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REGULAR ARTICLE

HETEROSIS FOR YIELD AND YIELD ATTRIBUTED TRAITS IN RICE (*ORYZA SATIVA* L.)

J. GOKULAKRISHNAN

Department of Genetics and Plant Breeding, Annamalai University, Annamalainagar 608002, Tamil Nadu, India

ABSTRACT

Rice is the foremost food crop among cereals and it is staple food crop providing high calories for the people of South East Asia. The Objectives of the study was the extent of heterosis components of grain yield in F1 hybrids. The Materials for this study considered of parents and thirty F1 hybrids derived from crossing of three cross lines *viz.,* IR58025A, IR62829A and PUSA3A and ten testers. Pollen and spikelet fertility revealed the identification of ten testers. For heterosis studies majority of the crosses showed positive heterosis for the characters *viz.,* productive tillers, filled grains per panicle, spikelet fertility, thousand grain weight, grain yield per plant, grain length, grain breadth, grain L/B ratio, kernel L/B ratio, milling recovery, head rice recovery, and amylose content. Negative heterosis were recorded for the characters namely days to first flowering, plant height, panicle length, kernel length, kernel breadth and alkali digestion value. Hybrids IR58025A × ASD19, IR62829A × ASD16, PUSA3A × IR42 were found to record high per se performance, higher percentage of standard heterosis for majority of the traits.

Keywords: Heterosis, Hybrid vigour, Rice, Yield

INTRODUCTION

Rice is the foremost food crop among cereals. It is the staple food crop providing high calories for the people of South and South East Asian and African countries. To sustain the same level of self sufficient, India's rice production needs to be increased by 60 per cent by 2020 to meet the demand forever increasing population [1]. Hence India's rice production most have to reach 149 million tones by 2020.

The scope for exploitation of hybrid vigour depends on the direction and magnitude of heterosis and ease with which hybrids seeds can be produced [3]. Further, the extent of heterosis will have direct effect on breeding methodology in varietal improvement programme. Therefore, in the present investigation, a study was conducted 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 × tester analysis.

MATERIALS AND METHODS

The experimental materials comprised of three cytoplasmic male sterile lines *viz.,* IR 58025A, IR62829A, PUSA3A and ten testers (ADT 39, CO 43, IR 50, IR 36, IR 28, IR 42, IR 64, ASD 16, ASD 19, TRY 1) were crossed resulting in 30 hybrids using line × tester analysis.

The varieities were tested at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Annamalai University, Chidambaram during 2014-2016 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 normal nursery management practices were followed. Twenty five days old seedlings were transplanted in rows with spacing 15 cm between rows and 15 cm between plants. One seedling per hill was maintained. The row length of 3 meter 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 [4].

RESULTS AND DISCUSSION

Results revealed significant differences in all the studied genotypes in seven characteristics *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 noted 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×T) was also significant for all the characters. Similar results were recorded by Kadambavana Sundaram [5] and Singh [6].

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*Corresponding Author

J. Gokulakrishnan

Department of Genetics and Plant Breeding, Annamalai University, Annamalainagar 608002, Tamil Nadu, India

Email: gokulayamuna@gmail.com

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 (L1×T8) to 25.58 per cent (L1×T4). Twenty one hybrids showed significantly negative heterobeltiosis and the highest value was recorded by L2×T8 (23.08 per cent). The standard heterosis ranged from–23.24 (L1×T8) to 18.38 per cent (L1×T4). Out of thirty, hybrids recorded significantly negative standard heterosis. Only one hybrids showed significantly negative heterosis over mid parent. Maximum relative heterosis was observed in L3×T8 (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 value ranged from 1.54 (L2×T2) to 34.99 per cent (L2×T8). The heterobeltiosis was positive and significant in three out of thirty hybrids and had a range of–35.24 (L1×T8) to 19.08 per cent (L2×T8). With regard to standard heterosis, eleven hybrids recorded positive and significant values. The hybrid L3×T9 (23.22 per cent) recorded the maximum and the cross L2×T7 recorded the minimum value of–19.82 per cent.

For panicle length, the hybrid L1×T9 showed highest relative heterosis of 9.83 per cent followed by L2×T8 (8.02 per cent) and L2×T10 (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 (L2×T7) to–0.89 per cent (L1×T9) 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 (L3×T7) to 47.72 per cent (L2×T8). Fourteen hybrids possessed significantly positive relative heterosis. Highest better parent heterosis was observed in L2×T8 (18.01 per cent). The nine cross combinations exhibited significantly positive heterosis over mid parent. The standard heterosis was ranged from–32.99 (L3×T8) to 14.24 per cent (L1×T9) and significant positive heterosis over the standard parent was noticed in five crosses *viz.,* L1×T1, L1×T7, L1×T9, L1×T10 and L2×T8. For 1000 grain weight, three hybrids exhibited positive significant relative heterosis and the values ranged from–13.68 (L2×T9) to 20.16 per cent) (L2×T8) and two hybrids (L2×T8 and L2×T10) revealed positive and significant heterosis over better parent. High heterotic ability over the standard parent was observed in the cross L3×T8 (10.47 per cent) followed by L1×T8 (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 (L3×T8) 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 L2×T8 (65.73). Maximum standard heterosis was found in L1×T8 (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 [5]. Heterobeltiosis is the measure of hybrid vigour over better parent and much stress is placed for computing heterosis for commercial exploitation of hybrid vigour. 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 [6]. The cross combination PUSA 3A × IR 64 recorded negative heterosis in all the three type of heterosis for plant height, whereas Kadambavan Sundaram [5] reported both positive and negative heterosis for all the three type of heterosis.

For grains per panicle, only two hybrids namely IR 58025A × ADT 39 and IR 6282A × ASD 16 expressed positive and significant heterosis in all the three estimations. Amirtha Devorathinam [7], Lathasrikrishna *et al.* [8] observed high heterosis for all the three types. Out of thirty hybrids, two recorded positive relative heterosis while four hybrids recorded positively significant value for standard heterosis. Dhanakodi [9] and Thorat *et al.* [10], found both negative and positive values for all the three heterosis estimates.

Gokulakrishnan *et al.* [11] 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 25 A × ASD 19, IR 62829A × ASD 16 and PUSA 3A × IRA recorded higher percentage of heterosis for majority of the characters. Hence these hybrids can be recommended for commercial utilization.

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	1	3.38	465.07**	0.02	0.18	0.09	0.14	0.35
Genotypes	42	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 × 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 × T	1	563.54**	13.32**	8.31**	21.16**	0.28	80.60**	418.03**
Hybrid patent	1	678.68**	71.96**	0.65	8.24**	5.34	30.12**	134.34**
Error	42	4.76	224.40	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		
		Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)	Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)	Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)	Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)
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**
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
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
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**
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**
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**
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*
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**
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
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
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**
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**
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**
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**
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**
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**
17	L_2/T_7	-13.04**	-21.88**	-18.92**	1.54			-5.81	-10.21*	-19.82**	-14.44**	-21.94**	-21.94**
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**
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**
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**
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**
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
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
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**
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**
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**
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**
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**
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**
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

Contd...

S.No.	Hybrids	Grains per panicle			1000 grain weight			Grain yield per plant		
		Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)	Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)	Relative heterosis (d_1) (%)	Heterobeltiosis (d_{ii}) (%)	Standard heterosis (d_{iii}) (%)
1	L_1/T_1	17.60**	5.56**	5.56**	1.65	-5.31	1.16	5.85**	-13.54**	13.62**
2	L_1/T_2	13.85**	12.88**	-8.68**	0.02	-6.22**	-1.19	6.70**	-7.58*	5.07
3	L_1/T_3	14.52**	6.37**	-1.39	-2.20	-14.58**	5.47	6.23**	-12.46**	12.46**
4	L_1/T_4	15.74**	12.86**	-5.56**	-0.27	-9.78**	2.79	4.78	2.48	-14.67**
5	L_1/T_5	15.46**	9.38**	-2.78*	0.68	-4.81	-1.40	1.66	-10.66**	-1.81
6	L_1/T_6	18.05**	14.88**	-3.47**	6.36**	-2.08	7.33**	8.57**	6.03	-7.38
7	L_1/T_7	12.83**	-0.66	3.82**	1.43	-0.63	-8.37**	5.77*	1.07	-7.64*
8	L_1/T_8	20.52**	1.31	-19.44**	0.16	-13.42**	9.53**	5.01	-6.97	22.54**
9	L_1/T_9	11.15**	-9.37**	14.24**	1.80	-10.36**	8.60**	6.54**	-14.20**	16.98**
10	L_1/T_{10}	14.12**	2.43*	2.43*	-2.00	-5.81	-5.81	3.01	-5.61	-5.61
11	L_2/T_1	0.91	-3.81**	-3.82**	1.17	-9.58**	-3.40	-0.91	-25.63**	-2.26
12	L_2/T_2	-1.21	-6.51**	-15.28**	-0.67	-10.58**	-5.88	-1.46	-22.19**	-11.55**
13	L_2/T_3	3.03**	1.87	-5.56**	-8.93**	-23.43**	-5.47	2.11	-22.78**	-0.79
14	L_2/T_4	0.80	-3.07*	-12.15**	-1.19	-14.10**	-2.14	4.22	-4.79	-24.20**
15	L_2/T_5	0.97	0.00	-9.38**	0.82	-8.68**	-5.33	-7.27**	-25.86**	-18.51**
16	L_2/T_6	10.93**	6.90**	-3.13*	-12.71**	-22.85**	-15.44**	-14.15**	-24.71**	-34.23**
17	L_2/T_7	-27.40**	-32.23**	-29.17**	-4.13*	-20.18**	3.70	-21.13*	-32.15**	-38.00*
18	L_2/T_8	47.72**	18.01**	6.94**	20.16**	17.22**	0.98	65.73**	63.73**	7.82
19	L_2/T_9	-10.58**	-23.14**	-3.13**	-13.68	-26.87**	-11.40**	-19.31**	-40.71**	-18.42**
20	L_2/T_{10}	-7.83**	-12.15**	-12.15**	18.74**	9.33**	9.33**	-9.54**	-24.98**	-24.98**
21	L_3/T_1	-12.78**	-14.38**	-11.11**	0.79	-4.77	1.74	-3.51	-17.30**	8.69*
22	L_3/T_2	-7.14**	-17.39**	-14.24**	0.02	-4.88	0.23	-0.98	-9.62**	2.75
23	L_3/T_3	-12.01**	-16.72**	-13.54**	-3.47*	-14.58**	5.47	-29.32**	-38.84**	-21.43**
24	L_3/T_4	-8.89**	-17.73**	-14.58**	-3.41	-11.41**	0.93	-2.58	-9.97*	-15.50**
25	L_3/T_5	-13.51**	-1973**	-16.67**	1.70	2.53	1.05	-17.56**	-23.58**	-16.00**
26	L_3/T_6	2.77**	7.02	-3.47**	-5.57**	-11.84**	-3.37	13.66**	9.72**	2.98
27	L_3/T_7	-31.00**	-31.23**	-28.13**	-3.26	-6.61*	-11.23**	15.55**	14.03**	7.03
28	L_3/T_8	-15.16	-35.45**	-32.99**	-0.28	-12.88**	10.47**	-6.07*	-20.88**	-25.74**
29	L_3/T_9	-11.78	-19.56	1.39	-4.44*	-14.74**	3.30	-0.22	-15.77**	14.84**
30	L_3/T_{10}	-11.41**	-13.04**	-9.72**	-6.67**	-8.95**	-8.95**	-11.40**	-14.12**	-14.12**

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