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HETEROSIS FOR GRAIN YIELD AND ITS COMPONENT TRAITS IN RICE (*ORYZA SATIVA* L.)

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Abstract

The present investigation was carried out in rice involving 7 lines (STBN 12-14, IVT 1235, STBN 3, STBN 2, MTU 1001, IVT 1208 and STBN 13-11) and 3 testers (ADT 45, IR 50 and IR 66) to identify the heterosis in association with yield and its component traits in rice. The parents were mated in the Line × Tester method. The resultant twenty one hybrids were evaluated for five characters *viz.*, number of productive tillers per plant, panicle length, number of grains per plant, thousand grain weight and grain yield per plant. Maximum significant positive standard heterosis was possessed by the hybrid $L_1 \times T_1$ followed $L_6 \times T_2$ for most of the economic traits. The hybrid $L_1 \times T_1$ showed desirable performance based on *per se* and standard heterosis for most of the characters and so this hybrid could be exploited for further crop improvement.

Key words: Rice, line × tester, heterosis, grain yield per plant

Introduction

Rice *(Oryza sativa* L. 2n = 2x = 24) belonging to the genus *Oryza* includes 24 species, out of which 22 species are wild and only two species *viz*., *O. sativa* and *O. glaberrima* are cultivated. The genus *Oryza* belongs to the tribe oryzae in the family poaceae. Rice is the most important cereal crop cultivated widely in many parts of the world. Rice is the major source of nutrition for about 40 percent of world's population and in India about 65 percent of the population has rice as major constituent in the diet (Nidhi *et al*., 2003). Rice fields cover 11 percent of earth's entire arable land (IRRI, 2002). Rice provides 21 percent global human per capita energy and 1 percent of per capita protein. Asia account for 60 percent of the global population, about 92 percent of world rice production and 90 percent of global rice consumption.

Rice is the principle stable cereal food and source of calories for more than half of the world's population. It offers a wealth of material for genetic studies because of its wide ecological distribution and enormous variation encountered for various qualitative and quantitative characters. Hybrid rice technology exploits the phenomenon of heterosis, provides an opportunity to boost the yield of rice as rice hybrid varieties have a good yield advantage of 15-20 percent over the conventional high yielding varieties (Viramani and Kumar, 2004). It has been anticipated that hybrid rice technology will play a key role in ensuring food security worldwide in the future decades (Yuan, 2010). Many traits of economic importance in rice are quantitatively inherited.

For the succession in a breeding programme, the method of parent selection for hybridization is considered as a basic factor. Here, line × tester technique which was developed by Kempthorne, (1957) is used. Of the various approaches, exploitation of heterosis is considered as one of the desirable and sustainable approach. Information on the magnitude of heterosis is pre-requisite in the development of the hybrids. A good hybrid should manifest high amount of heterosis for commercial exploitation. Relative heterosis is of limited importance, because, it is only the deviation of F_1 from mid-parental value (Grakh and Choudhary, 1985). Heterobeltiosis is a measure of hybrid vigour over the better parent.

Swaminathan *et al*., (1972) and Bobby and Natarajan, (1994) stressed with the need for computing standard heterosis for commercial exploitation for hybrids. Hence, for the evaluation of hybrids standard heterosis is to be given more importance rather than the other two.

Materials and Methods

The present investigation was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, during February 2017. The biological materials used for this study comprised of ten genotypes, out of which seven genotypes were used as lines and three genotypes were used as testers. The details of the parental materials are STBN 12-14 (L_1), IVT 1235 (L_2), STBN-3 (L_3), STBN-2 (L_4), MTU 1001 (L_5), IVT 1208 (L_6), STBN 13-11(L_7), ADT 45 (T_1), IR 50 (T_2), IR 66(T_3). Seven lines and three testers were crossed in a line × tester mating fashion resulting in twenty one hybrids. The experimental materials consisted of twenty one hybrids with their ten parents were raised in the nursery and transplanted in rows spacing of 30cm between rows and 20 cm between plants during thaladi (Feb-May, 2017). Twenty five days old seedlings per hill was maintained. The row length of 3 m was maintained for each genotype. The experiment was laid out in a randomized block design with three replications. Recommended cultural practices and need based plant protection measures were also adopted to raise the crop. The resultant twenty one hybrids were evaluated for five characters *viz.*, number of productive tillers per plant, panicle length, number of grains per plant, thousand grain weight and grain yield per plant.

The mean of parents and F_1 hybrids were utilized for the estimation of heterosis. Relative heterosis (di) was estimated as percent deviation of the F_1 from the mid parental value (MP). Heterobeltiosis (dii) was estimated as percent increase or decrease of F_1 over better parent (BP). Standard heterosis (diii) for each character was expressed as percent increase or decrease of F_1 over the standard variety (SV) (Fonseca and Patterson, 1968). The significance of heterosis was tested using the formula suggested by Wynne *et al.*, (1970).

Results and Discussion

The variance due to lines and testers were significant for all the characters studied. The variance due to line × testers and hybrids were also significant for all traits. The results of the present study indicated that existence of significant differences among the lines, testers and hybrids. Therefore, further analyses were appropriate.

As per mean values, among the lines, two lines *viz.*, L_1 and L_5 recorded higher grain yield per plant (higher than mean of lines + 1CD). Maximum number of grains

Table 1: Mean performance for grain yield and its component traits in rice.

Parents /hybrids	Number of productive tillers per plant	Panicle length	Number of grains per panicle	Thousand grain weight	Grain yield per plant
L_1	16.87	21.86	133.47**	21.19**	39.66**
L_2	15.53	23.27	97.65	14.66	23.03
L_3	16.40	23.31	116.57**	17.58	24.60
L_4	11.83	23.46	130.60**	22.18**	20.00
L_5	21.33**	22.77	105.27**	15.82	43.77**
L_6	13.60**	23.38	66.40	16.72	28.40
L_7	19.33	21.90	66.58	27.44**	19.80
T_1	14.40	21.23	122.73**	14.58	35.10**
T_2	12.93	17.92	80.53	12.27	23.91
T_3	14.33	23.56**	137.43**	21.55**	28.79
$L_1 \times T_1$	16.57**	21.72	130.48**	17.42**	35.74**
$L_2 \times T_1$	11.57	20.60	119.14**	17.84**	25.81
$L_3 \times T_1$	15.10	20.70	94.67	17.71**	26.44*
$L_4 \times T_1$	14.56	17.81	98.49	17.63**	21.67
$L_5 \times T_1$	11.66	17.38	66.36	18.49**	20.52
$L_6 \times T_1$	12.63	23.72*	119.78**	16.74**	20.74
$L_7 \times T_1$	13.97	21.44	98.44	17.59**	23.57
$L_1 \times T_2$	15.38	23.90**	110.27**	15.53	25.04
$L_2 \times T_2$	14.68	22.51	112.29**	14.81	37.56**
$L_3 \times T_2$	15.10	17.47	105.60**	16.67	31.56**
$L_4 \times T_2$	11.67	18.66	87.04	14.56	30.52**
$L_5 \times T_2$	14.68	20.07	100.92	15.78	28.60**
$L_6 \times T_2$	13.59	23.73**	121.71**	19.49**	18.62
$L_7 \times T_2$	14.67	24.03**	97.63	19.59**	18.11
$L_1 \times T_3$	14.96	22.66	118.75**	16.58	29.18**
$L_2 \times T_3$	11.80	21.79	94.78	13.50	29.52**
$L_3 \times T_3$	15.37	18.56	106.95**	16.56	23.31
$L_4 \times T_3$	13.55	18.44	73.58	14.56	24.67
$L_5 \times T_3$	14.68	21.63	112.90**	14.42	20.60
$L_6 \times T_3$	11.38	26.83**	102.93	15.71	31.71**
$L_7 \times T_3$	18.30**	22.60	102.42	14.67	18.84

*significant at 5% level; **significant at 1% level

Table 2: Percentage of heterosis for grain yield and its component characters in rice.

Char-acters	Number of productive tillers per plant			Panicle length			Number of grains per panicle			Thousand grain weight			Grain yield per plant		
Hybrids	RH (di)	HB (dii)	SH (diii)	RH (di)	HB(dii)	SH(diii)	RH(di)	HB(dii)	SH(diii)	RH(di)	HB(dii)	SH(diii)	RH(di)	HB(dii)	SH(diii)
$L_1 \times T_1$	6.01	-1.74	15.09**	0.82	-0.63	2.31	1.86**	-2.24**	6.32**	-2.63**	-17.82**	19.46**	-4.39**	-9.88**	1.82*
$L_2 \times T_1$	-22.72**	-25.54**	-19.68**	-7.43*	-11.49**	-2.98	8.12**	-2.92**	-2.92**	21.02**	21.69**	22.36**	-11.21**	-26.47**	-26.47**
$L_3 \times T_1$	-1.93	-7.91	4.88	-7.06*	-11.21**	-2.51	-20.88**	-22.86**	-22.86**	10.13**	0.72	21.47**	-11.43**	-24.67**	-24.67**
$L_4 \times T_1$	-0.00	-6.30	6.71	-20.30**	-24.08**	-16.12**	-22.24**	-24.59**	-19.75**	-4.08**	-20.51**	20.92**	-21.34**	-38.26**	-38.26**
$L_5 \times T_1$	3.72	-5.44	-5.88	-21.02**	-23.69**	-18.16**	-41.79**	-45.93**	-45.93**	21.61**	16.83**	26.79**	-47.97**	-53.12**	-41.53**
$L_6 \times T_1$	-9.76*	-12.27*	-12.27*	6.32*	1.44	11.70**	26.67**	-2.40**	-2.40**	6.95**	0.10	14.81**	-34.68**	-40.91**	-40.91**
$L_7 \times T_1$	-17.15**	-27.72**	-2.96	-0.60	-2.12	0.97	4.00**	-19.79**	-19.79**	-16.28**	-35.90**	20.64**	-14.13**	-32.84**	-32.84**
$L_1 \times T_2$	3.20	-8.83	6.78	20.18**	9.35*	12.57**	3.05**	-17.39**	-10.15**	-7.20**	-26.74**	6.49**	-21.21**	-36.85**	-28.64**
$L_2 \times T_2$	3.16	-5.47	1.97	9.27**	-3.29	6.00	26.04**	14.99**	-8.50**	9.99**	1.02	1.58	60.02**	57.09**	7.02**
$L_3 \times T_2$	2.98	-7.91	4.88	-7.06*	-11.21**	-2.51	7.15**	-9.41**	-13.96**	11.68**	-5.19**	14.33**	30.11**	28.28**	-10.08**
$L_4 \times T_2$	11.17*	1.13	1.13	-9.80**	-20.45**	-12.10**	-17.54**	-33.35**	-29.08**	-15.47**	-34.36**	-0.14	39.00**	27.65**	-13.04**
$L_5 \times T_2$	-34.72**	-45.33**	-19.00	1.34	-11.84**	-5.46	8.63**	-4.13**	-17.77**	12.34**	-0.27	8.23**	-15.48**	-34.66**	-18.50**
$L_6 \times T_2$	2.41	-0.10	-5.65	14.90**	1.48	11.74**	65.67**	51.14**	-0.83*	34.47**	16.56**	33.70**	-28.80**	-34.43**	-46.94**
$L_7 \times T_2$	-9.07*	-24.12**	1.88	20.68**	9.71*	13.17**	32.74**	21.24**	-20.45**	-1.35*	-28.62**	34.34**	-17.14**	-24.26**	-48.40**
$L_1 \times T_3$	-4.08	-11.28*	3.91	-0.21	-3.81	6.73	-12.33**	-13.59**	-3.24**	-22.41**	-23.05**	13.74**	-14.73**	-26.42**	-16.86**
$L_2 \times T_3$	-21.00**	-24.06**	-18.08**	-6.93*	-7.50	2.64	-19.37**	-31.04**	-22.77**	-25.45**	-37.37**	-7.43**	13.95**	2.56**	-15.88**
$L_3 \times T_3$	2.98	-7.91	4.88	-15.28**	-25.08**	-17.74**	-15.79**	-22.18**	-12.86**	-15.37**	-23.16**	13.58**	-12.68**	-19.03**	-33.58**
$L_4 \times T_3$	-5.61	-9.74	-18.94**	-21.57**	-21.73**	-13.16**	-45.09**	-46.46**	-40.04**	-33.39**	-34.34**	-0.11	1.13	-14.30**	-29.71**
$L_5 \times T_3$	-14.32**	-31.19**	1.94	-6.61*	-8.18*	1.88	-6.96**	-17.85**	-8.00**	-22.85**	-33.10**	-1.12	-43.21**	-52.93**	-41.30**
$L_6 \times T_3$	-18.54**	-20.63**	-21.00**	14.32**	13.88**	26.36**	0.99**	-25.11**	-16.13**	-17.92**	-27.71**	7.73**	10.88**	10.14**	-9.66**
$L_7 \times T_3$	8.71*	-5.34	27.08**	-0.59	-4.09	6.42	0.41	-25.48**	-16.55**	-40.10**	-46.53**	0.64	-22.46**	-34.56**	-46.33**

*significant at 5% level; **significant at 1% level; RH- Relative Heterosis; HB- Heterobeltiosis; SH- Standard Heterosis; Standard Parent- T1

per panicle was recorded in L_1, L_3 and L_4 and L_5. These results indicated that great variability existed among these lines and there is ample scope to combine different desirable characters in one or few lines. Similar findings are also reported earlier by Narasimhan *et al.*, (2007). Among the testers, T_1 recorded maximum grain yield per plant and number of grains per panicle (higher than mean of tester + 1CD). These results showed that these testers were of diverse in nature and their selection as parents is justified. Similar results are also confirmed earlier by Narasimhan *et al.*, (2007). Nine out of Twenty one hybrids registered maximum grain yield per plant where $L_2 \times T_2$ and $L_1 \times T_1$ were maximum yielders. Of these nine best hybrids, two hybrids ($L_1 \times T_1$ and $L_1 \times T_3$) showed more number of grains per panicle. Similar results are also reported earlier by Satheesh kumar *et al.*, (2010). (Table 1)

The results of heterosis for grain yield and its component traits in rice are presented in table 2. Among twenty one hybrids only two recorded positive significant relative heterosis for the number of productive tillers per plant. It was maximum with $L_4 \times T_2$ and $L_7 \times T_3$. None of the hybrids showed positive significant for this trait. Only two out of twenty one hybrids recorded positive significant standard heterosis for this trait. It was maximum with $L_7 \times T_3$ and $L_1 \times T_1$. The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme. The result is in confirmity with the findings of Srijan *et al.*, (2015).

Six out of twenty one hybrids registered positive significant relative heterosis for panicle length. It was maximum with $L_7 \times T_2$ followed by $L_1 \times T_2$ and $L_6 \times T_2$. Heterobeltiosis was positive and significant in three out of twenty one hybrids. It was maximum with L6 × T3 followed by $L_7 \times T_2$ and

$L_1 \times T_2$. Five out of twenty one hybrids showed positive significant standard heterosis for this trait. It was maximum with $L_6 \times T_3$ followed by $L_7 \times T_2$ and $L_1 \times T_2$. The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme. The result is in agreement with the findings of Padmavathi *et al.,* (2013).

Eleven out of twenty one cross combinations recorded positive significant relative heterosis for the number of grains per panicle. It was maximum with $L_6 \times T_2$ followed by $L_7 \times T_2$ and $L_6 \times T_1$. Three out of twenty one hybrids registered positive significant heterobeltiosis for this trait. It was maximum with $L_6 \times T_2$ followed by $L_7 \times T_2$ and $L_2 \times T_2$. Only one out of twenty one hybrids exhibited positive significant standard heterosis for this trait. It was maximum with $L_1 \times T_1$. The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme. The result is in corroboration with the findings of Tiwari *et al.,* (2011).

Eight out of twenty one hybrids recorded positive significant relative heterosis for thousand grain weight. It was maximum with $L_6 \times T_2$ followed by $L_5 \times T_1$ and $L_2 \times T_1$. Three out of twenty one hybrids registered positive significant heterobeltiosis for this trait. It was maximum with $L_2 \times T_1$ followed by $L_5 \times T_1$ and $L_6 \times T_2$. Fifteen out of twenty one hybrids exhibited positive significant standard heterosis for this trait. It was maximum with $L_7 \times T_2$ followed by $L_6 \times T_2$ and $L_5 \times T_1$. The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme. The result is in corroboration with the findings of Rukmini *et al.,* (2014).

Five out of twenty one hybrids recorded positive significant relative heterosis for this trait. It was maximum with $L_2 \times T_2$ followed by $L_4 \times T_2$ and L3 × T2. Five out of twenty one hybrids registered positive significant heterobeltiosis for this trait. It was maximum with $L_2 \times T_2$ followed by $L_3 \times T_2$ and $L_4 \times T_2$. Two out of twenty one hybrids exhibited positive significant standard heterosis for this trait. It was maximum with $L_2 \times T_2$ followed by $L_1 \times T_1$. The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme. The result is in corroboration with the findings of Padmavathi *et al.,* (2013).

In the present study the hybrids viz., $L_1 \times T_1$, $L_1 \times T_3$, $L_2 \times T_2$, $L_2 \times T_3$, $L_3 \times T_1$, $L_3 \times T_2$, $L_4 \times T_2$, $L_5 \times T_2$ and $L_6 \times T_3$ recorded high mean for grain yield per plant. The cross combination namely $L_2 \times T_2$ had high mean coupled with high standard heterosis for grain yield per plant. This hybrid would be advantageous for heterosis breeding. In general many of the cross combinations which registered high mean had also possessed high standard heterosis. Based on per se performance, the hybrids $L_3 \times T_2$ and $L_2 \times T_2$ were rated as the best for two out of five characters studied. These hybrids showed high per se performance for number of grains per panicle and grain yield per plant. The hybrid $L_1 \times T_1$ was rated as the best since they possessed significant standard heterosis for most of the characters *viz*., number of productive tillers per plant, number of grains per panicle, thousand grain weight and grain yield per plant. The hybrid $L_2 \times T_2$ recorded high standard heterosis for grain yield per plant.

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