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Line X Tester Analysis in Rice (*Oryza sativa* L.)

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Line x tester analysis using a set of three females (Lines) and eight males (testers) was carried out to estimates the extent of combining ability for yield and its components in rice (*Oryza sativa* L.). Experimental material comprising eleven parents, their twenty four hybrids were planted in a randomized block design with three replications during kharif 2007 at the National Agricultural Research Project farm, Navsari Agricultural University, Navsari. Combining ability analysis revealed that, sca variances were higher than gca variances for all the characters except days to maturity which indicated non-additive gene action in the expression of the traits, although non-additive gene action was predominant in the expression of most of the traits. The estimation of gca effects for parents indicating that males Sathi 34-36, GR-5 and female Jaya were the best general combiners for grain yield per plant and some yield contributing traits. The best specific crosses combinations are GR-11 x Sathi 34-36, Jaya x GR-103 and Jaya x IR-28 of either average x good, good x poor or good x average combination.

Key words: Rice, Line x Tester, GCA and SCA, Gene action.

Rice is life and more than half of the world's population depends on rice for calories and protein, especially in developing countries. The world population, particularly in that of the rice consuming countries is increasing at a faster rate. By the year 2025, about 756 million tonnes of paddy, which is 70 percent, more than the current production, will be needed to meet the growing demand.

Breeding strategies based on selection of hybrids require expected level of the combining ability (CA). In breeding high yielding varieties of crop plant, the breeders often face with the problem of selecting parents and crosses. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents (Sarker *et al*., 2002; Radish *et al*., 2007). The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters.

General combining ability (GCA) is attributed to additive gene effects and additive x additive epistasis and is theoretically fixable. On the other hand, specific combining ability attributed to non-additive gene action may be due to dominance or epistasis or both and is non-fixable. The presence of non-additive genetic variance is the primary justification for initiating the hybrid programme (Cockerham, 1961; Pradhan *et al*., 2006). So there is need to study various some quantitative and qualitative traits to get better understanding of inheritance and select or identify superior genotypes.

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Materials and Methods

The experimental materials comprised eleven rice genotypes, three genotypes (Jaya, GR-11, Gurjari) were used as females (designated as lines) and eight genotypes (GR-5, GR-8, IR-28, Pusa Basmati, GR-103, GR-6, Sathi-34-36, GR-7) designated as testers were used as males. These parents were crossed to produce 24 F1 hybrids according to line x tester mating design (Kempthorne, 1957). This study was conducted during 2006 – 2007 at National Agricultural Research Projects farm, Navsari Agriculture University, Navsari. Single seedlings of each entry were transplanted at 20 x 20 cm spacing in a randomized complete block design with three replications. In this study eleven traits includes days to 50 per cent flowering, days to maturity, panicle per plant, panicle length (cm), plant height (cm), grains per panicle (gr), 1000 grain weight (gr), harvesting index (%), amylose content (%), protein content (%) were evaluated based on standard evaluation system of rice (Scshu, 1988). During these study it is considered that calculation for GCA and SCA effects for days to 50 per cent flowering, days to maturity and plant height low scoring or negative values was considered as better parents

The data obtained for each character were analysed by the usual standard statistical procedure (Panse and Sukhatme, 1978). The variances for

general combining ability and specific combining ability were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were performed using t-test.

Results and Discussion

Analysis of variance for combining ability

The analysis of variances displayed highly significant differences among the genotypes for all characters that depicted wide range of variability for the genotypes. The results are presented in Table 1. The variance estimates for gca and sca, suggested that both additive as well as non-additive gene action were important in the inheritance of various traits. The magnitude of gca variances was higher than sca variances for days to maturity for which predominance of additive gene action. This was further supported by high magnitude of σ^2gca/σ^2sca ratios. The magnitude of sca variances was higher than gca variances for remaining all other characters indicating predominance of non-additive gene action.

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

Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Panicles per plant	Panicle length (cm)	Plant height (cm)	Grains per panicle	Grain yield per plant (g)	1000 grain weight (g)	Harvest index (%)	Amylose content (%)	Protein content (%)
Replication	2	7.347	55.54	0.63	0.87	37.84	4.71	4.055	1.051	3.961	0.936	0.075
Female	2	1570.51	3667.62	37.15	157.54	799.84	12458.46	559.718	160.836	40.874	79.805	0.768
Male	7	1233.93	807.36	27.42	88.58	752.63	5372.68	449.789	77.66	106.367	10.452	4.153
Female x male	14	472.89	359.94	10.64	37.62	269.07	2206.47	156.951	32.546	46.264	20.299	1.516
Error	46	22.88	27.84	0.63	1.85	60.25	110	11.186	2.52	9.106	1.574	0.208
σ2f		64.47	151.58**	1.52	6.46*	31.14	514.50*	22.9	6.60*	1.35	3.25*	0.02
σ2m		134.53	86.42	2.98	9.57	77.80*	584.7	48.87*	8.37	10.88	0.98	0.43
σ2mf		149.9**	110.12**	3.37**	11.7**	72.2**	698.69**	49.01**	10.09**	12.63*	6.23**	0.43**
σ2gca		83.58	133.81	1.92	7.31	43.86	533.64	29.98	7.08	3.95	2.63	0.13
σ2sca		149.93	110.12	3.37	11.74	72.21	698.69	49.01	10.09	12.63	6.23	0.43
σβ2gca/ σ2sca		0.55	1.21	0.57	0.62	0.6	0.76	0.61	0.7	0.31	0.42	0.31

*Significant at 5 % **Significant at 1 %

This was further supported by low magnitude of σ^2gca/σ^2sca ratios, although non-additive gene action predominant in the expression of most of the traits.

The presence of non-additive genetic variance is the primary justification for initiating the hybrid programme (Cockerham, 1961). although non-additive gene action predominant in the expression of most of the traits such result was supported by, Dwivedi and Nanda (1979), Panwar *et al*. (1985), Dhaliwal and Sharma (1990), Majunder *et al*. (1990), Ram *et al*. (1991), Satyanarayana *et al*., (1998), Annadurai and Nadarajan (2001), Singh *et al*. (2005) and Panwar (2005).

General Combining Ability

The GCA is recognized as a measured of additive action, none of the female or male was observed to be good general combiner for all the traits studied (Table 2) An overall appraisal of gca effects revealed that among females, Jaya was found to be good general combiner due to its highly significant GCA effects for days to 50 per cent flowering, plant height, grain yield per plant and

Table 2. Estimating general combining ability effects of parents for different characters in rice.

Parents	Days to 50 % flowering	Days to maturity	Panicles per plant	Panicle length (cm)	Plant height (cm)	Grains per panicle	Grain yield per plant (g)	1000 grain weight (g)	Harvest index (%)	Amylose content (%)	Protein content (%)
Females											
Jaya	-0.36**	8.29*	-0.68**	0.1	-6.43**	-14.85**	4.73**	-0.11**	0.83	1.88**	-0.08**
GR-11	-7.90**	-14.20**	-0.75**	2.51**	1.69	26.23*	0.18	-2.53**	0.66	-1.75**	-0.12**
Gurjari	8.26**	5.91*	1.43**	-2.61**	4.73	-11.38**	-4.92**	2.64**	-1.50**	-0.12**	0.20**
SE (gi)	0.98	1.11	0.14	0.31	1.47	2.14	0.64	0.3	0.59	0.25	0.09
SE (gi-gj)	1.38	1.56	0.2	0.44	2.09	3.03	0.9	0.43	0.83	0.36	0.13
Males											
GR-5	-7.16**	-5.27**	3.24**	1.29*	-1.77**	17.34	5.06*	2.67**	0.71	-0.80**	-0.23**
GR-8	-1.72**	-1.05**	-1.77**	-4.20**	0.44	-12.01**	-0.92**	-1.29**	-5.03**	0.13	-0.64**
IR-28	-6.61**	-7.83**	0.68*	1.48*	-4.22**	29.87	4.4	2.29**	-1.04**	2.15**	0.77**
Pusa Basmati-1	3.5	8.83	-1.44**	-4.41**	-2.33**	-29.46**	-1.11**	0.52	-3.15**	-0.31**	0.68**
GR-103	11.72*	7.27	0.86**	3.35**	-1.33**	1.2	-0.55**	-3.32**	-0.70**	0.33	0.59**
GR-6	-2.61**	-1.38**	-1.77**	-0.53**	9.66	-29.24**	-7.61**	0.04	1	-1.55**	-0.71**
Sathi 34-36	-17.27**	-14.50**	0.86**	3.93**	-15.44**	31.98**	11.41**	3.69**	1.81	0.32	0.37**
GR-7	20.16**	13.94*	-0.66**	-0.91**	15	-9.68**	-10.67**	-4.61**	6.41*	-0.27**	-0.82**
SE (gj)	1.6	1.81	0.24	0.51	2.41	3.5	1.04	0.5	0.96	0.42	0.15
SE ((gi-gj)	2.26	2.56	0.33	0.72	3.41	4.95	1.48	0.7	1.36	0.59	0.21

*Significant at 5 % **Significant at 1 %

amylose content Singh et al. (1996) and Watanesk (1993) in rice observed good female parents for yield and its contributing traits. Among the males, Sathi 34-36 was found to be best general combiner for days to 50 per cent flowering, days to maturity, panicles pre plant, panicle length, plant height, grains per panicle, grain yield per plant, 1000 grain weight and protein content. IR-28 for days to 50 per cent flowering, days to maturity, panicles per plant, panicle length, Plant height, 1000 grain weight, amylose content and protein content, these finding are agreed with Rogbell *et al*. (1998) and Singh *et al* (1996).

On the whole, the females Jaya and GR-11were observed good general combiners for four characters. These may help to develop heterotic hybrids. Male Sathi 34-36, IR-28 and GR-5 were good general combiners for most of the yield contributing characters. Therefore, these parents may be useful in future breeding programme.

Specific Combining Ability

A specific combining ability effect is the index to determine the usefulness of a particular cross combination in the exploitation of heterosis. In the present study none of the cross combination was found good cross combination for all traits studied (Table-3). The crosses GR-11 x Sathi 34-36, Jaya x GR-103 and Jaya x IR-28 exhibited highest and significant SCA effect for grain yield per plant, above cross combinations was found to be best specific

Table 3. Estimation of specific combining ability for different characters

Parents	Days to 50 % flowering	Days to maturity	Panicles per plant	Panicle length (cm)	Plant height (cm)	Grains per panicle	Grain yield per plant (g)	1000 grain weight (g)	Harvest index (%)	Amylose content (%)	Protein content (%)
Jaya x GR-5	-14.08**	-10.51**	0.17	2.30*	-7.01	9.81	1.56	1.36	3.42*	4.08**	0.57*
Jaya x GR-8	5.47	1.93	-0.38	-4.37**	2.76	-20.81**	0.54	-0.62	1.49	-1.46	-0.40
Jaya x IR-28	-5.97*	-4.29	2.55**	2.60**	-6.56	2.29	4.31*	1.57	6.19**	0.00	0.79**
Jaya x Pusa Basmati-1	10.91**	11.04**	-1.04*	2.51**	10.54*	9.96	-0.45	-1.34	0.12	-3.47**	-0.68*
Jaya x GR-103	-19.63**	-18.06**	2.21**	0.41	-3.45	45.62**	6.45**	5.51**	-1.11	1.41	0.17
Jaya x GR-6	14.02**	16.59**	-1.39**	-1.40	1.87	6.74	2.68	-2.30*	-3.63*	-1.63*	-0.01
Jaya x Sthi-34-36	11.02**	6.04	-2.71**	-3.01**	2.65	-25.14**	-16.12**	-0.86	-6.35**	-0.85	-0.77**
Jaya x GR-7	-1.75	-2.73	0.60	0.95	-0.79	-28.48**	0.99	-3.31**	-0.14	1.92*	0.34
GR-11 x GR-5	1.12	-2.68	-1.28**	-2.96**	-4.13	-6.26	-2.27	2.03*	-4.27*	-0.51	0.31
GR-11 x GR-8	-10.65**	-3.90	-1.33**	-0.44	-10.69*	24.76**	-0.47	2.45**	-0.59	1.97**	0.26
GR-11 x IR-28	6.23*	8.54**	-1.67**	-1.26	7.30	9.21	-4.84*	-0.62	-4.10*	0.99	-0.84**
GR-11 x Pusa Basmati-1	4.79	0.20	0.87*	0.07	7.75	-24.12**	-3.36	-2.12*	2.44	0.39	-0.03
GR-11 x GR-103	8.90**	12.09**	-1.18**	-2.30*	-4.91	-19.12**	-0.63	-6.15**	3.69*	-1.88*	-0.43
GR-11 x GR-6	-7.43*	-11.23**	1.88**	4.84**	-4.58	-1.67	-4.94**	1.00	2.26	2.44**	0.06
GR-11 x Sathi 34-36	1.23	-3.45	2.95**	-0.85	6.19	32.76**	14.55**	2.36**	1.94	0.12	1.26**
GR-11 x GR-7	-4.20	0.43	-0.23	2.90**	3.08	-15.56*	-4.19*	1.04	-1.37	-3.53**	-0.59*
Gurjari x GR-5	12.95**	13.19**	1.11*	0.66	11.15*	-3.55	-5.48**	-3.39**	0.84	-3.56**	-0.88**
Gurjari x GR-8	5.18	1.97	1.72**	4.82**	7.93	-3.95	-0.07	-1.83*	-0.90	-0.51	0.14
Gurjari x IR-28	-0.26	-4.25	-0.88*	-1.34	-0.73	-11.50	0.53	-0.95	-2.09	-0.99	0.05
Gurjari x Pusa Basmati-1	-15.70**	-11.25**	0.16	-2.58**	-18.29**	14.15*	3.81*	3.47**	-2.56	3.08**	0.72**
Gurjari x GR-103	10.73**	5.97	-1.02*	1.88*	8.37	-26.50**	-5.81**	0.64	-2.57	0.47	0.25
Gurjari x GR-6	-6.59*	-5.36	-0.48	-3.44**	2.70	-5.06	2.25	1.29	1.37	-0.80	-0.04
Gurjari x Sathi-34-36	-12.26**	-2.58	-0.24	3.86**	-8.84*	-7.61	1.57	-1.49	4.41*	0.72	-0.49
Gurjari x GR-7	5.95*	2.30	-0.37	-3.86**	-2.29	44.04**	3.19	2.26	1.51	1.60*	0.24
SE (Sij)	2.77	3.13	0.41	0.89	4.18	6.06	1.18	0.86	1.67	0.72	0.26
SE (Sij-Skl)	3.92	4.44	0.58	1.26	5.91	8.57	2.57	1.22	2.36	1.03	0.37

*Significant at 5 % **Significant at 1 %

combinations for grain yield along with most of yield contributing traits. Rogbell *et al*. (1998), Chen et al. (1995) and Young & Virmani (1990) observed similar findings for good specific cross combinations in rice.

During these study crosses having high specific combination for grain yield per plant are GR-11 x Sathi 34-36, Jaya x GR-103 and Jaya x IR-28 involved average x good, good x poor and good x average combining parents, respectively. For grains per panicle, crosses *viz*., Jaya x GR-103, Gurjari x GR-7 and GR-11 x Sathi 34-36 were better combinations and involved poor x average, poor x poor and good x good combiners respectively and for panicles per plant, crosses viz., GR-11 x Sathi 34-36, Jaya x IR-28 and Jaya x GR-103 were the best specific combinations and involved poor x good, poor x good and poor x good combining parents, respectively. Similar trend was observed in rest of the characters. It appeared that crosses with one good and one poor or one average and one good general combining parents would produce hybrids with good specific combinations. Parents with highest gca effects will not necessarily generate top specific

cross combination as also reported earlier by Peng and Virmani (1990), Banumathy and Prasad (1991), Ramalingam *et al*. (1993), and Annadurai and Nadarajan (2001).

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