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ESTIMATION OF HETEROSIS FOR EARLINESS AND CERTAIN GROWTH CHARACTERS 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 best combining parents, nature of gene action and 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.,* days to 50 per cent flowering, plant height at maturity, number of tillers per plant, flag leaf length and flag leaf breadth. 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, sca* and standard heterosis for most of the characters and so this hybrid could be exploited for further crop improvement.

Keywords **:** heterosis, sca, gca, rice, growh

Introduction

Rice (*Oryza sativa* L. 2n=2x=24) 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. Rice is the major source of nutrition for about 40 per cent of world's population and in India about 65 per cent of the population has rice as major constituent in the diet (Nidhi *et al.,* 2003). 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 per cent 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. The exploitation of genetic variability of these traits done through hybridization and selection. Reduced plant height, moderate tillering, large and compact panicles, fertile spikelets per panicle, test weight and grain yield are the most important rice characters to be improved in breeding programs (Mackill and Lei 1997; Miller *et al.,* 1993 ; Nemoto *et al.,* 1995 ; Wayne & Dilday 2003 and Paterson *et al.,* 2005).

For the succession in a breeding programme, the method of parent selection for hybridization is considered as a basic factor. Here, line x 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. Heterosis reveals the type of gene action involved and it helps in the selection of suitable breeding methodology and parameters, which are employed for crop improvement programme. Heterotic studies can also provide the basis for exploitation of valuable hybrid combinations and their commercial utilization in future breeding programs Chowdhury *et al.* (2010). Therefore in the present investigation the superiority of the hybrids were estimated over the mid-parent, better parent and standard parent to judge the potential of crosses to be exploited in hybrid breeding programs.

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.,* days to 50 per cent flowering, plant height at maturity, number of tillers per plant, flag leaf length and flag leaf breadth.

The mean of parents and F_1 hybrids were utilized for the estimation of heterosis. Relative heterosis (di) was estimated as per cent deviation of the F_1 from the mid parental value (MP). Heterobeltiosis (dii) was estimated as per cent increase or decrease of F_1 over better parent (BP). Standard heterosis (diii) for each character was expressed as per cent 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

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.

As per mean values, among the lines, two lines L_3 and L_6 were early in flowering. Among lines, L_1, L_3 and L_7 had desirable reduced plant height. 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 was also earliest in flowering. T_3 have produced shortest plants. 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). (Table 1)

Among the 21 hybrids, two hybrids ($L_1 \times T_1$ and $L_1 \times T_3$) showed early flowering. $L_1 \times T_3$, $L_3 \times T_1$, $L_3 \times T_2$ and $L_5 \times T_2$ hybrids produced shorter plants. Among the hybrids, $L_1 \times T_3$ exhibited less plant height at maturity coupled with early flowering. Similar results are also reported earlier by Satheesh kumar *et al.* (2010). (Table 2)

Fifteen out of twenty one hybrids recorded negative significant relative heterosis for the days to 50 per cent flowering. It was maximum with $L_4 \times T_1$(-12.54) followed by $L_1 \times T_3$(-9.92) and $L_5 \times T_2$(-9.66). Eighteen out of twenty one hybrids registered negative significant heterobeltiosis for this trait. It was maximum with $L_4 \times T_1$ (-16.69) followed by $L_5 \times T_2$(-10.69) and $L_1 \times T_3$(-10.63). Six out of twenty one hybrids exhibited negative significant standard heterosis for this trait. It was maximum with $L_4 \times T_1$(-16.69) followed by $L_5 \times T_1$(-10.47) and $L_7 \times T_1$(-7.57). The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme. Negative heterosis for this trait was earlier reported by Srijan *et al.* (2015).

Thirteen out of twenty one hybrids exhibited negative significant relative heterosis for plant height at maturity. It was maximum with $L_6 \times T_2$ (-28.31) followed by $L_4 \times T_1$ (-27.14) and $L_5 \times T_2$(-16.96). Eighteen out of twenty one hybrids registered negative significant heterobeltiosis for this trait. It was maximum with $L_4 \times T_1$ (-37.67) followed by $L_6 \times T_2$ (-30.80) and $L_4 \times T_3$(-28.98). Standard heterosis was negative and significant in thirteen out of twenty one hybrids. It was maximum with $L_6 \times T_2$(-24.36) followed by $L_4 \times T_1$(-12.34) and $L_7 \times T_3$(-12.21). 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 Kumari Priyanka *et al.* (2014).

Six out of twenty one hybrids recorded positive significant relative heterosis for the number of tillers per plant. It was maximum with $L_6 \times T_3$(31.46) followed by $L_6 \times T_2$ (25.56) and $L_3 \times T_1$(20.43). Only three out of twenty one hybrids exhibited positive significant heterobeltiosis for this trait. It was maximum with $L_3 \times T_1$(20.43) and $L_6 \times T_3$(19.71). Twelve out of twenty one hybrids exhibited positive significant standard heterosis for this trait. It was maximum with $L_6 \times T_2$ (38.50) followed by $L_2 \times T_1$ (33.79) and $L_4 \times T_1$(32.33). The observed direction and magnitude of standard heterosis for this trait added ample scope for inclusion of this trait in heterosis breeding programme. The result is in confirmity with the findings of Neelam Venkateswara Rao (2006).

Five out of twenty one hybrids recorded positive significant relative heterosis for flag leaf length. It was maximum with $L_3 \times T_3$ (14.01) followed by $L_6 \times T_3$(9.79) and $L_2 \times T_1$(9.55). Three out of twenty one cross combinations registered positive significant heterobeltiosis for this trait. It was maximum with $L_2 \times T_1$(7.56) followed by $L_3 \times T_3$(6.82) and $L_6 \times T_3$(1.68). Three out of twenty one hybrids showed positive significant standard heterosis for this trait. It was maximum with $L_4 \times T_2$(11.80) followed by $L_2 \times T_1$(11.62) and $L_6 \times T_3$(11.14). The result indicated ample scope for this character for hybrid breeding programme. The result is in agreement with the findings of Srijan *et al* (2015) and Yadav *et al.* (2004).

Five out of twenty one hybrids recorded positive significant relative heterosis for flag leaf breadth. It was maximum with $L_3 \times T_3$(25.42) followed by $L_6 \times T_3$(18.20) and $L_6 \times T_1$(13.34). Two out of twenty one hybrids registered positive significant heterobeltiosis for this trait. It was maximum with $L_3 \times T_3$(14.25) followed by $L_6 \times T_3$(8.17). Two out of twenty one hybrids exhibited positive significant standard heterosis for this trait. It was maximum with $L_6 \times T_2$(23.05) followed by $L_3 \times T_3$(6.33). 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 Dorosti and Monajjerm (2014). From this study, it could be concluded that the hybrid $L_1 \times T_1$ was rated as the best since they possessed significant standard heterosis for most of the characters viz., days to 50 per cent flowering, plant height at maturity, number of tillers per plant and flag leaf breadth.

Table 1 : Mean performance for earliness and certain growth characters

Parents/ hybrids	Days to 50 per cent flowering	Plant height at maturity	Number of tillers per plant	Flag leaf length	Flag leaf breadth	Hybrids	Days to 50 per cent flowering	Plant height at maturity	Number of tillers per plant	Flag leaf length	Flag leaf breadth
L_1	84.33	82.44**	26.33*	29.76	1.33**	$L_7 \times T_1$	73.63**	82.49**	15.04	27.96**	1.09
L_2	84.00	91.46	22.51	41.13**	1.28**	$L_1 \times T_2$	82.00	87.52	17.38	29.93**	1.37**
L_3	73.00**	71.75*	17.13	28.63	0.95	$L_2 \times T_2$	83.35	88.08	20.89**	30.37**	1.13
L_4	88.00	123.96	36.20**	31.86*	1.03	$L_3 \times T_2$	79.51	82.93*	21.59**	26.86	1.38**
L_5	88.00	97.34	33.33**	38.55**	1.18	$L_4 \times T_2$	79.60	98.54	14.51	28.32**	1.08
L_6	79.33**	96.33	14.40	19.54	1.04	$L_5 \times T_2$	78.60	77.63**	13.77	24.70	1.05
L_7	81.67	77.62*	29.13**	25.37	1.04	$L_6 \times T_2$	82.54	66.66**	23.73**	23.67	0.93
T_1	79.67**	88.14	17.13	30.76**	1.17	$L_7 \times T_2$	80.21	77.86**	20.69**	18.62	1.04
T_2	86.00	89.65	23.40**	30.28**	1.12	$L_1 \times T_3$	75.37**	78.22**	15.30	27.34**	1.44**
T_3	83.00	82.10*	17.53	23.43	1.03	$L_2 \times T_3$	79.12	87.45	13.59	20.80	1.10
$L_1 \times T_1$	77.33*	85.97	21.11**	28.04**	1.40**	$L_3 \times T_3$	80.52	87.71	18.21	32.71**	1.22*
$L_2 \times T_1$	82.60	98.38	22.92**	28.32**	1.10	$L_4 \times T_3$	82.95	88.04	21.66**	30.01**	1.17
$L_3 \times T_1$	80.51	78.26**	20.63**	24.99	1.07	$L_5 \times T_3$	79.67	78.51**	17.11	24.67	1.30**
$L_4 \times T_1$	73.32**	77.26**	22.67**	27.44**	1.04	$L_6 \times T_3$	83.74	97.95	20.99**	25.45	1.05
$L_5 \times T_1$	78.79	86.59	18.58	22.77	1.06	$L_7 \times T_3$	80.63	77.38**	22.37**	22.59	1.03
$L_6 \times T_1$	75.78**	86.03	13.56	28.50**	1.17						

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

Table 2 : Percentage of heterosis for earliness and certain growth characters

Characters	Days to 50 per cent flowering			Plant height at maturity			Number of tillers per plant			Flag leaf length			Flag leaf breadth		
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)
$L_1 \times T_1$	-5.69**	-8.30**	-2.93*	0.80	-2.46**	-2.46**	-2.87*	-19.84**	23.21**	0.80	-2.46**	-2.46**	-7.34**	-8.84**	-8.84**
$L_2 \times T_1$	0.93	-1.67	3.68**	9.55**	7.56**	11.62**	15.66**	1.85	33.79**	9.55**	7.56**	11.62**	-21.05**	-31.00**	-7.74**
$L_3 \times T_1$	5.47**	1.05	1.05	-2.11**	-11.21**	-11.21**	20.43**	20.43**	20.43**	-2.11**	-11.21**	-11.21**	-15.83**	-18.75**	-18.75**
$L_4 \times T_1$	-12.54**	-16.69**	-16.69**	-27.14**	-37.67**	-12.34**	-14.97**	-37.37**	32.33**	-27.14**	-37.67**	-12.34**	-11.51**	-12.22**	-10.80**
$L_5 \times T_1$	-6.02**	-10.47**	-10.47**	-6.63**	-11.04**	-1.76**	-51.45**	-58.68**	-19.61**	-6.63**	-11.04**	-1.76**	-34.29**	-40.93**	-25.97**
$L_6 \times T_1$	-4.68**	-4.88**	-4.88**	-6.73**	-10.70**	-2.39**	-14.00**	-20.86**	-20.86**	-6.73**	-10.70**	-2.39**	13.34**	-7.34**	-7.34**
$L_7 \times T_1$	-8.72**	-9.84**	-7.57**	-0.47	-6.41**	-6.41**	-34.99**	-48.38**	-12.22**	-0.47	-6.41**	-6.41**	-0.37	-9.10**	-9.10**
$L_1 \times T_2$	-3.72**	-4.65**	2.93*	1.72**	-2.37**	-0.70	-30.11**	-34.00**	1.44	1.72**	-2.37**	-0.70	-0.30	-1.16	-2.70**
$L_2 \times T_2$	-1.94*	-3.08**	4.63**	-2.73**	-3.69**	-0.06	-9.00**	-10.74**	21.91**	-2.73**	-3.69**	-0.06	-14.63**	-26.15**	-1.26
$L_3 \times T_2$	0.10	-7.55**	-0.20	2.77**	-7.49**	-5.90**	6.53**	-7.74**	26.01**	2.77**	-7.49**	-5.90**	-8.80**	-11.29**	-12.67**
$L_4 \times T_2$	-8.51**	-9.55**	-0.08	-7.74**	-20.51**	11.80**	-51.32**	-59.93**	-15.33**	-7.74**	-20.51**	11.80**	-7.98**	-9.42**	-7.95**
$L_5 \times T_2$	-9.66**	-10.69**	-1.34	-16.96**	-20.24**	-11.92**	-32.71**	-48.66**	-0.12	-16.96**	-20.24**	-11.92**	-28.22**	-35.92**	-19.69**
$L_6 \times T_2$	-0.16	-4.03**	3.60**	-28.31**	-30.80**	-24.36**	25.56**	1.41	38.50**	-28.31**	-30.80**	-24.36**	-4.98**	-21.84**	23.05**
$L_7 \times T_2$	-4.32**	-6.73**	0.68	-6.91**	-13.15**	-11.66**	-21.22**	-28.97**	20.78**	-6.91**	-13.15**	-11.66**	-33.07**	-38.50**	-39.46**
$L_1 \times T_3$	-9.92**	-10.63**	-5.40**	-4.92**	-5.11**	-11.25**	-30.24**	-41.90**	-10.70**	-4.92**	-5.11**	-11.25**	2.62**	-8.12**	-11.11**
$L_2 \times T_3$	-5.25**	-5.81**	-0.69	0.77	-4.38**	-0.78	-32.13**	-39.63**	-20.70**	0.77	-4.33**	-0.78	-35.67**	-49.44**	-32.39**
$L_3 \times T_3$	3.23**	-2.99**	1.07	14.01**	6.82**	-0.49	5.06**	3.86*	6.28**	14.01**	6.82**	-0.49	25.42**	14.25**	6.33**
$L_4 \times T_3$	-2.98**	-5.74**	4.12**	-14.56**	-28.98**	-0.11	-19.37**	-40.16**	26.44**	-14.56**	-28.98**	-0.11	9.56**	-3.99**	-2.43**
$L_5 \times T_3$	-6.82**	-9.47**	0.00	-12.49**	-19.34**	-10.92**	-14.00**	-20.86**	-20.86**	-12.49**	-19.34**	-11.92**	-20.52**	-36.01**	-19.80**
$L_6 \times T_3$	3.17**	0.89	5.11**	9.79**	1.68**	11.14**	31.46**	19.71**	22.51**	9.79**	1.68**	11.14**	18.20**	8.17**	-17.25**
$L_7 \times T_3$	-2.07*	-2.86*	1.21	-3.11**	-5.76**	-12.21**	-4.14**	-23.23**	30.54**	-3.11**	-5.76**	-12.21**	-7.59**	-10.94**	-26.55**

*significant at 5% level   RH- Relative Heterosis   HB – Heterobeltiosis   SH – Standard Heterosis
**significant at 1% level

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