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RESEARCH ARTICLE

Evaluation of the heterobeltiotic and economic heterotic potential of wheat genotypes

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SUMMARY

Heterobeltiotic and economic heterotic performance of 28 F_1 obtained through crossing 8 commercial varieties, were evaluated for days to 50 % flowering, plant height, number of effective tillers per plant, length of main spike, number of spikelets per main spike, peduncle length of main spike, days to maturity, number of grains per main spike, 100 grains weight, grain weight per main spike, grain yield per plant and harvest index. Number of crosses exhibiting significant positive heterobeltiosis and economic heterosis for grain yield per plant were 6 and 15, respectively. The highest significant positive standard heterosis over GW-366 for grain yield per plant was exhibited by GW-411 x K-583 (59.48 %) followed by GW-366 x GW-411 (44.21 %). It also exhibited significant economic heterosis in desirable direction for yield attributing traits *viz.*, number of effective tillers per plant, number of spikelets per main spike, peduncle length of main spike, 100 grains weight and harvest index. The results revealed that the hybrid combinations GW-411 x K-583 and GW-366 x GW-411 could be recommended for improved yield and enhanced biological production of wheat, respectively.

Key Words : Economic heterosis, Grain yield, Heterobeltiosis, Wheat, Yield components

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Exploitation of heterosis is considered one of the outstanding achievements of plant breeding. Utilization of heterosis through hybrid wheat is more attractive than conventional plant breeding methods, which obtain lower yield gain (one % per year) in the northwestern plains zone - the bread bowl of India. In a self-pollinated crop like wheat, the utilization of heterosis depends mainly upon the direction and magnitude of heterosis. The study of heterosis and inbreeding depression has a direct bearing on the breeding methodology to be employed for varietal improvement. Studies of heterosis also provide useful information about combining ability of the parents and their usefulness in breeding programmes (Sharma *et al.,* 1986; Borghi *et al.,* 1988). Estimation of heterosis over the better parent (heterobeltiosis) may be useful in identifying true heterotic cross combinations. Wheat breeders dealing with various aspects of hybrid wheat found that the standard heterosis for grain yield, on a large plot basis, ranged from 6% (Borghi *et al.,* 1986) to as high as 41%. Fabriozino *et al.* (1998) stated that the expression of heterosis was due to genetic diversity, which was unpredictable and factors not elucidated in their studies. The present study has been carried out to estimate the heterosis (%) over better parent (BP) and over standard check (SH) for quantitative and qualitative traits in a 8/8 diallel set in bread wheat to identify parental lines that could be used for commercial production of hybrid wheat as well as isolation of pure lines among the progenies of heterotic F_1 (Busch *et al.,* 1974) for further amelioration of grain yield in bread wheat.

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MATERIAL AND METHODS

Eight commercial varieties of bread wheat (*Triticum aestivum*), *viz*., GW-366, Lok-1, GW-173, HD-2687, KRL-213, RAJ-4037, GW-411 and K-583 were crossed in all possible combinations excluding reciprocals. The 10 parents and their resulting 28 F_1's were planted in a Randomized Complete Block Design, with three replications at Main Wheat Research Station Junagadh Agricultural University, Junagadh, during *Rabi* - 2010. Each entry was planted in two rows of 2.5-meter length, with a plant-to-plant and row-to-row distance of 10 and 22.5 cm, respectively. Standard agronomic practices were followed from sowing till harvest.

For recording observations, 5 competitive plants were randomly selected and tagged from each treatment in each replication and the average value per plant was computed for various yield and its attributing traits *viz.*, days to 50 % flowering, plant height, number of effective tillers per plant, length of main spike, number of spikelets per main spike, peduncle length of main spike, days to maturity, number of grains per main spike, 100 grains weight, grain weight per main spike, grain yield per plant and harvest index. Magnitude of heterobeltiosis and standard heterosis were computed as per procedure suggested by Fonesca and Patterson (1968) and Meredith and Bridge (1972), respectively.

$$\textbf{Standard heterosis (\%)} = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

$$\textbf{Standard heterosis (\%)} = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

RESULTS AND DISCUSSION

The character-wise data of parents and hybrids were subjected to analysis of variance for the experimental design. Analysis of variance for different characters is presented in Table 1. Perusal of data revealed highly significant mean square differences due to genotypes for all the characters except number of effective tillers per plant, indicating experimental material had sufficient genetic variability for all the characters. The genotypic variance was further partitioned into variance due to parents, hybrids and parents vs hybrids. The mean square due to parents, hybrids and parents vs hybrids was highly significant for all the traits studied except variance due to parents for number of effective tillers per plant, indicating the performance of hybrids as a group was different than that of parents for most of the characters. This revealed the presence of considerable heterosis due to directional dominance.

The data on performance of hybrids with respect to heterosis over better parent revealed that 6 hybrids manifested significant positive heterosis over their better parents for grain yield per plant (Table 2). The highest magnitude of heterobeltiosis for grain yield per plant was exhibited by the hybrid LOK-1 x GW-411 (39.77 %) followed by GW-366 x HD-2687. It was observed that hybrid LOK-1 x GW-411 showed significant heterobeltiosis in desirable direction for yield contributing characters like number of effective tillers per plant, length of main spike and number of grains per main spike, while hybrid GW-366 x HD-2687 showed significant heterobeltiosis in desirable direction for yield contributing characters like length of main spike number of spikelets per main spike, number of grains per main spike, grain weight per main spike and harvest index, The results are in agreement with the results reported by Nehvi *et al.* (2000); Singh *et al.* (2004); Vanparia *et al*. (2006) and Singh *et al*. (2007).

In present study, well known variety GW-366 released by Junagadh Agricultural University in recent past has been used as standard check in order to obtain information on superiority of hybrids. The hybrids GW-411 x K-583 and GW-366 x GW-411 exhibited maximum grain yield per plant 23.50 g and 22.97 g, respectively. The highest yielding hybrid GW-411 x K-583 and GW-366 x GW-411 had highest standard heterosis 59.48 % and 44.21, respectively over the best check GW-366. In addition to this the hybrids GW-411 x K-583 and GW-366 x GW-411also exhibited significant standard heterosis in desirable direction for other yield attributing characters like number of effective tillers per plant, number of spikelets per main spike, peduncle length of main spike, 100 grains weight and harvest index. Several workers have

Table 1 : Analysis of variance showing mean squares for grain yield and its contributing characters in wheat

Source of variation	df	Days to 50 % flowering	Plant height (cm)	No. of effective tillers per plant	Length of main spike (cm)	No. of spikelets per main spike	Penducle length of main spike (cm)	Days to maturity	No. of grains per main spike	100 grain weight (g)	Grain weight per main spike (g)	Grain yield per plant (g)	Harvest index (%)
Replications	2	1.13**	1.45**	9.48*	0.38**	1.46**	1.13**	1.51**	1.47**	0.02	0.52**	0.85**	0.05
Genotypes	35	151.73**	70.72**	8.11	1.64**	18.80**	29.30**	47.18**	50.84**	0.22**	6.74**	23.19**	46.06**
Parents	7	190.37**	113.22**	5.83	1.93**	34.16**	79.95**	57.10**	15.39**	0.59**	2.41**	26.72**	78.52**
Hybrids	27	143.79**	60.71**	10.46	1.52**	14.69**	17.13**	45.63**	55.03**	0.11**	7.93**	23.02**	38.79**
Parents vs hybrids	1	95.71**	43.54**	29.78	2.58**	22.26**	3.15**	13.41**	185.93**	0.32**	4.66**	3.00**	14.93**
Error	70	1.43	1.50	0.80	0.03	0.09	0.62	21.00	1.25	0.08	0.40	0.65	1.41

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Estimates of heterobeltiosis (H) and standard heterosis (SH) for different characters in wheat

Sr. No.	Hybrids	Days to 50 % flowering		Plant height (cm)		No. of effective tillers per plant		Length of main spike (cm)	
		H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)
1.	GW-366 x lok-1	3.82**	-10.51**	19.65**	-2.98**	-17.82	-17.43	-1.85	-2.93*
2.	GW-366 x GW-173	6.61**	-17.55**	-6.15**	-6.05**	-11.29	-11.06	-8.15**	-9.16**
3.	GW-366 x HD-2687	2.77**	3.29**	9.76**	9.18**	-8.62	-10.17	14.07**	12.82**
4.	GW-366 x KRL-213	2.46**	-3.18**	0.24	-0.29	-31.03**	-38.07*	13.33**	12.09**
5.	GW-366 x RAJ-4037	-1.47**	-0.97	2.07**	1.53**	1.15	-0.33	-4.51**	-4.54**
6.	GW-366 x GW-411	3.73**	4.26**	4.53**	3.80**	32.18**	57.37**	10.74**	1.10
7.	GW-366 x K-583	3.14**	3.67**	0.66	0.12	-13.22	17.82	-5.20**	-0.44
8.	LOK-1 x GW-173	0.88	-21.98**	7.31**	-15.74**	2.68	7.47	-8.63**	-19.67**
9.	LOK-1 x HD-2687	1.63**	-11.70**	16.51**	5.81**	23.95*	68.28**	13.25**	-0.44
10.	LOK-1 x KRL-213	1.76**	-11.58**	15.03**	4.47**	19.35	56.67**	6.48**	2.93*
11.	LOK-1 x RAJ-4037	3.92**	-9.71**	6.32**	-3.44**	27.54	45.66**	-0.92	-0.95
12.	LOK-1 x GW-411	9.54**	-4.83**	14.07**	3.60**	61.27**	70.72**	12.80**	6.23**
13.	LOK-1 x K-583	14.13**	-0.84	4.60**	-5.00**	58.80**	60.18**	-5.86**	-1.14
14.	GW-173 x HD-2687	2.07**	-21.75**	15.80**	-9.85**	13.77	32.11**	-3.98*	-17.91**
15.	GW-173 x KRL-213	4.51**	-19.88**	19.57**	-6.92**	15.02	46.14**	-9.13**	-12.16**
16.	GW-173 x RAJ-4037	-7.26**	-17.77**	20.12**	-6.49**	-19.88	-21.44	-10.08**	-10.11**
17.	GW-173 x GW-411	-8.16**	-16.74**	17.10**	-8..84**	2.90	24.30	-5.02**	-10.55**
18.	GW-173 x K-583	-9.13**	-16.34**	16.29**	-9.47**	29.11*	56.67**	-10.88**	-6.41**
19	HD-2687 x KRL-213	-12.68**	6.47**	8.18**	9.89**	-21.56	-35.61*	-6.90**	-10.00**
20.	HD-2687xRAJ-4037	0.95	8.35**	1.98**	6.39**	14.37	38.47*	-4.73**	-4.76**
21.	HD-2687 x GW-411	-0.58	6.70**	8.10**	7.33**	-15.57	-16.28	4.20**	-1.87
22.	HD-2687 x K-583	1.63**	9.08**	5.54**	6.63**	-4.79	-13.88	-4.78**	0.00
23.	KRL-213x RAJ-4037	5.03**	-1.59**	1.86**	2.79**	-9.14	-13.68	-1.47	-1.50
24.	KRL-213 x GW-411	6.36**	-0.34	2.79**	2.07**	-25.27*	35.62	-2.96*	-4.03**
25.	KRL-213 x K-583	7.82**	1.02	3.05**	3.99**	-38.17**	26.32	-6.31**	-1.61
26.	RAJ-4037 x GW-411	5.09**	16.67**	4.84**	4.10**	8.45	27.54	2.22	9.52**
27.	RAJ-4037 x K-583	7.50**	18.10**	0.25	1.29**	8.70	87.19**	-0.42	4.58**
28.	GW-411 x K-583	2.75**	12.89**	0.65	0.12	60.07**	63.68**	-7.74**	-3.11*
	SE±	0.31	0.31	0.32	0.32	1.35	1.35	0.13	0.13

Contd. Table 2

Sr. No.	Hybrids	No. of spikelets per main spike		Penduncle length of main spike (cm)		Days to maturity		No. of grains per main spike	
		H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)
1.	GW-366 x lok-1	-0.20	-2.68	-16.05**	-18.09**	3.50**	1.55**	10.73**	9.75**
2.	GW-366 x GW-173	-12.35**	-14.53**	-5.56**	-2.64**	2.20**	-3.79**	16.10**	15.07**
3.	GW-366 x HD-2687	15.69**	12.81**	19.14**	21.23**	4.98**	5.05**	21.72**	24.66**
4.	GW-366 x KRL-213	25.69**	22.56**	-16.30**	-18.34**	3.01**	3.08**	18.30**	21.35**
5.	GW-366 x RAJ-4037	9.29**	21.41**	-12.96**	-14.95**	3.11**	3.17**	17.38**	19.34**
6.	GW-366 x GW-411	3.37**	29.06**	15.56**	-17.59**	3.95**	4.02**	24.31**	23.21**
7.	GW-366 x K-583	0.06	28.87**	11.31**	-13.27**	1.80**	1.87**	11.67**	14.29**
8.	LOK-1 x GW-173	-3.57*	-22.56**	-16.09**	-12.88**	2.96**	-3.08**	3.90**	-7.05**
9.	LOK-1 x HD-2687	12.82**	0.96	-11.83**	-21.11**	1.12**	-0.78*	-1.97**	0.40
10.	LOK-1 x KRL-213	7.87**	2.68	-5.28**	-17.71**	3.43**	1.49**	-5.03**	-2.58**
11.	LOK-1 x RAJ-4037	-7.92**	2.29	-4.37**	-18.00**	4.95**	2.98**	4.06**	1.13
12.	LOK-1 x GW-411	-13.63**	7.84**	2.92**	16.37**	5.01**	3.04**	3.19**	1.61*
13.	LOK-1 x K-583	-12.04**	13.29**	-0.64	-13.79**	3.76**	1.81**	-2.91**	-0.63
14.	GW-173 x HD-2687	-9.19**	-18.74**	-18.72**	-16.33**	1.89**	-3.98**	-12.57**	-10.46**

Table 2 Contd…

Table 2 Contd.

Sr. No.	Hybrids	No. of spikelets per main spike		Penduncle length of main spike (cm)		Days to maturity		No. of grains per main spike	
		H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)
15.	GW-173 x KRL-213	13.30**	7.84**	-14.23**	-11.93**	1.86**	-4.02**	-9.27**	-6.93**
16.	GW-173 x RAJ-4037	-1.89	8.99**	-10.51**	-8.29**	-1.19**	-6.02**	-4.23**	-6.93**
17.	GW-173 x GW-411	-13.25**	8.32**	-11.92**	-9.67**	-1.07**	-6.77**	-4.35**	-5.81**
18.	GW-173 x K-583	-20.72**	2.10	-13.97**	-11.68**	-1.14**	-4.99**	-7.89**	-5.73**
19.	HD-2687 x KRL-213	7.23**	2.07	2.18**	-11.68**	1.20**	4.37**	8.24**	11.03**
20.	HD-2687xRAJ-4037	-7.92**	2.29	-2.30**	-11.81**	0.82*	3.72**	6.67**	8.30**
21.	HD-2687 x GW-411	-16.85**	3.82**	-2.53**	-12.06**	-0.77*	4.11**	20.41**	19.18**
22.	HD-2687 x K-583	-14.34**	10.33**	-4.71**	-14.45**	-1.48**	3.37**	8.10**	10.76**
23.	KRL-213x RAJ-4037	-8.43**	1.72	-1.00	-14.20**	1.35**	4.37**	5.63**	7.25**
24.	KRL-213 x GW-411	-16.39**	4.40**	-4.44**	-18.09**	0.63	3.63**	8.10**	9.75**
25.	KRL-213 x K-583	-17.16**	6.69**	-7.22**	-21.23**	-0.22	2.75**	2.67**	5.08**
26.	RAJ-4037 x GW-411	-10.41**	11.85**	4.98**	-34.52**	1.23**	6.38**	-2.22**	-3.71**
27.	RAJ-4037 x K-583	-9.29**	16.83**	-6.76**	-36.81**	-0.27	4.31**	-4.65**	-2.42**
28.	GW-411 x K-583	-0.68	27.92**	2.71**	-47.10**	-0.47	4.43**	-1.83**	0.47
	SE±	0.25	0.25	0.20	0.20	0.37	0.37	0.29	0.29

Contd…Table 2

Sr. No.	Hybrids	100- grain weight (g)		Grain weight per main spike (g)		Grain yield per plant (g)		Harvest index (%)	
		H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)	H (%)	SH (%)
1.	GW-366 x lok-1	-24.15**	6.19**	5.56**	4.20**	4.27**	9.28**	-5.52**	20.34**
2.	GW-366 x GW-173	-15.09**	-4.42*	6.81**	5.45**	1.17	-1.14	-9.45**	22.56**
3.	GW-366 x HD-2687	0.00	6.19**	18.05**	17.18**	11.83**	9.28**	3.01**	18.38**
4.	GW-366 x KRL-213	-6.89**	5.22**	16.85**	9.14**	7.93**	7.75**	-10.82**	19.27**
5.	GW-366 x RAJ-4037	-6.00**	6.73**	2.14*	8.87**	-1.92*	8.14**	-8.01**	28.51**
6.	GW-366 x GW-411	-1.63	20.88**	21.65**	22.54**	2.99**	44.21**	-3.63**	31.71**
7.	GW-366 x K-583	-3.83*	6.73**	9.36**	9.32**	-6.87**	43.44**	-23.72**	2.84**
8.	LOK-1 x GW-173	-8.93**	12.21**	-1.86	-8.50**	-25.08**	-23.13**	-6.30**	26.82**
9.	LOK-1 x HD-2687	-9.93**	19.56**	-4.24**	-4.94**	-23.49**	-21.50**	-7.36**	18.47**
10.	LOK-1 x KRL-213	-16.60**	10.71**	7.33**	3.80**	4.29**	7.00**	-6.57**	24.96**
11.	LOK-1 x RAJ-4037	-16.53**	10.80**	-8.85**	-2.85**	-5.54**	4.15**	-11.51**	23.62**
12.	LOK-1 x GW-411	-15.00**	12.83**	-3.09**	-2.38**	39.77**	41.12**	-9.67**	23.45**
13.	LOK-1 x K-583	-17.20**	9.91**	-2.71**	-2.74**	-10.69**	6.35**	-14.96**	14.64**
14.	GW-173 x HD-2687	4.00*	10.44**	-9.94**	-10.60**	-11.33**	-27.36**	-0.31	35.45**
15.	GW-173 x KRL-213	-0.16	12.83**	-9.64**	-12.61**	-22.68**	-22.80**	-2.56**	32.40**
16.	GW-173 x RAJ-4037	-2.96	10.18**	-13.12**	-7.40**	-29.54**	-22.31**	-8.84**	27.35**
17.	GW-173 x GW-411	-2.02	11.77**	-6.90**	-6.22**	-24.96**	-18.24**	-3.93**	31.30**
18.	GW-173 x K-583	-2.07	8.67**	-3.07**	-3.11**	-34.22**	-21.66**	-2.14**	32.97**
19.	HD-2687 x KRL-213	-10.88**	0.71	2.96**	1.65	-7.83**	-7.98**	-14.75**	14.02**
20.	HD-2687xRAJ-4037	-7.33**	5.22**	-3.43**	2.93**	-16.69**	-8.14**	-4.26**	33.75**
21.	HD-2687 x GW-411	-1.86	11.95**	8.35**	15.36**	-15.71**	-8.16**	-16.50**	14.11**
22.	HD-2687 x K-583	2.87	14.46**	8.27**	8.23**	-19.04**	-3.58**	-22.92**	3.91**
23.	KRL-213x RAJ-4037	2.88	16.81**	-4.89**	1.37	-7.53**	1.95	-4.01**	34.10**
24.	KRL-213 x GW-411	-1.24	12.65**	5.81**	6.58**	-4.19**	4.40**	0.66	37.57**
25.	KRL-213 x K-583	3.03	14.34**	0.40	0.37	-8.10**	9.45**	0.46	35.44**
26.	RAJ-4037 x GW-411	-5.20**	8.14**	-13.68**	-10.05**	-21.22	43.52**	-3.97**	33.04**
27.	RAJ-4037 x K-583	1.99	13.19**	-13.77**	-10.15**	-10.57**	6.50**	-1.69**	36.21**
28.	GW-411 x K-583	-1.12	9.73**	-3.60**	-3.64**	-33.58**	59.48**	-0.62	35.04**
	SE±	0.07	0.07	0.16	0.16	0.21	0.21	0.31	0.31

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Five most heterotic crosses (Standard heterosis) for grain yield per plant along with *per se* performanceand their heterotic effects for component characters in wheat

Sr. No.	Crosses	Grain yield per plant (g)	*Per se* grain yield per plant (g)	Days to 50 % flowering	Plant height (cm)	No. of effective tillers per plant	Length of main spike (cm)
1.	GW-411 x K-583	59.48**	23.50	12.89**	0.12	63.68**	-3.11*
2.	GW-366 x GW-411	44.21**	22.97	4.26**	3.80**	57.37**	1.10
3.	RAJ-4037 x GW-411	43.52**	22.72	16.67**	4.10**	27.54	9.52**
4.	GW-366 x K-583	43.44**	22.70	3.67**	0.12	17.82	-0.44
5.	LOK-1 x GW-411	41.12**	22.52	-4.83**	3.60**	70.72**	6.23**

Contd…Table 3

Sr. No.	Crosses	No. of spikelets per main spike	Penducle length of main spike (cm)	Days to maturity	No. of grains per main spike	100 grain weight (g)	Grain weight per main spike (g)	Harvest index (%)
1.	GW-411 x K-583	27.92**	47.10**	4.43**	0.47	9.37**	-3.64**	35.04**
2.	GW-366 x GW-411	29.06**	17.59**	4.02**	23.21**	20.88**	22.54**	31.71**
3.	RAJ-4037 x GW-411	11.85**	34.52**	6.38**	-3.71**	8.14**	-10.05**	33.04**
4.	GW-366 x K-583	28.87**	13.27**	1.87**	14.29**	6.73**	9.32**	2.84**
5.	LOK-1 x GW-411	7.84**	16.37**	3.04**	1.61**	12.83**	-2.38**	23.45**

also reported the presence of considerable degree of heterosis for grain yield per plant in wheat (Nehvi *et al*., 2000; Singh *et al*., 2004; Vanparia *et al*., 2006; Singh *et al*., 2007).

Yield is one of the most important economic character and is the final product of the multiplicative interaction of contributing traits. Hence, selection for yield *per se* may not be effective unless the yield contributing characters are given proper emphasis as there being no gene for yield *per se* (Grafius, 1964). In the present study, it was revealed that high positive and significant standard heterosis for grain yield per plant in the cross GW 411 x K 583 was accompanied by positive and significant standard heterosis for number of tillers per plant, number of spikelets per spike, 100-grain weight and harvest index (Table 3). In addition to this, the cross GW-366 x GW-411 showed significant and positive heterobeltiosis for grain yield per plant also had desired standard heterosis for days to maturity, grain weight per main spike and 100-grain weight. Similarly, the crosses GW-366 x K-583 for number of spikelets per spike, peduncle length, 100-grain weight, and harvest index; LOK-1 x GW-411 for 100-grain weight, number of grains per main spike and harvest index; RAJ-4037 x GW-411 for number of tillers per plant, grain weight per main spike and peduncle length expressed significant and desirable heterobeltiosis for various yield components. Thus, the results revealed that the number of tillers per plant, 100-grain weight, harvest index, number of spikelets per spike and number of grains per main spike were the main contributors towards increased grain yield per plant.

The results also indicated that the heterosis for grain yield per plant was associated with heterosis for component characters. The contribution of different yield components toward the heterosis for grain yield per plant has also been reported by Nehvi *et al.* (2000), Singh *et al.* (2004), Tariq *et al.* (2004), Vanparia *et al.* (2006) and Singh *et al.* (2007).

It is pertinent to note that the crosses of either poor x poor or poor x good general combining parents also showed significant heterobeltiosis. The probable explanation for this type of behaviour seems from the fact that poor yielding parents could have different constellation of genes, showing complementary interactions when brought together in cross combinations.

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