Kragujevac J. Sci. 31 (2009) 85-90. UDC 575.21/22:633.11

GENETIC AND PHENOTYPIC VARIABILITY OF NUMBER OF SPIKELETS PER SPIKE IN WINTER WHEAT

Veselinka Zečević[1], Desimir Knežević[2], Jelena Bošković[1], Danica Mićanović[3] and Biljana Dimitrijević[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] *Small Grains Research Centre, Kragujevac, Republic of Serbia*

(Received April 15, 2009)

ABSTRACT. In this paper it was analyzed the genetic and phenotypic variability of the fertile and sterile spikelets number per spike in ten cultivars of winter wheat (KG-56, Srbijanka, Lepenica, Oplenka, Ljubičevka, Jugoslavija, Zagrepčanka, Nizija, Slavonija and Baranjka), which are originated from different selection centers. Experiment was performed by random block system in five repetitions on the experimental field of Small Grains Research Centre of Kragujevac in the two years. It was performed an analysis of the examined characteristics of 50 plants in the full maturity stage. Significant differences among cultivars, production years and their interaction were determined. The highest average value of number of fertile spikelets per spike had a cultivar Ljubičevka (20.7), and the lowest cultivar Lepenica (18.4). Variability of this trait was similar in both years of research (V=7.3%; V=7.8%, respectively). The average number of sterile spikelets per spike was higher in the first (1.12) than in the second year (0.96). The lowest average sterile spikelets per spike established at cultivars Ljubičevka and Jugoslavija (0.5), and the highest at cultivars Zagrepčanka and Nizija (1.6). By the analysis of components of phenotypic variance it was established that in expression of fertile spikelets per spike years had the greatest impact (35.05%), but something smaller proportion belonged to the cultivars (20.62%). However, genotypes had the largest share in the expression of number of sterile spikelets per spike (57.45 %), which means that spike sterility mostly depends to genetic factors.

Key words: wheat, cultivar, number of spikelets per spike, variability

INTRODUCTION

Grain yield is a complex trait that highly influenced by many genetic and environmental factors (KRALJEVIĆ-BALALIĆ *et al*., 1995). In plant breeding program, direct selection for yield as such could be misleading. A successful selection depends upon the information on the genetic variability and association of morpho-agronomic traits with grain yield (ALI *et al*., 2008). Grain yield is under big influence of spike properties, and interdependence and correlation between spike length and spikelet number per spike (MARTINČIĆ *et al*., 1996). However, a spikelet number per spike plays a very important role in

the possible increase of grain yield of new genotypes. All spikelet florets are not fertile and the number of fertile florets depends significantly of genotype and ecological factors (SABO *et al*., 2002). The apical and basal spikelets are often sterile, and in each spikelet the third floret (counting from the base) is often sterile and the fourth floret usually sterile. Apart from these differences, the spikelets and florets are indistinguishable at maturity (STEWART, 1950).

The successful process of wheat breeding based on the knowledge of characteristics of genotypes, environment and their interaction. 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 genotype-environment interaction presence complicate selection of superior genotypes. 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 study was to evaluate the variability of number of spikelets per spike in genetically divergent wheat cultivars that can be used as parent cultivars in breeding programs to improve grain yield in wheat.

MATERIAL AND METHODS

Ten winter wheat cultivars (KG-56, Srbijanka, Lepenica, Oplenka, Ljubičevka, Jugoslavija, Zagrepčanka, Nizija, Slavonija and Baranjka) originated from different selection centers and countries were selected for this study. The experiment was performed in randomized block design in five replications with plot of $5m^2$ size on the experimental field of Small Grains Research Centre, Kragujevac in two years. Seeding rate was with 650 seeds per m^2. For analysis of number of spikelets per spike were used 50 plants (10 plants per replication) in full maturity stage.

The following parameters were computed: the average value ($\bar{x}$), the standard deviation (S), the variance (σ^2), the coefficient of variation (V) as an index of relative variability of the trait, 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

Number of fertile spikelets per spike. - The highest average value of number of fertile spikelets per spike had a cultivar Ljubičevka (20.7), which had the smallest number of sterile spikelets per spike (Table 1 and 3). The lowest number was in the cultivar Lepenica (18.4) which had in average one of sterile spikelets per spike. Higher average values of fertile spikelets are determined in the second (20.3) than in the first year (18.9). Variability of fertile spikelets per spike was similar in both years of investigation (V =7.3%; V=7.8%, respectively). The highest variability was at cultivar Nizija in the first year (V=10.6%) and Baranjka in the second year (V =10.5%), but the lowest at the Jugoslavija cultivar in the first year (V=5.3%). Study of number of spikelets per spike is important because the number of spikelets per spike significantly affect the grain number and grain mass per spike in wheat. In previous research (ZEČEVIĆ *et al*., 2004; ÁLVARO *et al*., 2008; BILGIN *et al*., 2008) established a significant positive correlation between the number of spikelets per spike and other spike

components (spike length, number of grains and grain weight per spike) which directly influence the grain yield of wheat cultivars.

Table 1. Mean values and variability for number of fertile spikelets per spike in wheat

Cultivar	1st year			2nd year			Average
	$\bar{x} \pm s_{\bar{x}}$	S	V (%)	$\bar{x} \pm s_{\bar{x}}$	S	V (%)	$\bar{x} \pm s_{\bar{x}}$
KG-56	19.4±0.20	1.42	7.4	19.8±0.22	1.58	8.1	19.6±0.21
Srbijanka	20.0±0.15	1.09	5.5	21.2±0.21	1.49	7.1	20.6±0.18
Lepenica	17.8±0.20	1.41	7.8	19.0±0.22	1.56	8.3	18.4±0.21
Oplenka	19.0±0.20	1.40	7.4	21.4±0.21	1.48	7.0	20.2±0.20
Ljubičevka	20.2±0.16	1.14	5.7	21.2±0.24	1.68	8.0	20.7±0.20
Jugoslavija	19.6±0.15	1.04	5.3	20.4±0.18	1.28	6.3	20.0±0.16
Zagrepčanka	18.6±0.20	1.43	7.8	20.1±0.25	1.74	8.7	19.4±0.22
Nizija	17.5±0.26	1.84	10.6	20.1±0.18	1.28	6.4	18.8±0.22
Slavonija	18.3±0.21	1.50	8.3	19.5±0.22	1.53	7.9	18.9±0.22
Baranjka	18.9±0.19	1.35	7.2	20.1±0.29	2.09	10.5	19.5±0.24
Average	18.9±0.19	1.36	7.3	20.3±0.22	1.57	7.8	-

By the analysis of variance were established statistically highly significant differences between cultivars and years, and a significant differences between interaction of cultivar x year (Table 2). The estimates of phenotypic variance indicated that in the expression of fertile spikelets per spike years had the greatest impact (35.05%), but something smaller proportion belonged to the cultivars (20.62%). This means that the number of spikelets per spike, as quantitative traits of wheat, greatly depended on the environmental factors (IQBAL & CHOWDHARY, 2000; SABO *et al*., 2002; ALI *et al*., 2008; BILGIN *et al*., 2008).

Table 2. Components of phenotypic variance for number of fertile spikelets per spike in wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				δ^2	%			
Replication	4	1.383	-	-	-	Cultivar	0.945	0.712
Cultivar	9	5.724	8.94**	0.40	20.62	Year	0.423	0.319
Year	1	35.641	55.69**	0.68	35.05	Cultivar x year	1.337	1.008
Cultivar x year	9	1.743	2.72*	0.22	11.34	V= 4.07 %		
Error	76	0.640	-	0.64	32.99			
Total	99	-	-	1.94	100.00			

Number of sterile spikelets per spike. - In a broad sense, a sterile floret or spike is one that has no grain at maturity. Terminology and relevant measurements are used by different scientist to define wheat sterility (BODRUZZAMAN, 2005). In this study found very high variability of number of sterile spikelets per spike by year and cultivars studied (Table 3 and 4). Number of sterile spikelets per spike was in the range of 0.4 (Jugoslavija in the first year and Ljubičevka in the second year) to 1.6 (Nizija in the first year). These values are similar to the results that other researchers have received (DYCK *et al*., 2004). The lowest average sterile spikelets per spike established at cultivars Ljubičevka and Jugoslavija (0.5), and the highest at cultivars Zagrepčanka and Nizija (1.6). The average number of sterile spikelets per spike was higher in the first than in the second year of research (1.12; 0.96, respectively).

Table 3. Mean values for number of sterile spikelets per spike in wheat

Cultivar	1st year	2nd year	Average
	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$	$\bar{x} \pm s_{\bar{x}}$
KG-56	0.9±0.11	0.8±0.11	0.8±0.11
Srbijanka	0.9±0.11	0.8±0.11	0.8±0.11
Lepenica	1.0±0.10	0.9±0.11	1.0±0.10
Oplenka	1.5±0.14	1.1±0.10	1.3±0.12
Ljubičevka	0.6±0.08	0.4±0.08	0.5±0.08
Jugoslavija	0.4±0.09	0.6±0.10	0.5±0.10
Zagrepčanka	1.5±0.12	1.6±0.11	1.6±0.12
Nizija	1.8±0.12	1.5±0.08	1.6±0.10
Slavonija	1.0±0.09	0.7±0.10	0.8±0.10
Baranjka	1.6±0.10	1.2±0.12	1.4±0.11
Average	1.12±0.11	0.96±0.10	-

The analysis of components of variance showed that genotype have the most impact in variability of sterile spikelets per spike (57.45 %), which means that spike sterility mostly depends to genetic factors (Table 4). It is known that the apical and basal spikelets are often sterile, and in each spikelet the third floret (counting from the base) is often sterile and the fourth floret usually sterile (STEWART, 1950). Spike sterility depends on environmental factors and plant nutrition with macro and micro-elements. When crops of wheat are stressed like cold temperature and boron deficiency during reproductive development, grain number in potentially fertile florets is reduced (RERKASEM, 1995; SUBEDI *et al*., 2000).

Table 4. Components of phenotypic variance for number of sterile spikelets per spike in wheat

Source of variation	DF	MS	Ft	Components of variance		LSD	0.01	0.05
				δ^2	%			
Replication	4	0.350	-	-	-	Cultivar	0.385	0.290
Cultivar	9	1.728	16.36^{**}	0.162	57.45	Year	0.172	0.129
Year	1	0.792	7.50^{**}	0.014	4.96			
Cultivar x year	9	0.107	1.01^{ns}	0.000	0.00	V=31.47 %		
Error	76	0.106	-	0.106	37.59			
Total	99	-	-	0.282	100,00			

References:

[1] ALI Y., B. MANZOOR ATTA, J. AKHTER, F. MONNEVEUX & Z. LATEEF (2008): Genetic variability, association and diversity studies in wheat (*Triticum aestivum* L.) germplasm. *Pak. J. Bot*., **40** (5): 2087-2097.

[2] ÁLVARO F., J. ISIDRO, D. VILLEGAS, L.F. GARCÍA DEL MORAL & C. ROYO (2008): Old and modern durum wheat varieties from Italy and Spain differ in main spike components. Field Crops Research, **106** (1): 86-93.

[3] BILGIN O., K.Z. KORKUT, İ. BAŞER, O. DAĞLIOĞLU, İ. ÖZTÜRK & T. KAHRAMAN (2008): Determination of variability between grain yield and yield components of durum wheat varieties (*Triticum durum* desf.) in Thrace region. *Journal of Tekirdag Agricultural Faculty*, **5** (2): 101-109.

[4] BODRUZZAMAN M., C. A. MEISNER, M. A. SUFIAN, M. A. SAMAD, M. SAIFUZZAMAN & M. A. SADAT (2005): Addressing wheat sterility through nutrient management. *Bangladesh Agricultural Research Institute-Wheat Research Center,* Dinajpur & CIMMYT Bangladesh, 1-19.

[5] DHUNGANA P., K.M. ESKRIDGE, P.S. BAENZIGER, B.T. CAMPBELL, K.S. GILL, AND I. DWEIKAT (2007): Analysis of genotype-by-environment interaction in wheat using a structural equation model and chromosome substitution lines. *Crop Science*, **47**: 477-484.

[6] DYCK A.J., M. A. MATUS-CÁDIZ, P. HUCL, L. TALBERT, T. HUNT, J. P. DUBUC, H. NASS, G. CLAYTON, J. DOBB & J. QUICK (2004): Agronomic performance of hard red spring wheat isolines sensitive and insensitive to photoperiod. *Crop Science*, **44** (6): 1976-1981.

[7] FALCONER D.S. (1981): *Introduction to quantitative genetics*. Longwan, London and New York.

[8] HADŽIVUKOVIĆ S. (1991): *Statistički metodi*. Drugo prošireno izdanje. Radnički univerzitet "Radivoj Ćirpanov", Novi Sad.

[9] IQBAL K. & A.M. CHOWDHARY (2000): Combining ability estimates for some quantitative traits in five spring wheat (*Triticum* aestivum L.) genotypes. Pakistan Journal of Biological Science, **3** (7): 1126-1127.

[10] KRALJEVIĆ-BALALIĆ M., M. DIMITRIJEVIĆ, S. PETROVIĆ (1995): Interakcija genotip / sredina za komponente prinosa. *I simpozijum oplemenjivanja organizama*. Vrnjačka Banja, 58.

[11] MARTINČIĆ J., M. BEDE & S. MARIĆ (1996): Connection between ear length and kernel yield and quality in winter wheat varieties. Proc. 10th Inter. Cereal Breed Congr., Port Caras, 111.

[12] RERKASEM, B. (1995): A general survey of the incidence of wheat sterility. Sterility in wheat in subtropical Asia: Extent, causes and solutions. *ACIAR Proceedings* No. 72, 8-12.

[13] SABO M., M. BEDE & Ž.U. HARDI (2002): Variability of grain yield components of some new winter wheat genotypes (*Triticum aestivum* L.). *Rostilnná Výroba*, **48** (5): 230-235.

[14] STEWART (1950): Basal sterility in wheat. *Nature*, **165**: 653-654.

[15] SUBEDI D. K., P. J. GREGORY, R. J. SUMMERFIELD & M. J. GOODING (2000): Pattern of grain set in boron-deficient and cold stressed wheat (*Triticum aestivum* L.). *Journal of Agricultural Science*, Cambridge, **134**: 25-31.

[16] WEIKAI Y. & L.A. HUNT (2001): Interpretation of genotype x environment interaction for winter wheat yield in Ontario. *Crop Science*, **41**: 19-25.

[17] ZEČEVIĆ VESELINKA, D. KNEŽEVIĆ & DANICA MIĆANOVIĆ (2004): Genetic correlations and path coefficient analysis of yield and quality components in wheat. *Genetics*, Belgrade, **36** (2): 151-159.