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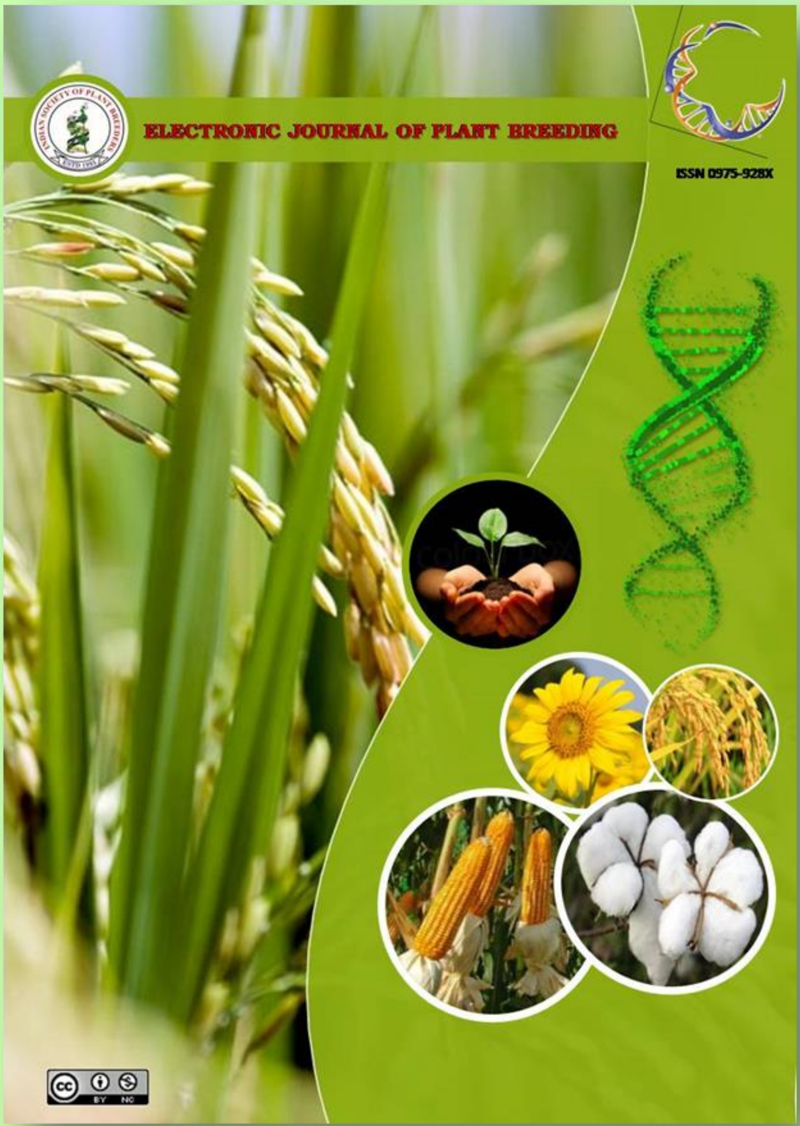

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Research Article

Heterosis and combining ability analysis for yield related traits in rice hybrids involving land races

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Abstract
The exploitation of heterosis is possible only when the parents involved in the crosses show high specific combining ability in the hybrids. Fifty hybrids generated from ten lines (land races) and five testers along with parents were evaluated for eight quantitative traits to elucidate the nature of gene action present in the inheritance of important quantitative traits. Preponderance of non additive gene action was observed for all the characters studied. RAJAMUDI and MOHINI SAMBA among the lines and ASD 16 and CO 47 among the testers were found to be good general combiners as they could contribute alleles with positive effect for improving the important quantitative traits. The crosses RAJAMUDI × ASD 16, RAJAMUDI × CO 47 and MOHINI SAMBA × ASD 16 performed better than the check varieties CO 51 and ASD 16 for most of the traits and showed significance for standard heterosis and these three crosses can be further forwarded to recombination breeding.

Key words
Heterosis, L × T analysis, Specific combining ability, General combining ability, yield traits, Rice.

Introduction

Rice (*Oryza sativa* L.) is a dietary staple food and one of the most important cereal crops, especially for people in Asia (Rohman *et al.*, 2014). In breeding high yielding varieties of crop plants, the breeders often face with the problems of selecting parents and crosses. Before initiating any crop improvement program, it is necessary to understand the genetic nature of the parents. The selection of parents on the basis of their mean performance does not necessarily lead to desired results (Rai and Asati, 2011; Satya and Jebaraj, 2015).

Rice being the staple food crop has an ever increasing demand which has been predicted to be 120 million tons by 2020. There is a quest to create new variability and tap new gene combinations so as to widen, the genetic base of the breeding material and also to bring about favourable combinations of alleles of different genes. The materials that generated will harbour genes for yield and related traits, grain quality, nutrition, pest and disease resistance or any abiotic stress tolerance depending on the parental lines chosen for creating the variability.

Since time immemorial landraces of rice which are numerous in number and are acclimatized to specific localities are reservoirs of gene of interest. These landraces are a good starting material to develop pre breeding lines or even improved cultivars. Thus the present study was formulated to identify good combining parents and specific cross combinations involving land races of rice and release of cultivars for grain yield and associated traits.

Material and Methods

By adopting the standard Line × Tester mating design (Kempthorne, 1957), 50 hybrid combinations were generated using ten rice landraces as lines *viz*., RAJAMUDI, ATHUR KICHILI, UPPAM MOLAGAI, MOHINI SAMBA, ARPUTHAM SAMBA, KARUR KURUVAI, RASAKADAM, JEERAGA SAMBA, SIVAPPU CHITHIRAIKAR AND CHERULI and five released rice varieties *viz*., ADT 37, ADT (R) 45, ASD 16, CO 51 and CO 47 as testers. The F_1s along with parents and two high yielding checks *viz*., CO 51 and ASD 16 were evaluated in Randomized Complete Block Design with three replications at Paddy Breeding Station, TNAU, Coimbatore during *rabi* 2016. Twenty one day old single seedlings were transplanted in a standard spacing of 20 cm. x 20 cm. with 12 plants per row. Recommended package of practices were followed to maintain a healthy crop. Crosses were made using wet cloth emasculation method as suggested by Chaisang *et al*. (1967).

Five random plants were tagged and numbered from each entry/replication for observing yield and yield attributing characters *viz.,* plant height (cm.), number of productive tillers per plant, panicle length (cm.), number of grains per panicle, spikelet fertility (%), hundred grain weight (g.) and grain yield per plant (g.). Days to 50% flowering of F_1s was recorded. The performance of F_1 hybrids was evaluated on the basis of heterosis estimates (Fonseca and Patterson, 1968) and standard heterosis against the best high yielding variety (Virmani *et al*. 1982). Land races cultivars were developed through selections, based on desirable characters such as grain yield. For the development of high iron and zinc content varieties, land races were used as parental line.

Results and Discussion

The analysis of variance revealed significant differences among the lines, testers and lines × testers (Table 1). This indicated that the treatments had wide genetic diversity among themselves. Significant variances due to lines × testers interaction for all the characters suggested the presence of significant variances for SCA among hybrids. These results emphasized the importance of combining ability studies and indicated good prospects for selection of suitable parents and crosses for the development of appropriate varieties and hybrids. The ratio of *gca* to *sca* variances ranged from 0.0163 to 0.159. These results indicated that the non-additive gene actions predominated over the additive gene actions for all the characters. Predominance of non additive gene action for grain yield and its components was also reported by many other workers (Satyanarayana *et al*., 2000; Rita and Motiramani, 2005; Venkatesan *et al*., 2007; Dalvi and Patel, 2009).

The proportional contribution of lines, testers and their interaction to the total variance are presented in Fig. 1. It is evident that high contribution of lines is for the traits days to 50% flowering, plant height and spikelet fertility. On the contrary, none of the testers showed high contribution for any of the traits. The contribution of crosses (line x tester) was found vital for number of productive tillers, panicle length, grains per panicle, hundred grain weight and grain yield per plant. These results were conformity with Akhter *et al*. (2010) and Yuni *et al*. (2017).

The estimates of *gca* effects (Table 2) indicated that the female parent RAJAMUDI was found to be a good general combiner for all the traits except plant height and hundred grain weight. Similarly, the female parent MOHINI SAMBA was also a good combiner for all the traits except number of productive tillers and hundred grain weight. Gulzar Sanghera and Wassem Hussain (2012) observed similar good general combining of female parents in rice. They used two lines and eighteen testers in their experiment.

The male parent ASD 16 was the best general combiner for all the traits except plant height and spikelet fertility. Similarly, CO 47 was found to be good combiner for all the eight traits. Rogbell *et al*.,(1998); Singh *et al*.,(1996) and Nadali bagheri and Jelodar (2010) observed similar good general combiner male parents for yield contributing traits in rice.

Trait wise comparisons were made among all the parents, desirable GCA effects were observed in seven parents (RAJAMUDI, MOHINI SAMBA, RASAKADAM, CHERULI, ASD 16, CO 51 and CO 47) for days to 50% flowering, seven parents (MOHINI SAMBA, ARPUTHAM SAMBA, KARUR KURUVAI, JEERAGA SAMBA, CHERULI, ADT (R) 45 and CO 47) for plant height, seven parents (RAJAMUDI, ATHUR KICHILI, UPPAM MOLAGAI, KARUR KURUVAI, ADT 37, ASD 16 and CO 47) for number of productive tillers, nine parents (RAJAMUDI, MOHINI SAMBA, ARPUTHAM SAMBA, KARUR KURUVAI, RASAKADAM, SIVAPPU CHITHIRAIKAR, ADT 37, ASD 16 and CO 47) for panicle length, six parents (RAJAMUDI, MOHINI SAMBA, ARPUTHAM SAMBA, JEERAGA SAMBA, ASD 16 and CO 47) for number of grains per panicle, seven parents (RAJAMUDI, ATHUR KICHILI, MOHINI SAMBA, KARUR KURUVAI, RASAKADAM, ADT (R) 45 and CO 47) for spikelet fertility, six parents (ARPUTHAM SAMBA, KARUR KURUVAI, RASAKADAM, SIVAPPU CHITHIRAIKAR, ASD 16 and CO 47) for hundred grain weight, seven parents (RAJAMUDI, UPPAM MOLAGAI, MOHINI SAMBA, SIVAPPU CHITHIRAIKAR, ADT 37, ASD 16 and CO 47) for grain yield per plant (Table 2). Above parents were considered as good general combiners for each of these characters respectively.

The estimates of specific combining ability of 50 crosses for eight characters are presented in Table 3. The usefulness of a particular cross in the exploitation of heterosis is judged by specific combining ability effects. Among the fifty hybrids, significant negative *sca* effect for each of the traits *viz*., days to 50 % flowering, and plant height were exhibited in 19 contributions. Of these a vast majority of the hybrids (15 combinations) possessed both earliness and short plant stature which are highly desirable in breeding programmes. Sixteen hybrids exhibited positive significant sca effect and considered as the best specific combiners for tall plants. Considering significant and positive values for rest of the traits, it could be deduced that 16, 20, 12, 23 and 19 hybrid combinations were good specific combiners for number of productive tillers per plant, panicle length, grains per panicle, spikelet fertility and hundred grain weight respectively. For grain yield, half of the hybrids (26 combinations) of the 50 tested, were good specific combiners.

Yield is a cumulative function of various components; the contribution of components for yield is through component compensation mechanism. This was proved in some of the crosses which were characterized by significant positive *sca* effect for grain yield and also exhibit significant positive *sca* effects for some of the component traits. Cross combination MOHINI SAMBA × ASD 16, CHERULI × CO 47, ARPUTHAM SAMBA × CO 51, UPPAM MOLAGAI × CO 47, ATHUR KICHILI × CO 47 and CHERULI × CO 51 recorded the highest *sca* value for yield and several yield attributing traits, followed by some other cross combinations like, ATHUR KICHILI × ADT (R) 45, RASAKADAM × ADT 37, JEERAGA SAMBA × ASD 16, UPPAM MOLAGAI × ADT 37, UPPAM MOLAGAI × CO 51, JEERAGA SAMBA × ADT 37, RAJAMUDI × ASD 16, KARUR KURUVAI × ASD 16, SIVAPPU CHITHIRAIKAR × ASD 16, MOHINI SAMBA × CO 47, JEERAGA SAMBA × ADT (R) 45, RASAKADAM × ADT (R) 45, SIVAPPU CHITHIRAIKAR × ADT 37, SIVAPPU CHITHIRAIKAR × CO 51, ARPUTHAM SAMBA × ADT (R) 45, CHERULI × ADT 37, RAJAMUDI × CO 51, RAJAMUDI × CO 47 and ARPUTHAM SAMBA × ASD 16. It is evident that cross combinations, which expressed high *sca* effects for grain yield, have invariably positive *sca* effects for one or more yield related traits also. Secondly, to get best specific combination for yield it would be important to give due weightage to yield related traits. Similar finding were reported earlier by Samrath Bedi and Deepak Sharma (2014)

All the 12 cross combinations involving four lines *viz*., RAJAMUDI, UPPAM MOLAGAI, MOHINI SAMBA and SIVAPPU CHITHIRAIKAR with three testers namely ADT 37, ASD 16 and CO 47 recorded high × high parental *gca* effects, suggesting that additive × additive type of gene action. Sandhyakishore *et al*., (2011), Damodar Raju *et al*., (2014) and Hasan *et al*., (2015) also reported interaction between positive alleles in crosses involving high × high combiners which can be fixed in subsequent generations if no repulsion phase linkages are involved.

Eight combinations involving the same four lines and two testers ADT (R) 45 and CO 51 showed high × low parental *gca* effects, indicating the involvement of additive × dominance genetic interaction. Peng and Virmani (1990) also reported about the possibility of interaction between positive alleles from good combiners and negative alleles from poor combiners in high × low crosses and suggested the exploitation of heterosis in F_1 generation. Their high yielding potential would be unfixable in succeeding generations. Similar results were also obtained by Dubey (1975). Twelve crosses *viz*., ATHUR KICHILI × ADT (R) 45, ATHUR KICHILI × CO 51, ARPUTHAM SAMBA × ADT (R) 45, ARPUTHAM SAMBA × CO 51, KARUR KURUVAI × ADT (R) 45, KARUR KURUVAI × CO 51, RASAKADAM × ADT (R) 45, RASAKADAM × CO 51, JEERAGA SAMBA × ADT (R) 45, JEERAGA SAMBA × CO 51, CHERULI × ADT (R) 45 and CHERULI × CO 51 recorded low x low parental *gca* effects indicating over dominance and epistatic interactions.

If the F_1 of a cross between two parents exhibited high standard heterosis for traits evaluated, it can be forwarded in a recombination breeding programme to exploit the trait in further generation based on the gene action and specific combining ability of the cross.

In a study, two popular varieties CO 51 and ASD 16 were used as standard checks for the estimation of heterosis. Since two checks were in this experiment, trait wise best checks were considered for standard heterosis. Accordingly, days to 50% flowering and spikelet fertility were compared with CO 51 and rest of the traits with ASD 16. It could be witnessed that *per se* performance of parents and hybrids agreed well with general combining ability effects of parents and heterotic response of hybrids respectively. Thus, the potentiality of a genotype to be used as a parent in hybridization or a cross to be used as a commercial hybrid may be judged by comparing *per se* performance of parents and hybrids, along with combining ability effects of parents and heterotic response of hybrids.

Thus in the present study, significantly high standard heterosis and respective checks for the traits concerned revealed that forty two hybrids for days to 50% flowering, thirty nine for plant height, two for number of productive tillers, one for panicle length, two for grains per panicle, seven for spikelet fertility, and three for grain yield per plant were superior. Hence these combinations can be forwarded promised as they exhibit good *sca* effects.

The promising crosses for grain yield per plant on the basis of *per se* performance, SCA effects, GCA status and standard heterosis are presented in Table 4. The hybrids exhibiting higher *per se* performance, high heterosis and significant desirable *sca* effects for various traits involved either good × good, good × poor, average × good, poor × good and also poor × poor combining parents. Thus, crosses exhibiting high *sca* effects did not always involved parents with high *gca* effects. Hence interallelic interactions were also important for the expression of these characters.

A high degree of standard heterosis was observed for grain yield per plant *viz*., MOHINI SAMBA × ASD 16 (15.32%), RAJAMUDI × ASD 16 (14.45%) and RAJAMUDI × CO 47 (11.87%) over check variety ASD16. The parents of the crosses MOHINI SAMBA × ASD 16 and RAJAMUDI × ASD 16 were good general combiners for four traits including grain yield. These two crosses exhibited significant *sca* effects and standard heterosis for number of grains per panicle. Significant positive heterosis for grain yield per plant have been reported by many researchers, *viz*., Pandey *et al*.,(1995), Rogbell and Subbaraman (1997), Ramlingam *et al*.,(2000) and Yolanda and Vijendradas (1995).

Considering the *per se* performance, *sca* effect and heterotic response in desirable direction, the cross RAJAMUDI × ASD 16 showed its superiority for panicle length, grains per panicle, grain yield per plant. Whereas RAJAMUDI × CO 47 showed superiority for plant height and grain yield per plant. Similarly MOHINI SAMBA × ASD 16 showed superiority for days to 50% flowering were compared with CO 51 and grains per panicle and grain yield per plant over ASD 16. Similar results have been reported by Pandey *et al*., (1995), Ramlingam *et al*., (2000) and Annadurai and Nadarajan (2001). Hence it is concluded that these three crosses can be further exploited in recombination breeding.

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Table 1. Analysis of variance for combining ability in rice

Parents	df	Days to 50% flowering	Plant Height (cm.)	Number of productive tillers	Panicle length (cm.)	Grains per panicle	Spikelet fertility (%)	100 grain weight (g.)	Grain yield per plant (g.)
Lines	9	324.4202**	912.1568**	25.3167**	24.0892**	633.433**	678.8505**	0.3268**	258.5127**
Testers	4	72.9191**	217.8822**	92.1695**	53.7256**	440.6577**	224.4704**	0.3898**	61.9454**
Lines × Testers	36	53.6499**	48.4020**	16.0707**	9.4597**	190.3354**	168.1216**	0.1111**	84.2564**
Error	98	0.6571	0.3215	0.7946	0.3620	7.0582	0.8387	0.0018	2.4210
				Variance component					
gca		0.7584	2.5495	0.1169	0.0931	1.5050	1.4546	0.0009	0.4462
sca		17.6643	16.0268	5.0920	3.0326	61.0924	55.7610	0.0364	27.2785
gca/sca		0.0429	0.1591	0.0229	0.0307	0.0246	0.0261	0.0247	0.0163

*, ** Significant at 5 % level and 1 % level respectively.

Table 2. General combining ability effects of parents in rice

Parents	Days to 50% flowering	Plant Height (cm.)	Number of productive tillers	Panicle length (cm.)	Grains per panicle	Spikelet fertility (%)	100 grain weight (g.)	Grain yield per plant (g.)
Lines								
RAJAMUDI	-8.63 **	3.64 **	2.61 **	0.96 **	5.47 **	10.42 **	-0.04 **	8.02 **
ATHUR KICHILI	-0.23	4.65 **	0.68 **	-1.14 **	-1.36	3.67 **	-0.03 **	-3.67 **
UPPAM MOLAGAI	0.97 **	3.60 **	0.91 **	-1.09 **	-8.52 **	-3.52 **	-0.11 **	2.94 **
MOHINI SAMBA	-5.42 **	-7.53 **	0.15	2.21 **	13.12 **	4.76 **	-0.04 **	5.16 **
ARPUTHAM SAMBA	7.33 **	-8.54 **	-0.57 *	0.57 **	1.38 *	-0.16	0.08 **	-1.12 **
KARUR KURUVAI	2.65 **	-3.25 **	0.48 *	0.59 **	-2.85 **	4.88 **	0.19 **	-3.03 **
RASAKADAM	-0.79 **	6.61 **	-1.63 **	0.66 **	-2.78 **	3.13 **	0.05 **	-3.59 **
JEERAGA SAMBA	-0.10	-5.35 **	-1.05 **	-1.79 **	5.40 **	-4.36 **	-0.29 **	-1.68 **
SIVAPPU CHITHIRAIKAR	5.24 **	14.66 **	-1.65 **	0.36 *	-6.92 **	-6.20 **	0.22 **	0.86 *
CHERULI	-1.02 **	-8.49 **	0.08	-1.32 **	-2.96 **	-12.62 **	-0.03 *	-3.89 **
SE (g_i)	0.209	0.146	0.230	0.155	0.686	0.236	0.011	0.402
Testers								
ADT 37	2.56 **	1.46 **	0.43 *	0.29 **	-0.65	-0.09	-0.01	0.60 *
ADT (R) 45	0.27	-1.70 **	-2.72 **	-2.01 **	-2.56 **	1.85 **	-0.10 **	-0.02
ASD 16	-0.58 **	2.69 **	0.95 **	1.36 **	5.18 **	-3.53 **	0.17 **	0.76 **
CO 51	-0.76 **	1.40 **	-0.53 **	-0.57 **	-4.38 **	-1.61 **	-0.09 **	-2.46 **
CO 47	-1.48 **	-3.85 **	1.88 **	0.93 **	2.41 **	3.38 **	0.04 **	1.12 **
SE (g_j)	0.148	0.103	0.163	0.110	0.485	0.167	0.008	0.284

** Significant at 1 % level * Significant at 5 % level.

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Table 3. Specific combining ability effects of hybrids in rice

	Days to 50% Flowering	Plant Height (cm.)	Number of productive tillers	Panicle length (cm.)	Grains per panicle	Spikelet fertility (%)	100 grain weight (g.)	Grain yield per plant (g.)
RAJAMUDI × ADT 37	0.35	-0.05	-2.08 **	0.91 *	1.57	2.05 **	0.04	-5.30 **
RAJAMUDI × ADT (R) 45	4.24 **	1.28 **	1.80 **	-0.55	-1.58	-1.51 **	-0.01	-2.20 *
RAJAMUDI × ASD 16	-5.64 **	-3.72 **	-0.17	1.93 **	11.21 **	-5.74 **	-0.08 **	3.32 **
RAJAMUDI × CO 51	4.66 **	7.14 **	0.95	-2.27 **	-4.70 **	4.85 **	0.09 **	2.12 *
RAJAMUDI × CO 47	-3.61 **	-4.64 **	-0.50	-0.02	-6.49 **	0.35	-0.03	2.05 *
ATHUR KICHILI × ADT 37	-0.05	4.50 **	-2.61 **	0.12	12.20 **	-13.21 **	0.15 **	1.25
ATHUR KICHILI × ADT (R) 45	1.90 **	-6.19 **	-0.87	0.98 **	-2.62	3.12 **	-0.16 **	4.33 **
ATHUR KICHILI × ASD 16	-7.58 **	2.87 **	3.40 **	-0.79 *	-12.50 **	8.44 **	-0.03	-4.75 **
ATHUR KICHILI × CO 51	3.40 **	-5.50 **	1.28 *	1.73 **	-7.08 **	4.76 **	0.14 **	-5.68 **
ATHUR KICHILI × CO 47	2.32 **	4.33 **	-1.20 *	-2.05 **	10.00 **	-3.11 **	-0.10 **	4.84 **
UPPAM MOLAGAI × ADT 37	-0.92	0.92 **	1.29 *	1.30 **	-14.31 **	-2.02 **	0.15 **	3.53 **
UPPAM MOLAGAI × ADT (R) 45	-1.30 **	-4.90 **	-2.43 **	-1.88 **	5.54 **	-2.68 **	-0.10 **	-2.25 *
UPPAM MOLAGAI × ASD 16	-0.64	6.96 **	0.10	1.25 **	-17.67 **	13.82 **	-0.12 **	-9.93 **
UPPAM MOLAGAI × CO 51	-0.94 *	-4.87 **	1.79 **	-0.61	5.95 **	-12.46 **	0.15 **	3.38 **
UPPAM MOLAGAI × CO 47	3.79 **	1.89 **	-0.76	-0.07	20.50 **	3.34 **	-0.09 **	5.27 **
MOHINI SAMBA × ADT 37	1.27 **	3.07 **	2.05 **	-1.24 **	-2.35	-2.68 **	-0.35 **	-0.04
MOHINI SAMBA × ADT (R) 45	4.02 **	4.00 **	0.93	2.15 **	-3.10 *	-0.58	0.02	-5.81 **
MOHINI SAMBA × ASD 16	-2.46 **	-3.46 **	1.26 *	-0.97 **	3.69 *	6.04 **	0.41 **	6.48 **
MOHINI SAMBA × CO 51	3.45 **	0.32	-1.32 *	1.19 **	2.58	-9.31 **	0.02	-3.30 **
MOHINI SAMBA × CO 47	-6.29 **	-3.93 **	-2.93 **	-1.13 **	-0.81	6.52 **	-0.11 **	2.67 **
ARPUTHAM SAMBA × ADT 37	-1.61 **	-4.86 **	-0.29	0.61	7.40 **	-0.68	-0.01	-9.06 **
ARPUTHAM SAMBA × ADT (R) 45	-0.19	1.93 **	4.19 **	-1.00 **	-2.82	2.11 **	0.10 **	2.31 *
ARPUTHAM SAMBA × ASD 16	0.80	1.75 **	-0.75	-0.26	6.64 **	-4.60 **	-0.11 **	1.81 *
ARPUTHAM SAMBA × CO 51	-0.43	1.54 **	-1.73 **	1.50 **	-5.88 **	0.37	0.01	5.57 **
ARPUTHAM SAMBA × CO 47	1.43 **	-0.36	-1.41 **	-0.86 *	-5.33 **	2.79 **	0.02	-0.63
KARUR KURUVAI × ADT 37	0.74	-3.78 **	-0.81	-2.21 **	1.22	7.30 **	-0.14 **	-2.34 *
KARUR KURUVAI × ADT (R) 45	-3.71 **	-1.61 **	-1.93 **	-3.48 **	-1.13	6.29 **	0.12 **	2.37 **
KARUR KURUVAI × ASD 16	5.08 **	3.72 **	-1.87 **	1.41 **	4.00 *	-18.64 **	-0.15 **	2.87 **
KARUR KURUVAI × CO 51	-7.22 **	1.91 **	2.61 **	2.80 **	2.02	0.16	0.07 **	-3.84 **
KARUR KURUVAI × CO 47	5.11 **	-0.24	2.00 **	1.47 **	-6.10 **	4.89 **	0.09 **	0.95
RASAKADAM × ADT 37	4.51 **	2.41 **	2.56 **	0.06	6.36 **	-1.49 **	0.12 **	4.02 **
RASAKADAM × ADT (R) 45	-5.74 **	-1.52 **	0.31	2.07 **	2.47	-5.12 **	-0.09 **	2.42 **
RASAKADAM × ASD 16	7.32 **	-1.11 **	-3.63 **	0.04	1.13	6.62 **	-0.14 **	1.08
RASAKADAM × CO 51	-3.24 **	0.50	-1.75 **	-0.12	0.08	3.94 **	-0.11 **	-6.10 **
RASAKADAM × CO 47	-2.85 **	-0.27	2.51 **	-2.05 **	-10.04 **	-3.96 **	0.22 **	-1.41
JEERAGA SAMBA × ADT 37	0.82	2.21 **	2.19 **	-0.58	-2.56	3.07 **	-0.23 **	3.34 **
JEERAGA SAMBA × ADT (R) 45	-1.50 **	-3.81 **	-0.93	1.35 **	-2.38	6.00 **	-0.13 **	2.55 **
JEERAGA SAMBA × ASD 16	7.29 **	1.48 **	-0.67	-1.58 **	-0.66	-8.91 **	0.26 **	3.90 **
JEERAGA SAMBA × CO 51	-3.34 **	0.27	-1.59 **	-0.32	2.96	0.03	-0.27 **	1.14
JEERAGA SAMBA × CO 47	-3.28 **	-0.15	1.00	1.13 **	2.64	-0.20	0.37 **	-10.92 **
SIVAPPU CHITHIRAIKAR × ADT 37	-4.12 **	-1.64 **	2.32 **	0.09	-3.51 *	9.67 **	0.16 **	2.35 *
SIVAPPU CHITHIRAIKAR × ADT (R) 45	-0.03	5.33 **	0.47	-0.35	3.00	-12.47 **	0.04	1.29
SIVAPPU CHITHIRAIKAR × ASD 16	0.76	-2.30 **	-0.07	1.89 **	-3.07 *	4.55 **	-0.15 **	2.77 **
SIVAPPU CHITHIRAIKAR × CO 51	2.00 **	-2.05 **	-0.45	-2.80 **	1.48	1.96 **	0.19 **	2.32 *
SIVAPPU CHITHIRAIKAR × CO 47	1.39 **	0.66 *	-2.26 **	1.18 **	2.10	-3.70 **	-0.24 **	-8.73 **
CHERULI × ADT 37	-1.00 *	-2.77 **	-4.61 **	0.93 **	-6.00 **	-2.01 **	0.11 **	2.25 *
CHERULI × ADT (R) 45	2.29 **	5.49 **	-1.53 **	0.69 *	2.64	4.84 **	0.21 **	-5.02 **
CHERULI × ASD 16	-4.92 **	-6.18 **	2.40 **	-2.92 **	7.24 **	-1.60 **	0.11 **	-7.55 **
CHERULI × CO 51	1.65 **	0.74 *	0.21	-1.10 **	2.59	5.69 **	-0.30 **	4.40 **
CHERULI × CO 47	1.98 **	2.71 **	3.54 **	2.40 **	-6.46 **	-6.92 **	-0.13 **	5.92 **
SE (g_j)	0.47	0.33	0.51	0.35	1.53	0.53	0.02	0.90

** Significant at 1 % level * Significant at 5 % level.

Table 4. Comparison of three promising crosses for grain yield per plant with *per se* performance, SCA effects, GCA status and standard heterosis

*, ** Significant at 5 and 1 per cent probability levels, respectively;

SI.No.	Hybrids	Traits	*Per se* performance	SCA effect	GCA status	Standard heterosis (%)
1.	MOHINI SAMBA × ASD 16	DFF	76.60	-2.46**	G x G	8.40*
		PH	96.73	-3.46**	G x P	-0.23
		NPT	16.07	1.26*	A x G	-4.93
		PL	23.41	-0.97	G x G	-2.63
		NGP	140.27	3.69*	G x G	7.90**
		SF	82.55	6.04**	G x P	-2.76**
		HGW	2.36	0.41**	P x G	-0.98
		GYP	40.40	6.48**	G x G	15.32**
2.	RAJAMUDI × ASD 16	DFF	70.20	-5.64**	G x G	-0.66
		PH	107.63	-3.72**	P x P	11.02**
		NPT	17.10	-0.17	G x G	1.18
		PL	25.07	1.93**	G x G	4.24*
		NGP	140.13	11.21**	G x G	7.79**
		SF	76.43	-5.74**	G x P	-9.97**
		HGW	1.87	-0.08**	P x G	21.29**
		GYP	40.10	3.32**	G x G	14.45**
3.	RAJAMUDI × CO 47	DFF	71.33	-3.61**	G x G	0.94
		PH	100.17	-4.64**	P x G	3.33**
		NPT	17.70	-0.50	G x G	4.73
		PL	22.69	-0.02	G x G	-5.66**
		NGP	119.67	-6.49**	G x G	-7.95**
		SF	89.43	0.35	G x G	5.34**
		HGW	1.79	-0.03	P x G	-24.93**
		GYP	39.20	2.05**	G x G	11.87**

DFF Days to 50% flowering, PH Plant height, NPT Number of productive tillers per plant, PL Panicle length, NGP Number of grains per panicle, SF Spikelet fertility, HGW Hundred grain weight GYP Grain yield per plantFor standard heterosis , the check CO 51 was used for comparison of days to 50% flowering and spikelet fertility. For other traits ASD 16 was used.

GCA Status: G = Good parent having significant GCA effect in desired direction; A = Average parent having either positive or negative but non-significant GCA effects; P = Poor parent having Significant GCA effects in undesired direction.

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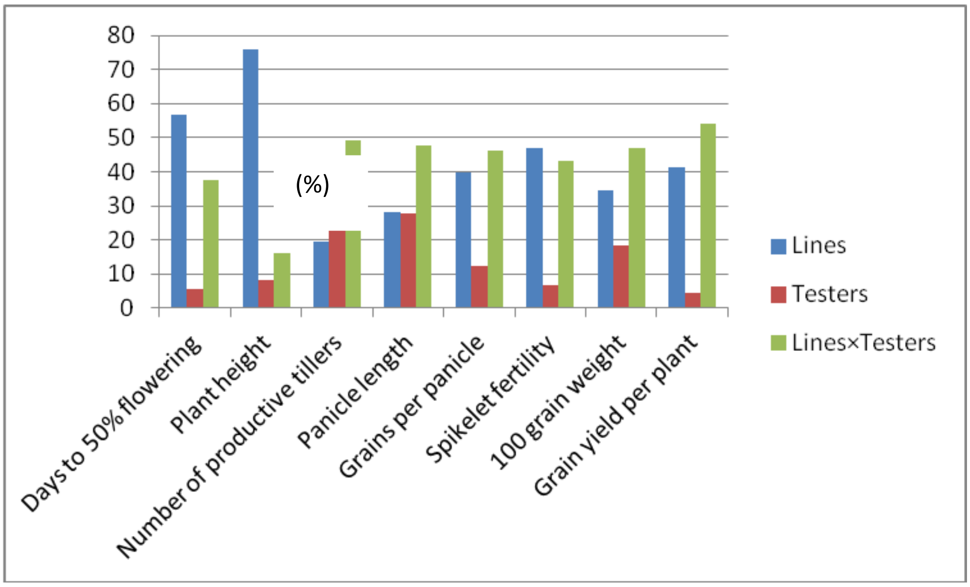

Fig. 1. Proportional contribution of lines, testers and their interactions to total variance in a set of line × tester crosses in rice

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