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PHENOTYPIC VARIABILITY AND HERITABILITY OF PLANT HEIGHT IN WHEAT (*TRITICUM AESTIVUM* L.)

Veselinka ZEČEVIĆ, Desimir KNEŽEVIĆ, and Danica MIĆANOVIĆ

Agriculture Research Institute SERBIA, Center for Small Grains Kragujevac, 34000 Kragujevac, Serbia and Montenegro

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Variability, heritability and components of variance 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 during two seasons. A total number of 60 plants have been analyzed in the full maturity stage. The analyzed cultivars displayed very significant differences in the average value of plant height. The average variability of plant height was V=7.4%. The lowest variability of plant height was found in the Fundulea cultivar (V=5.2%), and the highest in Norin 10 (V=9.8%) cultivar. The obtained heritability value in broad sense was very high for plant height (h^2=95.9%). Phenotypic analysis of variance indicated that there was a larger influence of genetic factors for plant height (84.32%) than influence of environmental factors on expressing of analyzed yield components.

Key words: wheat, cultivar, plant height, variability, phenotypic variance, heritability

Corresponding author: Veselinka Zečević, Agriculture Research Institute SERBIA, Center for Small Grains Kragujevac, S. Kovačevića 31, 34000 Kragujevac, Serbia and Montenegro. tel.: 381-34-333-046; fax: 381-34-304-100; e-mail: joca@knez.uis.kg.ac.yu

INTRODUCTION

The aim of wheat breeding is to achieve high and stable grain yield and high quality in created cultivars. The successful process of wheat breeding based on the knowledge of characteristics of genotypes as well interaction of genotypes and environments. The ideal cultivar for high grain yield or for any other desirable traits need to express genetic potential in different environment with low value of variance in different environmental factors of growing. The wheat grain yield is a result of contribution many traits as well as plant height, length of spike, number of spikelets per spike etc. which are in positive correlation with grain yield. The investigation of variability, heritability and components of phenotypic variance of plant height are very important for the cultivar creation. The grain yield of wheat is variable trait which depends on numerous yield components and environmental factors (KRALJEVIĆ-BALALIĆ *et al*., 1995). The yield variability is less studied than yield itself. The investigation of many components of yield in genetically different wheat cultivars is very important for choosing the genotypes for the wheat breeding which will possess particularly desirable traits. Plant height has very important influence on harvest index and grain yield, harvest index increases at semi-dwarf wheat cultivars (PETROVIĆ *et al*., 1994; 1997; KOBILJSKI and DENČIĆ, 1995).

The aim of this paper was to study components of phenotypic variability, and heritability of plant height 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 (Russia, Italy, Great Britain, USA, Japan, Hungary, Bulgaria, China, Poland, Belgium, Brazil, Rumania, France, Macedonia, Croatia and Yugoslavia) were examined. The experiment was performed in randomized block design in three replication on the experimental field of Center for Small Grains, Kragujevac, Yugoslavia. 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 plant height 60 plants were used 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, and the significant differences between the average value were estimated by LSD-test values (HADŽIVUKOVIĆ, 1991).

The heritability in broad sense was determined as ratio of genetic/phenotypic variance ($h^2=\sigma^2_g/\sigma^2_f$ x 100). 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 wheat cultivars showed significant phenotypic variability for plant height in wheat. High variability of plant height of wheat depends on investigated cultivars and years. There were very significant differences among the analyzed cultivars and average values of plant height. Significant differences between years indicated that analyzed two vegetation periods were ecologically divergent (Table 1).

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

Cultivar	Plant height (cm)							
	1st year			2nd year			Average	
	$\bar{x} \pm s_{\bar{x}}$	S	V (%)	$\bar{x} \pm s_{\bar{x}}$	S	V (%)	$\bar{x} \pm s_{\bar{x}}$	V (%)
Kavkaz	84.9±0.68	5.24	6.2	78.4±0.65	5.02	6.4	81.6±0.66	5.8
Bezostaja 1	93.6±0.62	4.79	5.1	77.0±0.84	6.51	8.5	85.3±0.73	6.8
Mironovskaja 808	117.7±0.81	6.27	5.3	101.7±0.90	6.94	6.8	109.7±0.86	6.0
San Pastore	82.6±0.75	5.81	7.0	78.6±0.71	5.47	7.0	80.6±0.73	7.0
Mara	75.0±0.97	7.53	10.0	70.6±0.77	5.97	8.5	72.8±0.87	9.2
Brimstone	61.5±0.47	3.66	5.9	61.2±0.46	3.57	5.8	61.4±0.46	5.8
Pernel	57.7±0.52	4.00	6.9	57.9±0.53	4.12	7.1	57.8±0.52	7.0
Brock	58.6±0.57	4.42	7.5	59.3±0.80	6.21	10.5	59.0±0.68	9.0
Phenix	80.4±0.56	4.34	5.4	78.7±0.73	5.64	7.2	79.6±0.69	6.3
Blue Boy	125.7±0.69	5.33	4.2	118.8±1.01	7.82	6.6	122.2±0.85	5.4
Seneca	120.5±0.80	6.21	5.2	110.5±1.47	11.35	10.3	115.5±1.14	7.8
Pike	107.3±1.00	7.73	7.2	93.0±0.86	6.68	7.2	100.2±0.93	7.2
Florida	77.9±1.10	8.53	10.9	72.1±0.95	7.34	10.2	75.0±1.02	10.6
Hart	96.5±0.91	7.05	7.3	83.9±1.22	9.49	11.3	90.2±1.06	8.8
Norin 10	47.6±0.7	5.44	11.4	53.2±0.70	4.36	8.2	50.4±0.70	9.8
Akakomugi	97.8±0.74	5.76	5.9	86.5±0.59	4.48	5.2	92.2±0.66	5.6
Bankut 1205	110.9±0.78	6.08	5.5	107.3±0.98	7.59	7.1	109.1±0.88	6.3
Szegedi 7610	61.9±0.55	4.26	6.9	62.5±0.58	4.50	7.2	62.2±0.56	7.0
Szegedi 768	61.9±0.54	4.22	6.8	62.1±0.48	3.70	5.9	62.0±0.51	6.4
Pobeda	72.5±0.67	5.16	7.1	75.5±0.51	3.99	5.3	74.0±0.59	6.2
Katya	81.1±0.57	4.42	5.4	72.8±0.56	4.33	5.9	77.0±0.56	5.6
Rubin	73.7±0.59	4.54	6.2	64.6±0.64	4.98	7.7	69.2±0.62	7.0
Dobrudza 1	72.0±1.01	7.82	10.8	72.8±0.65	5.06	6.9	72.4±0.83	8.8
Peking 8	86.9±0.81	6.29	7.2	80.5±0.80	6.21	7.7	83.7±0.80	7.4
Pai Yu Pao	81.3±0.91	7.06	8.7	75.7±0.75	5.78	7.6	78.5±0.83	8.2
Jawa	83.8±0.84	6.54	7.8	84.1±0.97	7.48	8.9	84.0±0.90	8.4
Minister Dwarf	76.8±0.68	5.30	6.9	69.8±0.84	6.48	9.3	73.3±0.76	8.1
Frontana	114.1±0.85	6.57	5.8	99.1±0.97	7.50	7.6	106.6±0.91	6.7
Fundulea 262	73.7±0.39	3.00	4.1	72.5±0.60	4.64	6.4	73.1±0.50	5.2
Etoille de Choisy	69.2±0.78	6.01	8.7	72.3±0.80	6.22	8.6	70.8±0.79	8.6
KG-56	83.9±0.78	6.04	7.2	74.4±0.73	5.63	7.6	79.2±0.76	7.4
Lepenica	83.1±0.98	7.60	9.1	72.6±0.72	5.58	7.7	77.8±0.85	8.4
Srbijanka	84.9±0.68	5.26	6.2	78.9±0.74	5.77	7.3	81.9±0.71	6.8

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Cultivar	Plant height (cm)							
	1st year			2nd year			Average	
	$\bar{x} \pm s_{\bar{x}}$	S	V (%)	$\bar{x} \pm s_{\bar{x}}$	S	V (%)	$\bar{x} \pm s_{\bar{x}}$	V (%)
Levčanka	84.6±0.81	6.25	7.4	74.5±0.88	6.84	9.2	79.6±0.84	8.3
Sava	77.3±0.57	4.40	5.7	74.6±0.64	4.95	6.6	76.0±0.60	6.2
Partizanka	89.8±0.94	7.26	8.1	80.8±1.10	8.54	10.6	85.3±1.02	9.4
Jugoslavija	93.5±0.83	6.41	6.8	85.6±0.77	5.97	7.0	89.6±0.80	6.9
Evropa	81.2±0.64	4.94	6.1	72.7±0.43	3.36	4.6	77.0±0.54	5.3
Lasta	72.9±0.67	5.19	7.1	69.6±0.60	4.61	6.6	71.2±0.64	6.8
Polimka	87.0±0.97	7.49	8.6	78.9±0.85	6.62	8.4	83.0±0.91	8.5
Zemunka	90.3±0.93	7.19	8.0	81.4±0.56	4.32	5.3	85.8±0.76	6.6
Krajinka	92.1±0.71	5.51	6.0	87.6±0.65	5.01	5.7	89.8±0.68	5.8
Kraljevica	93.6±0.86	6.66	7.1	87.0±0.78	6.02	6.9	90.3±0.82	7.0
ZA-149	78.4±0.96	7.48	9.5	64.8±0.81	6.26	9.6	71.6±0.88	9.6
Skopjanka	80.2±0.54	4.20	5.2	75.7±0.46	3.60	4.8	78.0±0.50	5.0
Radika	76.1±0.60	4.68	6.1	69.8±0.67	5.20	7.4	73.0±0.64	6.8
Baranjka	73.8±0.81	6.27	8.5	68.3±0.92	7.16	10.5	71.0±0.86	9.5
Zlatna Dolina	68.2±0.65	5.02	7.4	60.0±0.67	5.18	8.6	64.1±0.66	8.0
Njivka	61.9±0.55	4.26	6.9	63.2±0.63	4.91	7.8	62.6±0.59	7.4
Poljarka	73.8±0.76	5.87	7.9	74.6±0.68	5.26	7.0	74.2±0.72	7.4
Average	82.6±0.74	5.75	7.1	76.6±0.75	5.80	7.7	79.6±0.74	7.4

During investigated periods the highest average value of plant height had Blue Boy cultivar ($\bar{x}$ = 122.2 cm) which was the highest in the first ($\bar{x}$ = 125.7 cm) and second year ($\bar{x}$ = 118.8 cm). The lowest average value of plant height expressed Norin 10 cultivar ($\bar{x}$ = 50.4 cm) which had the lowest plant height in the first ($\bar{x}$ = 47.6 cm) and in the second year ($\bar{x}$ = 53.2 cm).

The Blue Boy cultivar had higher plant height for 53.6% in relation to average value of height of plant for the all analyzed cultivars. However, Norin 10 cultivar which carries dwarfing genes *Rht8* and *Rht9* (WORLAND *et al*., 1984; 1990) had shorter plant height for 36.7% in relation to average value of plant height for the all analyzed cultivars. The similar results reported DIMITRIJEVIĆ *et al*. (1995; 1996; 1997). Development of semi-dwarf wheat cultivar contributed to significant increasing of harvest index and grain yield of wheat. Increasing of yield in semi dwarf wheat are results of more efficient translocation of assimilates than in tall cultivars (BOROJEVIĆ, 1983; EVANS, 1984; DIMITRIJEVIĆ *et al.*, 2001). In investigation KRALJEVIĆ-BALALIĆ (1978) plant height was lower in some wheat cultivars (Mara, Bezostaya 1) than plant height for the same cultivars which were tested in this investigation.

The coefficient of variability for plant height was computed for each cultivars in both investigated years. The highest variability of plant height expressed Norin 10 (V=11.4%) in the first year and Hart cultivar (V=11.3%) in the second year of investigation. The lowest variability in Fundulea 262 (V=4.1%) in first year and in Evropa cultivar (V=4.6%) in second year were established for this trait. In average the lowest variability had Skopjanka (V=5.0). Variability of plant height in

analyzed cultivars, in average, was expressed and coefficient of variability have been on the same level in both years of investigation. The most stable cultivars San Pastore (V=7.0%) and Pike (V=7.2%) showed the same variability in both years of investigation. In average for all cultivars and years the coefficient of variability was very low (V=7.4%) what indicated that genotype had higher influence than environment on expression of plant height, what is in agreement with (HRISTOV *et al*., 1999).

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

Source of variation	DF	MS	Ft	Components of variance δ²	%	LSD	0.01	0.05
Replication	2	6.769	-	-	-	Cultivar	2.84	2.15
Cultivar	49	1265.951	359.48**	202.38	84.32	Year	8.34	6.33
Year	1	2755.604	771.61**	18.03	7.51	Cultivar x year	4.01	3.04
Cultivar x year	49	51.683	14.47**	16.04	6.68	h^2 = 95.9%		
Error	198	3.571	-	3.57	1.49	V = 7.4 %		
Total	299	-	-	240.02	100.0			

The heritability in broad sense was high for the plant height h^2=95.9% what indicated that genetic factors have higher influence than environment on the expression of this trait, what is in agreement with (PRODANOVIĆ, 1992; PETROVIĆ *et al.*, 1993; MLADENOVIĆ, 1995; MLADENOV, 1996).

The analysis of phenotypic variance established significant differences in the average value of plant height in the cultivars and years (Table 2). The highest percentage of the whole phenotypic variability, was assigned to genetic factor (84.3%) and lower impact of environment (7.5%) and (6.7%) to the cultivar/year interaction were assigned. The high values of heritability of plant height caused by high genetic variability in wheat have been reported by early investigation (MIHALJEV, 1968; DIMITRIJEVIĆ *et al*., 1996; MLADENOVIĆ, 1995; MLADENOV, 1996). They also established the highest impact of genetic factor on expression of this trait. Highly significant interaction genotype/year denoted different reaction of cultivars to ecology factor changes (PETROVIĆ *et al*., 2000).

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FENOTIPSKA VARIJABILNOST I HERITABILNOST ZA VISINU BILJKE PŠENICE (*TRITICUM AESTIVUM* L.)

Veselinka ZEČEVIĆ, Desimir KNEŽEVIĆ i Danica MIĆANOVIĆ

Institut za istraživanja u poljoprivredi SRBIJA, Centar za strna žita Kragujevac, 34000 Kragujevac, Srbija i Crna Gora

Izvod

U radu je proučavana varijabilnost, komponente fenotipske varijanse i heritabilnost za visinu biljke kod 50 genetički divergentnih sorti pšenice poreklom iz različitih selekcionih centara sveta. Istraživanja su obavljena u poljskom ogledu po slučajnom blok sistemu tokom dve vegetacione godine. Ogled je izveden po tipu ogleda retke setve (razmak od 20 cm između redova i 10 cm između biljaka u redu, sa dužinom reda od 1.0 m). U punoj fazi zrelosti pšenice urađena je analiza visine 60 biljaka u tri ponavljanja (3 x 20). Ustanovljene su visoko signifikantne razlike u prosečnim vrednostima između sorti za ovo svojstvo. Najveća prosečna visina biljke utvrđena je kod sorte Blue Boy (122.2 cm), a najmanja kod sorte Norin 10 (50.4 cm). Varijabilnost visine biljke bila je dosta niska, sa prosečnim koeficijentom varijacije od V= 7.4 %. Sorta Fundulea 262 (V=5.2 %) je pokazala najmanju varijabilnost za visinu biljke. Prosečna varijabilnost visine biljke bila je identična u obe godine istraživanja. Analizom fenotipske varijanse ustanovljen je visok udeo genotipa u ispoljavanju ovog svojstva (84.3 %), a znatno niži udeo godine (7.5 %) i interakcije sorta/godina (6.7 %). Takođe je utvrđena i visoka heritabilnost u širem smislu za visinu biljke (h^2=95.9%). Sve analize ukazuju da na ispoljavanje visine biljke znatno veći uticaj imaju genetički faktori od faktora spoljne sredine.

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