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RESEARCH ARTICLE

HETEROTIC STUDIES USING CYTOPLASMIC MALE STERILE LINES FOR ENHANCING YIELD ATTRIBUTED TRAITS IN RICE (*Oryza sativa* L.)

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ABSTRACT

A study was conducted to assess the magnitude of heterosis for grain yield and its components over mid parent (MP), Better parent (BP) and standard heterosis (SH) in rice hybrids (*Oryza sativa* L.) through line x tester analysis. The present study comprised of three lines and ten testers. The resultant thirty hybrids along with their thirteen parents were evaluated during 2009 to 2010 in a randomized block design with three replications at Plant Breeding Farm, Department of Genetics and Plant Breeding, Annamalai University, Chidambaram. The analysis of variance indicated significant amount of variability among the genotypes for all the seven traits studied. The cross combinations IR 58025A x ASD 19, IR 62829A x ASD 16, PUSA 3A x IR 42 were found to be promising for seed yield as they had high percentage of standard heterosis.

INTRODUCTION

Rice is the foremost food crop among cereals. It is the staple food crop providing high calories for the people of South, South East Asian and African countries. Ten years from now, the rice consumption is expected to increase upto 92 million tones demanding more production (Subbiah, 2006). Rice is being grown in an area of 17.89 lakh hectares with a production of 50 lakh tones (Statistical Hand book, 2010). The scope for exploitation of hybrid vigour largely depends on the direction and magnitude of heterosis and ease with which hybrids seeds can be produced. Further, the extent of heterosis will have direct effect on breeding methodology in varietal improvement programme. Therefore, in the present investigation, an attempt has been made to estimate the extent of heterosis for grain yield and its component traits over mid parent (MP), Better parent (BP) and standard parent (SP) in hybrid rice (*Oryza sativa* L.) through line x tester analysis.

MATERIALS AND METHODS

The experimental materials comprised of three cytoplasmic male sterile lines *viz*. IR 58025A, IR62829A, PUSA 3A, and ten testers (ADT 39, CO 43, IR 50, IR 36, IR 28, IR 42, IR 64, ASD 16, ASD 19, TRY 1). The lines and testers were crossed in a line X tester fashion resulting in 30 hybrids. The resultant thirty hybrids along with their thirteen parents were evaluated at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Annamalai University, Chidambaram during 2010 to 2011 in a randomized block design with three replications. Seeds of all hybrids and parents were sown on raised bed nursery in row spacing of 15 cm apart. One row per genotype was maintained and normal nursery management practices were followed. Twenty five days old seedlings were transplanted in rows with spacing of 15 cm between rows and 15 cm between plants. One seedling per hill was maintained. The row length of 3 meters was maintained at each genotype. Data on days to first flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, 1000 grain weight and grain yield per plant were recorded. Relative heterosis, heterobeltiosis as well as standard heterosis were estimated and tested by working out the standard errors.

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the genotypes for all seven traits *viz*., days to first flower, plant height, productive tillers per plant, panicle length, number of grains per panicle, 1000 grain weight and grain yield per plant. Significant difference between lines was observed for all the characters except 1000 grain weight. Significant difference among the testers was observed for days to first flower, plant height, productive tillers per plant, panicle length and grain yield per plant. The interaction effect (L x T) was also significant for all the characters. Similar results were recorded by Kadambavanasundaram, 1980 and Singh, 2000 (Table 1). For days to first flower, the relative heterosis for this trait was significant and negative in fifteen out of thirty hybrids and it ranged from -23.96 (L_3 x T_8) to 25.58 per cent (L_1 x T_4). Twenty one hybrids showed significantly negative heterobeltiosis. The highest value was recorded by L_2 x T_8 (23.08 per cent). The standard heterosis ranged from -23.24 (L_1 x T_8) to 18.38 per cent (L_1 x T_4). Out of thirty, twelve

Table 1. Analysis of variance for yield and its component characters in rice hybrids

Source	df	Days to first flower	Plant height	Number of Productive tillers per plant	Panicle length	Number of grains per panicle	1000 grain weight	Grain yield per plant
Replication	2	3.38	465.07	0.02	0.18	0.09	0.14	0.35
Genotypes	12	254.36**	242.33**	26.78**	5.53**	667.58**	8.35**	110.07**
Hybrids	29	183.92**	189.67**	18.39**	4.32**	475.50**	4.16**	76.24**
Lines	2	840.71**	218.41**	73.20**	16.57**	1700.87**	6.73	208.92*
Testers	9	157.00**	184.06**	24.31*	6.89**	521.37	3.20	76.30*
L x T	18	124.40**	189.28**	9.34**	1.68**	316.42**	4.36**	61.47**
Parents	12	389.25**	383.79**	49.23**	8.22**	1186.96**	16.68**	189.78**
Lines (P)	2	1063.50**	78.00**	42.27**	2.48**	614.00**	2.96**	66.96**
Testers (P)	9	220.05**	492.91**	55.32**	8.06*	1446.13**	12.62**	191.71**
L x T	1	563.54**	13.32**	8.31**	21.16**	0.28	80.60**	418.03**
Hybrid x patent	1	678.68**	71.96**	0.65	8.24**	5.34	30.12**	134.34**
Error	42	4.76	227.40	0.99	0.24	2.73	0.42	2.27

* Significant at 5 per cent level ** Significant at 1 per cent level.

Table 2. Estimates of heterosis for yield and its component characters

S.No	Hybrids	Days to first flower			Plant height			Productive tillers per plant			Panicle length			Grains per panicle			1000 grain weight			Grain yield per plant		
		di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
1	L_1 / T_1	11.57**	-2.59	1.62	-2.84	-3.59	-15.70	-6.06**	-9.19**	23.20**	3.33*	-3.54	-5.70**	17.60**	5.56**	5.56**	1.65	-5.31	1.16	5.85**	-13.54**	13.62**
2	L_1 / T_2	5.64**	-7.77**	-3.78	-2.37	-3.65	-17.04	-14.56**	-27.03**	-7.60	4.96**	-2.80	-3.32	13.85**	12.88**	-8.68**	0.02	-6.22**	-1.19	6.70**	-7.58*	5.07
3	L_1 / T_3	20.28**	2.42	14.59**	-3.74	-7.66	-13.45	-9.91**	-11.85**	11.62**	2.54	-7.77**	-2.16	14.52**	6.37**	-1.39	-2.20	-14.58**	5.47	6.23**	-12.46**	12.46**
4	L_1 / T_4	25.58**	8.00**	16.76**	-1.74	-11.98	-24.22	-9.77**	-26.22**	-6.57	0.43	0.31	-14.79**	15.74**	12.86**	-5.56**	-0.27	-9.78**	2.79	4.78	2.48	-14.67**
5	L_1 / T_5	16.13**	0.51	7.03	0.00	-7.29	-20.18	-4.51*	-15.36**	7.19	2.04	-0.61	-11.16**	15.46**	9.38**	-2.78*	0.68	-4.81	-1.40	1.66	-10.66**	-1.81
6	L_1 / T_6	24.43**	5.29*	18.38**	-1.07	-3.65	-17.04	-6.78**	-11.98**	11.46**	5.44**	1.29	-6.83**	18.05**	14.88**	-3.47**	6.36**	-2.08	7.33**	8.57**	6.03	-7.38
7	L_1 / T_7	9.52**	-4.17	-0.54	3.86	-10.36	-10.76	-9.18**	-25.56**	-5.73	3.04*	-4.81*	-4.81*	12.83**	-0.66	3.82**	1.43	-0.63	-8.37**	5.77*	1.07	-7.64*
8	L_1 / T_8	-5.33**	-8.97**	-23.24**	30.38**	7.29	-7.62	-16.24**	-35.24**	-18.38**	3.28*	0.43	-14.89**	20.52**	1.31	-19.44**	0.16	-13.42**	9.53**	5.01	-6.97	22.54**
9	L_1 / T_9	11.46**	-10.83**	15.68**	-2.58	-3.57	-15.25	-9.00**	-10.82**	12.94**	9.83**	3.54	-0.89	11.15**	-9.37**	14.24**	1.80	-10.36**	8.60**	6.54**	-14.20**	16.98**
10	L_1/ T_{10}	16.11**	3.24	3.24	-8.43	-14.80	-14.80	-8.98**	-18.55**	3.14	5.49**	-3.45	-1.47	14.12**	2.43*	2.43*	-2.00	-5.81	-5.81	3.01	-5.61	-5.61
11	L_2 / T_1	2.31	-8.29**	-4.32	1.38	-5.64	-17.49	-1.79	-18.57**	10.47*	-0.57	-8.35**	-10.39**	0.91	-3.81**	-3.82**	1.17	-9.58**	-3.40	-0.91	-25.63**	-2.26
12	L_2 / T_2	3.47*	-7.25**	-3.24	3.10	1.79	-23.32	1.54	1.33	-9.14*	0.98	-7.64**	-8.14**	-1.21	-6.51**	-15.28**	-0.67	-10.58**	-5.88	-1.46	-22.19**	-11.55**
13	L_2 / T_3	-1.11	-14.01**	-3.78	-7.16	-16.27	-21.52	-6.61	-18.90**	-1.72	-4.15**	-14.81**	-9.63**	3.03**	1.87	-5.56**	-8.93**	-23.43**	-5.47	2.11	-22.78**	-0.79
14	L_2 / T_4	2.55	-9.50**	-2.16	-1.88	-6.55	-29.60*	1.85	-3.20	-13.55**	-4.97**	-6.35**	-20.45**	0.80	-3.07*	-12.15**	-1.19	-14.10**	-2.14	4.22	-4.79	-24.20**
15	L_2 / T_5	5.71**	-6.09**	0.00	3.01	1.79	-23.32	8.06**	3.34	1.13	-1.18	-5.00**	-15.09**	0.97	0.00	-9.38**	0.82	-8.68**	-5.33	-7.27**	-25.86**	-18.51**
16	L_2 / T_6	-4.71**	-17.31**	-7.03**	9.71	5.49	-13.90	-17.90**	-26.36**	-17.17**	-8.36**	-13.10**	-20.09**	10.93**	6.90**	-3.13*	-12.71**	-22.85**	-15.44**	-14.15**	-24.71**	-34.23**
17	L_2 / T_7	-13.04**	-21.88**	-18.92**	1.54	9.56	-4.56	-5.81	-10.21*	-19.82**	-14.44**	-21.94**	-21.94**	-27.40**	-32.23**	-29.17**	-4.13*	-20.18**	3.70	-21.13*	-32.15**	-38.00*
18	L_2 / T_8	24.27**	23.08**	3.78	26.71*	10.12	-17.04	34.99**	19.08**	6.34	8.02**	6.45*	-12.21**	47.72**	18.01**	6.94**	20.16**	17.22**	0.98	65.73**	63.73**	7.82
19	L_2 / T_9	-16.03**	-31.25**	-10.81**	9.89	2.04	-10.31	-10.46**	-22.34**	-5.59	3.19*	-3.96	-8.06**	-10.58**	-23.14**	-3.13**	-13.68	-26.87**	-11.40**	-19.31**	-40.71**	-18.42**
20	L_2/ T_{10}	7.10**	-2.16	-2.16	-9.46	-20.64	-20.63	3.35	-2.18	-2.18	-5.46**	-14.53**	-12.77**	-7.83**	-12.15**	-12.15**	18.74**	9.33**	9.33**	-9.54**	-24.98**	-24.98**
21	L_3 / T_1	-21.14**	-27.19**	-10.27**	8.14	5.64	-7.62	-9.87**	-20.71**	7.58	-4.40**	-7.64**	-9.71**	-12.78**	-14.38**	-11.11**	0.79	-4.77	1.74	-3.51	-17.30**	8.69*
22	L_3 / T_2	-19.71**	-25.88**	-8.65**	13.14	12.83	-5.38	12.50	5.20	8.40*	0.77	-3.45	-3.97	-7.14**	-17.39**	-14.24**	0.02	-4.88	0.23	-0.98	-9.62**	2.75
23	L_3 / T_3	-18.62**	-22.37**	-4.32	0.76	-4.78	-10.76	9.31**	1.14	22.55**	-2.02	-8.93**	-3.38	-12.01**	-16.72**	-13.54**	-3.47*	-14.58**	5.47	-29.32**	-38.84**	-21.43**
24	L_3 / T_4	-19.16**	-24.12**	-6.49**	13.02	2.69	-14.35	9.84**	-2.20	0.77	-3.90**	-7.16**	-15.39**	-8.89**	-17.73**	-14.58**	-3.41	-11.41**	0.93	-2.58	-9.97*	-15.50**
25	L_3 / T_5	-17.65**	-23.25**	-5.41*	6.86	0.54	-16.14	19.22**	16.22**	19.75**	-2.11	-3.05	-11.64**	-13.51**	-1973**	-16.67**	1.70	2.53	1.05	-17.56**	-23.58**	-16.00**
26	L_3 / T_6	-22.94**	-26.32**	-9.19**	5.43	4.30	-13.00	10.21**	5.59	18.77**	-2.77*	-3.22	-10.98**	2.77**	7.02	-3.47**	-5.57**	-11.84**	-3.37	13.66**	9.72**	2.98
27	L_3 / T_7	-20.00**	-26.32**	-9.19**	-41.67**	-46.30**	-46.64**	7.89**	-3.67	-0.74	-0.97	-5.36**	-5.36**	-31.00**	-31.23**	-28.13**	-3.26	-6.61*	-11.23**	15.55**	14.03**	7.03
28	L_3 / T_8	-23.96**	-35.96**	-21.08**	45.16**	20.97	0.90	9.57**	-8.93*	-6.16	-5.38**	-11.12**	-19.00**	-15.16	-35.45**	-32.99**	-0.28	-12.88**	10.47**	-6.07*	-20.88**	-25.74**
29	L_3 / T_9	-19.23**	-21.25**	2.16	10.47	7.65	-5.38	9.72**	1.35	23.22**	-4.48**	-6.78**	-10.76**	-11.78	-19.56	1.39	-4.44*	-14.74**	3.30	-0.22	-15.77**	14.84**
30	L_3/T_{10}	-22.52**	-29.82**	-13.51**	3.18	-5.38	-5.38	10.05**	8.43*	11.72**	-0.40	-5.72**	-3.79	-11.41**	-13.04**	-9.72**	-6.67**	-8.95**	-8.95**	-11.40**	-14.12**	-14.12**

di – Relative Heterosis dii – Heterobeltiosis diii – Standard Heterosis

Hybrids recorded significantly negative standard heterosis. Negative heterosis for plant height is desirable for breeding short statured hybrids and varieties. Only one hybrid showed significantly negative heterosis over mid parent. Maximum relative heterosis was observed in L_3 x T_8 (45.16 per cent). Fourteen hybrids showed positive heterobeltiosis and twenty nine hybrids recorded negative standard heterosis, for productive tillers per plant. Significantly positive relative heterosis was observed in ten hybrid combinations and the values ranged from 1.54 (L_2 x T_2) to 34.99 per cent (L_2 x T_8). The heterobeltiosis was positive and significant in three out of thirty hybrids and had a range of -35.24 (L_1 x T_8) to 19.08 per cent (L_2 x T_8). With regard to standard heterosis, eleven hybrids recorded positive and significant values. The hybrid L_3 x T_9 (23. 22 per cent) recorded the maximum standard heterosis and the cross L_2 x T_7 the recorded a minimum value of -19.82 per cent. For panicle length, the hybrid L_1 x T_9 showed highest relative heterosis of 9.83 per cent followed by L2 x T_8 (8.02 per cent) and L_2 x T_{10} (5.49 per cent). Nine hybrids exhibited significantly positive relative heterosis. Out of the thirty crosses, only one cross showed positive significant better parent heterosis. The standard heterosis ranged from -21.94 (L_2 x T_7) to -0.89 per cent (L_1 x T_9) and none of the hybrids revealed positive significant heterosis, for filled grains per panicle. The relative heterosis for this trait ranged from -31.00 per cent (L_3 x T_7) to 47.72 per cent (L_2 x T_8). Fourteen hybrids possessed significantly positive relative heterosis. Highest better parent heterosis was observed in L_2 x T_8 (18.01 per cent).

The nine cross combinations exhibited significantly positive heterosis over mid parent. The standard heterosis was ranged from -32.99 (L_3 x T_8) to 14.24 per cent (L_1 x T_9) and significant positive heterosis over the standard parent was noticed in five crosses *viz*. L_1 x T_1, L_1 x T_7, L_1 x T_9, L_1 x T_{10} and L_2 x T_8. For 1000 grain weight, three hybrids exhibited positively significant relative heterosis and the values ranged from -13.68 (L_2 x T_9) to 20.16 per cent) ($_{L2}$ x T_8) and two hybrids (L_2 x T_8 and L_2 x T_{10}) revealed positive and significant heterosis over better parent. High heterotic ability over the standard parent was observed in the cross L_3 x T_8 (10.47 per cent) followed by L_1 x T_8 (9.53 per cent) and five hybrids exhibited positive significant heterosis over the standard parent. For grain yield per plant the relative heterosis ranged between – 29.32 (L_3 x T_8) to 65.73 and nine hybrids manifested significantly positive mid parent heterosis. Three hybrids showed positively significant heterobeltiosis and the highest value was recorded in L_2 x T_8 (65.73). Maximum standard heterosis was found in L_1 x T_8 (22.54 per cent) and only six hybrids exhibited positive and significant heterosis. A good hybrid should manifest high amount of heterosis for commercial exploitation. RH has limited importance it is only the deviation of F1 from mid parental value (Kadambavana Sundaram, 1980). Heterobeltiosis is the measure of hybrid vigour over better parent and much stress is placed for computing heterosis for commercial exploitation of hybrid vigrour. Hence for the evaluation of hybrids, standard heterosis is given greater importance when compared to other types of heterosis. For days to first flower, fourteen hybrids recorded significantly negative relative heterosis, twenty hybrids showed negative heterobeltiosis while twelve hybrids showed negative standard heterosis for this trait and similar results were also obtained by Singh (2000). The cross combination PUSA 3A x IR 64 recorded negative heterosis in all the three type of heterosis for plant height, whereas Kadambavansundaram (1980) reported both positive and negative heterosis for all the three type of heterosis. For grains per panicle, only two hybrids namely IR 58025A X ADT 39 and IR 6282A x ASD 16 expressed positive and significant heterosis in all the three estimations. Amirtha Devorathinam (1984) observed high heterosis for all the three types. Out of thirty hybrids, two recorded positive relative heterosis while four hybrids recorded positively significant values for standard heterosis. Dhanakodi (1990) found both negative and positive values for all the three heterosis estimates. Ramalingam *et al*. (1994) recorded high standard heterosis while Yolanda and Vijendradas (1995) and Gokulakrishnan *et al*. (2004) and Rahini et al (2010) reported negative and low heterosis for 1000 grain weight. They also observed that among the hybrid combinations for grain yield per plant, nine hybrids revealed positive and significant relative heterosis, three crosses for heterobeltiosis and six hybrids for standard heterosis. Keeping in view, the hybrids IR 580 25A x ASD 19, IR 62829A x ASD 16 and PUSA 3A x IR 64 recorded higher percentage of heterosis for majority of the characters. Hence these hybrids can be recommended for commercial utilization.

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