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Estimation of Heterosis and Heterobeltiosis of Some Quantitative Characters in Bread Wheat Crosses

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Abstract: Heterosis over mid and better parents was estimated in twenty crosses of bread wheat involving three varieties viz., PBW 222, LU26S and Uqab 2000 and two lines viz., 8952 and 8961. 1000-grain weight showed maximum heterosis over the mid parent (20.96%) followed by number of grains per spike (13.97%), plant height (-7.00%), grain yield per plant (-23.70%) and number of tillers per plant (-31.22%). The maximum heterobeltiosis was recorded for 1000-grain weight (12.58%), plant height (-18.51%), grains per spike (-20.71%), grain yield per plant (-25.39%) and tillers per plant (-33.16%).

Key words: Bread wheat, heterobeltiosis, homozygosity, mid parent

INTRODUCTION

Wheat is the most important food cereal of our country. The attainment of maximum crop yield is an important objective in most of the breeding programmes. Our wheat production has reached to the level of self sufficiency but still per acre yield is less than the other wheat growing countries. Previously exploitation of heterotic effects for more grain yield were largely attributed to cross pollinated crops, but evidence is now available to confirm presence of such effects in self pollinated crops like wheat. Briggle[1] and Sajnani[2] suggested the possibility of heterotic effects in wheat as well.

Khan and Khan[3] reported that maximum heterosis was obtained for tillers per plant (31.91%) followed by grain yield per plant (19.41%), 1000-grain weight (17.32%), number of grains per spike (11.37%) and plant height (5.23%). Chowdhry *et al.*[4] observed heterosis for traits like plant height, number of tillers per plant, 1000-grain weight and grain yield per plant. Akhter *et al.*[5] studied heterosis for characters like plant height and grain yield per plant.

Yield of grain is very important for the farmers and we can get good combinations through heterosis which can provide high grain yield. Standing ability is another important character which we can improve through this technique. Lodging resistance and short stature varieties developed through heterosis increase the grain yield by reducing the risk of lodging due of strong winds. Similarly we can improve characters like disease resistance, insect resistance, gain quality and early maturity through heterosis.

MATERIALS AND METHODS

The research work was carried out in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Five wheat varieties/lines viz., PBW 222, LU26S, Uqab 2000, 8952 and 8961 were crossed in a diallel fashion. The F_1s including direct crosses and their reciprocals were attempted during crop season 2001-2002.

These crosses were field planted on November, 8, 2003 to evaluate their performance as compared to their parents.

The seeds were sown by using dibble. Two seeds per hole were planted, later thinned to one seed per site, keeping plant to plant and line to line distance i.e. 15 and 30 cm, respectively with three replications. All the agronomic practices were performed uniformly. At maturity ten guarded plants were selected at random and data were recorded for the following yield and yield related parameters.

To estimate significant differences among parents and hybrids, the data were subjected to statistical analysis by using the analysis of variance technique Steel and Torrie[6]. Significant differences were further subjected to Duncan's new multiple range test (DMR).

The percent increase or decrease of F_1 hybrids over mid parent as well as better parent value was calculated to estimate possible heterotic effects for above mentioned parameters following Fonseca and Patterson[7].

The 't' value for heterosis was computed following the formula reported by Wynne *et al.*[8].

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RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among all the wheat genotypes for all the traits under study (Table 1).

Plant height (cm): The individual comparison of means of all genotypes (Table 2), indicated that among parents genotype 8952 had maximum plant height (115.84 cm), while the parent PBW 222 had minimum plant height (81.53 cm). Among F_1 hybrids 8952×Uqab 2000 had maximum plant height (116.38 cm), while cross PBW 222×Uqab 2000 had minimum plant height (91.35 cm). The heterotic effects in Table 3, indicated that seven out of twenty F_1 hybrids showed increase in the plant height over their mid parental values and their heterosis ranged from -7.00 (8961×8952) to 4.17% (8952×Uqab 2000). Eight crosses were highly significant in which six had negative values, while two with positive estimates and only one cross was significant but showed positive estimate. Eleven crosses were non-significant in which six showed negative estimates ranged from -0.35 (Uqab 2000×8961) to 1.59% (PBW 222×LU26S).

As for the heterobeltiosis is concerned two out of twenty F_1 hybrids exhibited the positive values ranged from 0.47 (8952×Uqab 2000) to 2.17% (LU26×Uqab 2000). Thirteen out of twenty crosses were highly significant. All of thirteen estimates were negative. Three crosses were significant and four were non-significant. Negative heterobeltiosis ranged from -0.39 (8961×Uqab 2000) to -18.51% (8952×PBW 222). The negative estimates of heterosis and heterobeltiosis for plant height are preferred over their mid and better parents in wheat breeding because dwarfness is a desirable character because of its responsiveness to fertilizer and resistance to lodging. The hybrid 8952×PBW 222 with 98.69 cm height is considered to be the best for further use in wheat breeding programme due to -4.35% decrease in height from the mid parent and -718.51% decrease in height from better parent. The results are in agreement with the research findings of Chowdhry *et al.*[4].

Number of tillers per plant: A perusal of Table 2 indicated the highly significant differences among treatment means for this trait. The average number of tillers per plant ranged from 8.33 (8952×LU26S) to 12.97 (PBW 222). All the crosses showed negative heterotic effect ranged from -0.45 (8952×Uqab 2000) to -31.22% (8952×LU26S). Nineteen out of twenty crosses were highly significant but showed negative estimates. Only one cross (8952×Uqab 2000) showed non-significant but negative results.

As for the heterobeltiosis is concerned all the crosses showed negative estimates ranged from -6.23 (8952×Uqab 2000) to -33.16% (8952×LU26S). All the results were highly significant but showed negative estimates. The negative estimates of heterosis and heterobeltiosis are not desirable because less number of tillers per plant means low yield. Similar results have been reported by Chakraborty and Tiwari[9].

Number of grains per spike: It is evident from Table 2 that marked differences were found for number of grains per spike among parents and hybrids which varied from 72.10 (Uqab 2000) to 46.30 (LU26S×8961). Heterotic effects for number of grains per spike of F_1 over their respective mid and better parents are given in Table 3.

Positive and highly significant heterosis was observed in nine crosses which surpassed mid parental value ranging from 2.86 (LU26S×PBW 222) to 13.97% (LU26S×Uqab 2000). One cross PBW 222×8952 showed positive but significant heterosis. Two crosses PBW 222×LU26S and Uqab 2000×8961 showed positive but non-significant heterosis. Five crosses viz., PBW 222×Uqab 2000, LU26S×8961, Uqab 2000×PBW 222, 8961×LU26S and 8961×Uqab 2000 showed negative and highly significant heterosis. Three crosses like Uqab 2000×8952, 8952×LU26S and 8952×8961 showed negative but non-significant heterosis. Heterobeltiosis estimates for grains per spike were also exhibited in Table 3. Positive and highly significant values were observed in six crosses, ranging from 2.68 (in two cross combinations LU26S×8952 and 8952×PBW 222) to 9.25% (8961×PBW 222) (Table 3). Two crosses i.e. PBW 222×LU26S and PBW 222×8952 showed positive but non-significant heterobeltiosis. The maximum negative heterobeltiosis (-20.71%) was shown by the cross PBW 222×Uqab 2000. Two crosses 8952×LU26S and 8952×8961 showed negative but non-significant heterobeltiosis. Presence of hybrid vigour in number of grains per spike had already been reported by Larik *et al.*[10].

1000-grain weight (g): Highly significant differences were found among parents and F_1 hybrids (Table 1). The perusal of Table 2 revealed that maximum grain weight (47.77 g) was recorded from the parent genotype 8952, while the minimum grain weight (34.00 g) was recorded from the parent genotype PBW 222. Among the crosses, minimum 1000-grain weight was exhibited by the cross i.e. Uqab 2000×PBW 222 (41.23 g) while the maximum weight was shown by the cross Uqab 2000×LU26S (49.00 g) closely followed by the cross PBW 222×LU26S (48.40 g). Thirteen out of twenty crosses showed positive and highly significant heterosis over their mid parents ranging from 5.24 (Uqab 2000×8952) to 20.96% (PBW 222×Uqab 2000).

Table 1: Analysis of variance (mean square values) for different traits in wheat

S.O.V	df	Plant height	Tillers/plant	Grains/spike	1000-grain weight	Grain yield/plant
Replication	2	1.19^{NS}	0.52^{NS}	0.65^{NS}	5.34^{NS}	2.36^{NS}
Genotype	24	249.86**	3.66**	141.80**	33.30**	18.54**
Error	48	6.84	0.75	3.60	2.35	2.12

* = Significant, ** = Highly significant, NS = Non-significant

Table 2: Mean performance and statistical significance for different traits in wheat

Crosses	Plant height (m)	Tillers/plant	Grains/spike	1000-grain weight (g)	Grain yield/plant(g)
PBW222	81.54g	12.97a	50.10jk	34.00i	17.70hi
LU26S	110.00b-d	12.47ab	50.03jk	47.60ab	23.38b-d
Uqab2000	107.60cd	10.40c-f	72.10a	39.47h	23.62bc
8961	112.40a-c	12.93a	49.93jk	47.67ab	23.30b-d
8952	115.80a	11.77a-c	50.97i-k	47.77ab	22.35c-e
PBW222×LU26S	94.27ef	9.76d-g	50.97i-k	48.40ab	20.42e-h
PBW222×Uqab2000	91.36f	10.33c-f	57.17fg	44.43c-f	21.02c-g
PBW222×8961	97.68e	11.13b-d	52.63h-j	45.73b-f	21.61c-f
PBW222×8952	96.59e	10.77c-f	51.67h-k	47.37a-c	23.64bc
LU26S×PBW222	95.98ef	10.20c-f	51.50h-k	46.90a-d	19.87e-I
LU26S×Uqab2000	112.40a-c	10.13c-f	69.60a	46.23a-e	25.19ab
LU26S×8961	107.90cd	9.93d-g	46.30l	47.10abc	18.63g-I
LU26S×8952	108.20cd	9.83d-g	52.33h-j	46.03a-f	19.46f-I
Uqab2000×PBW222	93.66ef	9.80d-g	59.03d-f	41.23gh	19.61e-I
Uqab2000×LU26S	107.40cd	10.57c-f	65.40b	49.00a	27.39a
Uqab2000×8961	109.60b-d	9.16fg	61.80cd	46.50a-d	21.89c-f
Uqab2000×8952	112.0a-c	9.36cfg	60.60de	45.90b-f	21.30c-g
8961×PBW222	98.06e	10.40c-f	54.73gh	43.47e-g	20.71d-g
8961×LU26S	110.60b-d	10.50c-f	48.17kl	47.80ab	20.33e-h
8961×Uqab2000	112.00a-c	10.43c-f	58.27ef	43.17fg	20.67d-g
8961×8952	1.61d	10.60c-f	54.00g-I	43.37e-g	19.67e-I
8952×PBW222	94.39ef	10.03def	52.33h-j	44.10d-f	20.18e-I
8952×LU26S	108.8b-d	8.33g	50.13jk	48.07ab	17.45i
8952×Uqab2000	116.40a	11.03b-e	64.80bc	47.13a-c	25.91ab
8952×8961	113.70ab	9.50d-g	50.30jk	47.23a-c	19.14f-I

Means having the same letters do not differ significantly at 0.05 level of probability by Duncan's multiple range test

Table 3: Estimation of percent heterosis (Hb%) and heterobeltiosis (Hbt%) for different parameters

	Plant height		Tillers/plant		Grains/spike		1000-grain weight		Grain yield/ plant	
Crosses	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%
PBW 222×LU26S	-1.59$^{N.S}$	-14.33**	-23.20**	-24.68**	1.80$^{N.S}$	1.73$^{N.S}$	18.63**	1.68$^{N.S}$	-0.58$^{N.S}$	-12.66**
PBW 222×Uqab 2000	-3.41**	-15.11**	-11.55**	-20.31**	-6.44**	-20.71**	20.96**	12.58**	1.73$^{N.S}$	-11.02**
PBW 222×8961	0.73$^{N.S}$	-13.11**	-14.03**	-14.14**	5.23**	5.06**	12.00**	-4.06**	5.42**	-7.25**
PBW 222×8952	-2.13*	-16.62**	-12.94**	-16.97**	2.24*	1.37$^{N.S}$	15.86**	-0.84$^{N.S}$	18.08**	5.80**
LU26S×PBW 222	0.21$^{N.S}$	-12.77**	-19.79**	-21.34**	2.86**	2.79**	14.95**	-1.47$^{N.S}$	-3.25**	-15.01**
LU26S×Uqab 2000	3.31**	2.17*	-11.37**	-18.72**	13.97**	-3.47**	6.20**	-2.87**	7.16**	6.62**
LU26S×8961	-3.00**	-4.02**	-21.78**	-23.20**	-7.37**	-7.46**	-1.12$^{N.S}$	-1.19$^{N.S}$	-20.19**	-20.33**
LU26S×8952	-4.15**	-6.56**	-18.84**	-21.12**	3.63**	2.68*	-3.46**	-3.63**	-14.91**	-16.79**
Uqab 2000×PBW 222	-0.97$^{N.S}$	-12.97**	-16.12**	-24.42**	-3.38**	-18.12**	12.25**	4.48**	-5.11**	-17.00**
Uqab 2000×LU26S	-1.31$^{N.S}$	-2.40*	-7.58**	-15.24**	7.10**	-9.29**	12.56**	2.94**	16.52**	15.93**
Uqab 2000×8961	-0.35$^{N.S}$	-2.48*	-21.43**	-29.12**	1.28$^{N.S}$	-14.29**	6.73**	-2.45*	-6.71**	-7.34**
Uqab 2000×8952	0.26$^{N.S}$	-3.29**	-15.49**	-20.40**	-1.52$^{N.S}$	-15.95**	5.24**	-3.91**	-7.35**	-9.85**
8961×PBW 222	1.11$^{N.S}$	-12.77**	-19.69**	-19.79**	9.43**	9.25**	6.45**	-8.81**	1.03$^{N.S}$	-11.11**
8961×LU26S	-0.56$^{N.S}$	-1.61$^{N.S}$	-17.32**	-18.81**	-3.63**	-3.73**	0.35$^{N.S}$	0.28$^{N.S}$	-12.91**	-13.06**
8961×Uqab 2000	1.78$^{N.S}$	-0.39$^{N.S}$	-10.57**	-19.33**	-4.51**	-19.19**	-0.92$^{N.S}$	-9.44**	-11.91**	-12.50**
8961×8952	-7.00**	-8.38**	-14.17**	-18.04**	7.04**	5.95**	-9.12**	-9.21**	-13.84**	-15.61**
8952×PBW 222	-4.35**	-18.51**	-18.87**	-22.62**	3.56**	2.68*	7.87**	-7.68**	0.80$^{N.S}$	-9.68**
8952×LU26S	-3.68**	-6.09**	-31.22**	-33.16**	-0.73$^{N.S}$	-1.64$^{N.S}$	0.80$^{N.S}$	0.63$^{N.S}$	-23.70**	-25.39**
8952×Uqab 2000	4.17**	0.47$^{N.S}$	-0.45$^{N.S}$	-6.23**	5.31**	-10.12**	8.06**	-1.33$^{N.S}$	12.71**	9.63**
8952×8961	-0.38$^{N.S}$	-1.85$^{N.S}$	-23.08**	-26.55**	-0.30$^{N.S}$	-1.31$^{N.S}$	-1.01$^{N.S}$	-1.12$^{N.S}$	-16.13**	-17.85**

Two cross combinations 8961×LU26S and 8952×LU26S showed positive but non-significant heterosis (Table 3). The hybrids LU26S×8952 and 8961×8952 showed highly significant but negative heterosis. Three cross combinations LU26S×8961, 8961×Uqab 2000 and 8952×8961 showed negative but non-significant heterosis. For heterobeltiosis, three hybrids like PBW 222×Uqab 2000, Uqab 2000×PBW 222 and Uqab 2000×LU26S showed positive and highly significant values. Three hybrids PBW 222×LU26S, 8961×LU26S and 8952×LU26S showed positive but non-significant heterosis over their better parents. Eight

crosses showed highly significant but negative estimates ranging from -2.87 (LU26S×Uqab 2000) to -9.44% (8961×Uqab 2000). Only one cross Uqab 2000×8961 showed significant but negative heterobeltiosis. Five cross combinations like PBW 222×8952, LU26S×PBW 222, LU26S×8961, 8952×Uqab 2000 and 8952×8961 showed negative and non-significant results. Similar results were reported by Atta and Khan[11].

Grain yield per plant (g): The analysis of variance for grain yield per plant is presented in Table 1. The individual comparison of means of all the genotypes is given in Table 2. The estimate of percent heterosis and heterobeltiosis for grain yield per plant of twenty wheat hybrids were given in Table 3. These estimates exhibited that five cross combinations PBW 222×8961, PBW 222×8952, LU26S×Uqab 2000, Uqab 2000×LU26S and 8952×Uqab 2000 showed positive and highly significant results. Three crosses like PBW 222×Uqab 2000, 8961×PBW 222 and 8952×PBW 222 showed positive but non-significant estimates. Twelve crosses revealed negative values ranging from -0.58 (PBW 222×LU26S) to -23.70% (8952×LU26S). Out of these twelve crosses, eleven were highly significant and one cross i.e. PBW 222×LU26S was non-significant. For heterobeltiosis, four crosses viz., PBW 222×8952, LU26S×Uqab 2000, Uqab 2000×LU26S and 8952×Uqab 2000 showed positive and highly significant results. Sixteen out of twenty hybrids showed negative estimates ranging from -7.25 (PBW 222×8961) to -25.39% (8952×LU26S). All the negative estimates were highly significant. The results obtained also supported by the earlier observations on heterotic effects in grain yield, reported by Atta and Khan[11].

A review of results made it clear that most of crosses exhibited remarkable heterosis over mid and better parents for various characters. However, crosses PBW 222×Uqab 2000, 8961×8952, Uqab 2000×8952 and Uqab 2000×LU26S may be considered for selection as hybrid or pure line wheat varieties after achieving desired homozygosity.

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