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Original scientific paper

VARIABILITY AND COMPONENTS OF VARIANCE FOR HARVEST INDEX IN WHEAT *(TRITICUM AESTIVUM* L.)

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Variability, heritability and components of variance were studied in 50 cultivars from different selection centers of the world. Plants were grown in the experimental field in 3 replications during two vegetative seasons. Samples of 60 wheat plants (20 plants in 3 repetitions) were analyzed in full maturity stage. Harvest index was calculated as the ratio of grain yield and total aerial part of the plant. The highest harvest index was found in cv. Peking 8 (44.6%), and the lowest in cv. Jawa (23.8%). On average for all cultivars, the harvest index was similar in both years of investigation (35.4%; 35.2% resp.). Cultivars showed differences in variability of harvest index. The mean coefficient of variation for all cultivars and both years was V = 12.0%. The lowest coefficient of variation was found in cv. Peking 8 (V_e = 7.0%), and the highest cv. Brock (V = 17.8%). High heritability (h^2 = 75%) was established for this trait. Highly significant differences in mean values for harvest index between cultivars were shown by analysis of variance. Differences between year and the interaction cultivar/year were also highly significant. Components of phenotypic variance showed that genetic factors (53.7%) had the highest impact on expression of harvest index, while the interaction cultivar/year showed less impact (35%). Year did not contribute significantly to the variance.

Key words: wheat, cultivar, harvest index, heritability, variability, components of variance

INTRODUCTION

The harvest index represents the ratio between economical yield (wheat grain yield) and biological yield (yield of grain and straw) (KRALJEVIĆ-BALALIĆ and BOROJEVIĆ, 1985). The proportion of total mass to grian yield in modern wheat cultivars is more than 2:1 which indicates excessive consumpiton of nutrients for straw formation instead of grain. This is one reason for decreasing the vegetative part of wheat to the optimal proportion during wheat breeding in order to increase the harvest index to more than 50% (PROTIĆ *et al.*, 1990). This can be achieved by using parents which are donors of dwarfing genes which lead to short plants. The gene combinations Rht1(4A) x Rht8(2D), Rht1 x Rht10(4D), Rht8 x Rht10, which are not present in modern wheat cultivars, can be expected in desirable recombinations (BOROJEVIĆ, 1990; BOROJEVIĆ *et al.*, 1994). Steam shortening in wheat enables higher lodging resistance, allows a higher rate of nitrogen supply, increase of yield and cultivation of wheat plants at high density. Some authors (DONALD and HAMBLIN, 1976; BOROJEVIĆ, 1986; SHARMA and SMITH, 1986) recommend a breeding program in which accumulation and distribution of dry matter can be used as selection criteria.

Previous investigations (PETROVIĆ *et al.*, 1994; KOBILJSKI and DENČIĆ, 1995) indicate negative correlations between those traits which indicates that decreasing vegetative mass leads to better translocation of matter to generative organs.

Distribution of dry mattrer as well as nitrogen among vegetative organs and grain express a strong positive correlation, as estimated by grain harvest index and nitrogen harvest index (LOFFLER *et al.*, 1985; ĐOKIĆ, 1986, 1988). A positive correlation was found between grain harvest index, nitrogen harvest index and yield. An negative correlation was observed only between grain harvest index and nitrogen concentration of grain (LOFFLER and BUSCH, 1982; ĐOKIĆ, 1988; GUSTAVO *et al.*, 1990).

The interaction between genotype and environment has a large influence on grain harvest index (KRALJEVIĆ-BALALIĆ *et al.*, 1995). Similar results were obtained for phenotypic variability for harvest index in spirng wheat (PRŽULJ, 1989). Low phenotypic variability was found for harvest index (DOTLAČIL and TOMAN, 1991).

The heritability of particular components of yield and quality has been investigated fully and depends on the variability of the genetic material examined, so that different results were found. A high heritability for harvest index was noted by some authors (PRŽULJ, 1989; MLADENOV, 1996; PETROVIĆ *et al.*, 1995).

The aim of this paper was a study of variability, heritability and the impact of particular components of the total phenotypic variability on harvest index in genetically diverse wheat cultivars which originated from different selection centers all over the world.

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, Rumunia, France, Macedonia and Croatia) were examined.

The experiment was performed in a randomized block design in three replications in the experimental field of the Center for Small Grains, Kragujevac, during 1993/94 and 1994/95. The seed were sown in 1 m long rows, with 0.20 m spaces between the rows and 0.10 m between each seed in the row. A total of 60 plants were analyzed in full maturity stage (20 plants per replication).

Harvest index was computed as the ratio between total grain mass and total plant mass (grain + straw).

HI = grain mass/grain mass + straw mass

The following parameters were calculated: mean value (x); variance (σ^2); coefficient of variation (CV) as an index of relative variability of the trait; heritability (h^2) as the ratio between genetic and phenotypic variance. The significance of differneces between mean values were estimated using the LSD test.

Analysis of variance was done using a randomized block design with two factors, allowing the components of variance to be calculated (σ^2_g-genetic; σ^2_{gl}-interaction; σ^2_E- environment; σ^2f-phenotypic).

RESULTS AND DISCUSSION

The analyzed cultivars showed differences in mean vlaue for harvest index. The highest harvest index was found for cv. Lasta (47.9%) and cv. Peking 8 (47.7%) in the second year. In the first year of investigation, the highest value for this trait was observed in cv. Fundulea 262 (42.0%). The lowest harvest index was found in cv. Jawa in both years of investigation (24.5% and 23.1% respectively). Mean harvest index for all analyzed cultivars was similar in the first (35.4%) and in the second (35.2%) year of investigation. All analyzed cultivars which originated from the Selection Centers of Yugoslavia had a harvest index above 30.0%, which indicates better adaptability in those cultivars. Some of the foreign cultivars had high general tillering but included many sterile secondary tillers which led to a lower harvest index. The values of harvest index obtained in this work are in agreement with the results obtained by other investigators (BOROJEVIĆ, 1992; DENČIĆ and BOROJEVIĆ, 1992; PETROVIĆ *et al.*, 1995; BALALIĆ and KOBILJSKI, 1996).

Coefficient of variation ranged from V = 6.4 – 20.0%, which indicated genetic variability in the investigated cultivars. The smallest variability of harvest index was shown by cv. Peking 8 (V = 6.4; 7.5% respectively in each year). The highest variability of harvest index was obtained in the first year for cv. Jawa (V = 20.0%). The highest variability of harvest index in the second year (V =

17.0%) and on average for both years (V = 17.8%) occurred in cultivar Brock. Cultivar Zlatna Dolina showed high stability of harvest index, because the coefficient of variation was identical in both years (V = 10.4%; Table 1). These resutls are in agreement with other investigations (KRALJEVIĆ-BALALIĆ *et al.*, 1995; PETROVIĆ *et al.*, 1995; BALALIĆ and KOBILJSKI, 1996) in which a consistently low value of harvest index variability was established.

The heritability for harvest index was high (h^2 = 75.0%). High heritability indicates dependence on genetic factors, and therefore little dependence on environmental factors. Lower values for heritability for harvest index (to 55%) were found by PETROVIĆ *et al.* (1995) and MLADENOV (1996). Also, in investigation of wheat cultivars was found that high heritability may be the cause of high genetic variability (MIHALJEV, 1968).

Table 1. Mean value and variability for harvest index in wheat (%)

Cultivar	Year						
	1994			1995			
	$\bar{x}\pm s_{\bar{x}}$	S	V(%)	$\bar{x}\pm s_{\bar{x}}$	S	V(%)	Average
Kavkaz	29.2±0.74	5.75	14.7	35.2±0.52	3.99	11.3	37.2
Bezostaja 1	35.2±0.72	5.59	15.9	27.3±0.50	3.91	14.3	31.2
Mironovskaja 808	31.4±.68	5.28	16.8	30.7±0.61	4.76	15.5	31.0
San Pastore	36.4±0.61	4.70	12.9	36.6±0.48	3.70	10.1	36.5
Mara	28.6±0.71	5.50	19.2	36.9±0.48	3.72	10.1	32.8
Brimstone	30.5±0.58	4.49	14.7	42.9±0.55	4.29	10.0	36.7
Pernel	27.3±0.67	5.21	19.1	34.0±0.50	3.91	11.5	30.6
Brock	31.2±0.75	5.83	18.7	30.4±0.67	5.16	17.0	30.8
Phenix	36.9±072	5.60	15.2	44.0±0.58	4.53	10.3	40.4
Blue Boy	26.0±0.50	3.88	14.9	23.1±0.46	3.59	15.5	24.6
Seneca	29.0±0.30	2.31	8.0	31.7±0.53	4.10	12.9	30.4
Pike	35.3±0.57	4.41	12.5	29.1±0.51	3.99	13.7	32.2
Florida	32.7±0.78	6.05	18.5	29.6±0.56	4.38	14.8	31.2
Hart	31.9±0.77	5.98	18.8	33.8±0.50	3.90	11.5	32.8
Norin 10	29.4±0.92	5.11	17.4	33.2±0.62	4.78	14.4	31.3
Akakomugi	38.7±0.54	4.15	10.7	30.2±0.61	4.72	15.6	34.4
Bankut 1205	30.7±0.76	5.86	19.1	28.3±0.41	3.16	11.2	29.5
Szegedi 7610	41.8±0.58	4.49	10.7	41.4±0.48	3.75	9.0	41.6
Szegedi 768	38.9±0.61	4.74	12.2	38.6±0.59	4.56	11.8	38.8
Pobeda	39.6±0.70	5.43	13.7	40.2±0.65	5.06	12.6	39.9
Katya	39.9±0.77	5.95	14.9	36.5±0.48	3.68	10.1	38.2
Rubin	37.0±0.455	4.25	11.5	43.0±0.45	3.50	8.1	40.0
Dobrudža 1	28.9±0.61	4.72	16.3	30.9±0.53	4.09	13.2	29.9
Peking 8	41.6±0.35	2.69	6.4	47.7±0.46	3.58	7.5	44.6

Pai Yu Pao	38.7±0.64	4.97	12.8	32.9±0.46	3.60	10.9	35.8
Jawa	24.5±0.64	4.93	20.0	23.1±0.44	3.42	14.8	23.8
Minister Dwarf	39.2±0.68	5.28	13.5	34.6±0.62	4.77	13.8	36.9
Frontana	36.0±0.41	3.19	8.8	35.6±0.40	3.11	8.7	35.8
Fundulea 262	42.0±0.48	3.72	8.8	42.1±0.62	4.81	11.4	42.0
Etoille de Choisy	33.1±0.72	5.56	16.8	33.7±0.56	4.30	12.8	33.4
KG-56	35.0±0.37	2.89	8.2	35.4±0.60	4.68	13.2	35.2
Lepenica	33.9±0.48	3.72	11.0	32.1±0.39	3.04	9.5	33.0
Srbijanka	35.3±0.40	3.09	8.7	33.5±0.60	4.68	14.0	34.4
Levčanka	39.1±0.46	3.60	9.2	37.1±0.43	3.31	8.9	38.1
Sava	34.4±0.44	3.44	10.0	28.9±0.32	2.50	8.7	31.6
Partizanka	36.9±0.38	2.96	8.0	30.4±0.44	3.38	11.1	33.6
Jugoslavija	38.9±0.46	3.55	9.1	36.6±0.57	4.43	12.1	37.8
Evropa	39.1±0.56	4.36	11.1	43.4±0.49	3.82	8.8	41.2
Lasta	34.9±0.53	4.12	11.8	47.9±0.53	4.12	8.6	41.4
Polimka	37.8±0.74	5.73	15.2	32.7±0.44	3.40	10.4	35.2
Zemunka	38.0±0.41	3.15	8.3	30.1±0.45	3.45	11.5	34.0
Krajinka	41.7±0.43	3.32	8.0	37.2±0.46	3.58	9.6	89.4
Kraljevica	37.2±0.41	3.16	8.5	35.0±0.45	3.49	10.0	36.1
ZA–149	41.9±0.52	4.05	9.7	39.2±0.52	4.04	10.3	40.6
Skopjanka	40.3±0.45	3.51	8.7	35.9±0.43	3.34	9.3	38.1
Radika	41.1±0.62	4.80	11.7	36.5±0.44	3.42	9.4	38.8
Baranjka	33.9±0.35	2.72	8.0	31.4±0.45	3.48	11.1	32.6
Zlatna Dolina	37.6±0.51	3.92	10.4	34.4±0.46	3.60	10 4	36.0
Njivka	39.5±0.51	3.95	10.0	36.6±0.49	3.82	10.4	38.0
Poljarka	37.6±0.43	3.32	8.8	38.4±0.41	3.17	8.2	38.0
Average	35.4±0.56	4.38	12.6	35.2±0.50	3.91	11.4	35.3

LSD	Cultivar	Year	Cultivar/Year
0.05	1.82	0.36	2.57
0.01	2.40	0.48	3.39

Coefficient of variaion:V = 12.0%

Heritability: h^2 = 75.0%

High significant differences for harvest index between invesitgations on wheat cultivars were obtained by analysis of variance. Differneces between years and the interaction cultivar/year were highly significant too. Components of phenotypic variability were analyzed and the highest impact was from genetic factors (56.7%). The impact of the interaction cultivar/year (35.0%) on the expression of harvest index was lower, while year had no influence (Table 2). In the investigation of DOTLAČIL and TOMAN (1991) low phenotypic variability was established. In contrast KRALJEVIĆ-BALALIĆ *et al.* (1995) showed a

high influence of the interaction cultivar/environment on harvest index and a high value for ecological variance.

Table 2. Components of phenotypic variance for harvest index in wheat

Source of Variation	DF	MS	F	Components of varince	
				δ^2	%
Repetition (R)	2	0.167	-	-	-
Cultivar (C)	49	139.247	54.56**	17.40	56.66
Year (Y)	1	4.633	1.82**	0.00	-
C x Y	49	34.842	13.65**	10.76	35.04
Error	198	2.552	-	2.55	8.30
Total	299			30.71	100.00

CONCLUSION

Significant differences in mean value for harvest index were obtained in wheat cultivars.

The highest harvest index was found for the cultivar Peking 8, which showed the lowest variability for this trait.

The highest stability of harvest index during the year of investigation was shown by cultivar Fundulea 262.

High variability (V = 12%) in grain harvest index was detected in the analyzed wheat cultivars. The highest variability for this trait was shown by cultivar Brock (V = 17.8%). High stability of harvest index during the year of investigation was exhibited by cultivar Zlatna Dolina which had the same coefficient of variation (V = 10.4%) in both years of investigation.

The heritability for harvest index was high (h^2 = 75.0%).

Phenotypic analysis of variance showed that harvest index is influenced by genetic and environmental factors with preponderance of genetic factors.

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