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GENETIC AND PHENOTYPIC VARIABILITY OF SPIKE LENGTH AND PLANT HEIGHT IN WHEAT

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ABSTRACT. The genetic and phenotypic variability for plant height and spike length were analyzed in ten winter wheat cultivars from different selection centers. The experiment was performed in randomized block design in five replications on the experimental field in two years. A total number of 50 plants have been analyzed in the full maturity stage. Average estimated values of plant height and spike length differed significantly among years and among cultivars. The highest average value for plant height established at Ljubičevka cultivar (89cm), and the lowest average plant height established at Zagrepčanka (64.0cm). Higher values are established in the second year than in the first year of investigation (69.1cm, 63.9cm, respectively). The variation coefficient of plant height for all examined cultivars and years varied from 2.7% to 6.1%. The highest average value for spike length showed Ljubičevka (9.8cm), and the lowest Slavonija (7.0cm). All investigated cultivars had higher average value of spike length in the second year (8.8cm) than in the first year (7.7cm). The variation coefficient of spike length for all examined cultivars and years varied from 5.3% (Jugoslavija) to 8.7% (Baranjka).

The highest influence on plant height expression had genetic factors (66.16%), but lower impact belonged to environmental factors (26.75%), and only 3.31% belonged to genetic/environment interaction. Spike length expression also highly depended to genetic factors (52.60%), but on this trait expression the environmental factors had higher influence (40.26%) than on plant height.

Key words: wheat, cultivar, plant height, spike length, variability

INTRODUCTION

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. 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).

Grain yield of wheat is the integration of many variables that affect plant growth throughout the growing period. Great efforts have been made to develop proper models that can predict wheat grain yield and distinguish the ideal crop. The knowledge of genetic association between grain yield and its components would improve the efficiency of breeding programs by identifying appropriate indices for selecting wheat varieties (EVANS & FISCHER, 1999). The grain yield of wheat is variable trait that depends on mainly yield components and environmental factors (KRALJEVIĆ-BALALIĆ *et al*., 1995). However, the variability of yield is more studied than yield components. The investigation of variability and components of phenotypic variance for plant height and spike length are very important for the cultivar creation in breeding programs. These two traits are quantitative characters which are in correlations with other yield components (ZEČEVIĆ *et al*., 2004b), and knowledge about the influence of genetic and environmental variability in genetically different wheat cultivars can be necessary for good selection of parents in breeding programs.

The aim of this paper was to study components of phenotypic variability for plant height and spike length in genetically divergent wheat cultivars which can be used as parent cultivars in breeding programs for improvement grain yield and quality in wheat.

MATERIALS 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 plant height and spike length were used 50 plants (10 plants per replication) in full maturity stage.

The following statistical 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. 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

The analyzed yield components are variable traits and their expression highly depended on the environmental factors. The investigated cultivars showed significant differences in the average values of plant height and spike length. It indicated diversity of investigated genotypes. Wheat cultivars showed significant phenotypic and genotypic variability for investigated yield components. Variability of plant height and spike length depended on both investigated cultivars and years, what are in agreement with previous study (KHAN *et al*., 2004).

Plant height. –The results of plant height are presented in Table 1. The highest average value established at Ljubičevka cultivar (89cm), which had the highest values in both years. The lowest average plant height established at Zagrepčanka (64.0cm), which had the lowest values in both investigated years. Higher values are established in the second year than in the first year of investigation (69.1cm, 63.9cm, respectively). Genetic diversity of wheat genotypes influenced the differences in plant height. The cultivars have shown their own genetic properties for plant height.

The plant height is a variable trait and its expression highly depends on the environmental factors. This is confirmed by high values of the coefficient of variation which ranged from 2.7% to 6.1% (Table 1). Average variation coefficient was similar in both years (4.0%, 4.9%). The lowest variability showed Oplenka in the first year (V=2.7%), and the highest variation coefficient had Baranjka in the second year (V=6.1%). In earlier investigations established higher variation coefficient for plant height than in ours (RONČEVIĆ *et al*., 1998; ZEČEVIĆ *et al*., 2004a). The differences are most likely caused by variability of genetic materials and environmental conditions in which field experiment was performed.

Table 1. Mean value and variability for plant height in wheat

Cultivar	Plant height (cm)						Average
	1st year			2nd year			
	$\bar{x} \pm S_{\bar{x}}$	S	V (%)	$\bar{x} \pm S_{\bar{x}}$	S	V (%)	
KG-56	79.8±0.40	2.82	3.6	91.0±0.62	4.36	4.8	85.4
Srbijanka	75.1±0.37	2.60	3.5	88.0±0.53	3.76	4.3	81.6
Lepenica	79.3±0.62	4.36	5.6	87.7±0.70	4.96	5.7	83.5
Oplenka	80.2±0.30	2.13	2.7	91.6±0.49	3.45	3.8	85.9
Ljubičevka	82.4±0.36	2.54	3.1	95.6±0.59	4.18	4.4	89.0
Jugoslavija	81.4±0.36	2.51	3.1	93.1±0.49	3.45	3.7	87.2
Zagrepčanka	61.7±0.49	3.44	5.6	66.3±0.54	3.83	5.8	64.0
Nizija	65.4±0.43	3.06	4.7	74.7±0.45	3.16	4.3	70.0
Slavonija	62.8±0.71	5.0	4.0	67.2±0.55	3.90	5.9	65.0
Baranjka	63.9±0.38	2.69	4.2	69.1±0.59	4.15	6.1	66.5
Average	73.2±0.44	3.12	4.0	82.4±0.56	3.92	4.9	77.8

The components of phenotypic variance were analyzed to evaluation the influence of genetic and environmental factors to phenotype (Table 2). According to the obtained results established significant differences in the average values for plant height in the cultivars and years. The highest influence on plant height expression had genetic factors (66.16%), but lower impact belonged to environmental factors (26.75%), and only 3.31% belonged to genetic/environment interaction. These results are in agreement with previous reported by DIMITRIJEVIĆ *et al*. (1997, 2001), PETROVIĆ *et al*. (2000), and ZEČEVIĆ *et al*. (2004a).

The plant height has very important influence on harvest index and grain yield, because harvest index increases at semi-dwarf wheat cultivars (KOBILJSKI & DENČIĆ, 1995; PETROVIĆ *et al*., 1997; ZEČEVIĆ and KNEŽEVIĆ, 1997). The relationship between yield and its components in wheat are investigated previously and established that the plant height had negative correlation with harvest index and positive correlation with spike length (ZEČEVIĆ *et al*., 2004b; LEILAH & AL-KHATEEB, 2005).

Table 2. Components of phenotypic variance for plant height in wheat

Source of variation	DF	MS	Components of variance		LSD	0.01	0.05
			δ^2	%			
Replication	4	11.60	-	-	Cultivar	2.821	2.126
Cultivar	9	1027.88	99.72	66.16	Year	1.261	0.950
Year	1	2050.28	40.32	26.75	Cultivar x year	3.989	3.007
Cultivar x year	9	30.65	4.99	3.31	V=3.1%		
Error	76	5.700	5.70	3.78			
Total	99	-	150.73	100.00			

Spike length. – This trait is genetically controled, but it highly depends to environmental factors. According to the results, the highest average value for spike length have shown Ljubičevka (9.8cm), and the lowest Slavonija 7.0cm. The cultivars had higher average values of spike length in the second year (8.8cm) than in the first investigated year (7.7cm). The results for spike length obtained in this study agree with those obtained in earlier investigation by RONČEVIĆ *et al*. (1998).

Table 3. Mean value and variability for spike length in wheat

Cultivar	Spike length (cm)						Average
	1st year			2nd year			
	$\bar{x} \pm S_{\bar{x}}$	S	V (%)	$\bar{x} \pm S_{\bar{x}}$	S	V (%)	
KG-56	8.0±0.07	0.50	6.3	9.2±0.10	0.71	7.9	8.6
Srbijanka	8.6±0.08	0.56	6.6	10.0±0.11	0.79	8.0	9.3
Lepenica	7.5±0.06	0.40	5.4	8.2±0.08	0.58	7.2	7.8
Oplenka	7.6±0.09	0.62	8.3	9.4±0.10	0.73	7.8	8.5
Ljubičevka	9.1±0.08	0.57	6.3	10.6±0.12	0.84	7.9	9.8
Jugoslavija	8.4±0.06	0.44	5.3	9.2±0.07	0.52	5.7	8.8
Zagrepčanka	7.2±0.08	0.55	7.8	8.4±0.08	0.58	6.9	7.8
Nizija	7.0±0.07	0.52	7.5	7.9±0.08	0.56	7.2	7.4
Slavonija	6.5±0.06	0.46	7.0	7.5±0.08	0.54	7.2	7.0
Baranjka	6.9±0.08	0.54	7.9	8.0±0.09	0.69	8.7	7.4
Average	7.7±0.07	0.52	6.8	8.8±0.09	0.65	7.4	8.2

The variation coefficient of spike length for all examined cultivars and years varied from 5.3% at Jugoslavija in the first year to 8.7% at Baranjka in the second investigated year. Obtained results for spike length variability agree with previous studies (DIMITRIJEVIĆ *et al*., 2000; ZEČEVIĆ *et al*., 2004c).

Spike length expression also highly depended to genetic factors (52.60%), but on this trait expression environmental factors had higher influence (40.26%) than on plant height. That showed phenotypic variance analysis (Table 4). Both of investigated traits highly depended to genetic and environmental factors. These results are in agreement with previous reported by DIMITRIJEVIĆ *et al*. (1996) and ZEČEVIĆ *et al*. (2004c). The spike length is yield components which highly positively correlated to number of spikelets per spike (RONČEVIĆ *et al*., 1998; ZEČEVIĆ *et al*., 2004b). Likewise, the spike length has strong indirect influence through number of spikelets per spike on grain weight per plant (ZEČEVIĆ *et al*., 2004b; LEILAH & AL-KHATEEB, 2005).

Table 4. Components of phenotypic variance for spike length in wheat

Source of variation	**DF**	**MS**	**Components of variance**		**LSD**	**0.01**	**0.05**
			δ^2	**%**			
Replication	4	0.337	-	-	**Cultivar**	0.336	0.253
Cultivar	9	8.332	0.81	52.60	**Year**	0.151	0.114
Year	1	31.136	0.62	40.26	**Cultivar x year**	0.476	0.358
Cultivar x year	9	0.254	0.03	1.95	V=3.4%		
Error	76	0.081	0.08	5.19			
Total	99	-	1.54	100.00			

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