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HETEROTIC AND HETEROBELTIOTIC PERFORMANCE OF SOME INTER VARIETAL HYBRIDS OF BREAD WHEAT (*TRITICUM AESTIVUM* L.) FOR MAJOR YIELD ASSOCIATED TRAITS

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ABSTRACT

The present investigation was carried out for the estimation of general magnitude of heterosis and heterobeltiosis among F_1 hybrids derived from six hexaploid bread wheat varieties which were TD-1, SKD-1, Imdad, Khirman, Moomal and H-68. Initially, 15 all possible one-way and 15 reciprocal crosses were made to rise F_1 generation by diallel method. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications; observations were recorded on nine metric traits out of which six are discussed in this research paper: Plant height, tillers per plant, spikelets per spike, grains per spike, 1000-grain weight and grain yield per plant. Cross SKD-1x Khirman produced dwarf plants, while hybrid SKD-1 x Khirman showed highest heterosis and heterobeltiosis for tillers per plant and spikeles per plant. Regarding traits, 100-grain weight, grains per spike and grain yield per plant combination of three parents Moomal, H-68 and SKD-1 resulted in highest magnitude of heterosis and heterobeltiosis.

Keywords: *Triticum aestivum*, heterosis and heterobeltiosis.

INTRODUCTION

A tremendous transition from Mendelian to molecular genetics has been observed in the biological research round the globe for effective and efficient manipulation of genetic architecture of important plant species that have lasting impact on crop improvement. The production of transgenic plants have opened up new vistas, however, the traditional / conventional plant breeding governed by the principles of classical genetics in many cases is inevitable. Despite of expertise and adequate budget, the plant breeders are sometimes compelled to practice age old hybridization and screening techniques to isolate the elite genotype which may further be subjected to analysis on molecular basis. It is a potential technique that fosters investigations and resolve biological problems related to the inheritance pattern of economically useful traits of crop plants. The same also provides basics to the understanding of plant molecular genetics.

The present research paper reveals influence of certain plant traits in terms of their contribution towards yield. The undertaken research pertains to estimation of magnitude of heterosis and heterobeltiosis in conventionally developed inter varietal F_1 hybrids of wheat.

Hexaploid wheat (*Triticum aestivum* L.) is the world's most important crop. In addition to its use for bread, large quantities of wheat are used for pastry, for unleavened breads such as chapatti in India and Pakistan, and for semolina products. These uses in combination with its nutritional and storage function, has made wheat a staple food for more than one third of the world's population. Therefore, wheat is the most important cereal and staple food for Pakistan as well. It has contributed more calories and protein to the world's diet than any other food crop and world trade in wheat than for all other food grains combined (Hanson *et al.*, 1982). The immediate superiority of crossbred progeny over their inbred parents or their inbred offspring, heterosis, is a manifestation of gene action. There are two general interpretations of heterosis: the accumulation of the effects of favorable dominant genes at different loci, and the interaction between different alleles at the same locus. The first hypothesis is generally understood as domination and the other super-dominance or over dominance. Heterosis term was coined by Shull (1914). Falconer and Mackay (1996) simply defined heterosis or hybrid vigor as the difference between the hybrid and the mean of two parents expressed as a percentage, often called mid-parent heterosis. When the hybrid results are compared against their better parent who uses or the prevailing commercial variety heterosis has been termed as useful heterosis (Meredith and Bridge, 1972). Heterobeltiosis, term first coined by Fonseca (1965) in wheat diallel analysis, refers to the phenomenon where F_1 hybrid obtained by crossing two genetically different parents show superiority over its better parent in one or combination of characters. Briggle, 1963; Sajnani, 1968 suggested the possibility of heterotic effects in wheat. Khan and Khan 1996 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%). Their study was conducted to estimate the level of heterosis and heterobeltiosis among F_1 hybrids of four lines and three testers in breeding heterosis and heterobeltiosis for wheat grain yield.

These studies would be helpful in selecting suitable parents for hybrid development and isolating transgressive segregates.

MATERIALS AND METHODS

The experimental material for studying and analyzing some economically useful metric traits through heterosis and heterobeltiosis consisted of six hexaploid bread wheat (*Triticum aestivum* L.) varieties *viz.* TD-1, SKD-1, Imdad, Khirman, Moomal and H-68, their 15 all possible one-way crosses and 15 inverted in F_1 generations were prepared in the Botanical Garden of the Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam. During the first week of November 2009, six parents and their 30 F1s (one-way hybrids and their reciprocals) were sown in six-by-six complete diallel cross of 36 items in a four replicated Randomized Complete Block. Each replication block was 55.5" x 15", where all the 36 items were randomized, space-seeded dibbled (leaving 1.5" boundary road) at a distance of 6" from plant to plant, and 1.5" from entry to entry (or line to line). At maturity, the observations were recorded for nine metric traits, however, six of them *viz;* plant height, tillers per plant, spikelets per spike, grains per spike, 1000-grain weight and grain yield per plant are discussed here.

Statistical analysis: Analysis of variance from the complete randomized blocks was performed using the Statistical Analysis System software (SAS) Statistix version 8.1. Heterosis estimates of F_1 hybrid was calculated as the deviation of F_1 from their mid-parent value expressed in percent. Heterobeltiosis was estimated as the deviation of the F_1 hybrid from its better parent mean, expressed in percent (Fonseca, 1965).

RESULTS AND DISCUSSION

Mean squares from such analysis of variance are presented in Table 1. Results showed that in F_1 diallel set, replication effects (mean squares) were highly significant ($P < 0.01$) for plant height and significant at $P < 0.05$ for grains per spike, grain yield per plant and 1000-grain weight. Significant block effects for these characters clearly show soil heterogeneity spots in the experimental plot and the vulnerability of these characters may be affected due to soil fertility patches. Replication mean square was non-significant for spikes per plant, tillers per plant, spike length, spikelets per spike and grain weight per spike. Genotype mean squares were highly significant ($P < 0.01$) for all characters except for spikes per plant and grain weight per spike. These results suggest that genotypes (parents, hybrids and their reciprocals) significantly differed from each other for these same characters and that the variability present in these characters may be exploited in the desired direction in the breeding program. Details of heterosis and heterobeltiosis for properties that have been studied are as under:

Heterosis and heterobeltiosis Analysis:

Mean performance of parents, F_1 hybrids, averaged over four repetitions - and where the estimated heterosis and heterobeltiosis estimates for all eight quantitative characters are presented in Table-02-03. These results are presented and discussed under separate headings / characters.

Plant height: Heterosis and heterobeltiosis estimates for plant height in F_1 diallel sets are given in Table-02. Maximum mid parent heterosis estimates of 20.6% was shown by the F_1 hybrid TD-1 x Khirman followed by 9.65% of SKD-1 x Imdad while the lowest value of -7.61% was recorded from the cross SKD-1 x Khirman. At heterobeltiosis was highest estimates of 14.68% out of the hybrid TD-1 x Khirman followed by the second highest value of 7.41% from SKD-1 x Khirman and lowest estimates given by the TD-1 x SKD-1 (- 10 , 69%) followed by the second lowest value of -10.43% is provided by the hybrid Khirman x Moomal. In the reciprocal F1s, the highest heterosis cross was in Khirman x TD-1 (27.06% heterosis) followed by Imdad x TD-1 provides 13.33% mid parent heterosis. On the other hand, the lowest heterosis that exhibit reciprocal cross was H-68 x Khirman (-5.92% value), followed by the second lowest value of 3.73% as shown by Khirman x Imdad. The lowest heterosis, hybrid H-68 x Khirman associated with top and parent H-68 for plant height recording 88.8 cm height. In the reciprocal hybrids, the highest heterobeltiosis value of 21.37% from Khirman x TD-1 followed by the second highest value of 5.16% given by the reciprocal cross H 68 x SKD-1 and the lowest estimates were recorded from the cross H-68 x Khirman (-11.84%), followed by the second lowest at -10.64% is given by Moomal x TD-1. Tallness is not a desirable trait in wheat lodging can occur during the storm results in reduced grain yield. So for this trait negative heterosis is desirable. The estimates of negative heterosis and heterobeltiosis for plant height are preferred in wheat breeding because dwarfness is a desired character (Budak & Yildirim, 1996).

Table 1. Mean squares from the analysis of variance of a 6x6 complete F_1 diallel cross of wheat for six traits.

Character	Replications DF=03	Genotypes DF=35	Error DF=105	C.V. %
F_1 Diallel Cross – 2009				
Plant height	102.214**	148.083**	7.4	3.242
Tillers per plant	1.355	22.577**	0.864	10.161
Spikelets per spike	4.09	37.67**	0.58	4.999
Grains per spike	49.78*	288.99**	27.09	7.229
1000-grains weight	26.51*	9.09**	3.00	3.743
Grain yield per plant	24.29*	17.90**	2.25	7.876

*Significant at P<0.05 and **Significant at P<0.01

Table 2. Heterosis, heterobeltiosis estimates for six traits in 6 × 6 F_1 complete diallel cross of wheat.

Hybrids	**plant height**		**tiller number per plant**		**spikelets per spike**	
	Heterosis (%)	Hetero-beltiosis (%)	Heterosis (%)	Hetero-beltiosis (%)	Heterosis (%)	Hetero-beltiosis (%)
One-way F_1 crosses during 2009						
TD-1 x SKD-1	-4.42	-10.69	27.90	6.80	0.14	-2.20
TD-1 x IMDAD	7.35	-1.59	-22.27	-35.47	-13.96	-18.81
TD-1 x KHIRMAN	20.06	14.68	-14.66	-32.25	-29.02	-29.26
TD-1 x MOOMAL	4.42	-3.34	-38.32	-39.69	-39.91	-40.85
TD-1 x H-68	6.81	-4.09	28.84	-2.00	-18.50	-23.21
SKD-1 x IMDAD	9.65	7.41	-16.43	-17.04	-37.64	-42.44
SKD-1 x KHIRMAN	-7.61	-9.73	71.79	61.22	0.99	-1.04
SKD-1 x MOOMAL	2.72	1.69	-19.70	-31.69	-21.03	-21.69
SKD-1 x H-68	5.44	1.02	15.05	2.28	-25.45	-31.31
IMDAD x KHIRMAN	-1.96	-6.11	-2.26	-7.62	-34.79	-38.65
IMDAD x MOOMAL	2.68	1.60	22.69	3.75	-19.02	-24.70
IMDAD x H-68	6.17	3.78	-4.80	-14.79	-31.08	-31.19
KHIRMAN x MOOMAL	-7.43	-10.43	43.16	15.62	4.12	2.84
KHIRMAN x H-68	3.73	-2.79	20.36	13.57	-11.17	-16.56
MOOMAL x H-68	4.74	1.33	-5.08	-26.64	-23.09	-28.60
Reciprocal F_1 crosses during 2009						
SKD-1 x TD-1	8.60	1.47	-25.29	-37.61	-38.37	-39.81
IMDAD x TD-1	13.33	3.89	22.14	1.40	-15.82	-20.56
KHIRMAN x TD-1	27.06	21.37	-27.53	-42.48	-37.76	-37.96
MOOMAL x TD-1	-3.46	-10.64	11.42	8.92	3.00	1.40
H-68 x TD-1	6.74	-4.15	-13.45	-34.17	-12.12	-17.20
IMDAD x SKD-1	6.80	4.62	3.86	3.11	-24.96	-30.74
KHIRMAN x SKD-1	2.45	0.11	-2.20	-8.21	-39.43	-40.65
MOOMAL x SKD-1	5.70	4.63	22.97	4.62	-24.71	-25.33
H-68 x SKD-1	9.21	5.16	-4.81	-15.38	-36.30	-41.30
KHIRMAN x IMDAD	-3.73	-7.80	-3.81	-9.08	-35.85	-39.65
MOOMAL x IMDAD	1.04	-0.03	20.75	2.11	-20.33	-25.92
H-68 x IMDAD	4.47	2.11	-6.29	-16.14	-32.17	-32.28
MOOMAL x KHIRMAN	7.91	4.41	-14.40	-30.87	-31.88	-32.72
H-68 x KHIRMAN	-5.92	-11.84	5.98	0.00	-37.07	-40.89
H-68 x MOOMAL	-3.39	-6.53	29.39	0.00	-21.86	-27.46

Number of tillers per plant: F_1 diallel set (Table-02), the highest rated heterosis and hybrid heterobeltiosis was SKD-1 x Khirman gives 71.79% heterosis and 61.22% heterobeltiosis estimates respectively followed by the next highest ranked hybrid Khirman x Moomal with 43.16% and 15.62% heterosis heterobeltiosis. On the other hand, the lowest rank hybrid TD was 1 x Moomal gave -38.32% to 39.69% heterosis and heterobeltiosis. In the reciprocal crosses, Moomal x SKD-1 exhibited high heterosis of 22.97%, followed by 22.14% of Imdad x TD-1 and the lowest ranking heterotic hybrid was Khirman x TD-1 with -27.53% followed by SKD-1 x TD-1 with 25.3% heterosis value. For heterobeltiosis, Moomal x TD-1 showed the highest value at 8.92% followed by 4.62%, the second highest value for Moomal x SKD-1. Negative estimates of heterosis and heterobeltiosis is desirable because less tillers per plant means low grain yield. Similar findings have been reported by Chowdhry *et al.* (2001), but Knobel *et al.* (1997) reported negative heterosis for this trait.

Table 3. Heterosis, heterobeltiosis estimates for six traits in 6 × 6 F_1 complete diallel cross of wheat.

Hybrids	**grains per spike**		**1000-grains weight**		**grain yield per plant**	
	Heterosis (%)	Hetero-beltiosis (%)	Heterosis (%)	Hetero-beltiosis (%)	Heterosis (%)	Hetero-beltiosis (%)
One-way F_1 crosses during 2009						
TD-1 x SKD-1	12.08	1.14	1.40	1.14	-0.41	-1.93
TD-1 x IMDAD	-17.48	-18.61	-1.28	-3.12	3.95	3.61
TD-1 x KHIRMAN	9.84	-1.63	7.29	5.04	13.41	1.80
TD-1 x MOOMAL	-10.82	-19.97	-3.58	-4.05	-18.11	-19.53
TD-1 x H-68	-7.94	-19.60	4.06	2.14	9.13	-2.34
SKD-1 x IMDAD	-15.02	-22.36	-4.20	-6.23	-21.57	-22.50
SKD-1 x KHIRMAN	28.46	27.39	4.98	3.04	12.23	-0.59
SKD-1 x MOOMAL	3.13	2.51	1.75	0.99	5.88	2.51
SKD-1 x H-68	28.53	23.90	8.75	7.01	13.34	0.08
IMDAD x KHIRMAN	-8.03	-16.60	-1.63	-5.45	-9.49	-18.97
IMDAD x MOOMAL	-7.79	-16.22	1.07	-0.34	0.38	-1.65
IMDAD x H-68	-10.96	-21.30	-1.35	-4.95	-9.84	-19.53
KHIRMAN x MOOMAL	30.03	29.74	4.82	2.12	17.10	6.81
KHIRMAN x H-68	7.93	4.89	6.82	7.28	34.09	33.61
MOOMAL x H-68	30.13	26.19	8.58	6.06	18.27	7.53
Reciprocal F_1 crosses during 2009						
SKD-1 x TD-1	-9.57	-18.40	-0.95	-1.20	-19.18	-20.41
IMDAD x TD-1	-16.88	-18.02	2.17	0.26	-0.73	-1.06
KHIRMAN x TD-1	-14.02	-22.99	1.45	-0.68	-9.23	-18.52
MOOMAL x TD-1	-9.48	-18.77	-2.13	-2.61	-16.89	-18.33
H-68 x TD-1	-6.56	-18.40	5.61	3.66	10.76	-0.88
IMDAD x SKD-1	-13.74	-21.19	-2.76	-4.82	-20.39	-21.33
KHIRMAN x SKD-1	30.39	29.30	6.56	4.58	13.90	0.89
MOOMAL x SKD-1	4.68	4.05	3.27	2.50	7.46	4.04
H-68 x SKD-1	30.46	25.76	10.38	8.61	15.04	1.59
KHIRMAN x IMDAD	-6.65	-15.35	-0.15	-4.04	-8.14	-17.76
MOOMAL x IMDAD	-6.41	-14.97	2.59	1.15	1.87	-0.20
H-68 x IMDAD	-9.63	-20.13	0.12	4.77	-8.50	-18.33
MOOMAL x KHIRMAN	31.99	31.69	6.39	3.65	18.84	8.39
H-68 x KHIRMAN	9.54	6.46	8.42	8.14	36.11	35.62
H-68 x MOOMAL	32.08	28.08	10.21	7.65	20.04	9.14

Number of spikelets per spike:

The F_1 diallel set (Table-02), was given the maximum heterosis of hybrid Khirman x Moomal with 4.12% value and even gave heterobeltiosis maximum value of 2.84%. The second highest heterosis, hybrid was SKD-1 x Khirman 1% heterosis which also gave second highest heterobeltiosis at -1.04%. In the reciprocal cross, Khirman x

SKD-1 gave the lowest heterosis of -39.43 followed by SKD-1 x TD-1 (-38.37) and Moomal x TD-1 gave the highest heterosis of 3.0% as also gave the highest heterobeltiosis of 1.40%. Lowest heterobeltiosis estimates of -41.30% was given by H 68 x SKD-1, followed by H-68 x Khirman with the second lowest better parent heterosis of -40.89%. These results are consistent with results from Rasul *et al.* (2002)

Number of grains per spike:

Maximum heterosis for grains per spike in F1 diallel set (Table-03) was given by Moomal x H-68 (30.13%), followed by the next highest ranked hybrid Khirman x Moomal with 30.03% value; while the lowest heterosis given hybrids were TD-1 x Imdad (-17.48%) and SKD-1 x Imdad (-15.02%), which also gave the lowest score for heterobeltiosis at -22.36% and -18; 61% respectively. The highest heterosis points hybrids also made the highest heterobeltiosis estimates. The reciprocal cross, highest point heterosis hybrid was H-68 x Moomal (32.08%), followed by the second highest Moomal and Khirman with 31.99% value and lowest ranking hybrid Imdad x TD-1 (-16.88%) having the second lowest hybrid Khirman x TD-1 (14.02%). For heterobeltiosis, Moomal x Khirman gave highest better parent heterosis of 31.69% followed by Khirman x SKD-1 gives the 29.3% value. The lowest heterobeltiosis estimates obtained from Khirman x TD-1 (-22.99%) followed by the second lowest value of -21.19% was given by Imdad x SKD-1. Abdullah *et al.* (2002) also reported similar results for this property.

1000-grain weight:

The F_1 diallel set (Table 03), the highest heterosis for 1000-grain weight is given by SKD-1 x H-68 (8.75%), followed by the second highest value (8.58%) of Moomal x H -68 and the lowest negative heterosis of -4.20% was made of SKD-1 x Imdad followed by the second lowest of the TD-1 x Moomal (-3.58%). For heterobeltiosis, Khirman x Moomal gave maximum value of 7.28% followed by the second highest of 7.01% of hybrid SKD-1 x H-68, while the lowest better parent heterosis of -6.23% was given by SKD-1 x Imdad followed by Imdad x Khirman (-5.45%). In the reciprocal cross, highest rated heterotic hybrid was the H-68 x SKD-1 (heterosis = 10.38%), followed by 10.21% value given by H 68 x Moomal while the lowest heterosis was given by the reciprocal cross Imdad x SKD-1 (-2.76%), followed by the second lowest value of -2.13% made by Moomal x TD-1. For heterobeltiosis was highest value observed in cross-H 68 x SKD-1 (8.61%), followed by the second highest value of 8.14% from the cross-H 68 x Khirman. The lowest better parent heterosis was shown by Imdad x SKD-1 (-4.82), followed by the second lowest value of -4.04% is given by the cross Khirman x Imdad. Here also one-way and the reciprocal cross, the highest heterosis and heterobeltiosis gave hybrids coming from one of their parents with the lowest / second lowest average 1000-grain weight and vice versa as has been the case with other hybrids for the corresponding metric traits as discussed earlier . Almost similar results were reported in previous findings by Fonseca and Patterson in 1968.

Yield of grain per plant:

In F_1 diallel set (Table 3), maximum heterosis, hybrid Khirman x H-68 with 34.09% heterosis estimates also made maximum heterobeltiosis at 33.61%, followed by the second highest heterosis, hybrid Moomal x H 68 (18.27% value), which also gave the second highest heterobeltiosis value of 7.53%. Similarly, the lowest heterosis value gives hybrid SKD-1 x Imdad (heterosis = -21.57%) also secured the lowest heterobeltiotic value at -22.50%, followed by the second lowest heterosis, hybrid TD-1 x Moomal with 18:11 % heterosis, which also gave the second lowest heterobeltiosis value of -19.53%. For this character also (exchange of grains per plant), the highest heterosis and heterobeltiosis points hybrids came from one of their parents with the lowest / second lowest gives the parent and vice versa supports already explained the trend of results that parental performance may not necessarily always provide high heterosis and heterobeltiosis value in its hybrids parents. These results supported previous findings of heterotic effects in grain yield (Akbar *et al.* 2007). Other intersections showed either significantly negative or non-significant positive heterosis for grain yield per plant. Such crossings were not important for the hybrid force in grain yield. Hybrid force expressed for this character had also been reported previously by many researchers as Krishna and Ahmad (1992); Subhani et al. (2000), Yagdi and Karan (2000) and Rasul et al. (2002).

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