J Agric. Res., 2017, Vol. 55(2):235-247
ISSN: Online: 2076-7897, Print:0368-1157
http://www.jar.com.pk

EXPLOITATION OF HETEROSIS AND COMBINING ABILITY EFFECTS IN WHEAT BREEDING

Sobia Ijaz*, Sadia Kaukab, Aziz-ur-Rehman** and Sanaullah*

ABSTRACT

The present research was carried out in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad Pakistan during the year 2013-14 to estimate heterosis and combining ability (GCA and SCA) of wheat genotypes for some quantitative traits. Six parents of bread wheat (*Triticum aestivum* L.), three as lines (9436, 9444, and 9452) and three as testers (Iqbal-2000, Farid-2006, Shahkar-95) were crossed and evaluated by using line × tester analysis. The female parent 9436 proved to be the best general combiner for plant height and number of grains per spike while female parent 9452 was the best for number of tillers per plant, flag leaf area and spike length. The genotype 9444 showed positive GCA effects for grain yield per plant and spike length. Iqbal-2000 proved to be best among male parents as general combiner for spike length, flag leaf area and number of grains per spike. The genotype Shahkar-95 exhibited positive GCA effects for plant height, number of tillers per plant, grain yield per plant and number of grains per spike, whereas Farid-2006 was the superior parent for plant height. Among crosses 9444 x Iqbal-2000 was the best specific combination for flag leaf area. The hybrid 9436 x Shahkar-95 was the best specific combination for number of grains per spike and spike length while hybrid 9452 x Farid-2006 was the best specific combination for plant height. The cross 9452 x Iqbal-2000 proved to be the best for grain yield per plant and number of tillers per plant. High mid parents and better parents heterosis interactions were recorded in 9436 x Iqbal-2000 (-4.586 and -9.72%) for plant height, 9444 x Iqbal-2000 (24.97 and 15.78%) for flag leaf area and (19.79 and 18.85%) and spike length, 9436 x Farid-2006 (16.58 and 14.85%) for number of grains per spike and 9452 x Iqbal-2000 (82.84 and 76.67%) for grain yield per plant. For number of tillers per plant 9436 x Farid-2000 showed the maximum heterosis (15.23%) and 9452 x Iqbal-2000 showed highest heterobeltiosis (5.35%). Intensive efforts are needed to select good combiner parents and combinations with high heterotic effects for development of wheat hybrid.

KEYWORDS: ***Triticum aestivum*; wheat; line x tester analysis; GCA; SCA; heterosis; heterobeltiosis; Pakistan.**

***Agronomic Research Institute, **Pulses Research Institute, AARI, Faisalabad, Pakistan.**

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a leading cereal of the world and a staple food in Pakistan. Its production goes ahead all crops including rice, maize and potatoes. During 2013-14, it was grown on an area of 9039 thousand hectares with annual production of 25300 thousand tons and average grain yield of 2796 kg per hectare. It adds 10.3 percent to value addition in agriculture and 2.2 percent to GDP (3). Tremendous efforts have been made in the past to improve the production and productivity by developing semi-dwarf varieties of wheat with maximum yield potential and better disease resistance. But due to evolutionary changes in disease pathogens there is a dire need of periodic replacement of wheat cultivars (17).

For an efficient breeding programme proper choice of parents is very important task. The parents should show the requisite traits as well as capable of producing better-quality hybrids. Heterotic studies can also be utilized to identify the superiority of F_1 hybrids over their parents. Its exploitation for enhancing the general combining ability and specific combining ability in the selection of parents is also established. It is obvious in any breeding programme that higher the heterosis and heritability, the selection process is simple and the response to selection is high. Combining ability analysis is used by breeders to choose parents with maximum potential for transmission of desirable genes to the progenies. Estimation on general combining ability effects for yield attributes has significant importance in the selection of parents for yield enhancement. (11).

Line × tester analysis is an excellent breeding approach to estimate combining ability effects of genotypes and also to present information about genetic mechanisms controlling yield and yield related traits. Anwar *et al.* (4) defined combining ability and described that high general combining ability effects were due to additive type of gene action, whereas high specific combining ability indicated non-additive gene effects. Various researchers have reported GCA and SCA effects for several wheat varieties/lines (4, 6). Their studies showed that a major portion of genetic variability for grain yield and its components was associated with higher general combining ability which is due to additive genetic variance but non-additive genetic variability due to specific combining ability was also equally important for yield components.

The present study was conducted to assess the level of heterosis and heterobeltiosis values among F_1 and relative magnitude of GCA and SCA for

some yield contributing traits and to assess the best combiner for successful wheat hybridization. The estimates thus obtained would be helpful to exploit the parents for further breeding programme.

MATERIALS AND METHODS

This study was conducted in the Department of Plant Breading and Genetics, University of Agriculture, Faisalabad, Pakistan during 2013-14 under normal conditions. Nine wheat crosses developed during Feb-March, 2012-13 from crossing of three lines (9436, 9444, 9452) and three testers (Iqbal-2000, Farid-2006, Shahkar-95).

The F_0 seeds of the crosses and parents were sown in 2nd week of November 2013-14 in RCBD with three replications maintaining plant to plant and row to row distance of 15 cm and 22.5cm, respectively. Two seeds were sown in a hole and later on thinning was done to keep one seedling per hole. At maturity ten plants were selected at random from each plot and data were recorded for plant height, flag leaf area, spike length, number of tillers per plant, number of grains per spike and grain yield.

The data were statistically analyzed for variance (20) to find out significant differences among parents and hybrids. Data for the traits which showed significant differences were analyzed for line × tester (19). The values of heterosis and heterobeltiosis were calculated according to the formulae (15) given below:

Heterosis % = $(F_1 - MP) \times 100 / MP$
Heterobeltiosis % = $(F_1 - BP) \times 100 / BP$

RESULTS AND DISCUSSION

Genetic variability

There were significant differences for flag leaf area but non-significant for plant height, spike length, number of grains per spike, number of tillers per plant and grain yield among replications (Table 1). Highly significant differences were computed among genotypes for the traits like plant height, number of tillers per plant, spike length, number of grains per spike and grain yield while non-significant differences for flag leaf area.

Table 1. Analysis of variance for various quantitative traits of wheat genotypes derived from line x tester analysis using three lines and three testers

S.O.V	DF	Plant	Flag height	No. leaf area	Spike of tillers/ plant	Grain of grains/ spike	Yield/ plant
Replication	2	1.19^{NS}	466.01*	0.83^{NS}	1.09^{NS}	0.47 ^{NS}	1.20 ^{NS}
Genotype	14	149.79**	71.30^{NS}	6.66**	4.05**	71.93**	56.47**
Parents	5	168.33**	57.31^{NS}	12.70**	4.57**	96.80**	38.01**
Parents vs crosses	1	218.12**	232.35^{NS}	1.73^{NS}	14.30**	34.84**	131.15**
Crosses	8	129.65**	59.90^{NS}	3.50**	2.44**	61.01**	58.68**
Lines	2	370.20*	43.24^{NS}	1.21^{NS}	6.06**	173.61**	6.70**
Testers	2	49.68**	85.25^{NS}	1.08^{NS}	0.39^{NS}	17.12**	17.87**
Lines x Testers	4	49.36**	55.55^{NS}	5.85 **	1.65*	26.66**	105.07**
Error	28	2.7	100.12	0.69	0.28	1.91	1.27
Total	44	153.25	637.43	8.18	5.42	74.31	58.94

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

After performing analysis of variance further line x tester analysis was carried out to compute the combining ability of the parents and crosses. The results in (Table 1) illustrated that parents exhibited highly significant variation for plant height, spike length, number of tillers per plant, number of grains per spike and grain yield per plant, while non-significant variation was found for flag leaf area. Lines accounted non-significant differences for flag leaf area and number of tillers per plant while highly significant differences for plant height, number of grains per spike, spike length and grain yield per plant. Testers showed highly significant differences for plant height, number of grains per spike and grain yield per plant but non-significant for flag leaf area, spike length and number of tillers per plant. Interaction of lines x testers showed highly significant variation for plant height, number of grains per spike, number of tillers per plant and grain yield per plant, while it was significant for spike length. Flag leaf area exhibited non-significant differences.

Crosses showed highly significant differences for plant height, spike length, number of tillers per plant, number of grains per spike and grain yield per plant while non-significant for flag leaf area. Interaction of parents vs crosses exhibited highly significant differences for plant height, number of grains per spike, spike length and grain yield and non-significant for number of tillers per plant and flag leaf area.

The male (testers) and female (lines) parents used in the study provided broad range of expression for various characters as shown in Table 2. The highest value for plant height was observed for line 9444 (106.81 cm) followed by 9452 (105.91 cm) and Iqbal-2000 (105.08 cm) while minimum

plant height was shown by tester Farid-2006 (88.62 cm). The male parent Shahkar-95 showed maximum value (56.68 cm^2) for flag leaf area followed by Farid-2006 (54.15 cm^2) and Iqbal-2000 (53.86 cm^2) while minimum value (45.93 cm^2) was exhibited by female parent 9444. Line 9444 showed maximum value (15.27) for the number of tillers per plant followed by Shahkar-95 (13.2) and Iqbal-2000 (12.53). Lowest number of tillers per plant was observed in female parent 9436 (9.4) (Table 2).

Table 2. Mean values of parents and crosses for various quantitative traits of wheat used in line x tester analysis

Parents	Plant height (cm)	Flag leaf are (cm2)	No. of tillers/ plant	Spike length (cm)	No. of grains/ spike	Grain yield/ plant (g)
94.36	93.78	46.73	9.40	9.00	53.87	16.91
9452	105.91	53.16	10.53	11.86	49.27	17.49
9444	106.81	45.93	15.27	11.46	53.33	23.3
Iqbal-20	105.08	53.86	12.53	11.27	61.63	16.31
Shahkar-95	97.51	56.68	13.20	12.63	63.7	23.61
Farid-2006	88.62	54.15	12.00	10.70	52.27	23.17
Crosses						
9436 × Iqbal-2000	94.87	58.32	9.80	10.82	60.37	18.48
9436 x Shahkar-95	100.06	54.08	12.40	11.99	65.30	25.23
9436 x Farid-2006	95.85	57.76	12.33	11.26	61.87	24.86
9452 x Iqbal-2000	112.68	58.46	13.20	13.13	57.57	30.90
9452 x Shahkar-95	112.96	55.74	11.40	12.13	54.97	20.9
9452 x Farid-2006	102.14	60.99	11.93	13.09	50.80	19.33
9444 x Iqbal-2000	108.05	62.36	11.60	13.62	57.93	21.64
9444 x Shahkar-95	104.14	51.09	12.70	12.2	53.30	29.67
9444 x Farid-2006	106.25	48.70	10.47	12.49	55.17	22.36

Spike length was maximum in Shahkar-95 (12.63 cm) followed by 9452 (11.86 cm) and 9444 (11.46 cm) while minimum value (9 cm) was noted for 9436 (Table 2). Maximum value for number of grains per spike was found in Shahkar-95 (63.7) followed by Iqbal-2000 (61.63) and 9436 (53.87) whereas 9452 showed minimum value (49.27). Grain yield per plant was maximum in Shahkar-95 (23.61 g) followed by 9444 (23.3 g) and Farid-2006 (23.17 g). Iqbal-2000 (male parent) showed minimum value (16.31 g) for grain yield per plant.

A considerable degree of hybrid vigour existed in most of the crosses for majority of the characters studied. Some hybrids even exceeded their better parents. However, some intermediate hybrids decreasing in favour of lower parents were also observed. Range in crosses for plant height was observed from 94.87 cm (9436 × Iqbal-2000) to 112.96 cm (9452 × Shahkar-95) (Table 2). The crosses 9452 × Shahkar-95 showed the greater value (112.96 cm)

than the best parent 9444 (106.81 cm) followed by 9452 × Iqbal-2000 (112.68 cm) and 9444 × Iqbal-2000 (108.05 cm). Maximum value (62.36 cm^2) for flag leaf area was observed in cross 9444 x Iqbal-2000 but cross 9444 × Farid-2006 showed minimum value (48.7 cm^2). The crosses 9444 × Iqbal-2000, 9452 × Farid-2006, 9452 × Iqbal-2000, 9436 × Iqbal-2000 and 9436 × Farid-2006 exhibited greater value than the best parent i.e. Shahkar-95 (56.68 cm^2).

The range for number of tillers per plant was observed from 9.8 (9436 × Iqbal-2000) to 13.2 (9452 × Iqbal-2000). The cross 9444 x Iqbal 2000 displayed maximum value (13.62 cm) for spike length and minimum value (10.82 cm) for cross 9436 x Iqbal-2000. It was observed that crosses 9444 Iqbal 2000, 9452 × Iqbal-2000 and 9452 x Farid-2006 showed greater values (13.62, 13.13 and 13.09 cm), respectively than better parent Shahkar-95 (12.63 cm) for spike length. Maximum number of grains per spike was observed in the cross 9436 x Shahkar-95 (65.3) while cross 9452 x Farid-2006 exhibited minimum value (50.8). The cross 9436 × Shahkar-95 showed greater values than better parent Shahkar-95 (63.7) for number of grains per spike.

A good degree of variation was recorded for grain yield per plant. Maximum (30.90g) and minimum (18.48 g) values were obtained from the crosses 9452 x Iqbal-2000 and 9436 x Iqbal-2000 respectively, whereas yield of parents of best performing cross 9452 x Iqbal-2000 was 17.49 and 16.31g per plant, indicating highest degree of heterosis and potential of the cross to be used as hybrid. The value of grain yield for better parent was 23.61g per plant shown by Shahkar-95. The crosses 9452 × Iqbal-2000, 9444× Shahkar-95, 9436 × Shahkar-95 and 9436 × Farid-2006 showed higher value than the parent.

Heterosis and combining ability studies

Estimates of variation due to GCA were partitioned for male and female parents for all characters studied to search out the prospective parents for successive breeding (Table 3). Results of SCA effects are shown in Table 4. Heterotic and heterobeltiotic values are given in Table 5 and 6, respectively. The detail of each character is discussed as under.

Plant height (cm)

In case of plant height, effects of negative heterosis and general combining ability effects are more important since more emphasis is placed upon

selection for short stature segregates in segregating population because these ultimately turn out short stature line which would be more responsive to fertilizer and tolerant to lodging. From this point of view, 9436 among female parents and Farid-2006 among male parents were potential parents and their values of were -7.18 and -2.70, respectively (Table 3). These results are in accordance with the findings of Chaudhry *et al.* (5) and Gerjanovic *et al.* (8).

Table 3. Estimation of general combining ability (GCA) for various quantitative traits of 3 lines and 3 testers of wheat

Parents	Plant height	Flag leaf area	No. of tillers/ plant	Spike length	No. of grains/ spike	Grain yield/plant
Lines						
9439	-7.18	0.33	-0.24	-0.95	8.04	0.76
9452	5.15	2.01	0.42	0.48	-3.03	-0.18
9444	2.03	-2.34	-0.18	0.47	-2.01	0.94
Testers						
Iqbal-20000	1.09	3.32	-0.22	0.22	1.15	0.5
Shahkar-95	1.61	-2.75	0.40	0.20	0.38	1.38
Farid-2006	-2.70	-0.57	-0.18	-0.02	-1.53	-1.43

Table 4. Estimation of specific combining ability (SCA) for various quantitative traits for 3 lines and 3 testers of wheat

Crosses	Plant height	Flag leaf area	No. of tillers/ plant	Spike length	No. of grains/ spike	Grain yield/plant
9436 × Iqbal-2000	-3.15	-1.72	-1.49	-0.75	-3.29	-4.43
9436 x Shahkar-95	1.52	0.11	0.49	0.83	2.41	0.99
9436 x Farid-2006	1.62	1.61	1.00	-0.07	0.89	3.44
9452 x Iqbal-2000	2.33	-3.26	1.24	0.12	1.97	7.40
9452 x Shahkar-95	2.09	0.09	-1.18	-0.45	0.14	-4.73
9452 x Farid-2006	-4.42	3.17	-0.07	0.33	-2.11	-2.67
9444 x Iqbal-2000	0.81	4.99	0.24	0.63	1.32	-2.97
9444 x Shahkar-95	-3.61	-0.21	0.69	-0.37	-2.55	3.73
9444 x Farid-2006	2.81	-4.78	-0.93	-0.26	1.23	-0.7

From the crosses only 33 percent crosses depicted negative SCA effects for plant height. If the parents with short stature are ideal one, then the crosses viz. 9452 × Farid-2006 (-4.42), 9444 x Shahkar-95 (-3.61) and 9436 x Iqbal-2000 (-3.15) may be considered as well (Table 4). However, almost 66 percent crosses showed positive SCA effects. These results confirm the studies of Chowdhry *et al.* (5) and Hasnain *et al.* (9).

In case of heterosis and heterobeltiosis maximum negative heterosis was shown by 9436 × Iqbal-2000 (-4.57%) followed by 9444 x Shahkar-95

(1.98%) whereas maximum negative heterobeltiosis was revealed by 9436 × Iqbal-2000 (-9.716%) followed by 9452 x Farid-2006 (-3.559%) and 9444 x Shahkar-95 (-2.499%). (13) observed negative heterosis in wheat whereas the positive heterosis has been reported Sing *et al.* (18) and Wu *et al.* (21)

Table 5. Heterotic values of crosses for various quantitative traits of wheat used in the line x tester analysis.

Parents	Plant height	Flat leaf area	No. of tillers/ plant	Spike length	No. of grains/spike	Grain yield/plant
Crosses						
9436 × Iqbal-2000	-4.57	15.94	-10.67	6.706	4.536	11.258
9436 x Shahkar-95	4.61	4.58	9.73	10.813	11.073	24.531
9436 x Farid-2006	5.09	14.51	15.23	14.314	16.581	24.051
9452 x Iqbal-2000	6.81	9.25	14.48	13.483	3.823	82.840
9452 x Shahkar-95	11.06	1.49	-3.96	-0.979	-2.690	-2.238
9452 x Farid-2006	5.01	13.68	5.86	16.046	0.059	-4.918
9444 x Iqbal-2000	1.98	24.97	-16.55	19.788	0.782	9.237
9444 x Shahkar-95	1.94	-0.43	-10.81	1.244	-8.920	26.470
9444 x Farid-2006	8.73	-2.68	-23.24	12.725	4.488	-3.786

Table 6. Heterobeltiotic values of crosses for various quantitative traits of wheat used in the line x tester analysis.

Parents	Plant height	Flat leaf area	No. of tillers/ plant	Spike length	No. of grains/spike	Grain yield/plant
Crosses						
9436 × Iqbal-2000	-9.716	8.280	-21.787	-3.993	-2.044	9.284
9436 x Shahkar-95	2.61	-4.587	-6.060	-5.067	2.512	6.861
9436 x Farid-2006	2.207	6.667	2.75	5.234	14.850	7.294
9452 x Iqbal-2000	6.39	8.541	5.347	10.708	-6.587	76.672
9452 x Shahkar-95	6.65	-1.658	-13.636	-3.958	-13.705	-14.908
9452 x Farid-2006	-3.559	12.631	-0.583	10.370	-2.512	-16.573
9444 x Iqbal-2000	1.160	15.781	-24.034	18.848	-6.003	-7.124
9444 x Shahkar-95	-2.499	-9.862	-16.830	-3.405	-16.326	25.667
9444 x Farid-2006	-0.524	-10.064	-31.434	8.987	3.450	-4.034

Flag leaf area (cm^2)

For flag leaf area, positive heterosis and GCA effects are more important because flag leaf area has much contribution in the photosynthetic activity and ultimately in grain yield which is our main objective. So much emphasis was placed on the selection of genotypes with greater flag leaf area. From this point of view, male parent Iqbal-2000 showed higher value (3.32) of GCA effects for flag leaf area followed by two female parents 9452 (2.01) and

9436 (0.33) (Table 3). These finding are in accordance with the results reported by Chowdhry *et al.* (5), Farooq *et al.* (7) and Nazir *et al.* (16).

The cross 9444 x Iqbal-2000 showed higher value of SCA effects for flag leaf area. If more flag leaf area is required, then crosses 9444 x Iqbal-2000, 9452 x Farid-2006 and 9436 x Farid-2006 may be used in future breeding programme because these have values of 4.99, 3.17 and 1.61 respectively (Table 4). Similar results have also been reported by Chowdhry *et al.*(5).

For heterosis and heterobeltiosis, the cross 9444 x Iqbal-2000 (24.969%) followed by 9436 × Iqbal-2000 (15.944%) and 9436 x Farid-2006 (14.512%) showed maximum heterosis while cross 9444 x Iqbal-2000 (15.781%) and 9452 x Farid-2006 (12.631%) showed maximum heterobeltiosis. Positive heterosis for flag leaf area is reported by Mahmood an Choudhry (14) (Table 5).

Number of tillers per plant

Number of tillers per plant also plays an important role in grain yield as more number of tillers are expected to result in better yielding ability. General combining ability effects calculated for this trait were of moderate magnitude. Among female parents, 9452 (0.42) exhibited higher and positive GCA effects followed by male parent Shahkar-95 (0.40). Apart from the above three parents, rest of others showed negative GCA.

For SCA effects, crosses 9452 × Iqbal-2000, 9436 × Farid-2006, 9444 × Shahkar-95, 9436 × Shahkar-95 and 9444 × Iqbal-2000 exhibited positive values (1.24, 1.00, 0.69, 0.49 and 0.24) (Table 4). These results are in accordance with the findings of Anwar *et al.* (4) and Farooq *et al.* (7).

Heterotic studies showed that cross 9436 x Farid-2006 and 9452 x Iqbal-2000 showed positive heterosis (15.233 and 14.484%) and heterobeltiosis (2.75 and 5.347%). Mahmood and Chaudhry *et al.* (14) and Wu *et al.* (21) also confirmed that mid parent and better parent heterosis for tillers per plant could be obtained in wheat.

Spike length (cm)

Spike length is an important yield component, since greater spikes length has more number of spikelets per spike and grains per spike which ultimately results in better grain yield potential. For this trait, parents with positive

general combining ability are required. Two parents, 9452 (0.48) and 9444 (0.47) among females followed by one male parent, Iqbal-2000 (0.22) showed positive values and for general combining ability effects. Similar results have also been obtained by Hasnain *et al.* (9).

In case of spike length, positive SCA effects are desired. Best crosses are those having positive and higher values of SCA effects. Specific combining ability was positive in 44 percent of crosses. The cross 9436 x Shahkar-95 (0.83) showed the highest value followed by crosses 9444 x Iqbal-2000 (0.63), 9452 x Farid-2006 (0.33) and 9452 x Iqbal-2000 (0.12) (Table 4). Similar studies have also been reported by Chowdhry *et al.* (5) and Hasnain *et al.* (9).

Among nine crosses eight crosses showed positive heterosis for this trait while five crosses showed positive heterobeltiosis. Maximum mid parent and better parent values were shown by 9444 x Iqbal-2000 i.e. (19.788 and 18.848%) (Table 5 and 6). Inam *et al*. (10) reported positive mid parent heterosis, while Singh *et al.* (18) have recorded a negative heterosis for spike length in wheat genotypes.

Number of grains per spike

Number of grains per spike is one of the most important yield components. In case of higher number of grains, grain yield also increases. Therefore, positive heterosis and combining ability effects are more important due to positive contribution of grain yield. Among male parents, Iqbal-2000 and Shahkar-95 showed positive value (1.15 and 0.38) of GCA effects. Among female parents, 9436 showed positive and higher value (5.04) (Table 3). It should be noted that value of female parent was higher than male parent. These results match with the findings of Farooq *et al*. (7) and Khan *et al.* (12).

Positive SCA effects were shown by 67 percent crosses for number of grain per spike. Potential crosses showing higher values of SCA effects were 9436 x Shahkar-95 (2.41), 9452 x Iqbal-2000 (1.97), 9444 x Iqbal-2000 (1.32), 9444 x Farid-2006 (1.23), 9436 × Farid-2006 (0.89) and 9452 x Shahkar-95 (0.14) (Table 4). Chowhry *et al.* (5) and Farooq *et al.* (7) have also reported similar results.

In case of heterosis seven crosses showed positive value. The cross 9436 x Farid-2006 showed the highest value (16.581%) followed by 9436 x Shahkar-

95 (11.073%) (Table 5). For heterobeltiosis the cross 9436 x Farid-2006 showed the highest value (14.850%) (Table 6). These results are in compliance with the findings of Afiah *et al.* (1) and Inam *et al.* (10) who observed mid and better parent heterosis for number of grains per spike in wheat.

Grain yield per plant (g)

Grain yield per plant is the ultimate objective which a breeder wants to improve. Positive GCA effects contribute towards achieving this goal. For grain yield per plant, one male parent (Shahkar-95) showed the highest GCA value (1.38) followed by female parent 9444 (0.94) and male parent Iqbal-2000 showed positive GCA effects (0.05) (Table 3). These results are in conformity with the findings Akbar *et al.* (2), Chowdhry *et al.* (5) and Khan *et al*. (12).

SCA effects were found much variable among crosses for grain yield per plant. The poorest cross with respect to SCA for grain yield per plant was 9452 x Shahkar-95 (-4.73) whereas cross 9452 x Iqbal-2000 (7.40) appeared as a best and most promising specific combiner. Positive specific combining ability effects were displayed in four crosses. Such positive effects were impressive in crosses 9444 x Shahkar-95 (3.73), 9436 x Farid-2006 (3.44) and 9436 x Shahkar-95 (0.99) (Table 4). Similar findings for this trait were also reported Akbar *et al.* (2) and Chowdhry *et al.* (5).

For heterosis and heterobeltiosis cross 9452 x Iqbal-2000 showed the highest value i.e. (82.840% and 76.672%) followed by 9444 x Shahkar-95 (26.470% and 25.667%). Also Afiah *et al.* (1) and Singh *et al.* (18) reported positive mid parent and better parent heterosis for grain yield per plant.

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Received: May 20, 2015 Accepted: June 22, 2016

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CONTRIBUTION OF AUTHORS:

Sobia Ijaz	**:**	**Planned and conducted the research experiment**
Sadia Kaukab	**:**	**Helped in data compilation and results interpretation**
Aziz-ur-Rehman	**:**	**Supervisor, helped in writeup**
Sanaullah	**:**	**Helped in data compilation and results interpretation**