Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP2: 488-491

S Ranjith Raja Ram
Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

R Anju
Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

KR Saravanan
Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Correspondence
S Ranjith Raja Ram
Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India

Heterosis analysis for yield and yield component traits in rice (*Oryza sativa* L.)

S Ranjith Raja Ram, R Anju and KR Saravanan

Abstract

An investigation in rice was undertaken to study the nature and magnitude of heterosis for yield and yield component traits involving seven lines and four testers and twenty eight hybrids were developed through line x tester mating design. Observations were recorded for ten characters *viz.*, days to 50 per cent flowering, plant height at maturity, number of productive tillers per plant, panicle length, number of grains per panicle, 100 grain weight, grain yield per plant, kernel length, kernel breadth and kernel L/B ratio. Significant heterosis for grain yield and yield component traits were observed in most of the hybrids. Four hybrids exhibited positive and significant heterosis over standard check for grain yield per plant. Standard heterosis and heterobeltiosis for grain yield ranged from -43.20 to 13.64% and -27.40 to 35.79% respectively. A total of three hybrids *viz.*, MTU 1001 X CO 51, IR 72 X TPS 5 and IR 72 X CO 51 were recorded higher grain yield over standard check and were identified as best hybrids for exploiting hybrid vigor. Most of the heterotic crosses for grain yield per plant were accompanied by heterosis for two or more component traits.

Keywords: rice, line x tester, heterosis, yield.

Introduction

Rice (*Oryza sativa* L. 2n=24) is the most important staple food crop for 65% of the global population. In India, rice is cultivated in the area of 44.5 million hectares and the annual rice production is about 131.9 million tonnes as per FAO stat. Division, 2015. Being the staple food of the population in India, improving its productivity has become a crucial importance (Subbaiah *et al.*, 2011) [5]. The government of India had set a target of expanding the cultivation of hybrid rice to 25% of the rice area by 2025 thereby contributing significantly towards national food security (Spielman *et al.*, 2013) [4]. The success of hybrid rice programme mainly depends upon the higher magnitude of heterosis for yield and yield contributing traits. Heterosis in rice was first reported by Jones (1926). In general, positive heterosis is desired for yield and negative heterosis for early maturity (Nuruzzaman *et al.*, 2002) [3]. Heterosis is expressed in three ways, depending on the criteria used to compare the performance of a hybrid (Gupta, 2000) [1]. The present study was undertaken to assess the nature and magnitude of heterosis.

Materials and Methods

The present investigation was carried out at Plant Breeding Farm, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India during the year 2017-2018. The experimental materials comprised of eleven rice genotypes, out of which MTU 1001 (L1), TRY 3 (L2), IR 72 (L3), ANNA 4 (L4), ASD 19 (L5), IR 36 (L6), WHITE PONNI (L7) were used as lines and MDU 5 (T1), ADT 36 (T2), TPS 5 (T3), CO 51 (T4) were used as testers. Staggered sowing of parents were taken up for the synchronization of flowering. The seeds were sown in raised nursery beds at ten days interval for synchronization. Seven lines and four testers were crossed in a line × tester mating fashion resulting in twenty eight hybrids.

In the crossing block, twenty six days old seedlings were transplanted at the rate of one seedling per hill with the spacing of 30cm between the rows and 20cm within the rows. Crosses were made between seven female and four male parents in line x tester fashion and totally 28 cross combinations were obtained by adopting hand emasculation and artificial pollination. The experiment was laid out in a randomized block design with three replications. Recommended cultural practices and plant protection measures were adopted.

Observations were recorded from five randomly selected plants in each treatment from three replications for ten characters *viz.*, days to 50 per cent flowering, plant height at maturity, number of productive tillers per plant, panicle length, number of grains per panicle, 100 grain weight, grain yield per plant, kernel length, kernel breadth and kernel L/B ratio. The mean of parents and F_1 hybrids were utilized for the estimation of heterosis. The relative heterosis (d_i), heterobeltiosis (d_{ii}) and standard heterosis (d_{iii}) were estimated as follows:

Relative heterosis (d_i) $= \frac{\overline{F_1}-\overline{MP}}{\overline{MP}} \times 100$

Heterobeltiosis (d_{ii}) $= \frac{\overline{F_1}-\overline{BP}}{\overline{BP}} \times 100$

Standard heterosis (d_{iii}) $= \frac{\overline{F_1}-\overline{SV}}{\overline{SV}} \times 100$

Where,

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

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

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

$\overline{SV}$ = mean of the standard variety

In the present study, CO 51 was considered as the standard parent.

Results and Discussion:

The analysis of variance for the ten traits were studied and presented in Table 1. All the twenty eight hybrids and eleven parents showed significance for all the characters such as days to 50 percent flowering, plant height, number of productive tillers per plant, panicle length, number of grains per panicle, 100 grain weight, grain yield per plant, kernel length, kernel breadth and kernel L/B ratio. The interaction effect (Line×Tester) indicating the existence of substantial amount of vigour in the hybrids. As a result highly significant at 1% level variation was observed among the hybrids which offers the scope for selection and further improvement by adopting suitable breeding procedure.

Percent heterosis over mid parents, better parents and commercial check were calculated for grain yield and yield related traits (Table 2). For plant height and days to 50% flowering negative heterosis were desirable but for rest of the characters positive heterosis were desirable.

The hybrids recorded 10.74 to 42.69% relative heterosis, -27.40 to 35.79% heterobeltiosis and -43.20 to 13.64% economic heterosis for grain yield per plant. The cross combinations MTU 1001 X CO 51, IR 72 X TPS 5 and IR 72 X CO 51 recorded highest potential for this trait (Table 2). Early maturing hybrids are desirable as they produce more yields per day and fit in multiple cropping systems. Maximum negative heterosis for days to 50% flowering was observed in the hybrid L_3×T_2 (-3.08 %) compared to standard check and -11.43% by the hybrid L_2×T_1 on better parent. Out of 28 hybrids, only two hybrids *viz.*, L_3×T_1 and L_3×T_2 registered significant negative standard heterosis.

Shorter plant type is an important character of a hybrid to withstand lodging. For plant height, Heterobeltiosis ranged from -3.07% (L_6×T_3) to -29.49% (L_4×T_3). The spectrum of variation for standard heterosis ranged from -4.06% (L_1×T_2) to -28.15% (L_4×T_3). 10 out of 28 cross combinations expressed maximum significant standard heterosis in negative direction. Number of productive tillers per plant is known to directly contribute towards grain yield. In case of productive tillers per plant, heterosis over better parent varied from 8.73% (L_7×T_1) to 25.61% (L_3×T_3). 10 hybrids out of 28, were registered positive significant values for heterobeltiosis. With respect to standard heterosis, the range was from 8.62% (L_5×T_3) to 22.28% (L_7×T_4) and 8 out of 28 hybrids recorded significantly positive values.

For panicle length, 12 among the 28 hybrids registered significantly positive heterobeltiosis and 4 out of 28 hybrids exhibited significantly positive standard heterosis for the above said trait. The hybrid L_3×T_4 (11.31%) recorded the highest standard heterosis in this regard. In respect to number of grains per panicle, 13 and 5 crosses exhibited positive and significant heterobeltiosis and standard heterosis respectively.The hybrid L_3×T_4 (5.72%) recorded the highest standard heterosis in this regard.

Out of 28 hybrids tested, 16 hybrids showed positively significant heterobeltiosis over their respective better parental values, while 3 crosses exhibited significant positive heterosis over standard check for hundred grain weight. The hybrid L_3×T_4 (6.32%) recorded the highest standard heterosis for hundred grain weight. For kernel length, the standard heterosis value ranged from 1.27% (L_2×T_4) to 22.49% (L_1×T_4). Out of 28 crosses, 13 and 9 hybrids have recorded positive significant standard heterosis and heterobeltiosis respectively.

For kernel breadth, the better parental values ranged from 3.33% (L_3×T_1) to 14.87% (L_7×T_4). Out of 28 hybrids, 21 have recorded the significantly positive heterobeltiosis value. The maximum significant and positive standard heterosis value of 27.89% was recorded by L_1×T_4. For kernel L/B ratio, the standard heterosis ranged from 4.69% (L_2×T_2) to 25.06% (L_4×T_2). 7 hybrids out of 28 crosses exhibited positive significant standard heterosis for this trait.

Conclusion

Among the hybrids, $L_1 \times T_4$ was identified as the best performing hybrid since it had possessed significant and positive standard heterosis for all the traits except days to 50 percent flowering, plant height and kernel L/B ratio. The next best hybrid identified was $L_3 \times T_4$, since it possessed desirable standard heterosis for almost all the traits except days to 50 percent flowering, plant height, kernel breadth, kernel L/B ratio. The hybrid $L_3 \times T_3$ showed short statured plant along with the desirable standard heterosis for the characters like number of productive tillers per plant, panicle length, grain yield per plant. The hybrid $L_3 \times T_2$ recorded earliness and also significant standard heterosis for kernel L/B ratio. The hybrid $L_4 \times T_4$ showed short statured plant and significant standard heterosis for kernel length.

Hence, from the foregoing discussion, it may be concluded that the crosses $L_1 \times T_4$ (MTU 1001 X CO 51) and $L_3 \times T_4$ (IR 72 X CO 51) can be rated as best hybrid and the hybrids $L_3 \times T_3$ (IR 72 X TPS 5), $L_3 \times T_2$ (IR 72 X ADT 36) and $L_4 \times T_4$ (ANNA 4 X CO 51) can be rated as better hybrids based on the magnitude of heterosis.

Table 1: Analysis of Variance for Ten Characters in Rice

Source	df	Days to 50 percent flowering	Plant height	Number of productive tillers per plant	Panicle length	Number of grains per panicle	100 grain weight	Grain yield per plant	Kernel length	Kernel breadth	Kernel L/B ratio
Replication	2	13.5274	1.3246	0.5346	1.1870	0.4126	0.0013	0.0349	0.0003	0.0044	0.0032
Hybrids	27	128.3574**	613.6949**	18.3288**	33.5816**	349.7347**	0.3040**	166.4565**	1.6593**	0.2439**	0.2353**
Line	6	482.6958**	2431.2472**	41.0053**	50.2114**	515.7821**	0.3500**	309.2446**	6.2126**	0.6943**	0.7296**
Testers	3	38.2971**	96.2451**	61.8038**	153.6758**	1707.8762**	1.5511**	771.4813**	1.9475**	0.6966**	0.4286**
Lines × Testers	18	25.2547**	94.0858**	3.5242**	8.0227**	68.0287**	0.0808**	18.0231**	0.0934**	0.0183**	0.0383**
Error	54	2.1898	1.2978	1.3731	1.5079	1.2367	0.0004	1.3511	0.0004	0.0009	0.0009

* - Significant at 5 percent Level
** - Significant at 1 percent Level

Table 2: Estimate of Heterosis over Mid Parent (MP), Better Parent (BP) and Standard Check (SC) for yield and yield contributing traits in rice

Hybrids	DFF			PH			NPT			PL			NG		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
L_1XT_1	6.42**	-0.80	14.24**	-9.29**	-14.54**	-10.15**	27.16**	7.64	-6.28	19.64**	16.26**	-6.67*	5.06**	3.93**	-8.87**
L_1XT_2	1.86	-5.58**	8.74**	-7.32**	-15.89**	-4.06**	5.03	0.87	-12.17**	5.94	0.69	-23.73**	10.98**	2.90**	-9.77**
L_1XT_3	4.14**	-2.28	12.54**	-4.25**	-8.45**	-6.71**	19.31**	14.94**	8.00	20.53**	7.91*	3.39	6.34**	1.12	-1.68**
L_1XT_4	8.71**	1.56	16.96**	-8.65**	-11.87**	-11.87**	25.81**	17.67**	17.67**	22.86**	7.96*	7.96*	11.75**	4.87**	4.87**
L_2XT_1	-4.89**	-11.43**	2.21	1.97*	-11.80**	27.02**	27.23**	5.62	-3.48	24.79**	21.24**	3.21	4.72**	4.19**	-9.69**
L_2XT_2	8.63**	0.60	16.09**	3.58**	-7.19**	33.66**	10.65**	3.87	-5.09	11.33**	0.29	-14.62**	12.37**	4.75**	-9.20**
L_2XT_3	-5.03**	-10.91**	2.74	2.33**	-12.63**	25.82**	17.88**	16.26**	9.24*	17.52**	10.97**	6.32*	6.28**	0.52	-2.27**
L_2XT_4	10.20**	2.68*	18.49**	-6.98**	-21.20**	13.49**	17.19**	12.14**	12.14**	11.80**	3.49	3.49	5.49**	-1.54**	-1.54**
L_3XT_1	-1.83	-2.53	-2.99*	-1.84*	-4.18**	0.73	25.39**	4.09	-4.88	20.64**	12.83**	4.05	4.26**	0.56	-7.14**
L_3XT_2	-1.32	-1.44	-3.08*	-7.04**	-12.72**	-0.44	11.50*	4.66	-4.36	12.03**	-2.54	-10.12**	10.87**	0.41	-7.28**
L_3XT_3	0.93	-0.49	0.45	-14.70**	-15.45**	-13.84**	27.37**	25.61**	18.03**	13.79**	11.66**	6.98*	8.59**	5.86**	2.93**
L_3XT_4	1.86	0.89	0.89	-5.82**	-5.88**	-5.77**	25.46**	20.05**	20.05**	15.82**	11.31**	11.31**	9.92**	5.72**	5.72**
L_4XT_1	0.73	-1.78	2.88	-11.40**	-20.70**	-16.63**	6.55	-3.86	-27.90**	13.94**	2.96	-17.35**	11.85**	0.71	-13.60**
L_4XT_2	2.06	-1.06	3.64*	-11.43**	-23.46**	-12.70**	12.33*	8.71	-12.84**	4.68	2.05	-30.37**	4.77**	0.43	-24.76**
L_4XT_3	-0.81	-2.61	2.01	-22.31**	-29.49**	-28.15**	9.22*	-1.80	-7.72	19.78**	0.40	-3.80	13.56**	-3.10**	-5.78**
L_4XT_4	-2.56*	-4.76**	-0.25	-14.63**	-21.86**	-21.86**	-4.71	16.62**	-16.62**	-7.74*	-23.98**	-23.98**	6.02**	-10.57**	-10.57**
L_5XT_1	3.10*	-3.90**	10.67**	-7.52**	-12.51**	3.11**	30.29**	8.57	-1.72	16.77**	13.30**	-9.04**	5.60**	1.36*	-13.04**
L_5XT_2	5.64**	-2.07	12.78**	-8.22**	-9.70**	6.43**	6.85	0.74	-8.81*	8.64*	3.41	-21.92**	4.12**	1.49*	-19.92**
L_5XT_3	8.22**	1.54	16.94**	-8.50**	-14.69**	0.54	17.76**	15.60**	8.62*	17.15**	4.74	0.35	10.09**	-0.28	-3.05**
L_5XT_4	13.48**	6.01**	22.09**	-8.60**	-15.53**	-0.44	2.90	-1.98	-1.98	12.80**	-1.01	-1.01	4.68**	-6.36**	-6.36**
L_6XT_1	-0.34	-3.76**	2.85	-4.38**	-4.76**	0.94	17.24**	1.81	-16.62**	14.60	11.13**	-10.79**	3.33**	1.71*	-9.91**
L_6XT_2	-1.40	5.33**	1.18	-3.89**	-7.29**	5.75**	3.60	2.51	-16.05**	5.16	0.15	-24.47**	9.63**	1.81	-10.39**
L_6XT_3	0.51	-2.27	4.45**	-1.17	-3.07**	2.73*	9.71*	2.66	-3.53	15.46**	3.17	-1.15	5.54**	0.84	-1.96**
L_6XT_4	-3.18*	-6.29**	0.15	-3.47**	-6.20**	-0.59	12.32**	2.16	2.16	16.24**	1.95	1.95	11.06**	4.71**	4.71**
L_7XT_1	7.24**	-5.21**	22.87**	-10.07**	-23.70**	15.10**	35.18**	8.73*	7.79	1.95	-3.53	-13.23**	1.85**	-0.59	-10.41**
L_7XT_2	10.71**	-2.65*	26.18**	-10.59**	-21.49**	18.43**	13.77**	2.89	2.00	21.89**	7.18*	-3.60	16.47**	6.64**	-3.89**
L_7XT_3	5.35**	-6.30**	21.45**	9.80**	-8.01**	38.77**	20.27**	17.13**	16.12**	12.21**	8.78**	4.22	4.67**	0.85	-1.95**
L_7XT_4	9.76	-2.78*	26.01**	4.71**	-12.94**	31.33**	22.81**	22.28**	22.28**	9.96**	4.43	4.43	7.75**	2.43**	2.43**

Table 2 contd…

Hybrids	GW			GY			KL			KB			K. L/B		
	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
L_1XT_1	13.45**	12.23**	-14.94**	20.90**	14.41**	-26.89**	9.87**	-5.71**	14.29**	14.99**	0.84	26.71**	-4.01*	-6.05**	-9.88**
L_1XT_2	9.71**	6.32**	-21.16**	31.17**	19.82**	-23.43**	7.19**	-6.08**	13.85**	20.38**	0.21	25.92**	-12.21**	-17.66**	-9.63**
L_1XT_3	8.16**	4.53**	-16.90**	21.70**	10.07**	-13.03**	15.12**	-0.28	20.88**	12.98**	1.15	27.11**	2.60	-0.90	-4.94**
L_1XT_4	21.35**	5.67**	5.67**	32.78**	8.82**	8.82**	10.74**	1.05*	22.49**	13.35**	1.78	27.89**	-2.33	-4.32*	-4.32*
L_2XT_1	8.44**	5.32**	-20.17**	16.32**	14.05**	-32.30**	4.79**	2.81**	-7.22**	7.69**	2.08	-3.29*	-3.12*	-9.65**	-4.07*
L_2XT_2	6.73**	5.34**	-24.75**	11.20**	5.11	-37.61**	2.58**	20.03**	-6.93**	5.47**	4.65*	-11.18**	-3.03*	-1.40	4.69**
L_2XT_3	6.21**	0.82	-19.85**	17.29**	2.70	-18.85**	1.53*	0.70	-9.12**	12.29**	4.11**	3.42**	-10.23**	-17.33**	-12.22**
L_2XT_4	5.73**	-9.38**	-9.38**	11.49**	-11.16**	-11.16**	6.46*	1.27*	1.27*	12.74**	4.21**	4.21**	-5.75**	-8.49**	-2.84
L_3XT_1	4.40**	4.03**	-21.16**	28.39**	15.51**	-17.57**	5.46**	-3.41**	0.83	7.44**	3.33*	-2.11	-2.57	13.77**	2.84
L_3XT_2	6.63**	2.61*	-22.79**	30.10**	13.23**	-19.20**	8.33**	1.50*	5.95**	5.69**	3.31	-9.61**	2.32	-1.76	17.16**
L_3XT_3	8.25**	5.35**	-16.25**	42.69**	35.23**	7.29**	9.85**	1.64*	6.10**	15.35**	8.48**	7.76**	-5.80**	17.60**	-1.73
L_3XT_4	21.34**	6.32**	6.32**	32.63**	13.64**	13.64**	13.84**	11.45**	16.34**	16.21**	8.95**	8.95**	-2.70*	-10.56**	6.67**
L_4XT_1	17.60**	1.44	-23.12**	22.75**	6.17	-39.44**	4.17**	-8.75**	5.37**	8.26**	3.75*	-7.71	-4.56**	-19.26**	7.16**
L_4XT_2	12.43**	0.63	-29.99**	20.22**	7.47*	-43.20**	11.87**	0.13	15.61**	8.42**	6.36**	-7.63**	3.16*	-5.77**	25.06**
L_4XT_3	7.54**	-9.05**	-27.70**	16.72**	-10.89**	-29.59**	13.49**	0.38	15.90**	16.61**	9.27**	8.55**	-4.06**	-19.72**	6.54**
L_4XT_4	-5.42**	-26.72**	-26.72**	2.52	-27.40**	-27.40**	7.72**	0.51	16.05**	15.77**	8.16**	8.16**	-7.90**	-19.26**	7.16**
L_5XT_1	19.40**	3.17*	-21.81**	22.00**	12.13**	-36.04**	2.31**	0.22	-9.27**	7.60**	4.17**	-1.32	-5.34**	-10.14**	-8.15**

L_5XT_2	17.48**	5.33**	-26.72**	20.61**	14.86**	-39.30**	1.29*	0.91	-7.95**	9.55**	6.38**	-5.66**	-7.98**	-11.14**	-2.47
L_5XT_3	8.34**	-8.23**	-27.04**	18.00**	-5.30*	-25.18**	1.69**	0.70	-8.83**	17.98**	11.66**	10.92**	-14.30**	-19.69**	-17.90**
L_5XT_4	8.36**	-15.92**	-15.92**	10.74**	-18.16**	-18.16**	6.30**	1.27*	1.27*	19.25**	12.50**	12.50**	-11.11**	-12.08**	-10.12**
L_6XT_1	9.25**	8.86**	-16.90**	17.94**	14.92**	-30.91**	3.79**	0.16	-6.49**	6.86**	5.00**	-0.53	-2.93	-7.65**	-6.05**
L_6XT_2	4.04**	-0.57	-24.10**	27.61**	19.90**	-27.92**	1.64**	0.47	-6.20**	10.08**	5.32**	-3.68*	-8.00**	-11.36	-2.72
L_6XT_3	7.49**	5.35**	-16.25**	16.63**	2.68	-18.87**	3.80**	1.25	-5.46**	17.10**	12.45**	11.71**	-11.50**	-16.87**	-15.43**
L_6XT_4	19.48**	5.34**	5.34**	12.19**	-10.19*	-10.19**	4.29**	0.83	0.83	17.94**	12.89**	12.89**	-11.51**	-12.26**	-10.74**
L_7XT_1	3.40**	0.58	-23.77**	12.26**	8.36**	-33.58**	0.84	0.56	-12.20**	5.88**	5.52**	0.66	-4.78**	-4.97**	-12.72**
L_7XT_2	3.32**	1.83	-27.04**	29.42**	20.51**	-26.13**	0.98	-1.18	-9.85**	9.85**	3.03	-1.71	-8.96**	-16.54**	-8.40**
L_7XT_3	9.09**	3.70**	-17.56**	18.57**	5.28*	-16.82**	2.88**	2.03*	-9.41**	17.16**	14.83**	14.08**	-12.22**	-13.23**	-20.62**
L_7XT_4	18.17**	1.42	1.42	30.36**	5.13**	5.13**	7.19**	0.39	0.39	17.58**	14.87**	14.87**	-8.83**	-12.72**	-12.72**

DFF- days to 50 percent flowering, PH- plant height, NPT- number of productive tillers per plant, PL- panicle length, NG- number of grains per panicle, GW- 100 grain weight, GY- grain yield per plant, KL- kernel length, KB- kernel breadth, K. L/B- kernel L/B ratio.
MTU 1001 (L1), TRY 3 (L2), IR 72 (L3), ANNA 4 (L4), ASD 19 (L5), IR 36 (L6), WHITE PONNI (L7) and MDU 5 (T1), ADT 36 (T2), TPS 5 (T3), CO 51 (T4)

Reference

1. Gupta SK. Plant Breeding: Theory and Techniques. Published by Updesh Purohit for Agrobios, India, 2000.
2. Jones J.W. Hybrid Vigour in Rice. J Am. Soc. Agron. 1926; 18:423-428.
3. Nuruzzaman M, Alam MF, Ahmed MG, Shohael AM, Biswas MK, Amin MR *et al*. Studies on Parental Variability and Heterosis in Rice. Pakistan J Biol. Sci. 2002; 5(10):1006-1009.
4. Spielman DJ, Kolady DE, Ward PS. The prospects for hybrid rice in India. Food Security. 2013; 5(5):651-665.
5. Subbaiah PV, Sekar MR, Reddy KHP, Reddy NPE. Variability and genetic parameters for grain yield and its components and kernel quality attributes in CMS based rice hybrids (*Oryza sativa* L.). International journal Applied Biology and Pharamaceutical Technology. 2011; 2(3):603-609.