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HETEROSIS FOR QUALITY CHARACTERS IN RICE (*ORYZA SATIVA* L.)

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Abstract

Twenty eight hybrids of rice along with their seven lines and four testers in a line × tester mating design were used to assess the extent of heterotic effects over mid, better and standard parent for grain yield per plant and quality characters. Out of 28 F_1 hybrids, two crosses namely STBN 25 × IR 64 (L_3×T_4) and RNR 15048 × ADT 43 (L_7×T_2) showed superior performance with significant positive heterosis for grain yield per plant and most of the quality characters. RNR 15048 × ADT 37 (L_7×T_1) exhibited high heterosis for grain L/B ratio, where as the cross MTU 1010 × ADT 43 (L_6×T_2) showed excellent heterosis for kernel L/B ratio. The cross RNR 15048 × ADT 43 (L_7×T_2) recorded significant standard heterosis for grain yield per plant in addition to the quality characters like grain length, grain L/B ratio, kernel length and kernel L/B ratio. Hence, these hybrids *viz.,* L_3 × T_4 and L_7 × T_2 could be utilized for further crop improvement programme.

Key words: Rice, Heterosis, L×T, Quality traits.

Introduction

Rice is one of the world's most important staple food crops and it is the primary source of food for more than half of the world's population. Rice (*Oryza sativa* L. 2n = 2x = 24) is an important cereal crop cultivated widely in many parts of the world. The genus *Oryza* belongs to the tribe *Oryzeae* and family Poaceae. Genus *Oryza* includes 24 species, of which only two species *viz., O. sativa* and *O. glaberrima* are cultivated.

Rice is grown throughout the world in 160.77 million hectares with the production of 486.15 million metric tonnes during 2016-17. The productivity is 4.51 metric tones per hectare. Similarly, in India the rice cultivated area was recorded to be 43.10 million hectares. The productivity and production were 3.82 metric tones per hectare and 109.70 million metric tonnes respectively (Anon, 2018).

To achieve the target yield level, rice varieties with a yield advantage of about 20 per cent over widely grown varieties must be developed with higher yield potential. Higher yields of rice have always been a predominant goal in rice breeding techniques.

For any successful breeding programme to improve grain yield and component characters, it is essential to know precisely the genetic architecture of these characters under prevailing conditions. It is very much essential to measure the extent of genetic dissimilarity among the parental lines involved in hybridization programmes for exploitation of heterotic vigour because high genetic dissimilarity among parental lines exhibits high heterotic response (Moll and Stubber, 1976). Serious attention is required to develop high yielding varieties of rice using various crop breeding techniques. The study of heterosis will provide the basic information regarding the breeding methodology to be employed for the varietal improvement. The cross combinations showing good heterosis involving parents with high general combining ability can be used in developing high yielding pure lines. It also helps in rejecting large number of crosses in first generation itself and selecting only those with high potential. In short the study of heterosis helps the plant breeder in eliminating the less productive crosses in early generations. Now a days, it has been mandatory to exploit heterosis in self pollinated crops like rice for enhancing crop productivity. Selection of parental cross combinations should be exploited on the basis of manifestation of heterosis for varietal improvement (Satheeshkumar, 2015). The objective of this experiment was to estimate the magnitude of heterosis for grain yield and its

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component characters.

Materials and Methods

Seven lines *viz.,* STBN 14 (L_1), STBN 15 (L_2), STBN 25 (L_3), STBN 26 (L_4), STBN 27 (L_5), MTU 1010 (L_6) and RNR 15048 (L_7) and four testers [ADT 37 (T_1), ADT 43 (T_2), CO 41 (T_3) and IR 64 (T_4)] and their twenty eight hybrids grown in randomized block design with three replication during Samba, 2017 at plant breeding farm (11°24'N latitude, 79°44'E longitude and ± 5.79m MSL), Faculty of agriculture, Annamalai University located at East Coastal Region of Tamil Nadu, India with soil pH of 8 to 8.5 and EC of 2.51 to 2.81 dSm^{-1}, twenty five days old seedlings were transplanted in 3m rows at a spacing of 20 × 15 cm between and within rows respectively. All the recommended package of practices was followed to raise a good crop.

For this study, estimation of heterosis of grain yield and quality traits *viz.,* grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth, kernel L/B ratio and grain yield per plant were recorded on five randomly selected plants in each replication.

Statistical analysis

Heterosis

The mean of parents and F_1 hybrids were utilized for the estimation of heterosis. Relative heterosis (d_i) was estimated as per cent deviation of the F_1 from the mid parental value (MP). Heterobeltiosis (d_{ii}) was estimated as per cent increase or decrease of F_1 over better parent (BP). Standard heterosis (d_{iii}) for each character was expressed as per cent increase or decrease of F_1 over the standard variety (SV) (Fonesca and Patterson, 1968).

$$\text{Relative heterosis } (d_i) = \frac{\overline{F_1} \quad \overline{MP}}{\overline{MP}} \quad 100$$

$$\text{Heterobeltiosis } (d_{ii}) = \frac{\overline{F_1} \quad \overline{BP}}{\overline{BP}} \quad 100$$

$$\text{Standard heterosis } (d_{iii}) = \frac{\overline{F_1} \quad \overline{SP}}{\overline{SP}} \quad 100$$

where,

$\overline{F_1}$ = Mean of the F_1 hybrid

$\overline{MP}$ = Mean of the mid parent

$\overline{BP}$ = Mean of the better parent

$\overline{SP}$ = Mean of the standard variety

In the present study, ADT 43 was considered as the standard parent.

Test of significance

The significance of heterosis was tested using the formula as suggested by Wynne *et al.,* (1970).

$$\text{'t' over Relative heterosis } (d_i) = \frac{\overline{F_1} \quad \overline{MP}}{3\sigma_e^2 / 2r^{\ 1/2}}$$

$$\text{'t' over Heterobeltiosis } (d_{ii}) = \frac{\overline{F_1} \quad \overline{BP}}{3\sigma_e^2 / 2r^{\ 1/2}}$$

$$\text{'t' over Standard heterosis } (d_{iii}) = \frac{\overline{F_1} \quad \overline{SP}}{3\sigma_e^2 / 2r^{\ 1/2}}$$

Where,

'σ_e^2' is the error variance obtained from the analysis of variance.

'r' is the number of replications.

The calculated 't' value was compared with the table value of 't' at the error degrees of freedom.

Results and Discussion

The analysis of variance showed significant differences among the hybrids, lines and interaction effect L × T for all the seven traits *viz.,* grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth, kernel L/B ratio and grain yield per plant. The tester was significant for grain length, grain breadth, kernel length, kernel breadth and grain yield per plant (Table 1). The similar results was observed by Satheeshkumar and Saravanan (2011), Montazeri *et al.,* (2014) and Satheeshkumar *et al.,* (2016).

The value of percentage heterosis of hybrids for all the seven characters over mid, better and standard parent are given in the Table 2. Heterosis for grain length ranged from –15.93 ($L_3 \times T_{-2}$) to 11.47 ($L_7 \times T_1$) percent for mid parent and –16.12 ($L_3 \times T_2$) to 10.87 ($L_7 \times T_1$) percent for better parent. For standard heterosis it was ranged from –7.72 ($L_7 \times T_4$) to 16.12 ($L_3 \times T_2$) percent and out of 28 hybrids, 8 hybrids recorded significantly positive standard heterosis. Similar findings were reported by Dar *et al.,* (2015) and Ramesh *et al.,* (2018) for this trait in rice.

For grain breadth, the range of heterosis from –18.10 ($L_2 \times T_2$) to 16.76 ($L_4 \times T_3$) percent for mid parent and –19.67 ($L_2 \times T_2$) to 14.01 ($L_4 \times T_3$) percent for better parent.

Table 1: Analysis of variance for combining ability for seven characters in rice.

Source	df	MSS						
		Grain length	**Grain breadth**	**Grain L /B ratio**	**Kernel length**	**Kernel breadth**	**Kernel L/B ratio**	**Grain yield per plant**
Replication	2	0.1739	0.0144	0.0821	0.0236	0.0127	0.1366	6.6521
Hybrid	27	0.9778**	0.0733**	0.1353**	1.1605**	0.0159**	0.2176**	72.3542**
Line	6	1.4832**	0.1455**	0.1539**	3.0346**	0.0270**	0.3300**	80.7432**
Tester	3	1.7120**	0.0749**	0.0685	1.0266**	0.0159*	0.1038	83.4951**
L´T	18	0.6870**	0.0490**	0.1403**	0.5531**	0.0122**	0.1992**	67.7010**
Error	76	0.1449	0.0071	0.0310	0.0596	0.0053	0.0484	5.4573

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

The range of standard heterosis it was from –8.79 ($L_2 \times T_3$) to 19.67 ($L_2 \times T_2$) percent and among the 28 hybrids, twelve hybrids recorded significantly negative standard heterosis. This findings is in accordance with that of Satheeshkumar *et al.,* (2016).

The range of heterosis for grain L/B ratio over mid parent was from –19.30 ($L_4 \times T_2$) to 20.15 ($L_7 \times T_1$) percent and better parent range was from –22.36 ($L_4 \times T_3$) to 13.30 ($L_7 \times T_1$) percent. The range for standard heterosis it was from –1.42 ($L_3 \times T_4$) to 28.33 ($L_7 \times T_1$) percent and nine hybrids recorded significantly positive standard heterosis similar observations have been reported earlier by Ramesh *et al.,* (2018) in rice.

The magnitude of heterosis for kernel length, ranged from –20.32 ($L_1 \times T_1$) to 25.21 ($L_6 \times T_3$) percent for mid parent and –24.97 ($L_1 \times T_3$) to 22.80 ($L_6 \times T_3$) percent for better parent. The standard heterosis ranged from –

Table 2: Estimates of heterosis for various traits in rice.

Hybrids	Grain length			Grain breadth			Grain L/B ratio			Kernel length		
	d_i	d_{ii}	d_{iii}	d_i	d_{ii}	d_{iii}	d_i	d_{ii}	d_{iii}	d_i	d_{ii}	d_{iii}
L1×T1	-5.35	-7.63*	13.83**	9.60**	4.80	-4.07	-13.92**	-15.85**	10.47**	-20.32**	-24.51**	22.67**
L1×T2	3.70	-2.12	-2.12	3.23	-5.27*	-5.27*	-0.25	-3.25	2.95	-18.88**	-19.84**	17.89**
L1T3	3.49	-2.73	-1.85	16.26**	13.82**	-4.95*	-11.21**	-18.03**	3.05	-16.19**	-24.97**	23.14**
L1T4	4.01	-2.48	-1.07**	3.29	-3.75	-6.92**	0.38	-0.38	6.00	-18.76**	-20.12**	18.17**
L2T1	-5.18	-9.72**	15.78**	1.17	-1.26	-5.05*	-6.45	-13.00	11.59**	-12.10**	-12.54**	19.02**
L2T2	-6.92*	-14.20**	14.20**	-18.10**	-19.67**	19.67**	13.77**	6.61	6.61	-18.82**	-21.83**	21.83**
L2T3	6.29*	-2.43	-1.54	3.56	-5.14*	-8.79**	1.0	-14.39**	7.62	-6.75*	-12.59**	19.06**
L2T4	-4.97	-12.98**	11.72**	-14.76**	-15.00**	17.80**	11.37**	2.13	7.01	-9.66**	-12.58**	13.44**
L3T1	3.01	-0.24	-0.67	2.82	0.81	-3.96	0.15	-1.07	3.05	7.18**	4.62	0.70
L3T2	-15.93**	-16.12**	16.12**	-17.50**	-19.45**	19.45**	2.54	0.49	4.67	-18.28**	-19.81**	19.81**
L3T3	-0.70	-1.36	-0.47	9.22**	0.46	-4.29	-9.81**	-17.54**	16.66**	10.36**	1.61	-2.20
L3T4	12.46**	13.27**	12.02**	-1.20	-1.93	-5.16*	3.74	-1.42	-1.42	5.36*	-4.26	-4.26
L4T1	4.50	3.20	-3.73	9.46**	4.92*	-3.96	-4.60	-7.43	0.00	-5.53*	-6.64	14.43**
L4T2	-9.41**	-13.50**	13.50**	11.59**	2.64	2.64	-19.30**	-22.30**	16.06**	-8.70**	-13.49**	13.49**
L4T3	-3.47	-8.22**	-7.39*	16.76**	14.01**	-4.29	-17.57**	-23.36**	23.66**	15.44**	9.94**	-1.59
L4×T4	-0.77	-5.89	-4.56	4.87**	-2.05	-5.27*	5.64	-7.06	0.41	-3.20	-7.85**	-8.76**
L5T1	9.07**	7.38*	0.17	2.65	-1.33	-2.09	6.03	0.30	1.93	7.13**	1.99	3.42
L5T2	1.94	-2.96	-2.96	-3.36	-3.74	-3.74	5.44	0.51	0.51	-12.60**	-13.21**	11.99**
L5T3	4.48	-0.97	-0.07	8.64**	-1.88	-2.64	-5.40	-18.59**	22.34**	3.90	-6.56*	-5.25
L5T4	1.87	-3.67	-2.28	-2.86	-4.10	-4.84*	4.73	-2.33	2.34	-14.28**	-15.29**	14.10**
L6T1	9.25**	8.21*	0.94	1.95	-2.62	-2.09	6.60	1.00	2.64	5.35	1.07	-7.35*
L6T2	0.65	-3.63	-3.63	-6.30**	-6.56**	-6.04**	7.08	2.24	2.24	3.69	-4.50	-4.50
L6T3	3.46	-1.36	-0.47	6.39**	-4.48*	-3.96	-4.60	-17.78**	3.35	25.21**	22.80**	3.42
L6T4	0.35	-4.57	3.19	-4.51*	-6.34**	-5.82**	4.78	-2.13	2.54	1.12	-6.43	-7.35
L7T1	11.47**	10.87**	3.43	-7.26**	-12.06**	10.22**	20.15**	13.30**	28.33**	18.85**	12.42**	3.04
L7T2	2.86*	6.62*	6.62*	-6.58**	-7.53**	-5.60*	11.48**	11.74**	17.52**	19.69**	20.81**	21.59**
L7T3	3.74	-0.70	0.0	1.27	-9.69**	-7.80**	0.42	-13.82**	25.14**	21.47**	20.92**	-1.17
L7×T4	-4.73	-9.04**	-7.72*	-11.77**	-14.10**	12.31**	7.77**	0.19	4.98	7.18**	-2.18	-3.14

*Significant at 5 percent level

**Significant at 1 percent level

d_i - Relative Heterosis ; d_{ii} -Heterobeltiosis ; d_{iii} – Standard Heterosis

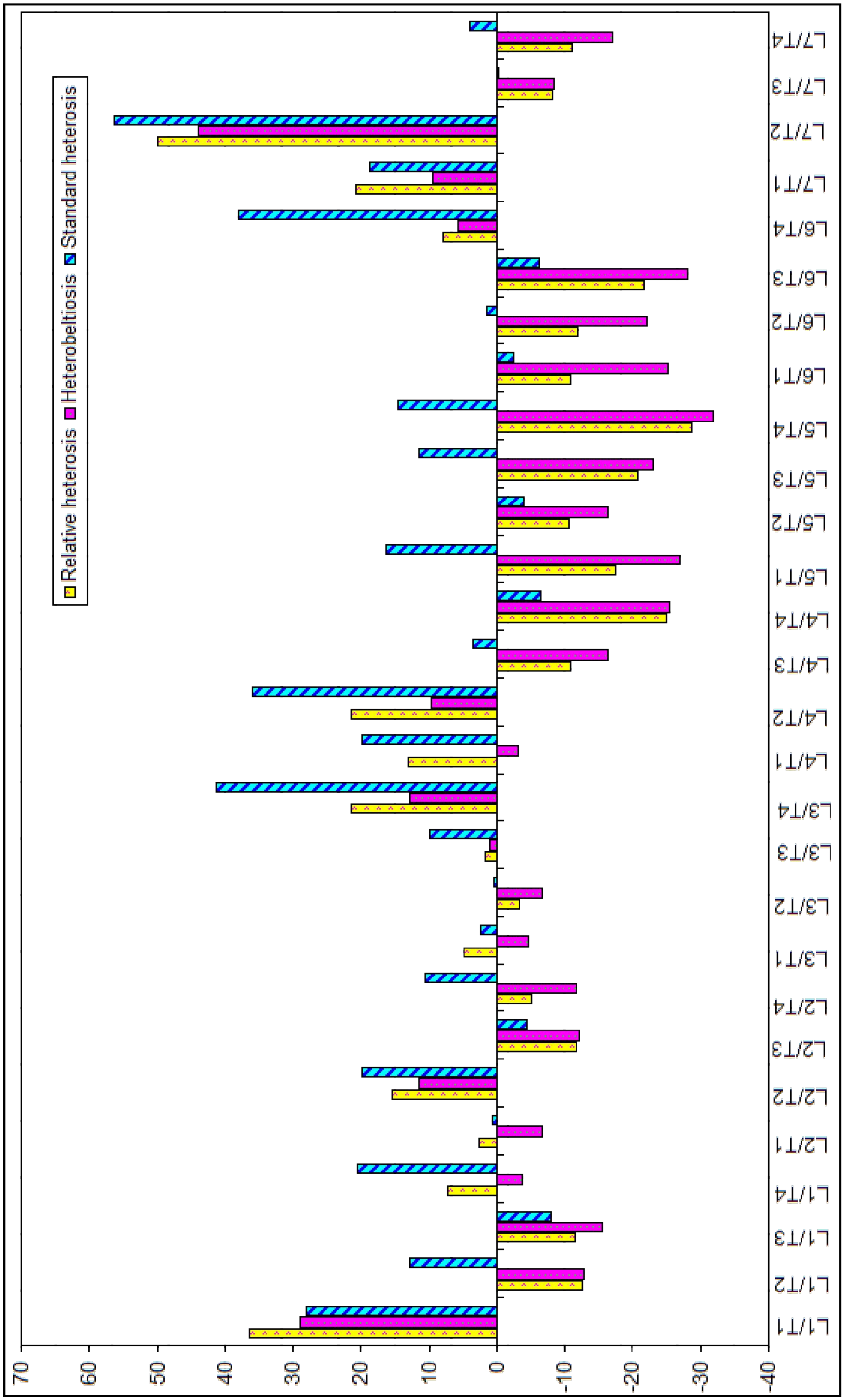

Fig. 1: Estimates of heterosis for grain yield per plant

Table 3: Continued. Estimates of heterosis for various traits in rice.

Hybrids	Kernel breadth			Kernel L/B ratio			Grain yield per plant		
	d_i	d_{ii}	d_{iii}	d_i	d_{ii}	d_{iii}	d_i	d_{ii}	d_{iii}
L1×T1	6.64**	5.24*	-2.69	-14.61**	-15.37**	11.22	36.47**	28.92**	28.02**
L1×T2	-0.14	-5.11*	-5.11*	4.63	2.18	7.19	-12.57*	-12.87	12.87
L1×T3	-2.20	-4.03	10.23**	4.35	0.58	13.73*	-11.54	-15.39*	-7.96
L1×T4	-0.64	-4.79	-6.46**	3.53	1.91	10.35	7.29	-3.80	20.44**
L2×T1	0.43	-0.29	-6.46**	-3.08	-8.46	-5.66	2.68	-6.54	0.61
L2×T2	-7.64**	-10.50**	10.50**	5.06	0.65	0.65	15.50*	11.40	19.91**
L2×T3	-7.76**	-7.89**	13.59**	15.81**	4.82	18.52**	-11.68*	-12.14	-4.42
L2×T4	-1.89	-4.11	-5.79*	-5.07	-12.37*	-5.12	-5.05	-11.71*	10.55
L3×T1	-3.13	-5.29*	-8.34**	8.54	6.40	14.16	4.75	-4.55	2.50
L3×T2	-3.15	-4.71	-4.71	-15.71**	-18.58**	12.64*	-3.23	-6.56	0.34
L3×T3	0.71	-0.97	-4.17	-9.34*	-11.66*	-0.11	1.74	1.09	9.97
L3×T4	-1.73	-2.47	-4.17	-9.35*	-9.76	-2.29	21.46**	12.82*	41.25**
L4×T1	10.12**	7.71**	-0.40	6.97	-7.70	-3.38	13.02*	-3.20	19.90**
L4×T2	0.14	-5.65*	-5.65*	-5.80	-7.91	-3.59	21.45**	9.75	35.94**
L4×T3	5.77*	2.88	-3.77	-15.26**	-18.40**	-7.73	-10.94*	-16.36**	3.60
L4×T4	3.68	-1.51	-3.23	-2.30	-3.92	4.03	-24.93**	-25.33**	-6.51
L5×T1	-0.56	-3.81	-4.85*	12.22*	6.77	10.02	-17.51**	-27.02**	16.23*
L5×T2	-6.63**	-7.13**	-7.13**	12.87*	8.93	8.93	-10.59	-16.35**	-3.98
L5×T3	-0.70	-3.40	-4.44	4.44	-4.82	7.63	-20.88**	-22.95**	11.56
L5×T4	-8.76**	-8.98**	-9.96**	12.88*	4.93	13.62*	-28.82**	-31.79**	14.59*
L6×T1	1.91	1.16	-6.46**	9.01	8.67	11.98*	-10.84**	-25.26**	-2.45
L6×T2	-6.76**	-10.90**	10.99**	11.63**	10.32**	12.96*	-11.84*	-22.15**	1.60
L6×T3	2.33	1.01	-5.52*	7.18	2.12	15.47**	-21.59**	-28.12**	-6.19
L6×T4	1.21	-2.47	-4.17	0.93	-3.62	4.36	7.91	5.71	37.97**
L7×T1	1.98	1.02	-6.59**	11.53*	11.12	15.36*	20.67**	9.43	18.76*
L7×T2	-4.87*	-9.29**	-9.29**	7.54	5.56	9.59	49.83**	43.95**	56.22**
L7×T3	-0.37	-1.87	-8.21**	2.16	-2.02	10.78	-8.26	-8.36	-0.32
L7T4	-3.85	-7.53*	-9.15**	-4.57	-6.54	1.20	-11.14*	-17.05**	3.85

*Significant at 5 percent level **Significant at 1 percent level

d_i - Relative Heterosis ; d_{ii} -Heterobeltiosis ; d_{iii} – Standard Heterosis

8.76 ($L_4 \times T_4$) to 23.14 ($L_1 \times T_3$) percent and fourteen hybrids recorded significantly positive standard heterosis. These results are in consonance with Rukmini Devi *et al.,* (2017).

Heterosis for kernel breadth ranged from –7.76 ($L_2 \times T_3$) to 10.12 ($L_4 \times T_1$) percent over mid parent and –10.90 ($L_6 \times T_2$) to 7.71 ($L_4 \times T_1$) percent for better parent. The range of standard heterosis it was from –9.96 ($L_5 \times T_4$) to 13.59 ($L_2 \times T_3$) percent. Significant and negative heterosis for this trait on all the three bases of estimation was observed in three crosses *viz.,* $L_5 \times T_2$, $L_5 \times T_4$ and $L_7 \times T_2$. Similar findings were reported by Satheeshkumar *et al.,* (2016) and Devi *et al.,* (2017) for this trait in rice.

For kernel L/B ratio, the range of heterosis over mid parent was from –15.71 ($L_3 \times T_2$) to 15.81 ($L_2 \times T_3$) percent and better parent range was from –18.58 ($L_3 \times T_2$) to 10.32 (L_6T_2) percent. The range of standard heterosis was from –7.73 ($L_4 \times T_3$) to 18.52 ($L_2 \times T_3$) percent and eight hybrids recorded significantly positive standard heterosis. This finding is in accordance with that of Satheeshkumar *et al.,* (2016) and Rukmini Devi *et al.,* (2017).

Heterosis for grain yield per plant, ranged from –28.82 ($L_5 \times T_4$) to 49.83 ($L_7 \times T_2$) percent for mid parent and –31.79 ($L_5 \times T_4$) to 43.95 ($L_7 \times T_2$) percent for better parent. For standard heterosis it was from –7.96 ($L_1 \times T_3$) to 56.22 ($L_7 \times T_2$) percent and eleven hybrids recorded significantly positive standard heterosis. Significant and positive heterosis for this trait on all the three bases of estimation was observed in three crosses *viz.,* $L_1 \times T_1$, $L_3 \times T_4$ and $L_7 \times T_2$ (Fig. 1). Similar observations have been reported earlier by Sandhyakishore *et al.,* (2016), Thorat *et al.,* (2017) and Parimala *et al.,* (2018).

In general, it was observed that positive and high magnitude of heterosis were noticed in yield and yield contributing characters. Among the twenty eight hybrid combinations, two hybrids namely $L_7 \times T_2$ showed high heterotic vigour for traits *viz.,* kernel length, grain L/B ratio, kernel length and grain yield per plant and $L_3 \times T_4$ expressed high heterosis for grain length and grain yield per plant. These two hybrids recorded significant standard heterosis for more than one quality characters in addition to that of grain yield per plant. Hence, these hybrids could be exploited as commercial hybrids/varieties for further crop improvement.

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