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Genotypic Differences and Heritability for Various Polygenic Traits in F_5 Wheat Populations

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Abstract: An experiment comprising twenty F_5 wheat populations derived from bi-parental crosses including a check cultivar was planted in Randomize Complete Block design with three replications at the University of Agriculture, Peshawar during 2013-14. Significant genotypic differences were observed for all the traits studied, except grain yield. F_5 wheat population PS-05 x PS-04 showed maximum mean values for plant height (96.5 to 128.6 cm), AUP-4006 x PS-04for 1000-grain weight (68.9 g), PS-05 x Ghaznavi for biological yield (6322 to 11978 kg ha^{-1}). Similarly, parent cultivar PS-05 exhibited maximum value for flag leaf area (18.3 to 32.3 cm^2), PS-04 for grains $spike^{-1}$ (62) and grain yield (3367 kg ha^{-1}). Moreover, check cultivar Atta Habib expressed maximum value for spike length (11.3cm) and harvest index (32.5%). High broad sense heritability was noticed for plant height (0.73), grains $spike^{-1}$ (0.57), 1000-grain weight (0.55) and biological yield (0.42). Moreover, low broad sense heritability was recorded for flag leaf area (0.29), spike length (0.25) and harvest index (0.27). F_5 wheat population PS-05 × Ghaznavi surpassed check cultivar, therefore it should be considered in future breeding programs.

Key words: Bread wheat · Genetic variability · Heritability · Yield components

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the important and strategic cereal crops for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed. It exceeds in acreage and production than any other grain crop (including rice, maize, etc.) [1].

Pakistan is far below in the international ranking of wheat production but it can be improved through appropriate steps. There is dire need for creative research. Better and high yielding genotypes should be made available to farmers. There is need for effective and objectives-oriented wheat breeding programs that could focus on the development of high yielding disease resistant varieties [2].

Genetic variability is pre-requisite for selecting high yielding genotypes. Heritability is a tool to predict the gain from selection in a population. Heritability, a measure of the phenotypic variance attributable to genetic causes, has predictive function of breeding crops. The higher heritability estimates, the simpler are the selection procedures. It has been emphasized that heritability alone is not enough to make sufficient improvement through selection generally in advance generations unless accompanied by substantial amount of genetic advance. The utility of heritability therefore increases when it is used to calculate genetic advance, which indicates the degree of gain in a character obtained under a particular selection pressure. Thus, genetic advance is yet another important selection parameter that aids breeder in a selection program [3]. The objectives of this research work were to estimate heritability for yield and yield associated traits and to identify superior genotypes for further breeding programs.

MATERIALS AND METHODS

To study genetic variability and heritability, twenty F_5 wheat populations including check cultivar Atta-Habib developed by crossing different wheat genotypes were evaluated at New Developmental Research Farm,

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Table 1: List of genotypes studied in the experiment.

S.No	Genotype	S.No	Genotype
1	Ghaznavi × Janbaz (F_5)	11	PS-05 x PS-04 (F_5)
2	Janbaz × AUP 4006 (F_5)	12	PS-05 x Ghaznavi (F_5)
3	PS-04 × Ghaznavi (F_5)	13	Janbaz × Ghaznavi (F_5)
4	AUP 4006 × PS-04 (F_5)	14	AUP 4006 x PS-05 (F_5)
5	PS-04 × AUP 4006 (F_5)	15	Janbaz (Parent)
6	AUP 4006 × Janbaz (F_5)	16	PS-04 (Parent)
7	PS-04 × Janbaz (F_5)	17	PS-05 (Parent)
8	PS-04 × PS-05 (F_5)	18	AUP 4006 (Parent)
9	Janbaz × PS-05 (F_5)	19	Ghaznavi (Parent)
10	Ghaznavi × PS-05 (F_5)	20	Atta Habib (Check cultivar)

The University of Agriculture, Peshawar during 2013-14 (Table 1). Experimental material was planted in randomized complete block (RCB) design with three replications. Each plot comprised four rows of four meter length with inter row space of 30 cm. The recommended cultural practices i.e. land preparation, sowing and hoeing were uniformly applied to minimize the environmental variation. Data were recorded on plant height, flag leaf area, spike length, grains spike^{-1}, 1000-grain weight, biological yield, grain yield and harvest index.

Statistical Analysis: Data obtained for each parameter were subjected to analysis of variance techniques appropriate for randomized complete block design, upon significant differences means were separated using LSD test at 5 % level of probability using computer software Statistics version 8.1 following the procedure of Steel and Torrie [4].

Heritability (BS): Heritability in broad sense was estimated as the ratio of genotypic variance to the phenotypic variance and was expressed in percentage following the procedure of Singh and Chaudhery [5].

Genotypic variance (Vg) = GMS – EMS/ r
Phenotypic variance (Vp) = Vg + Vp
Environmental variance (Ve) = EMS
$h^2_{(BS)}$ = Vg/ Vp

RESULTS AND DISCUSSION

Plant Height (cm): Analysis of variance revealed highly significant differences among genotypes for plant height (Table 2). The results of our findings are in close conformity with the earlier studies reported by Hussain *et al.* [6]; Zafar *et al.* [7] and Khan *et al.* [8] who also reported significant differences among genotypes for plant height in wheat. Plant height ranged from 96.5 to 128.6 with the mean value of 114.6 cm. The maximum plant height was attained by genotype PS-05×PS-04 (128.6 cm), followed by genotype Janbaz × PS-05 (125.8 cm) and PS-04 × PS-05 (125.7 cm), whereas the minimum plant height was produced by genotype Atta-Habib (96.5 cm), followed by genotype Ghaznavi (101.6 cm) (Table 3). Genetic (Vg), environmental (Ve) and broad sense heritability estimates are given in Table 4. Genetic variance (52.41) was greater than environmental variance (0.73) resulting in high broad sense heritability (0.73). In contrast, Khan *et al.* [8]; Aycicek and Yildrim [9]; Gupta and Verma [10] and Eid [11] reported low heritability coupled with low genetic advance for plant height.

Flag Leaf Area (cm^2): Genotypes had highly significant differences for flag leaf area (Table 2). The results of our findings are in close conformity with the earlier studies reported by Khan *et al.* [8] and Kalimullah [12] they also reported significant differences among genotypes for flag leaf area. Data for flag leaf area ranged between 18.3 and 32.3 cm^2 with mean value of 24.4 cm^2. The maximum value for flag leaf area was attained by genotype PS-04, while the minimum flag leaf area was attained by Janbaz × Ghaznavi (Table 3). Genetic (Vg), environmental (Ve) and broad sense heritability estimates are given in Table 4. Genetic variance (5.53) was less than environmental variance (13.40) resulting in low broad sense heritability (0.29). Khan *et al.* [8] and Choudhary *et al.* [13] also reported low to moderate heritability for this trait, which supports our results.

Spike Length (cm): Analysis of variance declared significant differences among genotypes for spike length (Table 2). The results in the current study are in agreement with those reported by Afridi and Khalil [14] and Anwar *et al.* [15], they also reported significant differences among genotypes for spike length. Spike length ranged between 9.7 and 11.3 cm with mean value of 10.5 cm. The maximum spike length was exhibited by genotype Atta-Habib followed genotype PS-04 × PS-05, while the minimum spike length was attained by genotype PS-04 (Table 3).

Table 2: Mean squares for various traits of 20 wheat genotypes during 2013-14

Traits	Replications (df=2)	Genotype (df=19)	Error (df=38)	CV (%)
Plant height	33.431	176.977**	19.749	3.88
Flag leaf area	58.9262	29.9968**	13.4022	14.97
Spike length	0.67825	0.61754*	0.31144	5.31
Grains spike^{-1}	38.15	109.483**	22.22	9.73
1000 grains weight	133.094	113.318**	24.069	9.16
Biological yield	4395881	3856577**	1208596	10.65
Grain yield	338016	212301^{NS}	181413	15.15
Harvest index	2.7332	16.0148*	7.629	10.1

Table 3: Mean performance for various traits of 20 wheat genotypes

Genotypes	PH (cm)	FLA (cm^2)	SPKL (cm)	GSPK (no.)	TGW (g)	BY (kg ha^{-1})	GY (kg ha^{-1})	HI (%)
Ghaznavi × Janbaz	110.8	20.7	10.7	54	46.4	10233	2845	27.8
Janbaz x AUP 4006	115.4	23.2	10.1	52	46.4	10489	2822	26.9
PS-04 x Ghaznavi	113.2	27.2	9.9	44	56.0	9867	2478	25.0
AUP-4006 x PS-04	117.7	22.4	10.4	34	68.9	10356	2856	27.7
PS-05 x AUP 4006	121.2	26.2	9.8	47	55.4	9745	2622	26.8
AUP 4006 x Janbaz	114.7	22.4	11.0	45	55.9	11167	2756	24.7
PS-04 x Janbaz	116.9	22.5	10.5	40	65.3	9989	2911	29.1
PS-04 x PS-05	125.7	25.5	11.1	52	54.2	11500	2933	25.7
Janbaz x PS-05	125.8	25.9	10.0	48	55.8	10889	2911	26.8
Ghaznavi x PS-05	117.1	26.8	11.0	50	49.8	10556	2644	25.1
PS-05 x PS-04	128.6	23.4	10.5	45	52.2	11156	2900	25.8
PS-05 x Ghaznavi	113.3	29.3	10.2	46	53.5	11978	3211	26.8
Janbaz x Ghaznavi	109.1	18.3	10.5	48	52.9	9545	2700	28.2
AUP 4006 x PS-05	118.5	26.8	10.3	51	50.1	10922	2633	24.1
Janbaz	111.4	24.0	10.4	54	50.0	10167	2900	28.4
PS-05	112.4	32.3	9.7	43	56.6	10822	2711	25.0
PS-04	108.9	23.3	10.8	62	45.8	10800	3367	31.2
AUP 4006	113.4	21.7	10.8	49	60.5	10311	2922	28.3
Ghaznavi	101.6	22.5	11.0	51	47.7	9722	3011	31.0
Atta Habib (Check)	96.5	24.6	11.3	56	48.0	6322	2078	32.5
Mean	114.6	24.4	10.5	48	53.6	10327	2811	27.3
$LSD_{0.05}$	7.3	6.1	0.9	7.8	8.1	1817.1	NS	4.6

Table 4: Genetic (Vg), environmental (Ve) variance and broad sense heritability (h_{BS}) estimates of various traits

Traits	Genetic variance (Vg)	Environmental variance (Ve)	Broad sense heritability (h_{BS})
Plant height	52.41	19.75	0.73
Flag leaf area	5.53	13.40	0.29
Spike length	0.10	0.31	0.25
Grains spike^{-1}	29.09	22.22	0.57
1000 grains weight	29.75	24.07	0.55
Biological yield	882660.33	1208596.00	0.42
Grain yield	10296.00	181413.00	-
Harvest index	2.80	7.63	0.27

Genetic (Vg), environmental (Ve) and broad sense heritability estimates are shown in Table 4. Genetic variance (0.10) was less than environmental variance (0.31) resulting in low broad sense heritability (0.25). The present findings are in close conformity with those obtained by Aycicek and Yildrim [9], who also observed low magnitude of heritability for spike length. On the other hand, Laghari *et al.* [16]; Memon *et al.* [20]; Ullah *et al.* [21] and Ajmal *et al.* [22], reported high heritability, whereas, Jan *et al.* [18] reported moderate heritability for spike length.

Grains Spike^{-1}: Genotypes expressed significant differences for grains spike^{-1}. The present findings are supported by Ali *et al.* [23]; Shah *et al.* [24] and Khan *et al.* [25], they also reported significant differences

among wheat genotypes for grains spike^{-1}. Grains spike^{-1} ranged from 34 to 62 with mean value of 48. The maximum grains spike^{-1} was produced by genotype PS-05, while the minimum grains spike^{-1} was produced by genotype AUP 4006 × PS-04 (Table 3). Genetic (Vg), environmental (Ve) and broad sense heritability estimates are given in Table 4. Genetic variance (29.9) was greater than environmental variance (22.22) resulting in moderate broad sense heritability (0.57). Results of this study are in agreement with those obtained by Khan *et al.* [8], who reported moderate heritability for grains spike^{-1}. Similarly, Gupta and Verma [10]; Maurya *et al.* [17] and Haq *et al.* [26] reported high estimates of heritability for grains spike^{-1}.

1000-Grain Weight (g): Analysis of variance revealed highly significant differences among genotypes for 1000-grain weight (Table 2). The results of our findings are in close conformity with earlier studies reported by Kalimullah [12]; Ahmad *et al.* [19]; Firouzian [27] and Tahir *et al.* [28], who also reported highly significant differences among genotypes for 1000-grain weight. Data for 1000-grain weight ranged from 45.8 to 68.9 g with mean value of 53.6 g. The maximum 1000-grain weight was exhibited by genotype AUP 4006 × PS-04, while the minimum 1000-grain weight was exhibited by genotype PS-05 (Table 3). Genetic (Vg), environmental (Ve) with broad sense heritability estimates are given in Table 4. Genetic variance (29.75) was greater than environmental variance (24.07) resulting in moderate broad sense heritability (0.51). These results are in close conformity with the previous observations of Khan *et al.* [8] and Eid [11], who found high magnitude of heritability for 1000-grain weight. On the other hand, Aycicek and Yildrim [9] and Jan *et al.* [18] reported low magnitude of heritability for 1000-grain weight.

Biological Yield (kg ha^{-1}): Analysis of variance revealed highly significant differences among genotypes for biological yield (Table 2). These results are in agreement with the findings of Khan *et al.* [25] and Wajid *et al.* [29], who also reported highly significant differences among genotypes for biological yield. Biological yield ranges from 6322 to11978 (kg ha^{-1}) with mean value of 10327 kg ha^{-1}. The maximum biological yield was produced by genotype PS-05 × Ghaznavi, while the minimum biological yield was produced by genotype Atta-Habib (Table 3). Genetic (Vg), environmental (Ve) and broad sense heritability estimates are given in Table 4. Genetic variance (882660.33) was less than environmental variance (1208596.00) resulting in moderate broad sense heritability (0.42). High estimate of broad sense heritability for biological yield in wheat has also been reported by Ajmal *et al.* [22]; Khan and Khalil [30] and Mangi *et al.* [31] who also observed high heritability for biological yield in wheat. In contrast, Rashidi [32] reported low heritability for biological yield.

Grain Yield (kg ha^{-1}): Analysis of variance expressed non-significant differences among genotypes for grain yield (Table 2). Lack of genetic variability in the current material may be due to the fact that all this material might have been advanced on the basis of higher yield. Non-significant genotypic difference had also been reported earlier by Maloo [33] and Said *et al.* [34]. These results are in contradiction to the earlier findings of Ajmal *et al.* [22] and Khan *et al.* [25] who also reported significant variation for grain yield of different genotypes. The difference may be due to difference in genetic material or environmental factors. Grain yield ranged from 2078 to 3367 kg ha^{-1} with mean value of 2811 kg ha^{-1}. Maximum grain yield was produced by genotype PS-05 while minimum grain yield was produced by genotype Atta-Habib (Table 3).

Harvest Index (%): Analysis of variance showed significant differences among genotypes for harvest index (Table 2). Khan *et al.* [8] and Rashidi [32], who also reported significant difference among wheat genotypes for harvest index. Harvest index ranged between 24.1 and 32.5 (%) with mean value of 27.3 (%). The maximum harvest index was observed for genotype Atta-Habib, while the minimum harvest index was noted for genotype AUP 4006 × PS-05 (Table 3). Genetic (Vg), environmental (Ve) and broad sense heritability estimates have been calculate (Table 4). Genetic variance (2.80) was lesser than environmental variance (7.63) resulting in low broad sense heritability (0.27). Similar results were also reported by Rashidi [32], who also reported low estimate of broad sense heritability for harvest index in wheat. In contrast, Khan *et al.* [8]; Gupta and Verma [10]; Mangi *et al.* [31] and Yadav *et al.* [35], who also observed high heritability for harvest index in wheat.

CONCLUSIONS

Significant differences were observed among tested genotypes for all the traits, except grain yield. Moderate to high broad sense heritability were recorded for plant height, grains spike^{-1}, 1000-grain weight and biological yield. Population PS-05 x Ghaznavi surpassed check cultivar for grains spike^{-1}, biological yield and grain yield. Therefore, this population needs to be utilized in future breeding program.

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