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Heterosis and Heterobeltiosis Analysis for Spike and its Related Attributes in Different Wheat Crosses

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Abstract: Yield component breeding and modification of the plant architecture offer possibilities to develop more efficient breeding systems for increased grain yield. Heterosis and heterobeltiosis studies were done at Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan following Matzinger' approach (1956) among seven wheat genotypes viz., Shahkar-95, Parwaz-94, Iqbal-2000, Uqab-2000, MH-97, 4072 and Punjab-96 for crosses in all possible combinations. Yield and yield related traits like plant height, number of tillers/plant, spike length, spikelets/spike, spike density, grain/spike, 1000-grains weight and grains yield/plant were investigated. Results for analysis of variance indicated significant differences among genotypes for many plant traits under study. Maximum significant heterosis (21.95%) was found in grain yield/plant followed by spike length (14.62%) and grain yield/spike (13.68%). While maximum heterobeltiosis was recorded for grain yield/plant (11.33%), followed by spike length (9.13%). It is concluded that 4072 x Punjab-96 cross showed best performance followed by Parwaz-94 x MH-97, Iqbal-2000 x parwaz-94 than other crosses under study. These crosses cab be utilized in further breeding programme as parents for contributing high yield not only under optimum environment but also under drought conditions as water use efficient crosses. The results of heterosis suggest that hybrid vigor is available for the commercial production of wheat and selection of desirable hybrid among the crosses having heterotic effects in other characters is the best way to improve the grain yield of bread wheat.

Key words: Heterosis, heterobeltiosis, grain yield, yield components, spring wheat

INTRODUCTION

Pakistan's agriculture sector involves 43.7% of labor force that produces their own food needs and ensures availability of food for the rest of nation and value-added activities. The potential role for agriculture in development is to reduce poverty and drive growth for countries which are agricultural based. Rapidly increasing population size requires agriculture growth compatible to convene essential level of food. The change in food utilization pattern with a change in per capita income level requires more proteins containing diet. The modification of agriculture from conventional to modern farming techniques is based on adequate availability of inputs like certified seeds, balanced use of fertilizers, mechanization, agricultural credit and opportunities of investment and agricultural research.

Wheat is an important cereal crop in the world and is leading food grain of Pakistan. It contributes 10.3% to value added in agriculture and 2.2% to GDP. The production of wheat is 2.53 million tonnes. Area under its cultivation is 9.039 thousand hectares with an average yield 2797 kg/hectare. The achievement of maximum crop yield is an important objective in most breeding programmes and the major emphasis in wheat breeding is on the development of improved varieties. Significant efforts have been made to find the economically feasible systems for the production of F1 hybrids with desirable plant characters. The possible heterosis utilization in wheat crop continues to be a foremost question. Selection of parental material used in the hybridization scheme does contribute extensively for the development of an appropriate genotype. The parents which are genetically superior and diverse in the traits of interest are utilized further for varietal development programme. Possible heterosis in wheat was suggested by Briggle (1963) and Sajnani (1968) as well. Krishna and Ahmed (1992) reported that maximum mean heterosis was obtained for 1000-grain weight (14.60%) and grain yield (12.52%). Yagdi and Karan (2000) and Rasul *et al*. (2002) observed significant heterosis and heterobeltiosis in spike length, number of spikelets/spike, number of grains/spike, 1000 gain weight and grain yield per plant. Jatoi *et al*. (2014) observed greater mid and high parent heterotic response under both normal and water stress environments for relative water content, leaf area, number of seeds/spike, seed index, harvest index and grain yield/plant.

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The present studies were under taken to estimate the level of heterosis and heterobeltiosis among F1 hybrids of five wheat varieties/lines. These information would be useful to investigate the performance and relationship of F1 hybrids and parents and to select suitable parents and population for designing an effective wheat breeding programme.

MATERIALS AND METHODS

The research work presented was carried out in the experimental area of the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan under field conditions, soil pH and EC of the field was 6.5 and about 4 dS/m, respectively.

Forty two F1 hybrids were made at Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan involving seven bread wheat varieties. F1 hybrids along with the parents were planted in the field in a randomized complete block design with three replications. Thirty plants of each genotype were grown in a 5 m long row in each replication. The plants were spaced 15 and 30 cm apart within and between the rows, respectively. Recommended agronomic practices were performed uniformly. At maturity ten guarded plants were selected randomly from each row for spike length, number of spikelets/spike, number of grains/spike, 1000-grain weight and grain yield/plant. The data were subjected to statistical analysis using the analysis of variance technique Steel *et al.* (1997) to determine significant differences among genotypes for the traits.

The significantly different genotypes were further evaluated for increase or decrease of F1 hybrids over mid parent (heterosis) as well as better parent (heterobeltiosis) was calculated for above mentioned parameters according to the procedure of Matzingar *et al.* (1962):

$$\text{Heterosis (\%)} = \frac{(F_1 - MP)}{MP} \times 100$$

$$\text{Heterobeltiosis (\%)} = \frac{(F_1 - BP)}{BP} \times 100$$

Where:

MP: Mid parental value of the particular F_1 cross $(P_1+P_2)/2$

BP: Better parent value in the particular F_1 cross

Difference of F1 mean from the respective mid parent and better parent value was evaluated by using t-test according to Wynne *et al.* (1970):

$$t = \frac{\bar{F}_{1ij} - MP_{ij}}{\sqrt{\frac{3}{8}\sigma^2_e}}$$

Where:

F_{1ij} : The mean of the ij^{th} F1 cross

Mp_{ij} : Mid parent value of the ij^{th} cross and

σ^2_e : Estimate of error variance

RESULTS AND DISCUSSION

The values of different plant traits of 47 genotypes were subjected to analysis of variance according to Steel *et al.* (1997) to sort out significant differences among 47 genotypes. The results (Table 1) showed that they were highly significant ($p \le 0.01$) differences among genotypes for all traits studied.

Table 2 indicated positive heterosis in spike length in 26 cross combinations out of which only 2 hybrids exhibited significant heterosis. Maximum heterosis was found in a cross between Parwaz-94 x MH-97 (14.62). While negative herosis was found in 16 crosses and maximum significant heterosis and heterobeltiosis was found in Punjab-96 x MH-97 with values (-12.04) and (-18.77), respectively. Positive heterobeltiosis was found in only 9 hybrids out of 42 with maximum increase in spike length in the same cross which displayed maximum positive heterosis in spike length.

18 cross combinations in Table 2 displayed increase in number of spikelets/spike. Maximum number of spikelets/spike was found in Parwaz-94 x MH-97 (5.98) and Iqbal-2000 x Parwaz-94 (5.65). Similarly, positive heterobeltiosis was found 10 crosses out of 42 hybrids. Highest value for increase in heterobeltiosis was found in 4072 x Shahkar-95 (4.32). While maximum negative heterobeltiosis was found in MH-97 x Parwaz-94 (-11.13).

Increase over the mid parent was indicated in 13 cross combinations for spike density, however, this increase was significant in only one of the crosses which was Punjab-96 x MH-97 (10.00). While 29 crosses possessed reduction in spike density. Maximum reduction in spike density was observed in Iqbal-2000 x MH-97 (-8.67). Maximum heterobeltiosis (3.90) was

Table 1: Mean squares of various plant traits in 7 x 7 diallel crosses of *Triticum aestivum* L

Source	DF	Spike length	Spikelets/spike	Spike density	Grains/spike	1000-grains weight	Grain yield/plant
Replication	2	1.83	2.22	0.039	16.47	5.81	2.23
Genotypes	48	1.54**	1.96**	0.037**	62.39**	12.43**	9.12**
Error	96	0.71	1.014	0.013	27.43	6.251	3.08
Mean		10.75	18.179	1.702	53.531	35.376	20.043
CV %		7.828	5.538	6.803	9.783	7.067	8.764

**: Significant at $p \le 0.01$, Significant at $p \le 0.05$, NS: Non-significant at $p > 0.05$

Table 2: Heterosis (%) and heterobeltiosis (%) effects in grain yield and related traits in 7x7 diallel crosses

	----- Spike length -----		----- Spikelet/spike -----		---- Spike density -----		----- Grains/spike -----		1000 grains weight		---- Grain yield/plant ----	
Crosses	Ht	Hb	Ht	Hb	Ht	Hb	Ht	Hb	Ht	Hb	Ht	Hb
Shahkar-95 x Parwaz-94	2.51^{NS}	-4.37^{NS}	-1.98^{NS}	-6.47^{NS}	-3.98^{NS}	-6.21^{NS}	4.27^{NS}	-0.25^{NS}	1.31^{NS}	-2.02^{NS}	-1.93^{NS}	-2.60^{NS}
Shahkar-95 x Iqbal-2000	1.48^{NS}	-5.78^{NS}	0.18^{NS}	-1.26^{NS}	1.47^{NS}	-4.22^{NS}	7.69^{NS}	6.62^{NS}	1.06^{NS}	-5.39^{NS}	0.12^{NS}	-8.91^{NS}
Shahkar-95 x Uqab-2000	2.48^{NS}	-0.89^{NS}	1.06^{NS}	-0.35^{NS}	-1.39^{NS}	-3.31^{NS}	-10.53^{NS}	-17.90^{**}	8.08^{NS}	-2.36^{NS}	1.44^{NS}	-3.61^{NS}
Shahkar-95 x MH-97	-0.67^{NS}	-2.79^{NS}	1.03^{NS}	0.54^{NS}	2.10^{NS}	0.51^{NS}	3.00^{NS}	1.59^{NS}	8.11^{NS}	2.12^{NS}	-0.93^{NS}	-4.20^{NS}
Shahkar-95 x 4072	0.36^{NS}	-1.84^{NS}	-5.77^{NS}	-6.12^{NS}	5.90^{NS}	-7.60^{NS}	-0.23^{NS}	-4.27^{NS}	-0.88^{NS}	-7.14^{NS}	1.04^{NS}	2.46^{NS}
Shahkar-95 x Punjab-96	-4.88^{NS}	-10.36^{NS}	-6.19^{NS}	-7.67^{*}	-1.64^{NS}	-5.70^{NS}	8.01^{NS}	4.79^{NS}	-1.52^{NS}	-11.71^{*}	-8.42^{NS}	-19.62^{**}
Parwaz-94 x Shahkar-95	5.23^{NS}	-1.84^{NS}	-5.00^{NS}	-9.35^{*}	-8.11^{*}	-10.26^{*}	-10.20^{NS}	-14.09^{*}	2.35^{NS}	-1.01^{NS}	-4.03^{NS}	-4.95^{NS}
Parwaz-94 x Iqbal-2000	3.33^{NS}	-7.51^{NS}	-4.69^{NS}	-7.78^{*}	-8.47^{NS}	-15.50^{**}	-4.87^{NS}	-9.85^{NS}	-5.52^{NS}	-8.65^{NS}	-11.72^{*}	-19.19^{**}
Parwaz-94 x Uqab-2000	7.95^{NS}	-2.37^{NS}	2.51^{NS}	-3.50^{NS}	-5.45^{NS}	-9.42^{NS}	-1.13^{NS}	-5.36^{NS}	-2.06^{NS}	-8.74^{NS}	0.09^{NS}	-4.27^{NS}
Parwaz-94 x MH-97	14.62^{**}	9.13^{NS}	-5.98^{NS}	1.82^{NS}	-7.34^{NS}	-8.09^{NS}	-6.50^{NS}	-9.35^{NS}	-4.40^{NS}	-6.71^{NS}	-9.93^{NS}	-13.47^{NS}
Parwaz-94 x 4072	-0.24^{NS}	-4.97^{NS}	-0.09^{NS}	-4.35^{NS}	0.24^{NS}	-0.30^{NS}	-1.19^{NS}	-1.50^{NS}	1.35^{NS}	-1.93^{NS}	0.57^{NS}	-3.09^{NS}
Parwaz-94 x Punjab-96	-4.82^{NS}	-15.97^{**}	-5.28^{NS}	-10.98^{**}	-1.24^{NS}	-7.42^{NS}	-0.79^{NS}	-8.96^{NS}	-0.84^{NS}	-8.33^{NS}	2.36^{NS}	-9.63^{NS}
Iqbal-2000 x Shahkar-95	-6.01^{NS}	-10.12^{**}	-1.09^{NS}	-2.52^{NS}	5.11^{NS}	-0.78^{NS}	-6.24^{NS}	-7.17^{NS}	9.04^{NS}	2.08^{NS}	-15.67^{**}	-23.28^{**}
Iqbal-2000 x Parwaz-94	7.20^{NS}	-4.05^{NS}	5.65^{NS}	2.22^{NS}	-2.20^{NS}	-9.70^{*}	13.68^{*}	7.73^{NS}	7.76^{NS}	4.20^{NS}	2.43^{NS}	-6.23^{NS}
Iqbal-2000 x Uqab-2000	3.68^{NS}	2.49^{NS}	-2.88^{NS}	-5.60^{NS}	-6.34^{NS}	-9.90^{*}	5.83^{NS}	-3.76^{NS}	-4.63^{NS}	-8.22^{NS}	1.35^{NS}	-3.20^{NS}
Iqbal-2000 x MH-97	1.79^{NS}	-4.62^{NS}	-6.99^{*}	-7.66^{*}	-8.67^{*}	-15.06^{**}	6.05^{NS}	3.59^{NS}	1.72^{NS}	0.76^{NS}	-7.66^{NS}	-18.50^{**}
Iqbal-2000 x 4072	5.86^{NS}	-0.87^{NS}	1.10^{NS}	0.00^{NS}	-4.87^{NS}	-11.72^{**}	-1.72^{NS}	-6.59^{NS}	-2.19^{NS}	-2.27^{NS}	-7.17^{NS}	-11.99^{NS}
Iqbal-2000 x Punjab-96	0.14^{NS}	-1.40^{NS}	-7.36^{*}	-10.10^{**}	-7.67^{NS}	-9.17^{NS}	0.36^{NS}	-12.29^{*}	4.68^{NS}	-0.09^{NS}	0.78^{NS}	-4.66^{NS}
Uqab-2000 x Shahkar-95	-6.39^{NS}	-9.47	-3.01^{NS}	-4.37^{NS}	4.27^{NS}	2.22^{NS}	0.53^{NS}	-7.75^{NS}	4.58^{NS}	-5.52^{NS}	-1.03^{NS}	-5.95^{NS}
Uqab-2000 x Parwaz-94	7.95^{NS}	-2.37^{NS}	2.14^{NS}	-3.85^{NS}	-5.12^{NS}	-9.10^{*}	8.40^{NS}	3.76^{NS}	-1.88^{NS}	-8.57^{NS}	-10.66^{*}	-14.55^{*}
Uqab-2000 x Iqbal-2000	-4.42^{NS}	-5.52^{NS}	-2.52^{NS}	-5.24^{NS}	2.32^{NS}	-1.16^{NS}	-5.33^{NS}	-13.91^{*}	1.94^{NS}	-1.89^{NS}	4.92^{NS}	0.20^{NS}
Uqab-2000 x MH-97	0.87^{NS}	-4.44^{NS}	-0.36^{NS}	-2.45^{NS}	-1.03^{NS}	-4.45^{NS}	6.75^{NS}	-0.80^{NS}	-0.28^{NS}	-4.90^{NS}	1.62^{NS}	-6.46^{NS}
Uqab-2000 × 4072	3.13^{NS}	2.37^{NS}	-3.91^{NS}	-5.60^{NS}	-6.32^{NS}	-9.79^{*}	-1.08^{NS}	-5.59^{NS}	5.25^{NS}	1.22^{NS}	-8.98^{NS}	-9.68^{NS}
Uqab-2000 × Punjab-96	-5.04^{NS}	-7.56^{NS}	-2.27^{NS}	-2.44^{NS}	3.20^{NS}	0.87^{NS}	5.93^{NS}	1.35^{NS}	-3.64^{NS}	-4.47^{NS}	6.05^{NS}	-2.50^{NS}
MH-97 × Shahkar-95	6.76^{NS}	4.50^{NS}	-0.36^{NS}	1.08^{NS}	-5.69^{NS}	-7.17^{NS}	-3.74^{NS}	5.05^{NS}	0.56^{NS}	-5.01^{NS}	-17.54^{**}	-20.26^{**}
MH-97 × Parwaz-94	0.73^{NS}	-4.10^{NS}	7.50^{*}	-11.13^{**}	-8.36^{*}	-9.09^{*}	4.18^{NS}	0.10^{NS}	4.64^{NS}	2.12^{NS}	-12.88^{**}	-16.31^{**}
MH-97 × Iqbal-2000	-1.30^{NS}	-7.51^{NS}	4.01^{NS}	5.83^{NS}	-1.57^{NS}	0.61^{NS}	-1.73^{NS}	-2.67^{NS}	-3.59^{NS}	-0.94^{NS}	-12.56^{*}	4.78^{NS}
MH-97 × Uqab-2000	3.06^{NS}	-2.37^{NS}	-0.89^{NS}	-2.97^{NS}	-3.84^{NS}	-7.17^{NS}	4.91^{NS}	-2.51^{NS}	-4.56^{NS}	-8.99^{NS}	-7.00^{NS}	-14.39^{**}
MH-97 × 4072	2.58^{NS}	2.51^{NS}	0.91^{NS}	0.54^{NS}	-0.30^{NS}	-0.56^{NS}	-5.81^{NS}	-8.41^{NS}	1.32^{NS}	0.44^{NS}	-3.99^{NS}	-10.99^{**}
MH-97 × Punjab-96	6.16^{NS}	-1.96^{NS}	2.85^{NS}	0.52^{NS}	-3.82^{NS}	-9.17^{*}	-6.60^{NS}	-16.67^{**}	-3.27^{NS}	-8.51^{NS}	-17.41^{**}	-29.57^{**}
4072 × Shahkar-95	-0.62^{NS}	-2.79^{NS}	4.69^{NS}	4.32^{NS}	5.54^{NS}	3.63^{NS}	4.16^{NS}	0.38^{NS}	0.84^{NS}	-5.53^{NS}	-8.10^{NS}	-12.02^{*}
4072 × Parwaz-94	-2.68^{NS}	-7.28^{NS}	-5.39^{NS}	-9.42^{*}	-2.60^{NS}	-3.13^{NS}	1.94^{NS}	1.62^{NS}	1.38^{NS}	-1.90^{NS}	4.32^{NS}	0.52^{NS}
4072 × Iqbal-2000	-4.32^{NS}	-10.40^{*}	0.73^{NS}	-0.36^{NS}	4.94^{NS}	-2.62^{NS}	1.65^{NS}	3.39^{NS}	2.00^{NS}	1.92^{NS}	13.01^{NS}	7.14^{NS}
4072 × Uqab-2000	3.13^{NS}	-2.37^{NS}	3.20^{NS}	1.40^{NS}	0.61^{NS}	-3.10^{NS}	4.54^{NS}	-0.23^{NS}	0.35^{NS}	-3.50^{NS}	9.58^{NS}	8.74^{NS}
4072 × MH-97	5.89^{NS}	5.82^{NS}	-0.36^{NS}	-0.72^{NS}	-5.87^{NS}	-6.11^{NS}	3.23^{NS}	0.38^{NS}	1.41^{NS}	0.53^{NS}	-2.74^{NS}	-9.83^{NS}
4072 × Punjab-96	9.26^{*}	0.84^{NS}	1.24^{NS}	-0.67^{NS}	-7.90^{NS}	-13.22^{**}	-8.94^{NS}	-16.67^{**}	-1.33^{NS}	-5.89^{NS}	21.95^{**}	11.33
Punjab-96 × Shahkar-95	8.20^{NS}	1.96^{NS}	3.89^{NS}	2.26^{NS}	-4.31^{NS}	-8.26^{NS}	-11.37^{*}	-21.88^{**}	1.87^{NS}	-8.68^{NS}	4.48	-8.31
Punjab-96 × Parwaz-94	-4.82^{NS}	-15.97^{**}	1.39^{NS}	-4.70^{NS}	5.95^{NS}	-0.68^{NS}	-10.90^{*}	-18.23^{**}	12.17^{NS}	3.69^{NS}	5.36	-6.98
Punjab-96 × Iqbal-2000	-2.99^{NS}	-4.48^{NS}	-4.85^{NS}	-7.67^{*}	-2.27^{NS}	-3.84^{NS}	-0.48^{NS}	-13.02^{*}	-6.84^{NS}	-11.08^{*}	6.4	2.23
Punjab-96 × Uqab-2000	3.60^{NS}	0.84^{NS}	2.44^{NS}	2.26^{NS}	-1.27^{NS}	-3.50^{NS}	-12.36^{*}	-16.15^{**}	2.60^{NS}	1.72^{NS}	6.25	-2.32
Punjab-96 × MH-97	-12.04^{*}	-18.77^{**}	-2.50^{NS}	-4.70^{NS}	10.00^{*}	3.90^{NS}	-7.18^{NS}	-17.19^{**}	2.07^{NS}	-3.45^{NS}	8.9	-7.14
Punjab-96 × 4072	0.15^{NS}	-7.56^{NS}	-2.31^{NS}	-4.18^{NS}	-3.02^{NS}	-8.63^{NS}	8.14^{NS}	-1.04^{NS}	-1.46^{NS}	-6.01^{NS}	-5.05	-13.31^{*}

observed in Punjab-96 x MH-97 closely followed by 4072 x Shahkar-95 (3.63) hybrids.

Number of grains/spike indicated that 20 hybrid combinations out of 42 were positive while remaining crosses showed negative heterosis. Positively significant heterosis was found in a cross between Iqbal-2000 x Parwaz-94 (8.40). Maximum heterobeltiosis (7.73) and (6.62) was found in Iqbal-20000 x Parwaz-94 and Shahkar-95 x Parwaz-94, respectively.

A perusal of the Table 2 showed that 24 crosses showed increase in 1000-grains weight over their mid parent value. Results showed that 18 hybrids exhibited reduction in 1000-grains weight. Punjab-96 x Parwaz-94 (12.17), Iqbal-2000 x Shahkar-95 (9.04) and Shahkar-95 x MH-97 (8.11) had maximum positive heterosis in 1000-grains weight. Number of crosses showed negative heterosis were 18. Maximum positive heterobeltiosis was found in a cross between Iqbal-2000 x Shahkar-95 (4.20).

Heterosis for grain yield/plant was also given. The results showed that 20 crosses exhibited increase in grain yield/plant over mid parent values out of which only 2 were significant. Maximum positive heterosis was found in 4072 x Punjab-96 (21.95). While positive heterobeltiosis was found in 7 crosses out of which same hybrid having maximum positive heterobeltiosis (11.33) was found for grain yield/plant.

Genetic variability among genotypes is an important factor in plant improvement. The results showed presence of genetic difference was found in seven wheat genotypes and their F1 hybrids. These results are in agreement with Mahpara *et al.* (2008) who indicated that genetic variation was found among various wheat genotypes and their F1 hybrids. The superiority of hybrids over the better parent is important for determining the feasibility of commercial utilization of heterosis and identifying the parental combinations capable of producing the highest level of transgressive segregants. In this study, because the parent wheat varieties are highly adapted varieties, heterosis over the mid-parent and over the better-parent has played the most significant role for improvement in grain yield. Investigation about the magnitude of heterosis is desirable for deciding the directions of future breeding programmes.

However, in self-pollinated breeding progress has been made through the use of chemical hybridizing agents, the degree of heterosis and absence of heterotic groups remain the restrictive factors in hybrid wheat breeding programmes. Some researchers (Austin *et al.*, 1980; Maluszynski *et al.*, 2001; Fasoula and Fasoula, 2002) also reported that maximum heterosis should be transferred successfully in pure lines through conventional breeding.

In most breeding programmes, maximum crop yield is a main objective and emphasis for development of wheat varieties with maximum superior traits. Production of F1 hybrids along with desirable plant and yield traits is major aim of our research. Choice of parents used for hybridization contributes much for the development of superior hybrids. Parents used in the breeding programme must be superior genetically and diverse in traits under study. The increase or decrease in the productivity and vigor of hybrids as compared to their parents is main contribution for heterotic effects which expressed in F1 and following generations.

Positive heterosis over mid parents was observed for spike length in most of crosses. It is noted that if length of spike increased, then number of grains/spike and spike density also increased. These results are in agreement with Rasul *et al.* (2002); Yagdi and Karan (2000); Iqbal (2004) and Mahpara (2008). Number of spikelets/spike is also an important yield contributing component and plays an important role in grain yield because when number of spikelets/spike increased then not only spike length increases but number of grains/spike also improved to contribute high yield. Positive heterosis was found for spikelets/spike in this manuscript and same kind of heterotic effects were reported by Abdullah *et al.* (2002); Rasul *et al.* (2002) and Mahpara (2008). Several yield components appeared to be important yield determinants in high yielding cross (Liver and Hyne, 1968). Results indicated that the crosses showing heterosis for grain yield/plant were not heterotic for all the characters. It was supported by the findings of Grafius (1959), who suggested that there could be no separate genetic system for yield because yield is an end product of complex interactions between its various components. Furthermore, yield and yield related traits having significant positive heterosis are important for selection of these traits in crosses for future breeding programme.

At present, wheat production's situation in Pakistan is better than past, but it is direly required to increase its productivity through incorporation of desirable genes into wheat. Now plant breeders are trying to develop high yielding wheat genotypes which are superior and adaptive to a wide range of environments. Choice of parent varieties used in the hybridization process contributes significantly for the development of a suitable and potential genotype. Genetically superior parents having the desired trait under study are utilized for varietal development.

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