Research Article

HETEROSIS STUDIES FOR GRAIN YIELD AND RELATED CHARACTERS IN RICE (*Oryza sativa* L.)

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Abstract- The experiment was conducted with three CMS lines i.e., IR 68887 A, IR 79159 A and APMS 6 A which were crossed with eleven diverse male parents in line x tester fashion in order to assess the extent of Heterosis for grain yield and yield attributing traits in rice. The analysis of variances revealed considerable genetic differences among the genotype. The parent (effective tillers per plant and milling %), hybrids (fifty per cent flowering, effective tillers per plant and hulling %) and parent vs Hybrids comparison were significant except panicle length, effective tillers per plant and grain length. A perusal of mean value revealed that the parent IR 04N 106 (15.42 g) was superior in respect for grain yield per plant, whereas among all the hybrids, IR 68887A X MILYANG 63(30.53), IR 68887A X IR 77186-148-3-4-3(24.26), IR 79159 A X IR 09A 104 (23.29), APMS 6 A X IR 04N 106 (22.80) and APMS 6 A X IR 07 A 166(21.29) recorded maximum grain yield per plant. The highest standard Heterosis for grain yield per plant was registered for the hybrid IR 68887 A x MILYANG 63 followed by IR 68887 A x IR 77186-148-3-4-3 and IR 79159 A x IR 09A 104.

Key words- Line x Tester, Heterosis, Grain yield and Rice

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Introduction

The commercial exploitation of hybrid vigour in rice was demonstrated in China in 1976 by Professor Yuan Long Ping and his team of scientists. The high productivity of hybrid rice enabled China to increase its rice production from 129 to 200 million tonnes. Developments in China encouraged the International Rice Research Institute (IRRI) and other countries to initiate research on exploring potentials of hybrid rice technology. [1] Reviewed the status and prospects for breeding hybrid rice and concluded that exploitation of heterosis through hybrid breeding offered an important option to increase yield in this self-pollinated crop. Even though tremendous gains in heterosis breeding have been achieved by China and other countries during the last two decades, it is felt that the maximum yield potential of hybrid rice has not been fully studied and exploited as yet [2]. Hybrid rice technology appears to be the most feasible and readily adoptable to increase the yield level in rice. Extensive research work is going throughout India and abroad on different aspects of hybrid rice. Several pioneer hybrids have shown a yield advantage of around 20% over current three-line hybrids on commercial scale. The average yield of rice hybrids is 6.3 t/ha while that of the inbred varieties is 4.5 t/ha [3]. Therefore, the breeders are now making concentrated efforts to evolve better hybrids suited in wider environmental condition. Therefore, The Present Piece of Research Work Reports the Results Of Magnitude Of Heterosis For Yield, Its Attributes For WBPH Tolerant Genotypes In Rice.

Materials and Methods

The three CMS lines i.e., IR 68887 A, IR 79159 A and APMS 6 A which were crossed with eleven diverse male parents in line x tester fashion to developed 33 hybrids at Main Rice Research Station, Anand Agricultural University, Nawagam (Gujarat) during *khariif*-2014. The resultants 33 hybrids, 14 parents and three

varieties and a hybrid KRH 2 as checks were evaluated in a Randomized Complete Block Design with three replications during *khariif*-2015. Each plot consisted of twenty plants in a row keeping 20 and 15 cm inter and intra row spacing, respectively. Non-experimental border row was also planted on both sides of experimental blocks to eliminate border effects. The recommended package of agronomical practices and plant protection measures, obligatory to raise good crop were followed both in nursery as well as field. Five randomly selected competitive plants from each replication were tagged for the purpose of recording the observations on thirteen characters viz., plant height (cm), panicle length (cm), number of effective tillers per plant, number of grains per panicle, grain yield per plant (g), test weight (g), grain length (mm), grain breadth (mm), grain L/B ratio, hulling (%), milling (%) and head rice recovery (%), whereas days to 50% flowering was recorded on population basis. The mean data was analysed to compute extent of Heterosis in rice.

Results and Discussion

The Result Obtained under the Present Investigation Are presented in [Table-1]. The analysis revealed significant differences in the parents for all the characters except all the characters were found highly significant except effective tillers per plant and milling %. The analysis of variances further revealed that hybrids showed significant differences for all the traits except days to fifty per cent flowering, effective tillers per plant and hulling %. This indicated the presence of wide genetic variability among the parents as well as hybrids with respect to most of the characters under study. Parents vs. hybrids comparison also showed significant differences for all the traits except for panicle length, effective tillers per plant and grain length. However, apart from indicating genetic interactions, the measure of relative heterosis has relatively less importance than heterobeltiosis.

Therefore, it is better to measure the heterosis in terms of superiority over the parent rather than mid parent.

Table-1 Analysis of variance for grain yield and its components in rice

Source	Replication	Genotype	Parents	Female	Male	Female vs Male	Hybrid	Parent vs Hybrid	Check vs Hybrid	Between Checks	Error
Degree of freedom	2	50	13	2	10	1	32	1	1	3	100
Days to 50 % flowering	75.94	241.67**	276.12**	75.40	42.67	115.60	136.23	2454.03**	704.97**	475.31**	130.01
Plant height (cm)	35.94**	1201.75**	1379.99**	553.42**	1477.30**	103.00**	1043.62**	7403.87**	45.79*	277.17**	9.36
Panicle length (cm)	48.06**	8.73**	14.18**	42.64**	2.97	3.47	7.07**	0.88	23.03*	1.69	4.88
Effective tillers/ plants	0.38	0.38	0.55	1.36*	0.42	0.01	0.333	0.13	997.00**	0.67	0.33
Grains per panicle	47.13	4422.79**	1814.17**	1405.25**	2708.55**	334.7**	5737.07**	5057.71**	9806.53**	9837.38**	24.12
Test weight (gm)	8.97**	62.22**	27.25**	18.56**	1.65**	7.90**	63.89**	351.45**	338.36**	1.78*	0.48
Grain yield / plant (gm)	52.56**	74.03**	23.82**	16.61*	16.80**	5.42	80.18**	729.83**	75.32**	87.63**	5.98
Grain length (mm)	14.79**	1.85**	1.64**	0.08	1.97**	0.07	2.06**	1.35	1.55	3.11**	0.45
Grain breadth (mm)	0.22**	0.35**	0.52**	0.06	0.64**	0.01	0.25**	0.96**	1.53**	0.58**	0.03
Grain L/B ratio	4.13**	0.95**	1.55**	0.27	1.88**	0.04	0.60**	3.70**	2.70**	2.77**	0.20
Hulling %	118.50**	8.26**	6.05*	0.72	3.84	1.94	7.07	34.89**	1.39	87.79**	3.45
Milling %	118.32**	4.64	5.88	15.58	2.70	0.99	15.45**	54.56**	5.70	0.27	5.12
Head rice recovery (%)	1287.67**	44.77	67.32**	109.11	32.31	16.59	116.01**	659.36**	44.36	12.17	40.36

Note: * and ** indicate significance at 5% and 1% level, respectively

However, the commercial usefulness of a hybrid would primarily depend on its performance in comparison with the best commercial variety of the concerned crop species. Overall performance of the hybrids with respect to heterobeltiosis for yield per plant, was observed for cross IR 68887 A x MILYANG 63, (253.16%) which was followed by cross APMS6 A x MILYANG 63 (214.07%) and IR 79159 A x MILYANG 63 (131.96%) manifested significant desirable heterosis for grain yield per plant: eighteen hybrids for days to fifty percent flowering; 28 hybrids for plant height; 27 hybrids for effective tillers per plant; 24 hybrids for grains per panicle; 14 hybrids for test weight; 18 hybrids for grain length 13 hybrids for grain breadth; 14 hybrids for grain length: breadth ratio; 5 hybrids for hulling %; 15 for milling % and 11 for head rice recovery %. Similar findings were reported by [4-14]. The hybrid, KRH 2 released for general cultivation, therefore used as standard variety in order to obtain information regarding superiority of new hybrids over best cultivated variety. A perusal of the results [Table-3] revealed that hybrids which showed significant heterosis over standard check variety, KRH 2 in desired direction viz., 32 hybrids for days to days to fifty percent flowering, 28 for plant height, 16 hybrids for effective tillers per plant, 7 hybrids for grains per panicle, 20 hybrids for test weight, 11 hybrids for grain yield per plant, 15 hybrids for grain length, one for grain breadth, 2 for grain length: breadth ratio and one hybrid for milling %. None of the hybrids however manifested significant desirable standard heterosis for panicle length, hulling % and head rice recovery %. As observed in the present study several workers have also reported the presence of

considerable heterosis for yield and its attributes [8-14]. The results of grain yield per plant [Table-4] revealed that 10 crosses exhibited significant positive sca effects.

The most promising five cross combinations with significant and positive sca effects were IR 79159 A x IR 09A 104, IR-68887 A x IR 77186-148-3-4-3, IR 68887 A x POKKALI, APMS 6 A x IR 05N 412 and IR 68887 A x MILYANG 63. These all five hybrids also manifested significant heterobeltiosis and standard heterosis over all the four checks for grain yield per plant

Conclusion

The degree and magnitude of various heterotic effects were varied from cross to cross and character to character. However, greater amount of heterobeltiosis and standard heterosis were observed for grain yield per plant and its component traits days to fifty per cent flowering, plant height, panicle length, effective tillers per plant and test weight in desired direction. In present investigation, the top three hybrids showing desirable heterobeltiosis were IR 68887 A x MILYANG 63, APMS 6 A x MILYANG 63 and IR 79159 A x MILYANG 63, whereas, for standard heterosis over the hybrid check KRH 2 the crosses IR 68887 A x MILYANG 63 and IR 68887 A x IR 77186-148-3-4-3 and IR 79159 A x IR 04N 166 depicted higher magnitudes for grain yield per plant. These hybrids also exhibited significant and desirable heterosis for days to 50 % flowering, plant height, grains per panicle, test weight grain length.

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr. No	Hybrids	Days to 50% flowering					Plant height				
		% Heterosis over					% Heterosis over				
		BP	GAR 13	Gurjari	GR 11	KRH 2	BP	GAR 13	Gurjari	GR 11	KRH 2
1	IR 68887 A X MILYANG 54 (GAYABYEO)	-7.80**	-16.58**	-1.52	-15.86**	-20.00**	15.79**	13.10**	16.86**	11.69**	12.99**
2	IR 68887 A X MILYANG 55	-5.67**	-14.65**	0.76	-13.92**	-18.15**	28.17**	30.68**	35.02**	29.05**	30.54**
3	IR 68887 A X MILYANG 63	-3.55	-12.73**	3.03	-11.97**	-16.31**	35.40**	27.09**	31.32**	25.51**	26.96**
4	IR 68887 A X POKKALI	-2.48	-11.77**	4.17*	-11.00**	-15.38**	-53.36**	-27.00**	-24.57**	-27.91**	-27.07**
5	IR 68887 A X IR 77186-148-3-4-3	0.71	-8.88**	7.58**	-8.09**	-12.61**	-14.9**	-23.41**	-20.87**	-24.37**	-23.49**
6	IR 68887 A X IR 04N 106	-5.67**	-14.65**	0.76	-13.92**	-18.15**	-33.45**	-25.29**	-22.81**	-26.22**	-25.37**
7	IR 68887 A X IR 05N 412	-0.35	-9.84**	6.44**	-9.06**	-13.54**	-8.23**	-4.47*	-1.30	-5.66**	-4.57*
8	IR 68887 A X IR 07A 166	1.06	-8.56**	7.95**	-7.77**	-12.30**	-4.28*	-8.06**	-5.00*	-9.20**	-8.15**
9	IR 68887 A X IR 09A 104	-7.45**	-16.26**	-1.14	-15.53**	-19.69**	-3.51*	-7.54**	-4.47*	-8.70**	-7.64**
10	IR 68887 A X IR 09N 534	-2.13	-11.44**	4.55*	-10.68**	-15.07**	-19.67**	-25.83**	-23.37**	-26.76**	-25.91**
11	IR 68887 A X IR 10 A 117	1.06	-8.56**	7.95**	-7.77**	-12.30**	-20.78**	-27.71**	-25.31**	-28.61**	-27.78**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	-1.67	-5.67**	11.36**	-4.85**	-9.54**	-15.10**	-17.07**	-14.32**	-18.11**	-17.16**
13	IR 79159 A X MILYANG 55	1.34	-2.78	14.77**	-1.94	-6.77**	-23.68**	-22.19**	-19.61**	-23.16**	-22.27**
14	IR 79159 A X MILYANG 63	-13.71**	-17.22**	-2.27	-16.50**	-20.61**	-8.2**	-13.83**	-10.97**	-14.90**	-13.92**
15	IR 79159 A X POKKALI	-0.67	-4.71*	12.50**	-3.88*	-8.61**	-44.29**	-12.81**	-9.91**	-13.89**	-12.90**
16	IR 79159 A X IR 77186-148-3-4-3	-21.74**	-24.92**	-11.36**	-24.27**	-28.00**	-11.65**	-20.48**	-11.48**	-21.48**	-20.57**
17	IR 79159 A X IR 04N 106	2.34	-1.82	15.91**	-0.97	-5.84**	-26.74**	-17.75**	-15.02**	-18.78**	-17.84**
18	IR 79159 A X IR 05N 412	-9.70**	-13.37**	2.27	-12.62**	-16.92**	-26.73**	-23.73**	-21.19**	-24.68**	-23.80**
19	IR 79159 A X IR 07A 166	-7.69**	-11.44**	4.55*	-10.68**	-15.07**	-18.64**	-21.85**	-19.25**	-22.82**	-21.93**

20	IR 79159 A X IR 09A 104	-5.69**	-9.52**	6.82**	-8.74**	-13.23**	-21.11**	-24.41**	-21.90**	-25.35**	-24.49**
21	IR 79159 A X IR 09N 534	-4.68*	-8.56**	7.95**	-7.77**	-12.30**	34.91**	24.56**	28.70**	23.01**	24.44**
22	IR 79159 A X IR 10 A 117	0.33	-3.74*	13.64**	-2.91	-7.69**	-12.32**	-19.99**	-17.33**	-20.98**	-20.07**
23	APMS 6 A X MILYANG 54 (GAYABYEO)	-6.73**	-6.63**	10.23**	-5.83**	-10.46**	-16.9**	-16.57**	-13.80**	-17.61**	-16.66**
24	APMS 6 A X MILYANG 55	-11.54**	-11.44**	4.55*	-10.68**	-15.07**	-16.00**	-14.36**	-11.51**	-15.42**	-14.44**
25	APMS 6 A X MILYANG 63	-7.69**	-7.59**	9.09**	-6.80**	-11.38**	-28.26**	-27.98**	-25.58**	-28.88**	-28.05**
26	APMS 6 A X POKKALI	-10.58**	-10.48**	5.68**	-9.71**	-14.15**	-49.30**	-20.64**	-18.00**	-21.63**	-20.72**
27	APMS 6 A X IR77186-148-3-4-3	-19.23**	-19.15**	-4.55*	-18.45**	-22.46**	0.64	1.03	4.39*	-0.23	0.93
28	APMS 6 A X IR 04N 106	-11.54**	-11.44**	4.55*	-10.68**	-15.07**	-23.08**	-13.65**	-10.78**	-14.72**	-13.73**
29	APMS 6 A X IR 05N412	-1.92	-1.82	15.91**	-0.97	-5.84**	-23.76**	-20.64**	-18.00**	-21.63**	-20.72**
30	APMS 6 A X IR 07A 166	-7.69**	-7.59**	9.09**	-6.80**	-11.38**	-24.01**	-23.71**	-21.18**	-24.66**	-23.79**
31	APMS 6 A X IR 09A 104	-6.73**	-6.63**	10.23**	-5.83**	-10.46**	-19.42**	-19.11**	-16.42**	-20.11**	-19.19**
32	APMS 6 A X IR 09N 534	0.00	0.11	18.18**	0.97	-4.00*	-23.67**	-23.37**	-20.82**	-24.33**	-23.45**
33	APMS 6 A X IR 10 A 117	10.58**	10.69**	30.68**	11.65**	6.16**	-26.9**	-26.61**	-24.17**	-27.53**	-26.69**
Heterosis in desirable direction		18	28	2	27	32	28	28	28	28	28
Range	Minimum	-21.74	-24.92	-11.36	-24.27	-28.00	-53.36	-27.98	-25.58	-28.88	-28.05
	Maximum	10.58	10.69	30.68	11.65	6.16	35.40	30.68	35.02	29.05	30.54
S. Ed $\pm$		1.83		1.83							

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr.No	Hybrids	Panicle length					Effective tiller per plant				
		% Heterosis over					% Heterosis over				
		BP	GAR 13	Gurjari	GR 11	KRH 2	BP	GAR 13	Gurjari	GR 11	KRH 2
1	IR 68887 A X MILYANG 54 (GAYABYEO)	-0.61	-8.63**	-1.36	-0.49	-13.25**	14.14**	8.71**	-1.78**	-0.88*	2.77**
2	IR 68887 A X MILYANG 55	-11.01**	-19.04**	-12.60**	-11.84**	-23.14**	9.90**	6.78**	-3.52**	-2.63**	0.95*
3	IR 68887 A X MILYANG 63	-3.22*	-11.03**	-3.95*	-3.11*	-15.53**	0.00	-2.84**	-12.21**	-11.40**	-8.14**
4	IR 68887 AX POKKALI	-10.75**	-17.95**	-11.42**	-10.65**	-22.10**	7.92**	4.86**	-5.26**	-4.39**	-0.86*
5	IR 68887 A X IR77186-148-3-4-3	10.17**	1.28	9.34**	10.30**	-3.84*	3.96**	1.01*	-8.74**	-7.89**	-4.50**
6	IR 68887 A X IR 04N 106	9.79**	0.93	8.97**	9.92**	-4.17**	8.91**	5.82**	-4.39**	-3.51**	0.05
7	IR 68887 A X IR 05N412	9.79**	0.93	8.97**	9.92**	-4.17**	7.92**	4.86**	-5.26**	-4.39**	-0.86*
8	IR 68887 A X IR 07A 166	4.37**	-4.05*	3.59*	4.49**	-8.90**	10.89**	7.74**	-2.65**	-1.75**	1.86**
9	IR 68887 A X IR 09A 104	-3.47*	-11.26**	-4.20**	-3.36*	-15.75**	-1.98**	-4.76**	-13.95**	-13.16**	-9.96**
10	IR 68887 A X IR 09N 534	3.60*	-4.75**	2.83	3.72*	-9.57**	10.89**	7.74**	-2.65**	-1.75**	1.86**
11	IR 68887 A X IR 10 A 117	5.35**	-3.15*	4.56**	5.47**	-8.05**	1.98**	-0.91*	-10.47**	-9.65**	-6.32**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	48.31**	0.85	8.88**	9.83**	-4.25**	10.10**	4.86**	-5.26**	-4.39**	-0.86*
13	IR 79159 A X MILYANG 55	47.19**	0.09	8.06**	9.00**	-4.97**	12.00**	7.74**	-2.65**	-1.75**	1.86**
14	IR 79159 A X MILYANG 63	42.48**	-3.11*	4.60**	5.51**	-8.01**	8.00**	3.90**	-6.13**	-5.26**	-1.77**
15	IR 79159 A X POKKALI	44.84**	-1.51	6.33**	7.26**	-6.49**	13.00**	8.71**	-1.78**	-0.88*	2.77**
16	IR 79159 A X IR77186-148-3-4-3	40.12**	-4.71**	2.87	3.77*	-9.53**	11.00**	6.78**	-3.52**	-2.63**	0.95*
17	IR 79159 A X IR 04N 106	47.19**	0.09	8.06**	9.00**	-4.97**	20.00**	15.44**	4.30**	5.26**	9.14**
18	IR 79159 A X IR 05N412	45.86**	-0.81	7.08**	8.01**	-5.83**	6.00**	1.97**	-7.87**	-7.02**	-3.59**
19	IR 79159 A X IR 07A 166	41.14**	-4.02*	3.62*	4.52**	-8.88**	3.00**	-0.91*	-10.47**	-9.65**	-6.32**
20	IR 79159 A X IR 09A 104	37.23**	-6.68**	0.75	1.63	-11.40**	4.00**	0.05	-9.60**	-8.77**	-5.41**
21	IR 79159 A X IR 09N 534	59.62**	8.55**	17.19**	18.21**	3.06	7.00**	2.93**	-7.00**	-6.14**	-2.68**
22	IR 79159 A X IR 10 A 117	57.87**	6.94**	15.46**	16.46**	1.53	16.00**	11.59**	0.83*	1.75**	5.50**
23	APMS 6 A X MILYANG 54 (GAYABYEO)	3.02	-3.47*	4.21**	5.12**	-8.36**	16.16**	10.63**	-0.04	0.88*	4.59**
24	APMS 6 A X MILYANG 55	7.78**	-1.87	5.94**	6.86**	-6.83**	3.64**	9.67**	-0.91*	0.00	3.68**
25	APMS 6 A X MILYANG 63	5.67**	-10.27**	-3.13*	-2.28	-14.81**	1.92**	1.97**	-7.87**	-7.02**	-3.59**
26	APMS 6 A X POKKALI	3.02	-1.46	6.39**	7.32**	-6.44**	-5.08**	7.74**	-2.65**	-1.75**	1.86**
27	APMS 6 A X IR77186-148-3-4-3	6.96**	2.60	10.77**	11.74**	-2.59	-1.89**	0.05	-9.60**	-8.77**	-5.41**
28	APMS 6 A X IR 04N 106	-7.24**	-11.02**	-3.94*	-3.10	-15.52**	-7.08**	1.01*	-8.74**	-7.89**	-4.50**
29	APMS 6 A X IR 05N412	3.62*	-0.60	7.31**	8.25**	-5.63**	10.68**	9.67**	-0.91*	0.00	3.68**
30	APMS 6 A X IR 07A 166	-8.51**	-6.93**	0.48	1.35	-11.64**	-2.73**	2.93**	-7.00**	-6.14**	-2.68**
31	APMS 6 A X IR 09A 104	-7.62**	-9.33**	-2.12	-1.27	-13.92**	1.74**	12.55**	1.69**	2.63**	6.41**
32	APMS 6 A X IR 09N 534	1.14	-3.73*	3.94*	4.84**	-8.60**	3.57**	11.59**	0.83*	1.75**	5.50**
33	APMS 6 A X IR 10 A 117	-6.32**	-10.14**	-2.98	-2.14	-14.68**	1.80**	8.71**	-1.78**	-0.88*	2.77**
Heterosis in desirable direction		21	2	20	22	0	27	27	4	5	16
Range	Minimum	-11.01	-19.04	-12.60	-11.84	-23.14	-7.08	-4.76	-13.95	-13.16	-9.96
	Maximum	59.62	8.55	17.79	18.21	3.06	20.00	15.44	4.30	5.26	9.14
S. Ed $\pm$		1.59		1.59			0.41		0.41		

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr. No	Hybrids	Grains per panicle					Test weight				
		% Heterosis over					% Heterosis over				
		BP	GAR 13	Gurjari	GR 11	KRH 2	BP	GAR 13	Gurjari	GR 11	KRH 2
1	IR 68887 A X MILYANG 54 (GAYABYEO)	129.27**	-14.49	-44.33**	-17.57	-14.49	-1.45**	2.07**	-23.87**	10.63**	-4.56**
2	IR 68887 A X MILYANG 55	98.04**	-26.14**	-51.92**	-28.80**	-26.14**	14.91**	19.02**	-11.22**	29.01**	11.29**
3	IR 68887 A X MILYANG 63	231.71**	23.71*	-19.46*	19.27*	23.71*	-6.91**	-3.58**	-28.08**	4.51**	-9.84**
4	IR 68887 AX POKKALI	254.64**	32.27**	-13.89	27.51**	32.27**	53.09**	58.57**	18.28**	71.87**	48.27**
5	IR 68887 A X IR77186-148-3-4-3	131.77**	-13.56	-43.73**	-16.67	-13.56	32.91**	37.66**	2.68**	49.21**	28.72**
6	IR 68887 A X IR 04N 106	257.7**	40.12**	-8.78	35.08**	40.12**	-5.82**	-2.45**	-27.24**	5.74**	-8.79**
7	IR 68887 A X IR 05N412	-48.53**	-80.81**	-87.50**	-81.50**	-80.81**	2.36**	6.03**	-20.92**	14.92**	-0.86
8	IR 68887 A X IR 07A 166	184.15**	5.97	-31.01**	2.17	5.97	56.36**	61.96**	20.80**	75.55**	51.44**
9	IR 68887 A X IR 09A 104	161.93**	-2.31	-36.40**	-5.82	-2.31	-5.82**	-2.45**	-27.24**	5.74**	-8.79**
10	IR 68887 A X IR 09N 534	-25.82**	-72.34**	-81.99**	-73.33**	-72.34**	30.53**	35.20**	0.84	46.54**	26.41**
11	IR 68887 A X IR 10 A 117	182.10**	-30.99**	-55.08**	-33.47**	-30.99**	-2.89**	0.58	-24.98**	9.02**	-5.95**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	10.90	-19.12*	-47.35**	-22.03**	-19.12*	-12.99**	4.54**	-22.03**	13.31**	-2.25**
13	IR 79159 A X MILYANG 55	14.69	-16.36	-45.55**	-19.36**	-16.36	-4.53**	14.71**	-14.44**	24.33**	7.25**
14	IR 79159 A X MILYANG 63	118.64**	59.46**	3.81	53.73**	59.46**	-45.91**	-35.01**	-51.52**	-29.56**	-39.23**
15	IR 79159 A X POKKALI	3.46	-24.54**	-50.88**	-27.26**	-24.54**	-41.68**	-29.92**	-47.73**	-24.05**	-34.48**
16	IR 79159 A X IR77186-148-3-4-3	21.54*	-33.13**	-56.47**	-35.53**	-33.13**	3.93**	24.88**	-6.85**	35.35**	16.76**
17	IR 79159 A X IR 04N 106	37.32**	0.15	-34.80**	-3.45	0.15	-19.58**	-3.37**	-27.93**	4.74**	-9.65**
18	IR 79159 A X IR 05N412	-60.65**	-71.30**	-81.32**	-72.33**	-71.30**	4.87**	26.01**	-6.01**	36.58**	17.82**
19	IR 79159 A X IR 07A 166	63.83**	19.48*	-22.22*	15.18	19.48*	0.17	20.36**	-10.23**	30.46**	12.54**
20	IR 79159 A X IR 09A 104	56.98**	14.49	-25.47**	10.37	14.49	-17.70**	-1.11*	-26.24**	7.19**	-7.54**
21	IR 79159 A X IR 09N 534	49.13**	8.76	-29.20**	4.85	8.76**	-3.59**	15.84**	-13.60**	25.56**	8.31**
22	IR 79159 A X IR 10 A 117	201.62**	-26.22**	-51.97**	-28.87**	-26.22**	-8.04**	10.49**	-17.59**	19.76**	3.31**
23	APMS 6 A X MILYANG 54 (GAYABYEO)	-4.09	-42.82**	-62.78**	-44.88**	-42.82**	-18.80**	4.84**	-21.80**	13.64**	-1.97**
24	APMS 6 A X MILYANG 55	-6.63	-44.34**	-63.76**	-46.34**	-44.34**	-13.60**	11.62**	-16.74**	20.98**	4.37**
25	APMS 6 A X MILYANG 63	206.01**	82.44**	18.77*	75.88**	82.44**	21.38**	56.82**	16.97**	69.97**	46.63**
26	APMS 6 A X POKKALI	-37.83**	-63.53**	-76.26**	-64.84**	-63.53**	20.07**	55.12**	15.70**	68.14**	45.04**
27	APMS 6 A X IR77186-148-3-4-3	56.33**	-13.99	-44.01**	-17.09	-13.99	-28.47**	-7.59**	-31.07**	0.16	-13.59**
28	APMS 6 A X IR 04N 106	89.81**	13.16	-26.33**	9.10	13.16	19.64**	54.56**	15.28**	67.52**	44.51**
29	APMS 6 A X IR 05N412	23.33**	-26.47**	-52.13**	-29.12**	-26.47**	13.11**	42.69**	6.43**	54.66**	33.42**
30	APMS 6 A X IR 07A 166	60.39**	-4.38	-37.75**	-7.81	-4.38	25.80**	61.34**	20.34**	74.87**	50.85**
31	APMS 6 A X IR 09A 104	25.56**	-25.14**	-51.27**	-27.83**	-25.14**	21.38**	56.82**	16.97**	69.97**	46.63**
32	APMS 6 A X IR 09N 534	33.04**	-20.68**	-48.36**	-23.53*	-20.68**	-1.39**	25.74**	-6.21**	36.29**	17.57**
33	APMS 6 A X IR 10 A 117	162.74**	-35.73**	-58.16**	-38.04**	-35.73**	-15.79**	8.79**	-18.85**	17.92**	1.73**
Heterosis in desirable direction		24	6	1	5	7	14	24	9	30	20
Range	Minimum	-60.65	-80.01	-87.50	-81.50	-80.81	-45.91	-35.01	-51.52	-29.56	-39.23
	Maximum	257.7	82.44	18.77	78.75	82.44	56.36	61.96	20.80	75.55	51.44
S. Ed $\pm$		9.41	9.41				0.48	0.48			

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr. No	Hybrids	Grain yield per plant					Grain length				
		% Heterosis over					% Heterosis over				
		BP	GAR 13	Gurjari	GR 11	KRH 2	BP	GAR 13	Gurjari	GR 11	KRH 2
1	IR 68887 A X MILYANG 54 (GAYABYEO)	67.39**	20.74**	4.75**	44.31**	-11.05**	17.61**	-3.56**	-1.70**	0.98*	6.66**
2	IR 68887 A X MILYANG 55	28.54**	21.67**	5.56**	45.43**	-10.36**	0.20	-16.67**	-15.06**	-12.75**	-7.84**
3	IR 68887 A X MILYANG 63	253.16**	134.16**	103.16**	179.88**	72.51**	10.35**	-5.69**	-3.87**	-1.25**	4.30**
4	IR 68887 AX POKKALI	130.1**	48.68**	29.00**	77.71**	9.54**	-10.55**	-12.81**	-11.12**	-8.71**	-3.57**
5	IR 68887 A X IR77186-148-3-4-3	78.17**	86.06**	61.43**	122.39**	37.08**	2.66**	0.00	1.93**	4.70**	10.60**
6	IR 68887 A X IR 04N 106	31.67**	37.83**	19.58**	64.74**	1.54	-14.44**	-16.63**	-15.02**	-12.71**	-7.80**
7	IR 68887 A X IR 05N412	-40.55**	-42.76**	-50.33**	-31.58**	-57.83**	9.84**	5.46**	7.49**	10.41**	16.63**
8	IR 68887 A X IR 07A 166	64.79**	33.17**	15.54**	59.17**	-1.89	3.38**	0.70	2.64**	5.43**	11.37**
9	IR 68887 A X IR 09A 104	41.18**	42.02**	23.22**	69.75**	4.63**	17.07**	2.40**	4.37**	7.21**	13.25**
10	IR 68887 A X IR 09N 534	-13.22**	-27.71**	-37.28**	-13.60**	-46.74**	-4.22**	-8.68**	-6.92**	-4.39**	0.99*
11	IR 68887 A X IR 10 A 117	60.95**	4.41*	-9.42**	24.79**	-23.08**	8.01**	-12.97**	-11.29**	-8.88**	-3.75**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	34.38**	-3.08	-15.91**	15.84**	-28.60**	15.17**	-5.59**	-3.76**	-1.15*	4.42**
13	IR 79159 A X MILYANG 55	-7.29**	-12.19**	-23.81**	4.96**	-35.31**	-4.84**	-20.79**	-19.26**	-17.07**	-12.40**
14	IR 79159 A X MILYANG 63	131.96**	53.82**	33.46**	83.86**	13.33**	1.25**	-13.41**	-11.73**	-9.33**	-4.23**
15	IR 79159 A X POKKALI	4.51**	-32.49**	-41.43**	-19.32**	-50.27**	-10.84**	-15.70**	-14.07**	-11.74**	-6.77**
16	IR 79159 A X IR77186-148-3-4-3	15.76**	20.88**	4.87**	44.48**	-10.95**	1.55**	-4.03**	-2.17**	0.49	6.14**
17	IR 79159 A X IR 04N 106	16.54**	-32.88**	-41.77**	-19.77**	-50.55**	-4.58**	-9.78**	-8.04**	-5.54**	-0.22
18	IR 79159 A X IR 05N412	-12.69**	-15.98**	-27.11**	0.42	-38.10**	-11.44**	-16.33**	-14.72**	-12.40**	-7.47**
19	IR 79159 A X IR 07A 166	74.57**	41.05**	22.38**	68.59**	3.92*	-8.17**	-13.21**	-11.53**	-9.13**	-4.01**
20	IR 79159 A X IR 09A 104	77.54**	78.63**	54.98**	113.50**	31.60**	-15.29**	-25.88**	-24.45**	-22.40**	-18.03**
21	IR 79159 A X IR 09N 534	53.48**	27.89**	10.96**	52.86**	-5.78**	-12.07**	-16.93**	-15.33**	-13.03**	-8.13**
22	IR 79159 A X IR 10 A 117	64.46**	6.73**	-7.40**	27.56**	-21.37**	5.70**	-14.84**	-13.19**	-10.83**	-5.81**
23	APMS 6 A X MILYANG 54 (GAYABYEO)	-5.46**	-31.86**	-40.88**	-18.55**	-49.80**	3.41**	-15.17**	-13.53**	-11.18**	-6.18**
24	APMS 6 A X MILYANG 55	45.38**	37.65**	19.43**	64.53**	1.41	-4.8**	-20.83**	-19.29**	-17.10**	-12.44**
25	APMS 6 A X MILYANG 63	214.07**	28.70**	11.66**	53.83**	-5.18**	5.25**	-10.05**	-8.31**	-5.82**	-0.52
26	APMS 6 A X POKKALI	88.53**	21.86**	5.73**	45.65**	-10.22**	6.17**	3.03**	5.02**	7.87**	13.94**
27	APMS 6 A X IR77186-148-3-4-3	26.26**	31.86**	14.40**	57.60**	-2.85	-15.32**	-17.83**	-16.24**	-13.97**	-9.12**

28	APMS 6 A X IR 04N 106	47.84**	74.85**	51.70**	108.99**	28.82**	-5.04**	-7.82**	-6.04**	-3.48**	1.95**
29	APMS 6 A X IR 05N412	44.24**	38.82**	20.44**	65.93**	2.27	3.54**	-0.63	1.29**	4.04**	9.90**
30	APMS 6 A X IR 07A 166	102.02**	63.26**	41.64**	95.13**	20.27**	11.62**	8.35**	10.44**	13.44**	19.83**
31	APMS 6 A X IR 09A 104	38.47**	39.35**	20.90**	66.55**	2.66	7.64**	-5.82**	-4.00**	-1.39**	4.16**
32	APMS 6 A X IR 09N 534	78.37**	48.61**	28.93**	77.62**	9.48**	-7.12**	-11.38**	-9.66**	-7.21**	-1.99**
33	APMS 6 A X IR 10 A 117	99.96**	29.76**	12.58**	55.09**	-4.40*	16.47**	-6.12**	-4.31**	-1.71**	3.83**
Heterosis in desirable direction		28	25	23	27	11	18	4	7	8	15
Range	Minimum	-40.55	-42.76	-50.33	-31.58	-57.83	-15.32	-25.88	-24.45	-22.40	-18.03
	Maximum	253.16	134.16	103.16	179.88	72.51	17.61	8.35	10.44	13.44	19.83
S. Ed ±		1.76		1.76		0.48		0.48			

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr. No	Hybrids	Grain breath					Grain length : breadth ratio				
		% Heterosis over					% Heterosis over				
		BP	GAR 13	Gurjari	GR 11	KRH 2	BP	GAR 13	Gurjari	GR 11	KRH 2
1	IR 68887 A X MILYANG 54 (GAYABYEO)	-22.48**	1.44**	12.95**	-18.40**	12.46**	52.91**	-4.09**	-12.35**	24.80**	-4.58**
2	IR 68887 A X MILYANG 55	-20.54**	4.31**	16.16**	-16.09**	15.65**	27.14**	-19.37**	-26.31**	4.93**	-19.78**
3	IR 68887 A X MILYANG 63	14.35**	7.19**	19.36**	-13.77**	18.84**	-4.65**	-11.29**	-18.92**	15.44**	-11.74**
4	IR 68887 AX POKKALI	14.35**	7.19**	19.36**	-13.77**	18.84**	-23.48**	-17.95**	-25.01**	6.78**	-18.36**
5	IR 68887 A X IR77186-148-3-4-3	9.31**	10.59**	23.14**	-11.04**	22.61**	-7.33**	-8.89**	-16.73**	18.56**	-9.35**
6	IR 68887 A X IR 04N 106	-1.53**	-7.58**	2.91**	-25.66**	2.46**	-14.41**	-8.80**	-16.65**	18.68**	-9.27**
7	IR 68887 A X IR 05N412	4.74**	-1.70**	9.46**	-20.93**	8.99**	1.59**	8.20**	-1.11**	40.81**	7.66**
8	IR 68887 A X IR 07A 166	0.10	26.80**	41.19**	2.00**	40.58**	1.40**	-20.09**	-26.96**	3.99**	-20.49**
9	IR 68887 A X IR 09A 104	27.27**	28.10**	42.65**	3.05**	42.03**	-7.32**	-19.58**	-26.50**	4.65**	-19.99**
10	IR 68887 A X IR 09N 534	19.01**	10.46**	23.00**	-11.15**	22.46**	-18.76**	-16.66**	-23.83**	8.45**	-17.08**
11	IR 68887 A X IR 10 A 117	-1.83**	11.76**	24.45**	-10.09**	23.91**	12.12**	-20.81**	-27.62**	3.06**	-21.21**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	-33.67**	-13.07**	-3.20**	-30.07**	-3.62**	77.54**	11.19**	1.63**	44.70**	10.63**
13	IR 79159 A X MILYANG 55	-24.23**	-0.65**	10.63**	-20.08**	10.14**	28.34**	-18.56**	-25.57**	5.97**	-18.98**
14	IR 79159 A X MILYANG 63	0.38**	4.97**	16.89**	-15.56**	16.38**	-8.07**	-15.96**	-23.19**	9.37**	-16.38**
15	IR 79159 A X POKKALI	9.01**	13.99**	26.93**	-8.31**	26.38**	17.81**	-24.80**	-31.27**	-2.14**	-25.18**
16	IR 79159 A X IR77186-148-3-4-3	-6.38**	-2.09**	9.02**	-21.24**	8.55**	9.09**	-0.26	-8.85**	29.79**	-0.77**
17	IR 79159 A X IR 04N 106	4.13**	8.76**	21.11**	-12.51**	20.58**	-7.88**	-15.78**	-23.02**	9.60**	-16.20**
18	IR 79159 A X IR 05N412	-6.76**	-2.61**	8.44**	-21.66**	7.97**	-4.36**	-12.47**	-20.00**	13.91**	-12.91**
19	IR 79159 A X IR 07A 166	2.16**	29.67**	44.40**	4.31**	43.77**	-14.1**	-32.27**	-38.09**	-11.86**	-32.61**
20	IR 79159 A X IR 09A 104	3.38**	8.10**	20.38**	-13.04**	19.86**	-19.73**	-30.26**	-36.26**	-9.25**	-30.62**
21	IR 79159 A X IR 09N 534	24.41**	29.93**	44.69**	4.52**	44.06**	-29.22**	-35.29**	-40.86**	-15.79**	-35.61**
22	IR 79159 A X IR 10 A 117	-3.63**	0.65**	12.08**	-19.03**	11.59**	19.45**	-15.59**	-22.85**	9.85**	-16.01**
23	APMS 6 A X MILYANG 54 (GAYABYEO)	-15.28**	10.85**	23.44**	-10.83**	22.90**	21.79**	-23.64**	-30.21**	-0.64*	-24.03**
24	APMS 6 A X MILYANG 55	-16.35**	9.54**	21.98**	-11.88**	21.45**	13.64**	-27.90**	-34.11**	-6.18**	-28.27**
25	APMS 6 A X MILYANG 63	34.95**	31.11**	46.00**	5.47**	45.36**	-26.44**	-31.52**	-37.41**	-10.89**	-31.87**
26	APMS 6 A X POKKALI	12.77**	9.80**	22.27**	-11.67**	21.74**	-7.05**	-5.99**	-14.08**	22.34**	-6.47**
27	APMS 6 A X IR77186-148-3-4-3	11.64**	12.81**	25.62**	-9.25**	25.07**	-25.71**	-27.01**	-33.29**	-5.02**	-27.38**
28	APMS 6 A X IR 04N 106	36.56**	32.94**	48.03**	6.94**	47.39**	-31.29**	-30.56**	-36.53**	-9.63**	-30.91**
29	APMS 6 A X IR 05N412	8.33**	5.23**	17.18**	-15.35**	16.67**	-6.46**	-5.37**	-13.51**	23.14**	-5.85**
30	APMS 6 A X IR 07A 166	-15.05**	7.84**	20.09**	-13.25**	19.57**	27.66**	0.66*	-8.00**	31.00**	0.15
31	APMS 6 A X IR 09A 104	16.75**	17.52**	30.86**	-5.47**	30.29**	-6.72**	-19.72**	-26.62**	4.48**	-20.12**
32	APMS 6 A X IR 09N 534	18.01**	14.64**	27.66**	-7.78**	27.10**	-23.41**	-22.55**	-29.21**	0.79*	-22.94**
33	APMS 6 A X IR 10 A 117	-2.06**	11.50**	24.16**	-10.30**	23.62**	19.33**	-15.64**	-22.90**	9.78**	-16.07**
Heterosis in desirable direction		13	6	1	27	1	14	3	1	24	2
Range	Minimum	-33.67	-13.07	-3.20	-30.07	-3.62	-31.29	-35.29	-40.86	-15.79	-35.61
	Maximum	36.56	32.94	48.03	6.94	47.39	77.54	11.19	1.63	44.70	10.63
S. Ed ±		0.13		0.13		0.32		0.32			

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr. No	Hybrids	Hulling %					Milling %				
		% Heterosis over					% Heterosis over				
		BP	BP	GAR 13	Gurjari	GR 11	BP	BP	GAR 13	Gurjari	GR 11
1	IR 68887 A X MILYANG 54 (GAYABYEO)	1.53	-2.90*	-1.99	-1.96	-2.67*	6.42**	1.50	3.45*	2.83	0.96
2	IR 68887 A X MILYANG 55	2.98*	-1.51	-0.58	-0.56	-1.28	3.82*	3.87*	5.86**	5.23**	3.32*
3	IR 68887 A X MILYANG 63	1.79	-2.65*	-1.73	-1.71	-2.42	5.15**	1.51	3.46*	2.84	0.97
4	IR 68887 AX POKKALI	-0.45	-4.79**	-3.90	-3.87**	-4.57**	1.65	2.63	4.60**	3.98*	2.09
5	IR 68887 A X IR77186-148-3-4-3	0.52	-2.93*	-2.02	-1.99	-2.70*	0.83	-1.01	0.89	0.28	-1.54
6	IR 68887 A X IR 04N 106	-3.58**	-7.79**	-6.92**	-6.90**	-7.57**	3.13	-1.27	0.63	0.03	-1.79
7	IR 68887 A X IR 05N412	1.05	-3.36**	-2.45	-2.43	-3.13*	1.87	-0.37	1.55	0.94	-0.89
8	IR 68887 A X IR 07A 166	0.72	-3.67**	-2.77*	-2.74*	-3.45**	7.41**	-2.81	-0.94	-1.53	-3.32*
9	IR 68887 A X IR 09A 104	2.36	-2.11	-1.19	-1.16	-1.87	4.02	2.83	4.81**	4.18**	2.29
10	IR 68887 A X IR 09N 534	0.73	-3.67**	-2.76*	-2.74*	-3.44**	-11.7**	-1.09	0.81	0.21	-1.61
11	IR 68887 A X IR 10 A 117	-1.7	-5.99**	-5.11**	-5.08*	-5.77**	5.42**	-13.24**	-11.58**	-12.10**	-13.70**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	1.68	-4.24**	-3.34**	-3.31*	-4.01**	0.88	1.43	3.38*	2.76	0.89
13	IR 79159 A X MILYANG 55	1.56	-4.35**	-3.45**	-3.43**	-4.12**	0.41	-2.94	-1.07	-1.67	-3.45*
14	IR 79159 A X MILYANG 63	2.30	-3.66**	-2.75*	-2.73*	-3.43**	5.07**	-3.39	-1.53	-2.12	-3.90*

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15	IR 79159 A X POKKALI	2.78*	-3.20*	-2.29	-2.27	-2.97*	3.90	1.10	3.04	2.43	0.56
16	IR 79159 A X IR77186-148-3-4-3	1.93	-4.00**	-3.10*	-3.07*	-3.77**	4.38**	-0.03	1.89	1.28	-0.56
17	IR 79159 A X IR 04N 106	2.82*	-3.17*	-2.26	-2.24	-2.94*	1.84	0.43	2.36	1.75	-0.10
18	IR 79159 A X IR 05N412	1.92	-4.02**	-3.12*	-3.09*	-3.79**	5.10**	-2.01	-0.13	-0.73	-2.53
19	IR 79159 A X IR 07A 166	3.08**	-2.92*	-2.00	-1.98	-2.69*	-3.49*	0.28	2.20	1.59	-0.26
20	IR 79159 A X IR 09A 104	-6.23**	-11.69**	-10.86**	-10.84**	-11.48**	5.55**	-7.60**	-5.83**	-6.39**	-8.10**
21	IR 79159 A X IR 09N 534	0.76	-5.11**	-4.21**	-4.19**	-4.88**	2.51	0.37	2.29	1.68	-0.17
22	IR 79159 A X IR 10 A 117	1.04	-4.84**	-3.95**	-3.92*	-4.62**	3.04	-1.36	0.53	-0.07	-1.89
23	APMS 6 A X MILYANG 54 (GAYABYEO)	2.86	-2.16	-1.24	-1.22	-1.93	1.82	2.30	4.26**	3.64*	1.75
24	APMS 6 A X MILYANG 55	1.3	-3.65**	-2.74	-2.72*	-3.42**	3.78*	-0.62	1.28	0.68	-1.15
25	APMS 6 A X MILYANG 63	3.6**	-1.46	-0.53	-0.51	-1.22	1.38	1.46	3.41*	2.79	0.92
26	APMS 6 A X POKKALI	-0.27	-5.14**	-4.25**	-4.23**	-4.92**	1.76	-1.04	0.85	0.25	-1.57
27	APMS 6 A X IR77186-148-3-4-3	0.07	-4.82**	-3.93**	-3.90**	-4.60**	3.15	1.02	2.96	2.34	0.48
28	APMS 6 A X IR 04N 106	1.53	-3.43**	-2.52	-2.50	-3.20*	3.36*	1.01	2.95	2.34	0.48
29	APMS 6 A X IR 05N412	-1.15	-5.97**	-5.09**	-5.07**	-5.75**	5.40**	-0.14	1.78	1.17	-0.67
30	APMS 6 A X IR 07A 166	2.33	-2.66*	-1.75	-1.73	-2.43	2.54	0.56	2.49	1.88	0.03
31	APMS 6 A X IR 09A 104	0.59	-4.32**	-3.42**	-3.40**	-4.10**	7.22**	-1.83	0.06	-0.54	-2.35
32	APMS 6 A X IR 09N 534	0.07	-4.95**	-4.06**	-4.04**	-4.73**	3.86*	1.96	3.92*	3.29*	1.42
33	APMS 6 A X IR 10 A 117	1.26	-3.69**	-2.78*	-2.76**	-3.46**	3.56*	2.05	4.01*	3.38*	1.51
Heterosis in desirable direction		5	0	0	0	0	15	1	10	6	1
Range	Minimum	-6.23	-11.69	-10.86	-10.89	-11.48	-11.70	-13.24	-11.58	-12.10	-13.70
	Maximum	3.60	-1.46	-0.53	-0.51	-1.22	7.41	3.87	5.86	5.23	3.31
S. Ed ±		1.29		1.29		1.62		1.62			

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-2 Magnitude of heterobeltiosis (better parent) and standard heterosis for different characters in rice

Sr.No	Hybrids	Head rice recovery %				
		% Heterosis over				
		BP	BP	GAR 13	Gurjari	GR 11
1	IR 68887 A X MILYANG 54 (GAYABYEO)	14.86**	-19.86**	-19.16**	-20.29**	-25.27**
2	IR 68887 A X MILYANG 55	-6.17	-11.68**	-10.91*	-12.16**	-17.64**
3	IR 68887 A X MILYANG 63	15.80**	7.31	8.25	6.74	0.07
4	IR 68887 AX POKKALI	-2.98	-9.87*	-9.08*	-10.35*	-15.95**
5	IR 68887 A X IR77186-148-3-4-3	-13.14**	-23.92**	-23.25**	-24.32**	-29.05**
6	IR 68887 A X IR 04N 106	-11.23*	-16.44**	-15.71**	-16.89**	-22.08**
7	IR 68887 A X IR 05N412	-2.81	-8.52	-7.72	-9.01*	-14.69**
8	IR 68887 A X IR 07A 166	-32.49**	-36.45**	-35.90**	-36.79**	-40.74**
9	IR 68887 A X IR 09A 104	1.55	-6.51	-5.69	-7.01	-12.82**
10	IR 68887 A X IR 09N 534	-20.8**	-29.13**	-28.51**	-29.51**	-33.91**
11	IR 68887 A X IR 10 A 117	-2.09	-16.49**	-15.75**	-16.93**	-22.12**
12	IR 79159 A X MILYANG 54 (GAYABYEO)	3.64	-22.47**	-21.79**	-22.88**	-27.70**
13	IR 79159 A X MILYANG 55	-4.25	-28.38**	-27.75**	-28.76**	-33.21**
14	IR 79159 A X MILYANG 63	30.98**	-2.02	-1.16	-2.54	-8.63
15	IR 79159 A X POKKALI	19.84**	-10.35*	-9.56*	-10.83*	-16.40**
16	IR 79159 A X IR77186-148-3-4-3	-7.00	-30.43**	-29.82**	-30.80**	-35.12**
17	IR 79159 A X IR 04N 106	-3.45	-27.77**	-27.14**	-28.16**	-32.65**
18	IR 79159 A X IR 05N412	-16.69**	-37.68**	-37.13**	-38.01**	-41.89**
19	IR 79159 A X IR 07A 166	16.24**	-13.05**	-12.28**	-13.51**	-18.91**
20	IR 79159 A X IR 09A 104	17.96**	-11.76**	-10.98*	-12.23**	-17.71**
21	IR 79159 A X IR 09N 534	17.33**	-12.23**	-11.46**	-12.70**	-18.15**
22	IR 79159 A X IR 10 A 117	7.84	-19.33**	-18.62**	-19.76**	-24.77**
23	APMS 6 A X MILYANG 54 (GAYABYEO)	31.04**	4.03	4.94	3.47	-2.99
24	APMS 6 A X MILYANG 55	-3.57	-23.45**	-22.77**	-23.85**	-28.61**
25	APMS 6 A X MILYANG 63	15.55**	-8.27	-7.47	-8.76	-14.46**
26	APMS 6 A X POKKALI	-1.3	-21.65**	-20.96**	-22.07**	-26.94**
27	APMS 6 A X IR77186-148-3-4-3	8.29	-14.03**	-13.28**	-14.49**	-19.83**
28	APMS 6 A X IR 04N 106	6.29	-15.62**	-14.88**	-16.07**	-21.31**
29	APMS 6 A X IR 05N412	19.77**	-4.92	-4.08	-5.43	-11.33*
30	APMS 6 A X IR 07A 166	2.75	-18.43**	-17.72**	-18.87**	-23.94**
31	APMS 6 A X IR 09A 104	19.96**	-28.82**	-28.20**	-29.20**	-33.62**
32	APMS 6 A X IR 09N 534	0.35	-20.34**	-19.64**	-20.76**	-25.71**
33	APMS 6 A X IR 10 A 117	7.38	-14.75	-14.01**	-15.21**	-20.51**
Heterosis in desirable direction		11	0	0	0	0
Range	Minimum	-32.49	-37.68	-37.13	-38.01	-41.89
	Maximum	31.04	7.31	8.25	6.74	0.07
S. Ed ±				4.47		

Note: * and ** indicate level of significance at 5% and 1 %, respectively

Table-3 Comparative study of 5 crosses with higher sca effect, grain yield per plant, gca effect of parents and Significant desirable sca effects for other traits in rice

Sr. No	Hybrids	Mean Value For GY Per Plant	Heterosis for grain yield per plant over				Sca Effects for GY	Desirable heterosis for other traits over				Sca effects got desirable traits
			GAR 13	Gurjari	GR 11	KRH 2		GAR 13	Gurjari	GR 11	KRH 2	
1	IR 68887A X MILYANG 63	30.53	134.16**	103.16**	179.88**	72.51**	4.36**	DFF, GP	MI, HRR	DFF, TW, GP, GB, LB	DFF, GP, GL	GB, HRR
2	IR 68887A X IR 77186-148-3-4-3	24.26	86.06**	61.43**	122.39**	37.08**	4.93**	DFF, PH, ET, TW	PH, PL, TW, GL	DFF, PH, ET, PL, TW, GL, GB	DFF, PH, TW, GL	PH, GP, TW
3	IR 79159 A X IR 09A 104	23.29	78.63**	54.98**	113.50**	31.60**	5.04*	DFF, PH, ET, GP	PH, ET	DFF, PH, TW, GB	DFF, PH, GP, GB	PH, GP, GB
4	APMS 6 A X IR 04N 106	22.80	74.85**	51.70**	108.99**	28.52**	2.52**	DFF, PH, ET, TW	PH, TW	DFF, PH, TW	DFF, PH, TW, GP, GL, GB	DFF, PH, TW
5	APMS 6 A X IR 07 A 166	21.29	63.26**	41.64**	95.13**	20.27**	0.78	DFF, PH, ET, TW, GL, GB, LB	PH, TW, GL	DFF, PH, TW, GL, GB, LB	DFF, GL, PH, TW	GL, GB

DFF- Days to 50 % flowering, PH- Plant height (cm), PL- Panicle length, ET- Effective tillers per plant, GP- Grains per panicle, TW- Test weight, GY- Grain yield, GL- Grain length, GB- Grain breadth, LB- Grain L:B ratio, HULL- Hulling %, MILL- Milling %, HRR- Head rice recovery %.

Fig-1 Performance of hybrids for grain yield per plant (g).

Application of research: The acceptable amount of heterosis for yield and other yield contributing traits indicates that hybrids can be commercially exploited in the present conditions.

Research Category: Plant Breeding

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References

- [1] Virmani S. S. and Edwards I. B. (1983) *Agron. Abst.*, 119.
- [2] Chandrakala R. and Thiyagarajan K. (2010) *Electronic Journal of Plant Breeding*, 1(4), 1070-1078
- [3] Longping Yuan. (2004) FAO rice conference, Rome, Italy.
- [4] Tiwari V. N. and Sarathe M. L. (2000) *Oryza*, 37(2), 37-38

- [5] Janardhanam V., Nandarajan N. and Jebaraj S. (2001) *Madras Agric. J.*, 88 (10-12), 721-723.
- [6] Annadurai A. and Nandarajan N. (2001) *Madras Agric. J.*, 88(4-6), 300-303.
- [7] Veni B. K. and Rani N. S. (2003) *Madras Agric. J.*, 90(10-12), 633-636.
- [8] Patil D. V., Thiyagarajan K. and Kamble P. (2003) *Crop Res.*, 25(3), 514-519.
- [9] Manonmani S. and Khan A. K. F. (2003) *Madras Agric. J.*, 90(4-6), 228-231.
- [10] Veni B. K., Rani N. S. and Prasad A. S. R. (2005) *Oryza*, 42 (4), 256-259.
- [11] Rosamma C. A. and Vijaykumar N. K. (2005) *Indian J. Genet.*, 65(2), 119-120.
- [12] Patel V. P., Patel V. S., Patel A. I., Patel D. U. and Mali S. C. (2005) *Crop Prot. Prod.*, 2 (1), 27-31.
- [13] Sarvanan K., Anbanandan V. and Satheesh Kumar P. (2006) *Crop Res.*, 31 (2), 242-244.
- [14] Ushakumari R., Rangasamy and Devarathinam A. A. (2006) *Oryza*, 43(2), 148-150.