

LINE X TESTER ANALYSIS IN BREAD WHEAT [*Triticum aestivum* (L.)]

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ABSTRACT

*Heterosis and combining ability study for yield and yield attributes in bread wheat [*Triticum aestivum* (L.)] was carried out through line x tester analysis at Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Experimental materials comprising 12 parents (4 lines and 8 testers), their 32 crosses and a standard check GW 496. The material was planted in a randomized block design with two replications during rabi 2012-13. The analysis of variance for experimental design revealed that highly significant differences were existed among genotypes, parents and hybrids for all the traits, except for days to maturity and 100-grain weight for hybrids. However, mean square due to parents vs. hybrids was non-significant for length of main spike, spikelets per spike, 100-grain weight and protein content. Exploitable heterosis over mid parent, better parent and standard heterosis, out of 32 hybrids, few hybrids exhibited significant heterosis in desired direction for number of effective tillers, length of main spike, seed yield per spike, seed yield per plant, harvest index and protein content. The highest heterosis over standard check variety (GW 496) for seed yield per plant was registered by the cross GW 503 x GW 190 followed by GW 173 x GW 190, GW 11 x GW 190, GW 503 x GW 322 and GW 11 x GW 322. The analysis of variance for combining ability suggested that specific combining ability variances for m x f interaction were highly significant for plant height, number of effective tillers per plant and seed yield per spike. The magnitude of general combining ability variances was higher than the specific combining ability variances for all the characters which indicated preponderance of additive gene action in the inheritance of these traits. This was further supported by high magnitude of $\sigma^2_{gca} / \sigma^2_{sca}$ ratios. On the basis of general combining ability (gca) effects none of the parent was good general combiners for all the characters. Among females GW 11 and among males, GW 322 was found to be good general combiner for seed yield per plant, harvest index and protein content. The results of specific combining ability effects of different cross revealed that none of the crosses showed significant and negative specific combining ability effects for days to 50 per cent heading, days to maturity and plant height, whereas significant and positive specific combining ability effects were observed for number of effective tillers per plant, length of main spike and seed yield per spike. The three hybrids viz., GW 503 x GW 190, GW 11 x GW 190 and GW 503 x GW 322 showed significant positive relative heterosis and economic heterosis for seed yield per plant with non-significant specific combining ability effects and parents with significant general combining ability effects.*

KEY WORDS: Bread wheat, Heterosis, *Triticum aestivum* (L.)]

INTRODUCTION

Wheat (*Triticum aestivum* L.) is second important staple food crop in India next to rice. It widely cultivated food crop that is known for its remarkable adaptation to a wide range of environment. *Triticum* spp. originated from Middle-East region of Asia and is a member of family *poaceae*. It covers about 32 per cent of the total acreage under cereals in the world. The bread wheat (2n=42) and macaroni wheat (2n=28) is mostly growing in the central and the southern states and also in the North-West, while emmer wheat (2n=28) is confined to southern states of India and some part of Gujarat. India is the second largest producer of wheat in the world. It covers about 29.9 million hectares area with total production of 85.93 million tonnes and productivity 2.9 t/ha (Anonymous, 2010-11a). Gujarat ranks seventh in production and fourth in productivity (3.1 t/ha) next to Punjab, Haryana and Rajasthan. The area under wheat crop in Gujarat is about 15.8 million hectares with the production of 50.13 lakh tones (Anonymous, 2010-11b).

Heterosis breeding has proved to be a potential method of increasing yield in the self as well as cross fertilizing crops. However, commercial exploitation of heterosis in self-pollinated crops like wheat has been limited owing to technical difficulties involved in commercial hybrid seed production. Hybrid technology has been attempted in wheat by varied sterility induction techniques encompassing genetic male sterility, cytoplasmic genetic male sterility and more recently through chemical hybridizing agents (Mahajan *et al.*, 1999). Among these, chemical hybridizing agents have been reported to be impressive particular under less endowed areas. However, the utility of the technique in enhancing productivity in crop like wheat is still quite moot owing to polyploidy status of the crop and technical intricacies involved in hybrid seed production at commercial scale. Therefore, an early identification of superior, potential crosses is quite necessary to handle

the material in advanced generations, effectively and gainfully. There is need to improve the yield potential of wheat varieties as the genetic potential of present day cultivars of wheat appears to be fast reaching plateau and short span of cool season due to global warming. Heterosis studied in wheat gives idea about different types of gene effects which can be utilized further for improvement in production. The success of breeding procedure is determined by the useful gene combinations organized in the form of good combining lines and isolation of valuable germplasm. Some lines produce outstanding progenies on crossing with others, while others may look equally desirable, but may not produce good progenies on crossing. The lines, which perform well in combination, are eventually of great importance to the plant breeders. Hence, investigation on general and specific combining ability would yield very useful information. Accordingly, a good knowledge of gene action involved in the inheritance of quantitative characters of economic importance is required in order to frame an efficient breeding plan leading to rapid improvement. Line x Tester analysis is a useful technique for screening large number of lines for identification the best combiner. Similarly, knowledge about nature of gene action governing the expression of various traits could help in predicting the effectiveness of selection. The partitioning of genetic variances in to its components helps in formulation of an effective and sound breeding programme.

MATERIALS AND METHODS

Heterosis and combining ability study in bread wheat (*Triticum aestivum* L.) was carried out at the Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The experimental materials consisting of 44 entries including 4 lines as females, 8 testers as males and their 32 crosses and one standard check GW 496. The experiment was laid out in a randomized block design with two

replications during *rabi* 2012-13. Each entry was planted in a single row of 3.5 m length keeping a distance of 23 cm between rows and 10 cm between plants within the row. Fertilizer was applied at the rate of 120-60-00 NPK kg/ha. Five competitive plants were randomly selected to record the observations on eleven characters and mean values were subjected to statistical analysis. The analysis of variance was carried out as suggested by Panse and Sukhatme (1967). The analysis of the experimental material was done according to Griffing (1956a and b).

RESULTS & DISCUSSION

The analysis of variance (Table 1) for various characters revealed that considerable genetic variation existed among the parents and hybrids for all the traits under study. Comparison of mean squares due to parent vs. hybrids indicated presence of overall heterosis for all the characters except length of main spike, spikelets per spike, 100-grain weight and protein content indicating that the performance of hybrids was different than that of the parents for most of the characters.

With regard to heterosis (Table 2) over mid parent, better parent and standard heterosis, out of 32 hybrids, few hybrids exhibited significant heterosis in desired direction for number of effective tillers (0, 2, 0), length of main spike (0, 0, 1), seed yield per spike (0, 0, 1), seed yield per plant (4, 0, 5), harvest index (6, 0, 11) and protein content (1, 1, 3). The data revealed that none of the hybrid gave significantly negative heterosis over mid parent, better parent and standard check for days to 50 per cent heading, days to maturity and plant height. Ashutosh Kumar *et al.* (2011) reported same magnitude of standard heterosis for days to heading and plant height. For seed yield per plant, the high relative heterosis and economic heterosis expressed by the crosses GW 503 x GW 190, GW 173 x GW 190 and GW 503 x GW 322 (Table 6). These findings are accordance with Bilgin *et al.* (2011), who reported high heterosis for seed yield per plant. In case 100-

grain weight, being an important component of seed yield per plant, none of the cross gave significant positive heterosis. These results are in conformity of Yadav and Narsingini (2000), who observed negative heterobeltiosis for this trait.

The analysis of variance for combining ability and the estimates of variance components (Table 3) indicated that the mean squares due to lines were highly significant for all characters except days to 50 per cent heading and 100- grain weight indicated significant contribution of lines towards general combining ability variance components for most of the traits. The mean sum of squares due to testers was also highly significant for all the characters, suggesting larger contribution of testers towards gca variance component for all the characters. The mean sum of squares due to line x testers interaction were significant for plant height, number of effective tillers and seed yield per spike, revealed the significant contribution of hybrids for specific combining ability variance components. The magnitude of gca variance were higher than the sca variance for all the characters, which indicated preponderance of additive gene action in the inheritance of these traits. Therefore, selection for these traits in early generations would be effective to developing the varieties in wheat breeding programme. This was further supported by high magnitude of $\sigma^2_{gca} / \sigma^2_{sca}$ ratios. Preponderance of additive variance in the expression for these traits in wheat has also been reported by Joshi *et al.* (2004).

General and specific combining ability effects were estimated for parents and crosses, respectively. The summary of general combining ability effects of the parents (Table 4) revealed that none of the parent was found to be good general combiner for all the characters. These results are akin to the findings of Dhadhal and Dobariya (2006). An overall appraisal of general combining ability effects revealed that among the females, GW 503 was found to be good general combiner

for length of main spike, seed yield per plant and spikelets per spike, Lok-1 for plant height and 100-grain weight, GW 173 for days to maturity and number of effective tillers per plant, GW 11 for plant height, seed yield per plant, seed yield per spike, harvest index and protein content. Among the males, GW 496 for days to 50 per cent heading, days to maturity, plant height, length of main spike, 100-grain weight and protein content, GW 190 for days to 50 per cent heading, number of effective tillers, length of main spike, grain yield per plant and grain yield per spike, GW 273 for number of effective tillers, length of main spike, spikelets per spike and harvest index, GW 322 for number of effective tillers, seed yield per plant, spikelets per spike, 100-seed weight, harvest index and protein content, GW 366 for days to maturity and number of effective tillers, GW 438 for seed yield per spike and GW 438 for plant height. It also observed in view of most of the characters that parents which exhibited high *per se* performance also displayed good general combining ability effects. Hence, *per se* performance may be used effectively for the selection of parents. Similar result of positive association of *per se* performance and general combining ability and its use for selection of the parents were also reported by Ashutosh Kumar *et al.* (2011). In general, the line GW 11 and tester GW 322 was good general combiner for seed yield and most of the yield contributing traits. So, it was considered as a good source gene for increasing seed yield as well as protein content in wheat.

The results of specific combining ability effects (Table 5) of different crosses revealed that none of the crosses showed consistently significant and desirable specific combining ability effects for all the characters. None of the crosses expressed significant and negative specific combining ability effects for days to 50 per cent heading, days to maturity and plant height and significant and positive specific combining ability effects were observed for number of effective tillers per

plant, length of main spike and seed yield per spike. In general, the cross showing positive and desirable combining ability effect, involved either good x good, good x average, good x poor, average x average, average x poor and poor x poor combining parents. Therefore, information of general combining ability effects alone may not be sufficient to predict the magnitude of heterosis. Hence, information of general combining ability effects of the parents need not be supplemented by that of specific combining ability effects in crosses performance marked negative specific combining ability effects in crosses between good x good and good x average combiners could be attributed to lack of co-adaptation between favourable alleles of the parents involved, whereas marked positive specific combining ability effects in cross between poor x poor, average x poor and average x average. Combiners could be ascribed to better complementation between favourable alleles of the involved parents.

Comparative study of promising crosses identified on the basis of heterosis, combining ability and *per se* performance for seed yield per plant (Table 6) revealed that the hybrid viz., GW 503 x GW 190, GW 173 x GW 190 and GW 503 x GW 322 showed positive significant relative heterosis and economic heterosis (13.17, 11.60 and 11.06 %) and (28.40, 25.93 and 21.48 %) for seed yield per plant, respectively. The hybrid GW 173 x GW 190 and GW 503 x GW 322 showed positive significant relative heterosis (61.49 and 39.82 %), heterobeltiosis (47.73 and 19.17 %) and economic heterosis (73.33 and 53.33 %) for number of effective tillers per plant and also showed significant positive economic heterosis for harvest index (14.39 and 21.21 %), respectively. The significant economic heterosis in desirable direction was observed in most of the high heterotic hybrid of a seed yield per plant and number of effective tillers per plant, which indicating that the maximum contribution of this character towards yield heterosis. All the four crosses had recorded

significant value of standard heterosis for seed yield per plant. Non significant specific combining ability effects (absence of dominance) and parents with significant general combining ability effects (presence of additive gene action) are useful in identification of superior segregants. Normally, the specific combining ability effects do not contribute tangibly in the important of self pollinated crops, except were commercial exploitation of heterosis is feasible. Breeder's interest therefore rests in obtaining transgressive segregants through crosses by producing more potent homozygous lines. Therefore, the hybrids GW 503 x GW 190, GW 11 x GW 190 and GW 503 x GW 322 (with non-significant sca effects and parents with significant gca effects) is recommended to exploit additive and non additive type of gene action by high volume crossing like diallel selective mating design (Jensen, 1970) and bi-parental matting.

CONCLUSION

From the ongoing discussion, it can be concluded that the cross GW 503 x GW 190 followed by GW 173 x GW 190, GW 11 x GW 190, GW 503 x GW 322 and GW 11 x GW 322 were registered significant economic heterosis. The analysis of variance for combining ability indicated preponderance of additive gene action in the inheritance of all the traits studied. Among females, GW 11 and among males, GW 322 was found to be good general combiner for seed yield per plant, harvest index and protein content. The three hybrids viz., GW 503 x GW 190, GW 11 x GW 190 and GW 503 x GW 322 showed significant positive relative heterosis and economic heterosis for seed yield per plant with non-significant specific combining ability effects and parents with significant general combining ability effects.

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Table 1 : Analysis of variance for parents and hybrids for seed yield and its component characters in wheat

Source of variation	d.f.	Days to 50 % Heading	Days to Maturity	Plant Height (cm)	No. of Effective Tillers	Length of Main Spike (cm)	Seed Yield Per Plant (g)	Spikelets Per Spike	Seed Yield Per Spike (g)	100-Seed Weight (g)	Harvest Index (%)	Protein Content (%)
Replication	1	0.28	0.011	3.68	1.47	0.62	0.03	0.05	0.08	0.25	1.13	0.14
Genotype	43	27.15**	11.51**	52.69**	9.71**	1.78**	22.76**	3.40**	0.51**	0.18*	37.81**	0.42**
Parents	11	61.67**	22.59**	103.68**	5.60**	3.85**	35.37**	6.97**	0.59**	0.31**	58.18**	0.78**
Female	3	19.45*	9.33	222.45**	0.11	4.95**	16.85**	5.84**	0.44**	0.39*	43.98**	1.14**
Male	7	28.57**	13.39*	50.84**	7.39**	3.93**	47.16**	4.02**	0.70**	0.32**	66.36**	0.74**
Female vs. Male	1	420.08**	126.75**	117.18**	9.54**	0.05	8.41*	31.04**	0.29*	0.004	43.51**	0.005
Parents vs. Hybrid	1	47.28**	21.48*	83.52*	35.15**	0.00	6.95*	1.11	1.29**	0.06	12.81*	0.004
Hybrids	31	14.25**	7.26	33.60*	10.35**	1.11**	18.79**	2.21**	0.46**	0.14	31.40**	0.30**
Error	43	4.88	5.05	15.63	0.48	0.21	1.41	0.92	0.05	0.09	2.73	0.06

* and** indicates significant at $P = 0.05$ and $P = 0.01$ levels, respectively.

Table 2: Number of crosses showing significant and desirable heterosis over mid-parent, better parent and standard parent for different traits in wheat.

Sr. No.	Characters	Number of crosses showing significant and desirable heterosis		
		MP	BP	SC
1.	Days to 50 % Heading	0	0	0
2.	Days to Maturity	0	0	0
3	Plant Height (cm)	0	0	0
4	Number of Effective Tillers	0	2	0
5	Length of Main Spike (cm)	0	0	1
6.	Seed Yield Per Plant (g)	4	0	5
7	Spikelets Per Spike	0	0	0
8	Seed Yield Per Spike (g)	0	0	1
9	100-seed Weight (g)	0	0	0
10	Harvest Index (%)	6	0	11
11	Protein Content (%)	1	1	3

Table 3 : Analysis of variance (mean square) for combining ability, and estimates of components of variance for various characters in wheat

Source of variation	d.f.	Days to 50 % Heading	Days to Maturity	Plant Height (cm)	No. of Effective Tillers	Length of Main Spike (cm)	Seed Yield Per Plant (g)	Spikelets Per Spike	Seed Yield Per Spike (g)	100- Seed Weight (g)	Harvest Index (%)	Protein Content (%)
Replication	1	1.56	0.76	7.56*	1.59	0.50	1.82	0.003	0.26**	0.49*	0.15	0.003
Crosses	31	14.25**	7.26*	33.60*	10.35**	1.11**	18.79**	2.21**	0.46**	0.14	31.40**	0.30**
Females (Line)	3	5.75	3.43**	60.08**	16.53**	1.77*	39.08**	4.00**	1.51**	0.08	35.60**	0.75**
Males (Tester)	7	46.96**	26.33**	102.78**	29.05**	3.06**	64.60**	7.43**	0.99**	0.51**	118.95**	0.77**
Females x Males	21	4.55	1.45	6.76**	3.23**	0.36	0.62	0.21	0.13**	0.02	1.61	0.08
Error	31	4.53	3.63	15.43	0.49	0.21	1.34	0.79	0.03	0.08	2.93	0.07
COMPONENTS OF VARIANCES :												
σ^2 Females		0.07	0.12	3.33**	0.83**	0.08*	2.40**	0.23**	0.08**	0.003	2.12**	0.04**
σ^2 Males		5.30**	3.11**	12.00**	3.22**	0.33**	7.99**	0.90**	0.10**	0.06**	14.66**	0.08**
σ^2_{gca}		1.81**	1.11**	6.22**	1.62**	0.17**	4.26**	0.45**	0.09**	0.02**	6.30**	0.05**
σ^2_{sca}		-0.16	-1.80	-4.43	1.37**	0.07	-0.39	-0.35	0.04**	-0.03	-0.56	0.01
$\sigma^2_{gca}/\sigma^2_{sca}$		1.05	5.28	1.55	1.18	2.25	1.05	1.63	2.18	2.00	1.05	5.20

* and** indicates significant at $P = 0.05$ and $P = 0.01$ levels, respectively.

Table 4 : Estimation of general combining ability (gca) effects of parents for various characters in wheat

Source of variation	Days to 50 % Heading	Days to Maturity	Plant Height (cm)	No. of Effective Tillers	Length of Main Spike (cm)	Seed Yield Per Plant (g)	Spikelets Per Spike	Seed Yield Per Spike (g)	100-Seed Weight (g)	Harvest Index (%)	Protein Content (%)
FEMALE PARENTS (Lines) :											
GW 503	0.68	0.26	0.68**	-0.39*	0.37**	1.00**	0.61*	0.16**	-0.09**	-0.95*	-0.09
LOK 1	-0.56	-0.35	-0.81**	0.14	-0.23	-2.31**	-0.59*	-0.32**	0.05**	-1.43**	-0.21**
GW 173	-0.43	-0.42**	-2.18	1.32**	-0.32**	0.41	-0.11	-0.18**	-0.02	0.54	0.02
GW 11	0.32	0.51**	-2.31**	-1.08**	0.18	0.89**	0.09	0.34**	0.05	1.84**	0.28**
S.E. (g) _i ±	0.78	0.79	1.39	0.24	0.16	0.42	0.34	0.07	0.10	0.58	0.09
MALE PARENTS (Testers) :											
GW 496	-5.18**	-1.73*	-5.93**	-0.41	0.47**	0.50	-0.49	0.11	0.29*	-1.03	0.33**
GW 190	-1.68*	0.02	-2.68	0.73**	0.49**	4.85**	0.48	0.33**	0.03	0.73	-0.28**
GW 273	1.31	1.76*	-0.93	1.77**	0.83**	-0.10	1.20**	-0.35**	-0.30**	4.36**	-0.22**
GW 322	1.31	2.64**	1.31	2.97**	0.23	3.13**	1.53**	-0.26**	0.35**	6.73**	0.56**
GW 366	0.06	-2.23**	3.18*	0.67**	-0.40*	-1.15**	-0.89*	-0.34**	0.05	-2.67**	-0.02
GW 439	1.56	-0.10	-2.43	-1.92**	-0.73**	-3.79**	-0.71*	-0.04	0.06	-1.02	0.07
GW 428	0.31	1.39	4.31**	-1.14**	-0.88**	-2.50**	-0.19	-0.08	-0.18	-2.04**	-0.28**
GW 438	2.31**	-1.73*	3.18*	-2.68**	-0.01	-0.93*	-0.92*	0.64**	-0.31	-5.06**	-0.16
S.E. (g) _j ±	1.10	1.12	1.97	0.34	0.23	0.59	0.48	0.11	0.15	0.82	0.12

* and** indicates significant at $P = 0.05$ and $P = 0.01$ levels, respectively.

Table 5 : The estimates of specific combining ability (sca) for various characters in wheat

Crosses	Days to 50 % Heading	Days to Maturity	Plant Height (cm)	No. of Effective Tillers	Length of Main Spike (cm)	Seed Yield Per Plant (g)	Spikelets Per Spike	Seed Yield Per Spike (g)	100-Seed Weight (g)	Harvest Index (%)	Protein Content (%)
GW 503 x GW 496	0.81	0.10	1.31	-0.74	0.55	0.18	0.72	0.28	0.006	-0.52	-0.10
GW 503 x GW 190	0.31	-0.64	-0.93	-0.14	-0.02	0.33	0.08	0.01	0.11	-0.29	-0.07
GW 503 x GW 273	0.31	-0.39	1.31	-0.18	0.84*	-1.20	0.07	-0.17	0.10	0.08	0.36
GW 503 x GW 322	-0.68	-0.26	-0.43	-0.38	-0.15	0.65	0.23	0.02	0.09	0.20	-0.22
GW 503 x GW 366	-2.43	1.60	0.18	-0.08	0.23	0.24	-0.02	0.05	-0.15	-0.43	0.01
GW 503 x GW 439	2.06	1.48	0.81	0.51	-0.29	-0.01	-0.36	-0.07	0.08	-0.48	0.06
GW 503 x GW 428	-0.68	-1.01	-1.43	0.74	-0.44	0.19	-0.42	-0.11	-0.06	-0.40	0.02
GW 503 x GW 438	0.31	-0.89	-0.81	0.28	-0.70*	-0.38	-0.30	-0.02	-0.18	1.85	-0.05
Lok 1 x GW 496	0.06	-0.76	-2.68	0.46	0.16	0.00	-0.52	-0.10	0.05	0.46	-0.08
Lok 1 x GW 190	-0.43	0.48	1.06	-0.18	0.23	0.15	0.09	0.03	-0.08	0.48	0.04
Lok 1 x GW 273	-1.43	-0.26	-1.68	-0.22	-0.70*	-0.38	-0.07	0.005	-0.14	0.56	0.03
Lok 1 x GW 322	1.56	-0.64	0.56	0.38	-0.50	0.02	-0.05	-0.01	-0.006	-0.81	-0.008
Lok 1 x GW 366	-1.18	0.73	1.18	0.03	0.03	0.46	0.33	0.10	-0.006	0.49	-0.22
Lok 1 x GW 439	0.31	0.10	-0.68	-0.52	0.21	-0.3	-0.30	0.06	0.08	-0.15	0.28
Lok 1 x GW 428	0.56	0.60	1.06	0.005	0.26	-0.03	0.33	0.005	0.13	0.47	-0.05
Lok 1 x GW 438	0.56	-0.26	1.18	0.04	0.29	0.08	0.20	-0.09	-0.03	-1.51	0.01
GW 173 x GW 496	-2.06	0.29	-2.81	-0.21	-0.45	0.02	0.005	-0.04	-0.11	-0.02	-0.12
GW 173 x GW 190	0.43	0.04	-1.56	1.63**	-0.02	0.42	0.01	-0.40*	0.04	0.40	-0.002
GW 173 x GW 273	1.43	0.29	0.18	2.09**	0.08	0.48	-0.09	-0.26	-0.06	1.08	-0.26
GW 173 x GW 322	-1.56	0.42	0.43	1.89**	0.53	-0.8	-0.23	-0.31	0.01	0.70	0.09
GW 173 x GW 366	3.68*	-1.20	0.56	-1.30*	-0.27	-0.66	-0.09	0.15	0.16	-0.38	0.33
GW 173 x GW 439	-1.81	-0.82	-0.31	-1.20*	-0.10	0.32	0.21	0.26	-0.04	-0.03	0.08
GW 173 x GW 428	0.43	0.17	1.93	-1.47**	-0.05	-0.11	0.30	0.25	0.006	-0.75	-0.05
GW 173 x GW 438	-0.56	0.79	1.56	-1.43**	0.28	0.31	-0.12	0.34*	-0.006	-0.99	-0.07
GW 11 x GW 496	1.18	0.35	4.18	0.49	-0.26	-0.20	-0.20	-0.13	0.05	0.08	0.31
GW 11 x GW 190	-0.31	0.10	1.43	-1.30*	-0.18	-0.90	-0.19	0.35*	-0.08	-0.59	0.03
GW 11 x GW 273	-0.31	0.35	0.18	-1.69**	-0.22	1.10	0.09	0.42 *	0.10	-1.72	-0.12
GW 11 x GW 322	0.68	0.48	-0.56	-1.89**	0.12	0.11	0.05	0.29	-0.10	-0.09	0.13
GW 11 x GW 366	-0.06	-1.14	-1.93	1.35**	0.01	-0.04	-0.20	-0.31	-0.006	0.31	-0.12
GW 11 x GW 439	-0.56	-0.76	0.18	1.20*	0.18	-0.006	0.45	-0.25	-0.11	0.66	-0.42*
GW 11 x GW 428	-0.31	0.23	-1.56	0.73	0.23	-0.04	-0.20	-0.14	-0.06	0.69	0.08
GW 11 x GW 438	-0.31	0.35	-1.93	1.11*	0.12	-0.02	0.21	-0.22	0.21	0.65	0.11
S.E. (s _{ij}) ±	2.21	2.24	3.95	0.69	0.46	1.18	0.96	0.22	0.30	1.65	0.25

* and** indicates significant at $P = 0.05$ and $P = 0.01$ levels, respectively.

Table 6 : Promising crosses identified on the basis of heterosis, combining ability and *per se* performance

Sr. No.	Parameters	Best heterotic crosses			
		GW 503 x GW 190	GW 173 x GW 190	GW 11 x GW 190	GW 503 x GW 322
1.	Seed yield per plant (g)	26.00	25.50	24.65	24.60
2.	Relative heterosis for seed yield (%)	13.17 **	11.60 *	3.79	11.06 *
3.	Heterobeltiosis for seed yield (%)	-2.44	-4.32	-7.5	-1.6
4.	Standard heterosis for seed yield (%)	28.40**	25.93 **	21.73 **	21.48 **
5.	Sca effect for seed yield	0.33	0.42	-0.90	0.65
6.	Gca effect for grain yield :				
	(i) Female parent	1.00 **	0.41	0.89 **	1.00 **
	(ii) Male parent	4.85 **	4.85 **	4.85 **	3.13 **

* and ** significant at $P = 0.05$ and $P = 0.01$ levels, respectively.

[MS received: November 09, 2013]

[MS accepted: December 01, 2013]