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Research Note

Heterosis of certain important yield components in the population wheat (T*riticum aestivum* L.) crosses

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Abstract:
Heterotic and heterobeltiotic performances of 10 F1s obtained from half-diallel crossings of 5 commercial varieties were evaluated for plant height, number of tillers per plant, spike length, number of spikelets per spike, flag leaf area and number of grains per spike. The highest negative heterosis and heterobeltiosis were recorded in Daman-98 x Sehar (-7.74) for plant height. Daman-98 x Zam-04 showed maximum positive heterosis (44.05) whereas Daman-98 x Shafaq showed maximum positive heterobeltiosis (34.85) for number of tillers per plant. For spike length maximum heterosis and heterobeltiosis values were 38.40 and 31.26, respectively, for the hybrid Sehar x Gomal-08. Similarly for number of spikelets per spike maximum heterosis and heterobeltiosis were 45.66 and 42.59 for the cross Daman-98 x Gomal-08. Heterotic study for flag leaf area revealed that maximum positive heterosis for Daman-98 x Sehar (21.22), maximum positive heterobeltiosis for Daman-98 x Gomal-08 (18.01). Maximum positive heterosis was recorded for Daman-98 x Gomal-08 (33.32), whereas positive heterobeltiosis were found for Daman-98 x Gomal-08 (19.43) for grains per spike. The results revealed that the hybrid combinations Daman-98 x Gomal-08 and Daman-98 x Sehar could be recommended for improved yield and enhanced biological production of wheat, respectively.

Key Words:
Wheat, heterosis, heterobeltiosis, grain yield, yield components.

Maximum yield potential with best industrial quality combinations are the aims of the breeding programs. Exploiting heterosis for getting higher yield with improved quality has been largely used in cross-pollinated crops. In self pollinated crops evidences are available to confirm the potential use of heterosis (Haq and Laila, 1991), suggesting the easiest ways of the possibility of commercial exploitation of genetic potential of wheat crop. A number of explanations could be placed in this regard; the theory of dominant linked genes appears to be the most acceptable, both in the concept and utilization of hybrid vigour in self pollinated crops (Singh and Sharma, 1989). Heterotic studies can also be used for getting information about the increase or decrease of F1s over their mid-parent and better-parent (heterobeltiosis). Its use for elaborating the general and specific combining ability, in the selection process is also confirmed. Keeping in view the general rule of breeding, the higher the heterosis and heritability, the simpler the selection process and greater the response to selection. A diallel study was employed for determination of the out-yielding effects of wheat hybrids for 10 agronomic traits and their possible exploitation for commercial use.

The experimental material comprised half diallel crosses (Daman-98 x Sehar, Daman-98 x Shafaq, Daman-98 x Zam-04, daman-98 x Gomal-08, Sehar x Shafaq, Sehar x Zam-08, Sehar x Gomal-08, Shafaq x Zam-04, Shafaq x Gomal-08 and Zam-04 x Gomal-08) and their parents, which were planted in a randomized complete block design (RCBD) with three replications in the experimental area of the Gomal University D. I. Khan. The plant to plant and row to row distances were kept at 15 cm and 30 cm, respectively. At maturity, data were collected for plant height, number of tillers per plant, spike length, number of spikelets per spike, flag leaf area and number of grains per spike from ten guarded plants.

The values of mid-parent heterosis and better-parent heterosis (heterobeltiosis) were calculated according

to the scheme outlined by Matzinger *et al*., (1962). The data recorded for different characters were analyzed for variance in accordance with the method described by Steel and Torrie (1984). The traits showing significant differences were subjected to heterosis and heterobeltiosis calculation.

Analysis of variance, means of the parents and hybrids are given in tables 1, 2 and 3 respectively. Table 1 indicates significant to highly significant differences among the hybrids for all the traits studied. The details of each character are summarized below.

Plant Height: Plants with greater height are likely to lodge. Moreover, tall plants require more energy to translocate solutes to the grains and have lower grain weight ultimately lower grain yield. Short stature wheat is therefore preferred and negative heterosis is desirable. Maximum negative heterosis was shown by Daman-98 x Sehar (-7.74) fallowed by Sehar x Shafaq (-7.64) whereas maximum negative heterobeltiosis was revealed by the hybrid daman-98 x Sehar. Mahajan and Nagarajan (2001) also observed negative heterosis in wheat whereas the positive heterosis has been recorded by Wu et al., (2001) and Singh et al., (2004). The results showed that heterotic interaction improves genetic diversity and provides ample chances to select the desired combinations. The cross Daman-98 x Sehar and Sehar x Shafaq showed dominant inheritance whereas Daman-98 x Sehar exhibit over dominant gene action to develop genotypes having short plant height. These results are in close agreement with the findings of Abdullah et al. (2002) which has reported over dominant gene action in some wheat cross combinations. It is concluded from these findings that these lines can be useful in the improvement of varieties having shorter plant height.

Number of tillers per plant: Number of productive tillers directly contributes to plant yield. Positive heterosis for tillers per plant is therefore desirable in wheat. Heterotic studies revealed that heterotic effects were positive over their mid parents (Table 4). Maximum positive mid-parent heterosis was exhibited by Daman-98 x Zam-04 (44.05) fallowed by Daman-98 x Gomal-98 (37.25) and daman-98 x Shafaq (34.85). Maximum heterobeltiosis was shown by Daman-98 x Shafaq (34.85) fallowed by daman-98 x Zam-04 (33.33) and Daman-98 x Gomal-08 (24.97). Wu et al., (2001) and Mahmood and Chaudhry (2000) are also of the opinion that mid-parent and better-parent heterosis for tillers per plant could be obtained in wheat. Hence the crosses confirming the maximum heterosis Daman-98 x Zam-04 could further be used for getting improved yield in bread wheat.

Spike Length: Spike length showed positive heterosis and heterobeltiosis respectively (Table 4). Maximum heterosis and heterobeltiosis values were (38.40) and (31.26) respectively, for the hybrid Sehar x Gomal-08. Heterosis ranged from 7.02-38.40 and heterobeltiosis ranged between 6.13 to 31.26. These results are in close agreement with the findings of Jan et al., (2005). Inamullah et al., (2006) have reported positive heterosis, while singh et al., (2004) have recorded negative heterosis for spike length in wheat genotypes. Inheritance of spike length was observed as over dominance in all the cross combinations. Singh *et al*., (2004) also reported that heterosis resulting from inter allelic interactions of dominant types could not be fixed in subsequent generations.

Spikelets per Spike: In the case of spikelets per spike all the crosses showed positive heterosis and heterobeltiosis, respectively (Table 4). Hybrid vigour values for spikelets per spike ranged from 45.66 to -16.35 for mid-parent and 42.59 to -11.76 over better parent. Maximum heterosis and heterobeltiosis were (45.66) and (42.59) for the cross Daman-98 x Gomal-08. The predominant heterotic interaction with respect to spikelets per spike, in all hybrids showed the effectiveness of heterosis to grain yield. Singh et al., (2004) and Afiah et al., (2000) have also reported heterosis and heterobeltiosis for spikelets per spike. Abdullah *et al*., (2002) found negative heterosis in most of the crosses in the F1 level for spikelet number per spike and they informed that the heterosis could have resulted from gene effects of over dominance or additive effect.

Flag Leaf Area: Flag leaf area is an effective yield related trait. A larger flag leaf helps to synthesize photosynthates in greater quantities, which are translocated to grains increasing their weight. Positive heterosis for flag leaf area is thus desirable (Mahmood & Chaudhry, 2000). Hybrid vigour for flag leaf area ranged for mid-parent from 21.22 to -20.56 and for better-parent from 16.56 to -28.19. Heterotic studies for flag leaf area revealed that 6 out of 10 crosses had positive heterosis and 4 out of 10 crosses showed positive heterobeltiosis (Table 4). Maximum positive heterosis was recorded in Daman-98 x Sehar (21.22), followed by Daman-98 x Gomal-08 (15.15), whereas maximum heterobeltiosis was recorded for Daman-98 x Gomal-08 (18.01), followed by Daman-98 x Sehar (16.56).

Grains per Spike: Number of grains per spike directly determines the yield potential of a genotype. Analysis of the data revealed that 5 out of 10 crosses had

positive mid-parent heterosis and 4 out of 10 crosses had heterobeltiosis. For number of grains per spike negative heterosis was observed in 5 out of 10 crosses and 6 out of 10 crosses showed heterobeltiosis. Maximum positive heterosis was recorded for Daman-98 x Gomal-08 (33.32) fallowed by Daman-98 x Shafaq (15.48), whereas positive heterobeltiosis was shown by Daman-98 x Gomal-08 (19.43) followed by Shafaq x Gomal-08. These results could be verified from the findings of Inamullah et al., (2006) and Afiah et al., (2000) who observed positive or negative heterosis and heterobeltiosis for number of grains per spike in wheat. Hybrid vigour for mid-parent ranged from 33.32 to -16.22 and for better-parent from 19.43 to -21.33.

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Table 1. Analysis of variance for the traits studied.

Character	Genotype
Plant height (cm)	62.117**
No of tillers/plant	4.498**
Spike length (cm)	5.497*
No of Spikelets/spike	16.231**
Flag leaf area (cm^2)	64.107*
No of grains/spike	96.926**

*, **= significant at 5% and 1% level of probability respectively.

Table 2. Means of traits for the parents used

parent	Plant height (cm)	No of tillers/plant	Spike length (cm)	Spikelets/spike	Flag leaf area (cm^2)	Grains/spike
Daman-98	93.00	7.66	11.86	15.66	34.90	48.00
Sehar	100.66	9.00	11.93	17.33	31.21	54.66
Shafaq	91.33	7.66	12.06	15.66	43.20	38.00
Zam-04	96.00	9.00	11.66	17.00	40.15	45.00
Gomal-08	92.00	9.33	10.70	15.00	33.25	38.00

Table 3. Means of agronomic traits for the selected F_1s.

crosses	Plant height (cm)	No of tillers /plant	Spike length (cm)	Spikelets /spike	Flag leaf area (cm^2)	Grains /spike
Daman-98 x sehar	89.33	9.66	13.28	20.00	47.07	43.00
Daman-98 x shafaq	89.33	10.33	12.80	19.66	31.02	49.66
Daman-98 x zam-04	87.66	12.00	14.36	21.33	40.91	43.00
Daman-98 x gomal-08	100.33	11.66	14.33	22.33	39.24	57.33
Sehar x shafaq	88.66	10.00	15.00	20.66	33.72	50.66
Sehar x zam-04	98.66	9.66	13.40	20.00	38.19	43.33
Sehar x gomal-08	86.33	10.00	15.66	20.33	32.83	43.66
Shafaq x zam-04	91.33	8.33	13.43	19.00	35.47	47.33
Shafaq x gomal-08	92.66	9.33	13.41	20.33	36.81	41.66
Zam-04 x gomal-08	89.00	10.00	12.72	21.33	40.18	40.33

Table 4. Mid parent and heterobeltiosis for important traits of wheat in 10 hybrids (in per cent)

crosses	Plant height (cm)		No of tillers/plant		Spike length (cm)		Spikelets/spike		Flag leaf area (cm^2)		Grains/spike	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Daman-98 x sehar	-7.74*	-11.25*	15.96	7.33	11.64	11.31	21.24	15.40	21.22*	16.56*	-16.22	-21.33
Daman-98 x shafaq	-3.07	-3.94*	34.85	34.85	7.02	6.13	25.54	25.54	-20.56	-28.19	15.48*	3.45*
Daman-98 x zam-04	-7.23*	-8.68	44.05	33.33	22.10	20.15	30.61	25.47	9.02	1.89	-7.52	-10.41
Daman-98 x gomal-08	8.46*	7.88*	37.25	24.97	27.03	20.82	45.66	42.59	15.15*	18.01*	33.32*	19.43**
Sehar x shafaq	-7.64*	-11.92	20.04	11.11	25.05	24.37	25.25	19.21	-9.36	-21.94	9.34*	-7.31*
Sehar x zam-04	0.33	-1.98	7.33	7.33	13.60	12.32	16.51	15.40	7.03	-4.88	-13.04	-20.72
Sehar x gomal-08	-10.38	-14.23*	9.11	7.18	38.40	31.26	25.76	17.31	1.86	-1.26	-2.60	-20.12*
Shafaq x zam-04	-2.49	-4.86	0.00	-7.44	13.23	11.35	16.35	11.76	-14.88	-17.89	14.04*	5.17
Shafaq x gomal-08	1.08	0.71	9.82	0.00	17.83	11.19	32.61	29.82	-3.70	-14.79	9.63	9.63*
Zam-04 x gomal-08	-5.31	-7.29	9.11	7.18	13.77	9.09	33.31	25.47	9.48	0.07	-2.81	-10.37

MP : Mid-Parent BP: Best-Parent