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RESEARCH ARTICLE

Combining ability analysis for yield components and physiological traits in rice

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SUMMARY

Combining ability analysis for 7 varieties for yield components physiological traits and yield in a diallel fashion revealed that the progenies differed significantly for all characters indicating the involvement of both additive and non-additive type of gene action in expression of the characters. The relative magnitude of estimates of SCA variance was higher than that of GCA variance for all the characters indicating the predominance of non-additive gene action. The parent Indra was the best combiner among all the seven parents studied as it recorded positive gca effects for 6 characters *viz.,* panicle length, ear bearing tillers, number of seeds/panicle, biological yield, flag leaf nitrogen content and grain yield per plant. The crosses Samba mahsuri/Polasa prabha and Samba mahsuri/ Nellore mahsuri recorded high specific combining ability effects for exploitation. From an overall analysis that all characters *viz.,* days to 50 per cent flowering, ear bearing tillers/plant, harvest index, biological yield and flag leaf nitrogen content which are influencing grain yield are predominantly governed by non-additive gene action.

Key Words : Combining ability, Grain yield, Rice

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The information on combining ability and gene action for different yield contributing characters and physiological traits is important to achieve superior genotypes from the segregating population or in exploiting the heterosis in rice. Combining ability studies for these traits are frequently used by the plant breeder to evaluate parental lines for their usefulness in crosses and to assess the nature of gene action involved in the inheritance. Rice researchers are of the opinion that in order to increase the present yield potentiality in rice, it is necessary to identify the physiologically efficient genotypes and involve them in yield oriented projects. At this juncture, the genetic analysis of physiological characters will be of immense value to breeders, as very few attempts were made till now to generate information in these areas. The combining ability analysis (Grifing, 1956) gives an idea about the relative magnitude of additive and non additive types of gene action in expression of the traits. Diallel analysis in rice has been reported by many workers (Sarathe *et al.,* 1986). For rapid success in only conventional hybridization programme the choice of parents which can produce superior offsprings is very much essential. The choice of breeding methodology is a function of genetic architecture of the traders in the crop. The present study was made with a view to study the combining ability of indigenous rice cultivars for yield, its component traits and physiological traits.

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MATERIALS AND METHODS

Seven rice varieties *viz.,* Samba mahsuri, Polasa Prabha, Jagtial Samba, Nellore Mahsuri, Indra, Vijetha and Prabhat were crossed in diallel mating design (without reciprocals) during *Rabi* 2006 and *Kharif* 2007 seasons. These parents were selected based on their attributes for grain quality, cooking quality, reaction to pests and diseases and high

yield. The parental line Samba Mahsuri possessed excellent cooking quality. Polasa Prabha, Jagtial Samba and Nellore Mahsuri have got good grain quality. Indra is having biotic and abiotic stress tolerance like brown plant hopper (BPH) and salinity. Vijetha and Prabhat are high yielding varieties. These varieties showed great diversity for morphological and physiological traits. The twenty one F_1s and seven parents were grown at the experimental farm of Andhra Pradesh Rice Research Institute and Regional Agricultural Research station, Maruteru in a randomized block design (RBD) with three replications having 3m row length and 20 x 15 cm spacing. Each replication comprised of one row of parent and three rows of F_1s. Recommended agronomic practices were followed. Mean values on yield components *viz.,* days to 50 per cent flowering, plant height (cm), total tillers per plant, ear bearing tillers per plant, panicle length (cm), filled grains per panicle, unfilled grains per panicle and 1000 grain weight (g) and physiological traits *viz.,* chlorophyll content (mg/g), specific leaf weight (g/m^2), harvest index (%), biological yield (%) and flag leaf nitrogen content (%) and the data were analyzed.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed significant differences among the genotypes. Analysis of variance for combining ability indicted that the progenies differed significantly for all characters (Table 2) indicating the involvement of both additive and non-additive type of gene action in expression of the characters. The relative magnitude of estimates of SCA variance was higher than that of GCA variance for all the characters indicating the predominance of non-additive gene action. The proportion of non-additive genetic variance (σ^2s) was higher than the additive genetic variance (σ^2g) for all the yield components and physiological traits revealed the importance of non-additive gene effects in the expression of the characters and confining the earlier findings of Khaloque *et al.* (1978) and Sarathe *et al.* (1986). However, non-additive genetic variance offers good scope for the exploitation of hybrid vigour in improving the characters under study.

Table 1 : Analysis of variance for yield components and physiological traits in rice

Sources	d.f.	Days to 50% flowering	Plant height (cm)	Ear bearing tillers	Panicle length (cm)	No of seeds per panicle	1000 grain weight (g)	Chloro phyll content (mg/g)	Specific leaf weight (g/m^2)	Harvest index (%)	Biological yield (g)	Flag leaf N content (%)	Grain yield per plant (g)
		1	2	3	4	5	6	7	8	9	10	11	12
Replications	2	0.155	14.083	11.29	5.956	180.34	0.148	1.21	0.003	0.85	6.77	0.01*	0.99
Genotypes	27	137.466**	520.59**	33.64**	10.44**	2692.83**	58.99**	41.12**	0.55**	31.36**	164.53**	0.13**	37.38**
Parents	6	102.159**	820.22**	4.937	15.60**	3660.60**	142.41**	61.25**	0.66**	12.25	14.16*	0.02**	10.61**
Hybrids	20	146.511**	388.13**	31.03**	8.301**	2533.08**	36.74**	32.25**	0.55**	38.10**	144.33**	0.15**	28.89**
Parents vs hybrids	1	168.39**	1372.0**	258.04**	22.35**	81.147	3.29**	97.96**	0.04**	11.07	1470.64**	0.42**	367.69**
Error	54	0.821	7.454	10.45	2.00	60.33	0.07	6.34	0.003	5.54	12.304	0.001	1.34**
CV %		0.8863	2.8341	20.6454	6.3436	3.871	1.3102	12.9072	1.0842	5.0408	5.8976	2.3276	4.1794

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Combining ability analysis in a set of 7 X 7 diallel crosses in rice for yield components and physiological traits

Sources of variation	Days to 50% flowering	Plant height (cm)	Ear bearing tillers/plant	Panicle length (cm)	No of seeds/ panicle	1000 grain weight (g)	Chlorophyll content (mg/g)	Specific leaf weight(g/m^2)	Harvest index (%)	Biological yield (g)	Flag leaf N content(%)	Grain yield per plant (g)
	1	2	3	4	5	6	7	8	9	10	11	12
Gca	106.55**	514.45**	6.72*	5.31**	1619.27**	62.55**	7.26**	0.32**	5.15*	36.15**	0.067*	6.91**
Sca	28.47**	76.12**	12.50**	2.96**	691.42**	7.41**	15.55**	0.15**	11.97**	60.18**	0.036*	14.04**
Error	0.27	2.48	3.48	0.67	20.11	0.02	2.11	0.00	1.85	4.10	0.0005	0.45
σ^2 gca	11.81	56.89	0.360	0.515	177.68	6.95	0.57	0.035	0.37	3.56	0.0074	0.719
σ^2sca	28.20	73.64	9.015	2.291	671.31	7.39	13.44	0.145	10.12	56.08	0.036	13.6
σ^2 gca/ σ^2sca	0.419	0.773	0.04	0.225	0.265	0.941	0.043	0.244	0.036	0.064	0.206	0.053

* and ** indicate significance of values at P=0.05 and 0.01, respectively

The selection of parents with good general combining ability (gca) effects is a prime requisite for a successful breeding programme. The character wise estimation of gca effects (Table 2) of parents revealed that the parents Jagtial Samba, Nellore Mahsuri and Prabhat were good general combiners for earliness, while Samba mahsuri and Indra were the better general combiners for late flowering. The parental lines Indra and Vijetha for tallness while Samba Mahsuri, Jagtial Samba, Nellore Mahsuri and Prabhat for dwarfness were found to be superior combiners. The parental lines Prabhat and Indra appears to be good general combiners for ear bearing tillers. The parental lines Vijetha, Indra and Samba Mahsuri showed the highest gca effects for panicle length. Samba Mahsuri exhibited high gca effects followed by Nellore Mahsuri and Jagtial Samba for no. of seeds /panicle. Based on gca effects for 1000 grain weight, Prabhat for boldness followed by Vijetha and Indra, while Jagtial Samba, Nellore Mahsuri, Polasa Prabha and Samba Mahsuri for fineness were identified to be good combiners. However, the list of best general combiners and specific combinations are presented in Table 5.

The parental line Jagtial Samba with positive gca effect was good combiner for chlorophyll content. Polasa Prabha, Jagtial Samba, Nellore Mahsuri and Prabhat were good combiners for Specific leaf weight. Samba Mahsuri was found to be good general combiner for harvest index, while Indra and Vijetha were better general combiners for biological yield. Indra and Samba Mahsuri were good general combiners for flag leaf nitrogen content. The genotypes Indra and Samba Mahsuri were good general combiners for grain yield per plant and exhibited superior gca effects Fig. 1.

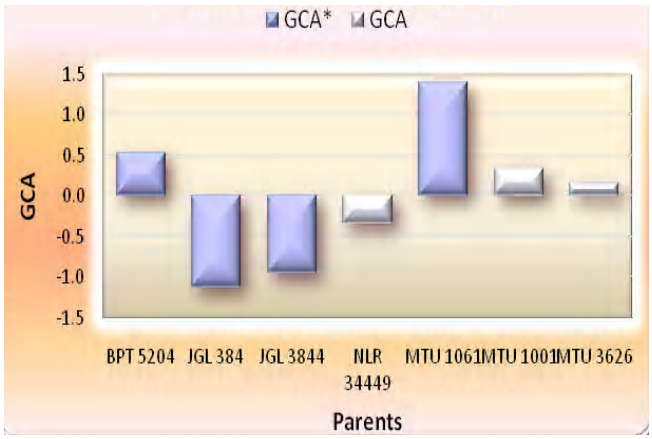

Fig. 1 : GCA effects for grain yield/ plant

The specific combing ability (sca) effect (Table 4) is an average performance of a specific cross combination expressed as deviation from the population mean and correlated with parental gca effects. The high sca effects may be associated

Table 4 : Specific combining ability (sca) effects of 21 F_1 hybrids for 12 characters in rice

Cross	Days to 50% flowering	Plant height (cm)	Ear bearing tillers/plant	Panicle length (cm)	No. of seeds/ panicle	1000 grain weight (g)	Chlorophyll content (mg/g)	Specific leaf weight (g/m²)	Harvest index (%)	Biological yield (g)	Flag leaf N content (%)	Grain yield per plant (g)
	1	2	3	4	5	6	7	8	9	10	11	12
1. Samba mahsuri/Polasa prabha	3.759**	4.000**	0.213	0.004	44.435**	1.689**	3.721**	0.356**	4.855**	4.694**	0.225**	5.174**
2. Samba mahsuri/Jagtial samba	2.907**	0.593	1.176	0.741	18.435**	2.52**	2.971**	0.219**	1.387	5.105**	0.271**	1.364*
3. Samba mahsuri/Nellore Mahsuri	2.130**	6.333**	0.676	0.975	40.369	0.093	0.136	0.132**	4.356**	6.71**	0.23**	5.892**
4. Samba mahsuri/Indra	5.759*	6.148**	1.287	0.512	33.231**	0.358**	1.791**	0.09**	0.215	1.074	0.024	0.466
5. Samba mahsuri/Vijetha	5.463**	4.963**	3.843*	1.377	16.157**	1.844**	3.559**	0.089**	1.084	3.856**	0.019	2.434**
6. Samba mahsuri/Prabhat	0.056	12.926**	4.102**	1.334	1.5099**	2.161**	5.761**	0.246**	0.858	3.065	0.058**	0.964
7. Polasa prabha/Jagtial samba	0.352	5.074**	1.306	0.434	5.787	0.027**	2.145	0.309**	6.588**	1.54	0.152	2.935**
8. Polasa prabha/Nellore Mahsuri	2.648**	0.815	3.509*	1.771	2.472**	2.107	3.529**	0.143**	5.921**	4.659**	0.056**	0.869
9. Polasa prabha/Indra	0.019	8.370**	0.861	0.125	1.546**	2.806**	5.617**	0.163**	3.35**	13.691**	0.055**	4.031**
10.Polasa prabha/Vijetha	1.352**	1.556	3.639*	0.681	34.38**	1.975**	0.951**	0.379**	0.594	1.266	0.110**	0.875
11.Polasa prabha/Prabhat	3.167**	6.407**	3.287*	0.597	6.046**	1.909**	1.965**	0.428**	1.683	4.257**	0.031	0.98
12.Jagtial samba/Nellore mahsuri	6.537**	11.926**	2.861	0.071	48.194**	1.187**	5.17**	0.612**	2.943**	1.246	0.138**	1.15
13. Jagtial samba/Indra	7.833**	10.556**	1.565	2.508**	0.213**	3.16**	2.791**	0.594**	4.206**	6.671**	0.148**	0.658
14. Jagtial samba/Vijetha	3.87**	0.704	0.991	1.548	16.287**	4.538**	2.575**	0.189**	0.375	9.589**	0.143**	4.596**
15. Jagtial samba/Prabhat	4.981**	5.667**	4.25**	0.563	13.38**	1.422**	1.339**	0.504**	1.682	2.833	0.067**	0.189
16. Nellore mahsuri/Indra	7.463**	6.963**	4.583**	0.312	22.194**	1.169**	0.699**	0.402**	0.671	9.607**	0.22**	4.019**
17. Nellore mahsuri/Vijetha	7.093**	14.444**	2.472	3.923**	16.546**	1.211**	2.634**	0.664**	2.274	3.29	0.089**	0.187
18. Nellore mahsuri/Prabhat	3.944**	10.074**	2.269	1.466	8.454**	3.872**	4.787**	0.392**	4.128**	0.388	0.242**	2.478**
19. Indra/Vijetha	9.130**	2.741	0.898	1.493	9.62**	0.606**	0.687**	0.3**	1.256	2.959	0.194**	2.258**
20. Indra/Prabhat	5.019**	0.889	1.028	2.729**	1.62**	1.511**	1.559**	0.29**	0.806	6.629**	0.212**	2.667**
21. Vijetha/Prabhat	0.278	0.630	4.583**	1.085	46.694**	3.087**	0.431**	0.026	3.897**	12.598**	0.008	2.944**

* and ** Indicate significance of value at P 0.05 and 0.01, respectively

Table 5 : List of best general combiner and best specific combiners for different characters

Sr. No.	Characters	Best general combiners (par cent)	Best specific combiners (cross)
1.	Days to 50% flowering	Nellore mahsuri	Indra/Vijetha
		Prabhat	Jagtial samba/Indra
2.	Plant height (cm)	Polasa prabha	Jagtial samba/Nellore mahsuri
		Jagtial samba	Polasa prabha/Indra
3.	Ear bearing tillers/plant	Prabhat	Vijetha/Prabhat
		Indra	Jagtial samba/Prabhat
4.	Panicle length (cm)	Indra	Jagtial samba/Indra
		Vijetha	Nellore mahsuri/Vijetha
5.	Number of seeds /panicle	Samba mahsuri	Vijetha/Prabhat
		Indra	Samba mahsuri/Polasa prabha
6.	1000 grain weight (g)	Vijetha	Jagtial samba /Indra
		Prabhat	Samba mahsuri/Jagtial samba
7.	Chlorophyll content (mg/g)	Jagtial samba	Polasa prabha/Indra
			Jagtial samba/Nellore mahsuri
8.	Specific leaf weight (g/m^2)	Prabhat	Jagtial samba/Prabhat
			Nellore mahsuri/Vijetha
9.	Harvest index (%)	Samba mahsuri	Polasa prabha /Nellore mahsuri
			Samba mahsuri /Polasa prabha
10.	Biological yield (g)	Indra	Vijetha /Prabhat
			Polasa prabha/indra
11.	Flag leaf N content (%)	Samba mahsuri	Samba mahsuri/Jagtial samba
		Indra	Samba mahsuri/Nellore mahsuri
12.	Grain yield/plant (g)	Indra	Samba mahsuri/Polasa prabha
		Samba mahsuri	Samba mahsuri/Nellore mahsuri

with high heterotic vigour. It is an important parameter in the selection of parents for hybridization.

Of the 21 crosses evaluated the crosses *viz.,* Jagtial Samba/Prabhat (LxH), Nellore Mahsuri/Indra (LxL) and Vijetha/ Prabhat (LxH) were the best specific crosses for productive tillers with non-additive gene action (Singh and Maurya, 1997 and Anna Durai *et al.,* 2009) for this trait. Next to ear bearing tillers/plant, length of the panicle, another important yield component and the cross combinations Jagtial Samba/ Indra (LxH) and Nellore Mahsuri/Vijetha (LxH) recorded high sca effects. Sharma *et al.* (2006), reported both additive and non-additive gene action.

For realizing higher grain yield, in addition to more number of filled grains; test weight should be more. The crosses Jagtial Samba/Indra (LxL), Polasa Prabha/Indra (LxH) and Samba Mahsuri/Prabhat (LxH) were the best specific crosses for 1000 grain weight. In the cross combination Jagtial Samba/Indra were two poor combiners complemented to produce best specific cross (Ganesan *et al.,* 1997).

Chlorophyll content is the most important physiological trait in rice as there is linear relationship between chlorophyll content and yield. Polasa Prabha/Indra (LxL) and Jagtial samba/Nellore Mahsuri (LxH) were the best specific crosses for chlorophyll content, Meenakshi *et al.* (1999) reported both additive and non-additive gene action for this trait. Among the crosses, Samba Mahsuri/Polasa Prabha (HxL), Polasa Prabha/Nellore Mahsuri (LxL) and Samba Mahsuri/Nellore Mahsuri (LxL) their parents with low gca complimented to produce high harvest index (Singh *et al.,* 2006 and Raju *et al.,* 2006). Vijetha/Prabhat (HxL) and Polasa Prabha/Indra (LxH) were the best specific crosses for biological yield and it was governed by non-additive gene action (Kumar *et al.,* 2005). Samba Mahsuri/Jagtial Samba (HxL) and Samba mahsuri/ Nellore mahsuri ((HxL) are the best specific crosses for flag leaf nitrogen content and it is governed by non-additive gene action (Pollmer *et al*., 1979). For grain yield, crosses *viz.,* Samba Mahsuri/Polasa Prabha (LxL) and Samba Mahsuri/Nellore Mahsuri (LxH) were the best specific crosses. The ratio of sca variance to the total variance was low also indicates the non-additive gene action governing this trait (Sharma *et al.,* 2006).

Based on gca effects Indra was the best parent among

all the seven parents studied as it recorded positive gca effects for 6 characters *viz.,* panicle length, ear bearing tillers, number of seeds/panicle, biological yield, flag leaf nitrogen content and grain yield per plant. In the present study, parents with high x low and low x low yielded good combinations suggesting that for getting good specific cross combinations the parents always need not be good general combiners. The sca effects in F_1s would be important in self pollinated crops to isolate good transgressive segregants. If additive genetic system is present, good segregants may appear from the crosses with high x low, low x high and low x low general combiners which can be isolated and maintained through pedigree method of breeding.

Thus, it appears from an overall analysis that all characters *viz.,* days to 50 per cent flowering, ear bearing tillers/plant, harvest index, biological yield and flag leaf nitrogen content which are influencing grain yield are predominantly governed by non-additive gene action. However, the role of additive component of gene action appear to be considerable along with non-additive effect in the case of days to 50 per cent flowering, plant height and 1000 grain weight.

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