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STUDIES ON HETEROSIS BREEDING FOR QUALITATIVE AND QUANTITATIVE TRAITS IN RICE (*ORYZA SATIVA* L.)

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Abstract

The present study was carried out to estimate the extent of heterosis, heterobeltiosis and standard heterosis for yield and component traits in rice. Analysis of variance indicated highly significant difference among the genotypes for various traits. Among the testers, significant different were noted for all the ten characters. A comparison of parents vs hybrids, reveal significant difference for majority of the characters indicating the existence of substantial amount of vigour in the hybrids. Estimation of heterosis for various yield contributing traits indicated that out of fifteen crosses studied out of fifteen hybrids only one hybrid HRK2000-58 × Try-1 recorded significant and positive heterosis over mid, better and standard parent for grain yield per plant. Among the hybrids PAU-2881-22-1-3-1 × Try-1, HRK2000-58 × Try-1, HRK2000-58 × Jaya and NLR34303 × Trguna were identified as promising as they recorded high magnitude of standard heterosis for number of productive tiller per plant, panicle length, number of filled grain per panicle, 100 grain weight and grain yield per plant. These hybrids may be recommended for commercial cultivation after further evaluation.

Key words: *Oryza sativa*, heterosis, qualitative traits.

Introduction

Rice (*Oryza sativa* L.), is the world leading cereal crop for more than fifty percent of world's population, with growing area of almost 150 million hectares and a total production of almost 600 million ton annuals (Khush, 2005). The world population is expected to reach 8 billion by 2030 and rice production must be increased by 50% in order to meet the growing demand for the world (Khush and Brar, 2002). More than 90% of the world's rice is grown and consumed in Asia. Rice accounts for 35-75% of the calories consumed by more than 3 billion Asians. In order to feed an estimated 5 billion rice consumers by 2025, rice varieties with higher yield potential and greater yield stability need to be developed (Khush, 2005) of the various approaches contemplated to break the existing yield barriers, hybrid rice technology offers the potential strategy, as hybrid rice varieties have a yield advantage of 15-20% over the conventional high yielding verities (Virmani, 1996). Rice contributes more than 40 percent of the country's total food grain production. According to the data released by the government of India, the total rice production in India stands at 104.32 million for the year 2015-16. Rice is mainly produced in the regions, such as West Bengal, Uttar Pradesh, Andhra Pradesh, Punjab and Tamilnadu. In India West Bengal is the largest rice producing state which produced about 15.75 million tonnes of rice over 5.46 million hectare cultivable area. It is the highest rice producing state in India with a yield of 2600 kg/ha. Uttar Pradesh is the second largest rice producing state with almost 5.86 million ha land under rice cultivation producing about 12.5 million tonnes of rice. The third largest rice producing state in the country is Punjab which produces about 11.82 million tonnes of rice in 2.97 million ha during 2015-2016. Tamilnadu producing about 7.98 million tonnes in 2.04 million ha area. Significant level of hectare has been reported by various workers in rice (Bagheri and Jelodar, 2010; Rahim *et al.,* 2010; Latha *et al.,* 2013).

Exploitation of heterosis in rice has been considered as an important tool for breeding the present yield barriers. The study on the magnitudes of heterosis is the most important prerequisite for under taking any heterosis breeding program (Saravanan *et al.,* 2004). The parents

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with optimal to intermediate genetic diversity reveals maximum heterosis (Moll and Stuber, 1974). The objectives of present study was to identify highly heterotic hybrids for various yield and important yield attributing traits in rice.

Materials and Methods

The present investigation was carried out conducted at Plant Breeding Farm, Faculty of Agriculture, Annamalai University. It is located at east coastal region of Tamilnadu, India with soil pH of 8 to 8.5 and EC of 2.51 to 2.81 dSm^{-1}. The site of the study is situated at 11°24 N latitude, 79°44E longitude and ±5.79m above mean sea level. The research material in the present study consist of five lines $Line_{1-}$ PAU-2881-22-1-3-1, $Line_{2-}$ HRK2000-58, $Line_{3-}$ CB99019, $Line_{4-}$ CN1229-7-5-8-2 and $Line_5$-NLR34303 and three testers $Tester_1$-Try-1, $Tester_{2-}$ Jaya and $Tester_3$-Triguna during kharif, all the genotypes were seeded in nursery at 3 dates, 10 days apart and transplanted in crossing blocks at 21 days after sowing. The seeds of F_1 hybrids generated during previous season along with the parents and standard checks were raised at standard spaces of 20 × 15cm in 5m rows in randomized block design with three replications. The recommended package of practices was followed to raise a good crop. Observation were recorded from each replication for yield traits *viz.,* days to 50 percent flowering, plant height, number of productive tiller per plant, panicle length, number of filled grains per panicle, 100 grain weight, grain yield per plant, kernal length, keral breadth and kernal L/B ratio were recorded ten randomly selected plants in each replications. Significant difference among hybrids and parents for various traits were estimated by analysis of variance. Heterosis was estimated as percentage increase or decrease of F_1 hybrids over mid parent, better parent and standard check CO1 for above mentioned parameters following standard methods (Fonseca and patterson, 1968). The t test was applied to determine significant difference of F_1 hybrid mean from respective better parent and standard check values using formulae as suggested by Wynne *et al.,* (1970).

Results and Discussion

The experimental data obtained on 10 characters were subjected to analysis of variance (Singh and Chaudhary, 1977). Hererosis was computed as per cent increase or decrease in the mean values of F1 over better parent and standard check variety as suggested by Hayes *et al.,* (1955).

The analysis of variance showed significant difference among the hybrids, for eight traits *viz*., days to 50 percent flowering, plant height, number of productive tiller per plant, panicle length, number of filled grains per panicle, grain yield per plant, kernel breadth, and kernel L/B ratio. The analysis of variance showed significant difference among the line, for all the characters except 100 grain weight and kernel breadth. For testers, the analysis of variance showed significant for all traits except plant height, 100 grain weight and kernel breadth and their interaction effect LXT showed significant difference for Days to 50 percent flowering, plant height, panicle length, grain yield per plant and kernel L/B ratio.

Heterosis was computed as per cent increase or decrease of F_1 over better parent (heterobeltiosis) and over the best commercial variety (standard heterosis). In the present investigation, the relative magnitude of heterosis over better parent and standard variety (Try1) were studied for ten characters. The nature and magnitude of heterosis differed for different traits in various hybrid combinations.

Growth duration has special significance in crop productivity and cropping system. For days to 50 percent flowering, negative heterosis is desirable, because

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 filled grains per panicle	100 grain weight	Grain yield per plant	Kernel Length	Kernel Breadth	Kernel L/B ratio
Replication	1	7.86	-0.01	40.57	0.1567	2.04	1.32	31.13	0.86	0.01	0.01
Hybrids	14	52.06**	12.03**	4.16*	18.01**	1059.23**	0.72	30.23**	0.01**	0.01	1.10**
Lines	4	38.75**	241.78**	12.95**	5.11**	1034.51**	0.27	13.47*	0.01**	0.02	0.68**
Testers	2	166.5**	1.51	30.50**	18.28**	637.26**	0.06	21.73**	0.01**	0.01	0.52*
Lines × Testers	8	60.00**	119.71**	3.04	8.24**	99.82	0.03	24.13**	0.01	0.01	1.50**
Error	22	4.30	0.95	72.58	0.83	92.74	3.39	4.97	0.931	0.01	0.19

* - Significant at 5% level,** - Significant at 1% level

this will cause the hybrids to mature earlier as compared to parents, thereby increasing their productivity day^{-1} unit area^{-1}. Six hybrids exhibited maximum significant and negative heterosis over better parent and two hybrids exhibited significant negative heterosis over standard variety. Heterosis for days to 50 percent flowering over better parent Patel *et. al.*, (1994) and Premkumar *et al.,* (2017).

Semi-dwarf plant height (80-100cm) is desirable to get high yield in rice varieties while tall varieties are usually susceptible to lodging and show low harvest index. On the other hand, very dwarf plants less than 70cm are related with low dry matter and low grain production. The tendency of the hybrids being taller than the parents are very obvious, but all 15 hybrids over better parent and standard variety were significantly better. Among 15 F_1 crosses studied, none of the hybrid significant negative heterosis. Present observations are in close agreement with the findings of other workers, *viz*., Lingaraju *et al.,* (1999) and Premkumar *et al.,* (2017). In the present investigation, plant height of F1 hybrids was almost equal or to some extent more than the parents as observed by Virmani *et al.,* (1982). Therefore, in order to develop rice hybrid possessing semi-dwarf plant type, both parents of the hybrids should be semi-dwarf, possessing the same semi-dwarfing gene. The study thus suggested that parents with semi-dwarf desirable plant height (80-100cm) should be chosen so that the hybrid derived from these do not become taller than 100cm even after manifestation of heterosis for plant height under irrigated ecosystem.

Early maturing hybrids are highly desirable because early maturing hybrids show lodging resistance. Among the 15 hybrids, 3 hybrids -11.05 (PAU2881-22-1-3-I × Jaya), -10.38 (HRK 2000-58 × Try) and -9.91 (CN 1229-7-5-8-2 × Try-1) recorded maximum negative significant and the hybrid -5.59 (PAU 2881-22-1-3-1 × Jaya) and -5.59 (HRK 200-58 × Triguna) recorded maximum negative significant standard heterosis. Eight crosses showed significant desirable negative heterosis for days to 50 per cent flowering. Present observations are in close agreement with the findings of Patel *et. al.,* (1994) and Premkumar *et al.,* (2017).

Higher number of productive tiller per plant is associated with higher productivity. Among the 15 hybrids, none of the hybrids recorded significant and positive heterosis over better parent and it range from -30.00 (HRK 2000-58 × Triguna) to 20.61 percent (NLR 34303 × Jaya), most of the hybrids showing significant positive heterosis as well as heterobeltiosis for this traits also exhibited heterosis for grain yield. The present findings are in accordance with the findings of Satya *et al.,* (1999), Singh (2000), Devi *et al.,* (2017) Thorat *et al.,* (2017). Higher number of Productive tillers per plant^{-1} is associated with higher productivity. For theis trait, 11 crosses also exhibited positive heterosis over standard variety. The importance of this component in influencing the yield is clear from the fact that most of the hybrids

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

Hybrids	DF		PH		NPT		PL		NFGP	
	HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
$L_1 \times T_1$	-5.66**	11.73**	9.39**	19.85**	-10.92	42.20**	-3.86	-5.27	7.48	2.47
$L_1 \times T_2$	-11.05**	-5.59**	10.61**	21.19**	6.82	29.36*	-3.29	-3.29	-13.80*	-13.80*
$L_1 \times T_3$	-8.42**	-2.79	10.39**	20.94**	-10.26	47.71**	-22.57**	-23.70**	-3.45	2.53
$L_2 \times T_1$	-10.38**	6.15*	20.41**	22.15**	-22.33**	18.35	7.69	3.25	12.74**	-6.20
$L_2 \times T_2$	1.10	2.23	20.29**	22.03**	-23.89**	25.69	7.89*	7.89*	-7.20	-7.20
$L_3 \times T_3$	-7.14**	-5.59*	16.83**	18.52**	-30.00**	15.60	-2.94	-6.94	-17.77**	-12.67
$L_3 \times T_1$	-9043**	7.26**	26.39**	25.54**	-17.24*	32.11*	-1.45	-2.89	-17.33*	-22.40**
$L_3 \times T_2$	1.68	1.68	25.79**	25.79**	0.84	10.09	10.90**	10.90**	-23.13**	-23.13**
$L_3 \times T_3$	-4.95*	-3.35	22.25**	19.73**	-5.03	55.96**	5.47	3.92	34.15**	-30.07**
$L_4 \times T_1$	-9.91**	6.70**	26.63**	25.79**	-5.75	50.46**	-14.22**	-17.76**	-10.90	-25.87**
$L_4 \times T_2$	0.52	8.94**	22.88**	29.88**	-14.11	28.44*	-8.44*	-8.44*	-11.47	-11.47
$L_4 \times T_3$	-2.58	5.59*	29.17**	26.51**	-15.08	39.45**	-30.01**	-32.90**	-10.86	-5.33
$L_5 \times T_1$	-8.20**	8.94**	25.66**	24.82**	-13.79	37.61**	-7.65	-17.28**	9.10	27.13**
$L_5 \times T_2$	6.15*	6.15*	17.05**	17.05**	20.61	44.95**	-6.66	-6.66	-9.61	5.33
$L_5 \times T_3$	7.14**	8.94**	27.63**	25.00**	-18.44*	33.94*	8.18	-9.83*	-5.03	10.67

* - Significant at 5% level, ** - Significant at 1% level

DF – Days to 50 per cent first flowering, **PH** – Plant height, **NPT** – Number of productive tillers per plant, **PL** – Panicle length, **NFGP** – Number filled grains per panicle, **HGW** – Hundred grain weight, **KL-** Kernel length, **KB** – Kernel breadth, **KLBR** – Kernel L/B ratio, **GYP** – Grain yield per plant, **HB** – Heterobeltiosis, **SH** – Standard heterosis.

Table 2: Contd.....

Hybrids	HGW		GYP		KL		Kb		KLBR	
	HB	SH	HB	SH	HB	SH	HB	SH	HB	SH
$L_1 \times T_1$	0.38	2.35	24.42*	2.33	0.00	0.00	-8.89	-19.61	2.99	53.33*
$L_1 \times T_2$	7.84	7.84	17.55	17.55	0.00	0.00	-17.65	-17.65	1.49	51.11*
$L_1 \times T_3$	73.32**	80.00	-23.12*	-15.64	-14.29**	-14.29**	6.00	3.92	-37.31*	-6.67*
$L_2 \times T_1$	-16.54	-14.90	50.64**	23.89*	16.67**	0.00	-8.89	-19.69	4.41	57.78**
$L_2 \times T_2$	9.80	9.80	13.11	13.11	14.29**	14.29**	-15.69	-15.69	20.59	82.22**
$L_3 \times T_3$	-8.54	-11.76	-10.40	-1.69	0.00	-14.29**	-18.00	-19.61	-7.35	40.00
$L_3 \times T_1$	-10.77	-9.02	-10.79	-18.90	0.00	-14.29**	-20.81*	-17.65	4.92	42.22*
$L_3 \times T_2$	-5.88	-5.88	-31.50**	-31.50**	0.00	0.00	-8.47	5.88	6.67	6.67
$L_3 \times T_3$	13.60	1.57	-25.82**	-18.60	16.67**	0.00	-22.03	-9.80	66.67**	55.56*
$L_4 \times T_1$	-14.68	-1.96	-9.24	-8.67	0.00	0.00	-0.00	-11.76	0.00	57.78**
$L_4 \times T_2$	-16.38	-3.92	-7.98	-7.40	14.29**	14.29**	-19.61	-19.61	14.08	80.00**
$L_4 \times T_3$	-27.99	-17.25	-23.70*	-16.28	0.00	0.00	-20.00	-21.57	-23.94	20.00
$L_5 \times T_1$	-15.38	-13.73	0.70	-9.09	0.00	-14.29**	-11.11	-21.57	-47.90**	-28.22**
$L_5 \times T_2$	-9.02	-9.02	-5.29	-5.29	7.14	7.14	0.00	0.00	-22.58	6.67
$L_5 \times T_3$	17.55	12.94	11.02	21.82*	16.67**	0.00	8.00	5.88	-27.42	0.00

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

DF – Days to 50 percent first flowering, **PH** – Plant height, **NPT** – Number of productive tillers per plant, **PL** – Panicle length, **NFGP** – Number filled grains per panicle, **HGW** – Hundred grain weight, **KL-** Kernel length, **KB** – Kernel breadth, **KLBR** – Kernel L/B ratio, **GYP** – Grain yield per plant, **HB** – Heterobeltiosis, **SH** – Standard heterosis.

showing significant positive heterosis as well as heterobeltiosis for this trait also exhibited heterosis for grain yield. The present findings are in accordance with the findings of Satya *et al*., (1999), Singh (2000), Devi *et al*., (2017) and Thorat *et al*., (2017).

The hybrids with positive heterosis values are desirable for panicle length as long panicle is generally associated with higher productivity. Out of 15 crosses only 2 crosses showed positive significant over better parent and standard heterosis. Heterosis with respect to 100 grain weight was expressed in positive as well as in negative directions, which is in conformity with the findings of Rahimi *et al*., 2010 and Devi *et al*., (2017). The hybrid PAU-2881-22-1-3-1 × Triguna showed maximum positive and significant standard heterosis 23.89 and heterobeltiosis 50.64 for grain yield per plant. In the present study, standard heterosis for number of productive tillers per plant exhibited a wide range as the values varied from 29.36 to 55.96 percent.

The hybrids NLR34303 × Try-1 exhibited highly significant and positive values for number of filled grain per panicle in standard heterosis. They also recorded significant and positive standard heterosis for the traits *viz.*, number of productive tillers per plant and plant height. The hybrids HRK2000-58 × jaya, CB99019 × Triguna and CN1229-7-5-8-2 × jaya showed significant and positive standard heterosis for other characters. The hybrids NLR34303 × Try-1, HRK2000-58 × Try-1, and CN1229-7-5-8-2 × jaya also showed significant and positive standard heterosis for five other traits. Hence, it may be concluded that, NLR34303 × Triguna and NLR34303 × Try-1 can be rated as best hybrids and the hybrids CB99019 × Triguna, NLR34303 × Try-1, HRK2000-58 × jaya and CN1229-7-5-8-2 × jaya can be rated as better hybrids based on the magnitude of heterosis.

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