number of productive spikelets /spike has influence on grain yield. These two traits are in positive correlation (BHATT, 1973). Obtained results for number of spikelets per spike are in agreement with results that were established in earlier investigation (PETROVIĆ *et al*., 1993; DIMITRIJEVIĆ *et al*., 1996; RONČEVIĆ *et al*., 1998).

The coefficient of variability for number of spikelets/spike was computed for each cultivar in both investigated year. Variability for number of spikelets/spike in analyzed cultivars, in average, was expressed and coefficient of variability has been the highest in Norin 10 cultivar (V = 12.4%) while the lowest in Bankut 1205 cultivar (V = 4.7%). Similar results for variability of number of spikelets/spike were reported by PETROVIĆ *et al*. (1993); IVEZIĆ (1994); KOBILJSKI *et al*. (1996); DIMITRIJEVIĆ *et al*. (1996; 2000). Results are displayed in Table 1.

Table 3. Components of phenotypic variance for number of spikelets per spike in wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				σ^2	%			
Replication	2	0.857	-	-	-	Cultivar	1.30	0.98
Cultivar	49	20.419	27.31**	2.69	57.36	Year	0.26	0.20
Year	1	16.799	22.47**	0.08	1.70	Cultivar x year	1.84	1.39
Cultivar x year	49	4.262	5.70**	1.17	24.95	h2=79.1%		
Error	198	0.748	-	0.75	15.99	V=7.5 %		
Total	299	-	-	4.69	100.00			

The heritability in broad sense for number of spikelets/spike was high (h^2 = 79.1%) what indicated that genetic factors had higher impact than environment on the expression of this trait (Table 3). The value of heritability of this trait is in agreement with values which established by PRODANOVIĆ *et al*., 1992; PETROVIĆ *et al*., 1993; MLADENOVIĆ, 1995; ŽIVANOVIĆ *et al*., 1995; MLADENOV, 1996; PETROVIĆ, 2000). The heritability in broad sense for this trait was the lowest in investigation that reported by MIHALJEV (1968).

The analysis of phenotypic variance established significant differences in the average value for number of spikelets/spike in the cultivars and years (Table 3). The highest percentage of the whole phenotypic variability for number of spikelets/spike was assigned to genetic factors (57.4%) than to environment (1.7%) and 25.0% were assigned to the cultivar/year interaction. Similar results and higher impact in the total phenotypic variability had genetic factors than environment presented by other authors (PETROVIĆ *et al*., 1993; MLADENOV, 1996;). In contrary of these results, the higher impact of environment than genetic factor on expression number of spikelets/spike was established by MLADENOVIĆ (1995). The low phenotypic variability for number of spikelets/spike was established by investigation (DOTLAČIL and TOMAN, 1991).

CONCLUSION

Average estimated values of spike length and number of spikelets per spike differed significantly among years and among cultivars. The highest average value of spike length had Mironovskaya 808 cultivar, and the lowest value was found in Etoille de Choisy and San Pastore cultivar. During investigated periods the highest average value of number of spikelets/spike had Sava cultivar, and the lowest value expressed Frontana cultivar.

The variability of spike length and number of spikelets per spike was low. The lowest variability for spike length was established in Pernel and the highest in Lepenica cultivar, while the lowest variability for number of spikelets per spike was estimated in Bankut 1205 and the highest in Norin 10 cultivar. The heritability values in broad sense were very high for length of spike and number of spikelets per spike. Phenotypic analysis of variance indicated that there was a larger influence of genetic factors for length of spike and for number of spikelets per spike than influence of environmental factors on expressing of analyzed yield components.

Received April 15th, 2004
Accepted May 28th, 2004

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GENETIČKA I FENOTIPSKA VARIJABILNOST KOMPONENTI PRINOSA KOD PŠENICE (*TRITICUM AESTIVUM* L.)

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Izvod

U radu je proučavana genetička i fenotipska varijabilnost dužine klasa i broja klasića po klasu kod 50 genetički divergentnih sorti pšenice. Istraživanja su obavljena u poljskom ogledu izvedenom po slučajnom blok sistemu u tri ponavljanja, tokom dve godine. Analize su uradjene na uzorku od 60 biljka u punoj fazi zrelosti. Utvrdjene su signifikantne razlike za dužinu klasa i broj klasića po klasu izmedju sorti i godina. Najveća vrednost dužine klasa ustanovljena je kod sorte Mironovskaya 808 (14,5 cm), a najmanja kod sorti Etoille de Choisy (8,1 cm) i San Pastore (8,2 cm). Sorta Sava je imala najveći broj klasića po klasu (28,2), a najmanja vrednost za ovo svojstvo utvrdjena je kod Frontane (19,2). Prosečna varijabilnost dužine klasa (V = 8,0%) i broja klasića po klasu (V = 7,5%) bila je dosta niska. Najmanju varijabilnost za dužinu klasa ispoljila je sorta Pernel (V = 4,8%), a za broj klasića po klasu sorta Bankut 1205 (V = 4,7%). Utvrdjena je visoka vrednost za heritabilnost u širem smislu za dužinu klasa (h^2 = 96,4%), a nešto niža vrednost za broj klasića po klasu (h^2 = 79,1%). Analizom komponenti fenotipske varijanse ustanovljeno je da genetički faktori imaju veći udeo u ispoljavanju dužine klasa (81,82%) i broja klasića po klasu (57,36%) od faktora spoljne sredine.

Primljeno 15. IV 2004.
Odobreno 28. V 2004.