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EARLY GENERATION TESTING FOR SPECIFIC COMBINING ABILITY AND HETEROTIC EFFECTS IN MAIZE VARIETY SARHAD WHITE

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ABSTRACT

Specific combining ability and heterotic effects for grain yield, flowering and morphological traits in maize variety Sarhad white analysed through Line x Tester mating design using 25 S_2 lines and two testers during kharif and rabi crop seasons of 2008-09. Observations were recorded on days to 50% flowering, plant height, ear height and grain yield. Among 50 evaluated testcrosses viz., 173 x Jalal, 192-1 x Jalal, 231-1 x Jalal, 237-1 x Jalal, 46-1 x Kiramat, 65-1 x Kiramat, 91-3 x Kiramat, 119-1 x Kiramat, 126-1 x Kiramat, and 195-1 x Kiramat, were identified as good specific combiners for grain yield. These hybrids could be utilized in maize heterosis breeding to exploit hybrid vigor. Significant negative heterosis over mid parent of flowering traits was exhibited for TC- 12-2, TC- 77-2, TC- 79-2, TC- 91-3, TC- 119-1, TC- 122-2, 126-1 and TC- 231-1. Maximum mid parent heterosis was detected for Kiramat crossed with SW 128-1 and SW-197-2 for plant height and ear height, respectively. Significant positive heterosis over mid parent of grain yield was found for TC- 12-2, TC- 77-2, TC- 151-1, TC- 220-1 and TC- 222-1. Significant negative heterosis over better parent of flowering traits was exhibited for all the testcrosses. Better parent heterosis for plant height ranged from -1.63 to 46.00%, while for ear height better parent heterosis varied from -20.53 to 14.21%. Significant positive heterosis over better parent of grain yield was showed for most of the testcrosses. Thus these crosses possess high heterosis which could be exploited commercially for higher yield in maize.

Keywords: maize, specific combining ability, mid parent heterosis, better parent heterosis, line x tester.

INTRODUCTION

Maize ranks third amongst the cereal crops in the world next to rice and wheat for area and production. It is one of the most important cereal crop in the world agriculture economy both as food for human beings, a feed for animals and industrial uses. Because of its immense potential, maize occupies the unique place as queen of cereals. Line × tester analysis is used to breed both self and cross pollinated plants and to estimate favorable parent, crosses and their specific combining ability (SCA). Early testing relies on the assumption that the combining ability of a line with a tester is determined during the early stages of selfing and does not change substantially with continued inbreeding in maize breeding population (El-Moula *et al*. 2004). In heterosis breeding programs, the selection of parents/inbreds based on their morphological diversity with good combining ability is very important in producing superior hybrids. The line × tester analysis is one of the simplest and efficient methods of evaluating large number of inbreds/parents for their combining ability (Kempthorne, 1957). Crossing of diverse inbred lines with testers provided sufficient variability for an effective selection of desirable traits. Suitable inbred lines and their specific combinations may be selected on the basis of combining ability effects with better mean performance. Maize is a highly cross pollinated crop and the scope for the exploitation of hybrid vigour will depend on the direction and magnitude of heterosis and also the type of gene action involved. The magnitude of heterosis provides information on extent of genetic diversity of parents in developing superior F_1s so as to exploit hybrid vigour and has direct bearing on the breeding methodology to be adapted for varietal improvement. Maize has great potential for heterotic manifestation and its exploitation. This could be the reason that number of hybrid varieties in maize is much higher than any other varietals types i.e. open pollinated, double cross, synthetics or three way crosses. Heterosis can be defined as the difference between the hybrid performance and the mean value of the inbred parents, which is known as mid-parent heterosis. However, the highest value of the best parent for a trait of interest, or high parent heterosis, is also used mainly for self-pollinated crops where breeders are interested in finding a hybrid with better performance than either of the parents (Lamkey and Edwards, 1999). Mid-parent heterosis and beter-parent heterosis are important parameters as they provide information about the presence of dominance and over dominance type of gene action in the expression of various. The present investigation was conducted to estimate early generation testing for specific combining ability and heterotic effects of the inbred lines and to identify the best hybrid combinations involving the inbred line derived from maize variety Sarhad white.

MATERIALS AND METHODS

This experiment was laid out at Khyber Pakhtunkhwa (KP) Agricultural University Peshawar during 2008-09. Twenty five best promising inbred lines were selected based on their performance in their

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S_2 generation and these selected 25 inbred lines were crossed with two different testers *viz.*, Jalal (OPV) and Kiramat (hybrid) during kharif season 2008 and generated 90 single cross hybrids which were evaluated during rabi season along with four commercial checks for their performance. The experiment comprised 81 entries (50 hybrids, 25 female lines 2 males and 4 checks) was sown in partially balanced lattice square design with two replications, each entry was raised in single rows with a row length of 5.0 m. The spacing maintained was 75 cm between the rows and 20 cm between the plants. The recommended package of practices was followed to raise a good crop. Data on days to mid silking were taken, when more than 50% plants in a row exhibit silking. Data on days to 50% pollen shedding were taken by regular visits to the field and number of days was counted from the date of the sowing to the date on which 50% plants in each plot exhibited pollen shedding. Plant height was taken with the help of meter rod from base of the plant up to the flag leaf node, at the time when plants exhibit maturity for all characters. Five plants in an entry were selected randomly and means were calculated. Ear height was measured with the help of the meter rod from base of the plant up to the node bearing upper ear. Means of five randomly selected plants in an entry were determined. Plots were harvested and shelled manually at full crop maturity. The shelled grain yield (Kg ha^{-1}) was calculated after adjusting the grain moisture content to 15 percent using the formula prescribed by Taran *et al*. (1998):

$$\text{Grain yield (tons ha}^{-1}) = \frac{\text{Field ear wt. x (100 – grain moisture content) x 0.8 x 26 x 10,000m}^2}{\text{n x 85 x 3.75m}^2 \text{ x 1000kg}}$$

Where

0.8 = Shelling percentage
26 = Standard number of plants in a rows plot-1
85 = Standard value of grain moisture for storage
3.75 = Area of sub plot
10,000 = Area of hectare in square meters
n = Number of plants harvested

The data recorded was subjected to analysis of variance (ANOVA) technique appropriate for 9×9 partially balanced lattice square design using program MS-Excel package. The mean of each character for each entry were subjected to line × tester analysis and the variance of specific combining ability of different cross combinations were estimated by the procedure developed by Kempthorne (1957). Specific combining ability effects were calculated using the expression:

$$si = \frac{Xij}{r} - \frac{Xi...}{tr} - \frac{X.j.}{lr} + \frac{X...}{ltr}$$

l = number of lines
t = number of testers
r = number of replications

Heterosis expressed as per cent increase or decrease of F1 hybrid over mid-parent (average or relative heterosis) and better parent (heterobeltiosis) were computed for each character using the following formulae (Hayes *et al.*, 1955).

$$\text{(i) Heterosis over mid parent (relative heterosis)} = \frac{F1 - MP}{MP} \times 100$$

$$\text{(ii) Heterosis over better parent (heterobeltiosis)} = \frac{F1 - BP}{BP} \times 100$$

The differences in the magnitude of heterosis were tested following the procedure given by Panse and Sukhatme (1961).

$$\text{a. Critical difference for mid parent heterosis} = \left(\frac{3MSSe}{2r}\right) 1/2 \times t$$

$$\text{b. Critical difference for better parent heterosis} = \left(\frac{2MSSe}{r}\right) 1/2 \times t$$

Where

r = Number of replications
MSSe = Error mean sum of square from analysis of variance table
t= Table value of 't' test at error degrees of freedom corresponding to 5% or 1% level of significance.

RESULTS AND DISCUSSIONS

Highly significant differences ($P \leq 0.01$) were observed among the 40 testcrosses for most of the traits studied viz. days to silking, days to pollen shedding, plant height, ear height and grain yield. Mean square for testcrosses was further partitioned into line, tester and line × tester interactions. Highly significant variations were observed among the testcross hybrids due to line effect as well as line × tester interactions for all the traits studied. Mean square due to line × tester interaction were highly significant for all traits, suggest that inbred lines were having different combining ability patterns and performed differently in crosses depending on type of tester used. Highly significant differences were observed among the testcrosses due to tester effect for all the traits except grain yield (Table-1). These results indicated that both inbred lines and testers were significant different from one each to another in testcrosses and the inbred line behaved differently in their respective testcrosses and that greater diversity exist between the two testers.

The SCA effects for grain yield, flowering and growth characters are listed in Table-2. The SCA effect is an important criterion for the evaluation of hybrids. The hybrids 77-2 × Kiramat and 151-1× Kiramat showed maximum negative and significant SCA effects for the trait days to pollen shedding and days to silking, respectively. Among the hybrids 237-1 × Jalal showed positive and significant SCA effect for plant height.

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Similar observations in maize were reported by Muppidathi (2006). Another hybrid 237-1 × Jalal showed positive and significant SCA effects for the trait ear height. For grain yield, the hybrid 126-1 × Kiramat recorded positive and significant SCA effects. Hence from the foregoing discussion it may be concluded that the hybrid 77-2 × Kiramat and 151-1× Kiramat are suitable for earliness. From the Figure-1, the following hybrids viz., 46-1 × Kiramat, 65-1 × Kiramat, 91-3 × Kiramat, 119-1 × Kiramat, 126-1 × Kiramat, 173-1 × Jalal, 192-1 × Jalal, 231-1 × Jalal and 237-1 × Jalal were identified as good specific combiners for grain yield. These hybrids could be utilized in heterosis breeding to exploit hybrid vigour for seed yield. Saleh *et al*. (2002) also identified hybrids with high SCA effects for more than one yield contributing characters that would be more rewarding in heterosis breeding.

Percent heterosis over mid parent and better parent were calculated and summarized for all the traits in Tables 3, 4. Negative heterosis over better and mid parent are desired for flowering traits in maize. Mid parent heterosis for days to silking ranged from -10.17 to 1.75%, while mid parent heterosis for days to pollen shedding varied from -11.02 to 6.31%. Maximum mid parent heterosis was detected for Kiramat crossed with SW 96-1 and SW 128-1 for days to silking and days to pollen shedding, respectively. Heterotic values for relative heterosis showed that inbred lines involving Kiramat as a tester exhibited early silking than Jalal tester used as parent for the flowering traits. Better parent heterosis for days to silking ranged from -11.76 to -0.84%, while Better parent heterosis for days to pollen shedding varied from -11.63 to -3.25%. Minimum better parent heterosis was detected for OPV Jalal crossed with SW 96-1 and SW 144-1 for days to silking and days to pollen shedding, respectively. It is evident from the table that OPV (Jalal) as a tester performed better than other testers for the flowering trait of better parent heterosis. Bhatnagar *et al*. (1993) observed high heterotic effects for early silking in early maize inbred lines. About 34 and 39 testcrosses exhibited significant mid parent and better parent heterosis in negative direction for days to silking. Thirty six and 40 hybrids showed significant mid parent and better parent heterosis in negative direction for days to pollen shedding. Mid parent heterosis for plant height ranged from -13.23 to 32.20% while for ear height, mid parent heterosis varied from -15.05 to 21.89%. Maximum mid parent heterosis was detected for Kiramat crossed with SW 128-1 and SW-197-2 for plant height and ear height, respectively. Better parent heterosis for plant height ranged from -1.63 to 46.00% while for ear height, better parent heterosis varied from -20.53 to 14.21%. It is evident from the table that Kiramat as a tester performed better than other testers for the morphological traits. Relative heterosis and better parent heterosis for ear height in negative direction are preferred because cob placement in middle on the plant is desired in maize breeding. For grain yield, heterotic effects among 50 testcrosses ranged from –41.03 to 54.03 and -32.25 to 32.02% over mid parent and better parent, respectively. From the Figures 2 and 3, it was illustrated that 23 and 23 hybrids showed desirable significant mid parent and better parent heterosis in positive direction for grain yield, respectively. Hybrids, as crosses of inbred lines with tester from different heterotic group, has positive yield heterosis which is in agreement with another investigators, who commonly assumed that the combination of lines of different heterotic groups originates hybrids with higher chances of genetic expression of the target effects of hybridization (Troyer, 1999; Tollenaar *et al*., 2004).

Table-1. Mean squares in respect of selected quantitative characters in maize.

Source of variation	df	Grain yield	Mean squares for flowering and morphological traits			
			Pollen shedding	Silking	Plant height	Ear height
Replications	1	0.20	0.75	2.23	13.51	1.80
Treatments	80	0.81**	9.03**	7.76**	556.77**	28.80**
Parents	26	0.73**	6.10**	5.73**	245.86**	19.04**
Crosses	49	0.84**	5.00**	4.83**	343.28**	34.01**
P. vs C.	1	2.73**	305.88**	221.78**	19916.19**	112.37**
Lines	24	0.97**	3.85**	4.30**	246.50**	36.34**
Testers	1	0.25*	29.16**	32.49**	5952.12**	25.22**
Line x tester	24	0.74**	5.14**	4.20**	206.36**	32.05**
Checks	3	0.44**	4.33**	4.46**	470.88**	9.84**
Error	80	0.06	0.74	0.81	18.56	1.95
Total	161					

** = Highly significant at 1% of probability
* = Significant at 5% of probability

Table-2. Specific combining ability effects of hybrids for different characters.

S_2 lines	Days to silking		Pollen shedding		Plant height		Ear height		Grain yield	
	J	K	J	K	J	K	J	K	J	K
SW12-2	0.07	-0.07	0.29	-0.29	-8.03**	8.04**	3.67**	-3.67**	0.16	-0.16
SW 46-1	-0.18	0.18	-0.46	0.46	3.41	-3.41	-1.69*	1.69*	-0.55**	0.55**
SW 65-1	-0.18	0.18	-0.71	0.71	0.06	-0.06	3.15**	-3.15**	-0.70**	0.70**
SW 77-2	1.82**	-1.82**	1.54**	-1.54**	-7.08**	7.08**	-0.68	0.68	0.29*	-0.29*
SW 79-2	0.57	-0.57	0.79	-0.79	4.16	-4.17	-0.48	0.48	-0.09	0.09
SW 91-3	0.57	-0.57	1.04*	-1.04*	-2.77	2.77	-5.40**	5.40**	-0.46**	0.46**
SW 96-1	-2.18	2.18	-1.46**	1.46**	12.39**	-12.39**	-1.90*	1.90*	0.14	-0.14
SW 119-1	-0.18	0.18	0.04	-0.04	-1.58	1.59	-6.25**	6.25**	-0.42**	0.42**
SW 122-2	0.57	-0.57	0.29	-0.29	-2.71	2.71	2.85**	-2.85**	0.04	-0.04
SW 126-1	-1.68**	1.68**	-0.96*	0.96	-5.04*	5.04*	0.15	-0.15	-0.92**	0.92**
SW 128-1	-0.93*	0.93*	-1.96**	1.96**	-0.23	0.24	0.10	-0.10	-0.07	0.07
SW 139-1	0.57	-0.57	1.04*	-1.04*	4.22*	-4.22*	-0.40	0.40	-0.13	0.13
SW 144-1	-1.68**	1.68**	-0.71	0.71	-0.38	0.39	0.57	-0.57	0.11	-0.11
SW 149-2	0.32	-0.32	0.29	-0.29	-2.04	2.04	2.15**	-2.15**	-0.10	0.10
SW 151-1	0.82	-0.82	3.04**	-3.04**	-1.63	1.63	-0.28	0.28	-0.20	0.20
SW 159-2	-0.43	0.43	0.04	-0.04	-1.54	1.54	-2.10	2.10	-0.14	0.14
SW 173-1	-0.93	0.93	-0.96*	0.96*	-6.90**	6.90**	-0.25	0.25	0.79**	-0.79**
SW 189-1	0.32	-0.32	-0.21	0.21	-3.09	3.09	1.47*	-1.47**	0.24*	-0.24*
SW 192-1	-0.93*	0.93*	-2.21**	2.21**	1.45	-1.45	0.67	-0.67	0.75**	-0.75**
SW 195-1	-0.18	0.18	0.04	-0.04	-3.59	3.58	3.75**	-3.75**	-0.39**	0.39**
SW 197-2	-0.68	0.68	-0.96*	0.96	2.01	-2.02	-5.60**	5.60**	0.03	-0.03
SW 220-1	0.57	-0.57	0.54	-0.54	-3.58	3.58	4.08**	-4.08**	0.24*	-0.24*
SW 222-1	1.57**	-1.57**	0.54	-0.54	3.97	-3.97	2.50**	-2.50**	0.29*	-0.29*
SW 231-1	1.57**	-1.57**	0.79	-0.79	-7.99**	7.99**	-1.58*	1.58*	0.64**	-0.64**
SW 237-1	0.82	-0.82	0.29	-0.29	26.50**	-26.50**	1.50*	-1.50*	0.45**	-0.45**
CD (0.01)	1.51		1.45		7.24		2.35		0.41	
CD (0.05)	1.06		1.01		5.07		1.64		0.28	

* Significant at 5% level ** Significant at 1% level
J = Jalal, K = Kiramat.

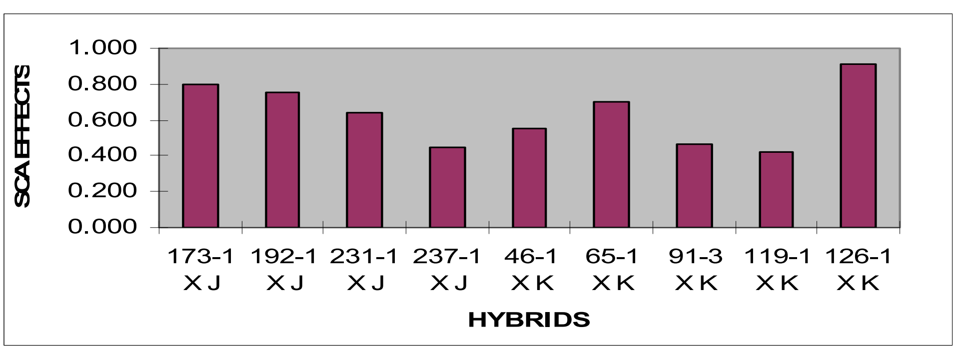

Figure-1. Experimental hybrids having desirable specific combining ability for grain yield.

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Table-3. Mid parent heterosis for different characters.

S_2 lines	Days to silking		Pollen shedding		Plant height		Ear height		Grain yield	
	J	K	J	K	J	K	J	K	J	K
SW12-2	-6.14**	-4.39**	-6.14**	-2.26**	0.27	25.56**	15.14**	3.35**	31.95**	6.84*
SW 46-1	-2.16**	0.43	-8.94**	-2.63**	5.82*	14.30**	6.68**	14.83**	-6.56**	11.13**
SW 65-1	-3.86**	-1.29*	-5.26**	2.26**	12.86**	26.57**	16.40**	5.92**	-21.54**	3.46**
SW 77-2	-2.56**	-6.84**	-3.83**	-4.39**	-10.60**	11.37**	-0.86	2.90**	19.86**	-9.12**
SW 79-2	-3.00**	-3.00**	-4.31**	-2.22**	24.07**	31.67**	13.55**	16.88**	-13.02**	-18.23**
SW 91-3	-4.24**	-4.24**	-7.17**	-6.09**	-2.58	14.46**	-15.05**	6.68**	-16.52**	-4.39**
SW 96-1	-7.89**	1.75**	-10.64**	-0.88	19.37**	13.91**	-3.14**	4.81**	5.35**	-15.11**
SW119-1	-6.09**	-3.48**	-8.94**	-4.39**	-6.31*	8.95**	-7.65**	15.70**	-21.13**	-7.38**
SW122-2	-4.39**	-4.39**	-6.49**	-2.68**	-13.23**	2.65	10.19**	1.56	-13.46**	-28.05**
SW126-1	-10.17**	-2.54**	-8.55**	-0.44	3.53	24.90**	0.18	0.88	-25.10**	15.43**
SW128-1	-7.30**	-2.15**	-5.68**	6.31**	17.92**	32.20**	-3.30**	-2.55**	43.09**	28.76**
SW139-1	-1.75**	-1.75**	-0.88	0.45	11.93**	18.78**	0.22	2.92**	12.37**	5.23**
SW144-1	-8.55**	-0.85	-11.02**	-3.93**	6.20*	19.67**	-0.44	-1.31	9.59**	-9.74**
SW149-2	0.00	0.88	-4.80**	-0.90	-1.76	14.13**	7.58**	1.07	-8.17**	-14.23**
SW151-1	0.87	0.00	0.42	-5.22**	4.20	19.31**	-0.71	1.51	42.96**	36.75**
SW159-2	-4.39**	-0.88	-6.55**	-1.80**	8.52**	24.62**	-4.86**	3.72**	-4.95**	-9.30**
SW173-1	-3.96**	1.32*	-6.55**	1.80**	-7.15**	16.51**	-2.16*	-0.13	23.21**	-33.35**
SW189-1	-2.68**	-1.79**	-9.79**	-4.39**	4.85	23.28**	4.34**	0.32	2.98**	-24.15**
SW192-1	-4.31**	0.86	-9.62**	2.59**	11.14**	22.50**	2.02*	0.86	24.18**	-30.14**
SW195-1	-2.54**	0.00	-2.16**	2.68**	-1.03	17.24**	9.09**	-2.81**	3.40**	10.89**
SW197-2	-3.93**	0.44	-6.96**	1.35*	-1.98	8.28**	-0.36	21.89**	5.76*	-8.02**
SW220-1	-0.88	-0.88	-3.48**	-0.45	-3.15	14.59**	15.68**	2.35*	54.03**	19.45**
SW222-1	0.88	-2.63**	-5.58**	-2.65**	6.50*	13.75**	-6.94**	-14.87**	40.59**	8.11**
SW231-1	-1.74**	-5.22**	-5.17**	-3.11**	-4.94	20.85**	-0.91	6.22**	5.04**	-41.03**
SW237-1	-1.77**	-2.65**	-4.80**	-0.90	16.19**	-11.48**	9.58**	5.46**	17.08**	-18.85**
CD(0.01)	1.85		1.77		8.86		2.87		0.50	
CD(0.05)	1.30		1.24		6.21		2.01		0.35	

* Significant at 5% level ** Significant at 1% level
J = Jalal, K = Kiramat.

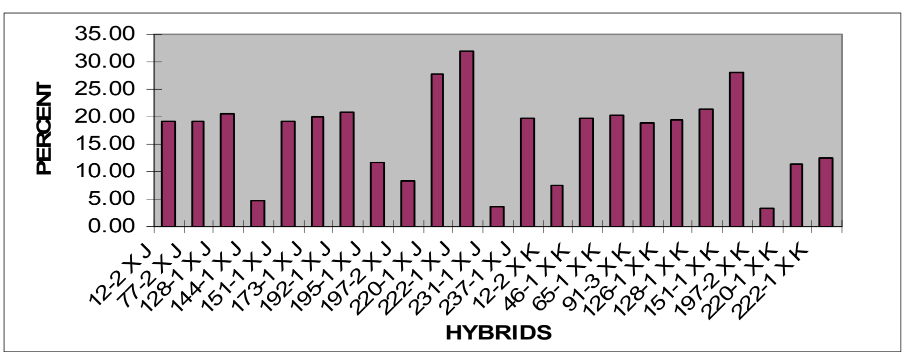

Figure-2. Experimental hybrids having desirable mid parent heterosis for grain yield.

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Table-4. Better parent heterosis for different characters.

S_2 lines	Days to silking		Pollen shedding		Plant height		Ear height		Grain yield	
	J	K	J	K	J	K	J	K	J	K
SW12-2	-10.08**	-8.40**	-13.01**	-12.20**	16.87**	44.26**	13.42**	-1.23	19.26**	7.43**
SW 46-1	-5.04**	-2.52**	-13.01**	-9.76**	16.96**	24.43**	-1.27	2.89*	-8.74**	19.84**
SW 65-1	-5.88**	-3.36**	-12.20**	-8.13**	26.70**	40.00**	7.72**	-5.09**	-16.69**	20.37**
SW 77-2	-4.20**	-8.40**	-8.13**	-11.38**	12.26**	38.00**	-4.12**	-3.51**	19.29**	-0.32
SW 79-2	-5.04**	-5.04**	-9.76**	-10.57**	36.35**	42.52**	14.30**	14.21**	-3.17**	-0.66**
SW 91-3	-5.04**	-5.04**	-10.57**	-12.20**	15.13**	33.37**	-20.53**	-3.33**	-4.58**	19.00**
SW 96-1	-11.76**	-2.52**	-14.63**	-8.13**	36.52**	28.39**	-2.63*	2.28*	-1.02**	-11.62**
SW 119-1	-9.24**	-6.72**	-13.01**	-11.38**	10.35**	26.52**	-6.75**	13.42**	-31.55**	-10.20**
SW 122-2	-8.40**	-8.40**	-12.20**	-11.38**	8.39*	26.52**	11.93**	0.18	-27.30**	-32.25**
SW 126-1	-10.92**	-3.36**	-13.01**	-8.13**	17.39**	39.57**	-1.93	-4.21**	-30.18**	19.33**
SW 128-1	-9.24**	-4.20**	-12.20**	-4.07**	32.17**	46.00**	-2.37*	-4.47**	20.50**	21.52**
SW 139-1	-5.88**	-5.88**	-8.13**	-9.76**	31.39**	37.48**	-0.70	-1.05	-5.60**	-0.90**
SW 144-1	-10.08**	-2.52**	-14.63**	-10.57**	26.61**	40.70**	-0.09	-3.86**	4.78**	-4.52**
SW 149-2	-4.20**	-3.36**	-11.38**	-10.57**	16.52**	33.48**	4.56**	-4.74**	-11.15**	-8.28**
SW 151-1	-2.52**	-3.36**	-3.25**	-11.38**	25.74**	42.00**	-2.19	-2.98*	19.22**	27.95**
SW 159-2	-8.40**	-5.04**	-13.01**	-11.38**	22.35**	38.43**	-4.19**	1.40	-6.36**	-1.43**
SW 173-1	-8.40**	-3.36**	-13.01**	-8.13**	7.30*	32.72**	-0.61	-1.49	19.90**	-28.36**
SW 189-1	-8.40**	-7.56**	-13.82**	-11.38**	18.43**	37.22**	3.42**	-3.51**	-8.46**	-24.87**
SW 192-1	-6.72**	-1.68*	-12.20**	-3.25**	26.26**	37.15**	2.02	-2.11	20.84**	-24.92**
SW 195-1	-3.36**	-0.84	-8.13**	-6.50**	16.96**	36.61**	10.53**	-4.39**	11.69**	31.06**
SW 197-2	-7.56**	-3.36**	-13.01**	-8.13**	11.83**	21.74**	-3.86**	14.04**	8.20**	3.46**
SW 220-1	-5.04**	-5.04**	-9.76**	-9.76**	17.65**	37.30**	13.45**	-2.63*	27.88**	11.32**
SW 222-1	-3.36**	-6.72**	-10.57**	-10.57**	23.30**	29.83**	-5.60**	-16.14**	32.02**	12.50**
SW 231-1	-5.04**	-8.40**	-10.57**	-11.38**	8.00*	35.30**	-4.12**	-0.35	3.73**	-35.77**
SW 237-1	-6.72**	-7.56**	-11.38**	-10.57**	31.04**	-1.63	4.39**	-2.63*	19.65**	-8.82**
CD (0.01)	2.14		2.04		10.23		3.32		0.57	
CD (0.05)	1.50		1.43		7.17		2.33		0.40	

* Significant at 5% level ** Significant at 1% level
J = Jalal, K = Kiramat.

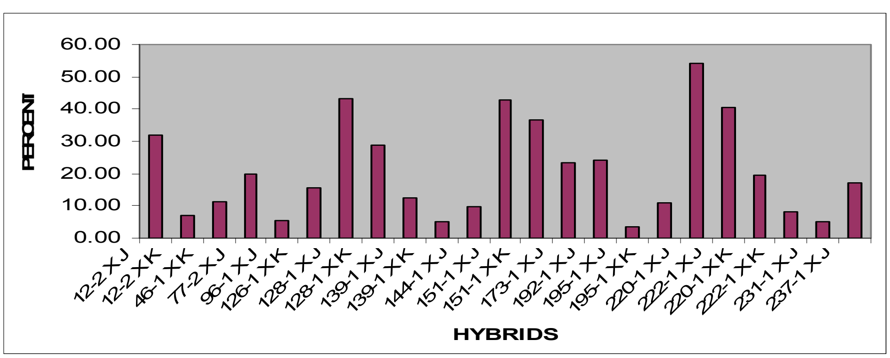

Figure-3. Experimental hybrids having desirable better parent heterosis for grain yield.

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CONCLUSIONS

The analysis of variance for genotypes including parents and hybrids for five quantitative characters revealed highly significant genotypic variance for all the characters indicating the presence of genetic variability in the material used for study. Results of our investigations indicated that promising single cross combinations with desirable SCA effects for grain yield, days to silking, days to pollen shedding plant height, and ear height, hence suggesting presence of valuable genetic material that could be successively used for further heterosis breeding work. The study also recognized significant heterotic groups, inbred lines grouped with tester, which were verified to be the best combinations to initiate source germplasm. The inbred lines in each group could be recombined and further improved using appropriate breeding schemes to enhance the level of heterosis. For broadening the genetic base of the group, some more germplasm will be tested and continuously infused into either group.

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