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Combining ability analysis for quality and nutritional traits in rice

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ABSTRACT

Combining ability analysis was carried out with seven parents and twenty one F1s in diallel mating without reciprocals for their quality and nutritional traits. The results indicated that the sca variance was greater than gca variance for all the characters under study except for milling percentage and protein content indicating that the trait was under the influence of non-additive gene action. Significant values of mean squares for both gca and sca for all the quality characters indicated considerable influence of both additive and non-additive variances. Non-additive gene action was predominant in governing the protein, iron and zinc contents as the ratio of gca variance to total variance was low. The results indicated that there was close relationship between mean performance of the parents and their gca effects in most of the cases studied. Based on gca effects Indra was the best parent among all the seven parents studied as it recorded positive gca effects for hulling, milling, head rice recovery, L/B ratio and grain yield per plant. The characters viz L/B ratio, volume expansion ratio, amylose, iron and zinc contents are predominantly governed by non-additive gene action. However the role of additive component of gene action appears to be considerable along with non-additive effect in case of head rice recovery, L/B ratio and elongation ratio.

Keywords: Combining; nutritional characters; diallel mating

INTRODUCTION

Quality of rice is governed by a combination of physicochemical properties of the kernel. The market value of milled rice largely depends upon the length and breadth of the kernel and its physical appearance. Though rice is the major energy source of more than half of the world population it lacks many essential nutrients. Rice based diets are the primary cause of micronutrient malnutrition throughout the developing world. Iron and zinc deficiencies are common in rice consuming regions. Cooking quality of rice is mainly determined by water uptake, volume expansion and kernel elongation. These traits are primarily influenced by the alkali value and amylose content of the kernels. The combining ability analysis (Griffing 1956) gives an idea about the relative magnitude of additive and non-additive types of gene action in expression of the

traits in varietal improvement program. The present study was made with a view to study the combining ability of indigenous rice cultivars for quality and nutritional traits.

MATERIAL 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 and Kharif 2009 seasons. These parents were selected based on their attributes for grain quality, cooking quality, reaction to pests and diseases and high yield. Vijetha and Prabhat are high yielding varieties. These varieties showed great diversity for morphological and quality 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, Andhra Pradesh in a randomized block design (RBD) with three replications having 3 m 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 quality traits viz kernel length:breadth ratio, cooking and eating qualities like elongation ratio, volume expansion ratio, amylose content, gelatinization temperature and nutritional qualities like protein, iron and zinc contents along with yield per plant were analyzed.

RESULTS and DISCUSSION

The results indicated that the sca variance was greater than gca variance (Table 1) for all the characters under study except for milling per cent and protein content indicating that the trait was under the influence of non-additive gene action (Kumar et al 2005). The ratio of gca component of variance to total genetic variance was around 0.5 for head rice recovery indicating the predominance of both additive and non-additive gene actions (Sharma and Mani 2008). Significant values of mean squares for both gca and sca for all the quality characters indicated considerable influence of both additive and non-additive variances (Krishna Veni et al 2006). When both types of gene actions govern the character by simple pedigree method it exploits the genetic variance. Non-additive gene action was predominant in governing the protein content, iron and zinc content as the ratio of gca variance to total variance was low (Kumar et al 2006).

Among 21 hybrids studied for hulling percentage three crosses viz Jagtial Samba/Prabhat (L x H), Jagtial Samba/ Vijetha (L x L) and Samba Mahsuri/Nellore Mahsuri (L x H) were the best specific combinations (Table 4) (Mani et al 1998). Among the parents Prabhat, Polasa Prabha and Nellore Mahsuri were the best general

Table 1. Combining ability analysis for quality characters

Cross	Hulling (%)	Milling (%)	Head rice recovery (%)	L/B ratio	Volume expansion ratio	Elongation ratio	Gelatinization temperature	Amylose content (%)	Protein content (%)	Iron (ppm)	Zinc (ppm)	Grain yield/ plant (g)
Gca	2.30**	21.48**	49.31**	0.16**	0.50**	0.06**	1.46**	10.61**	1.22**	140.35**	11.95**	6.91**
Sca	2.24**	54.71**	11.65**	0.05**	0.65**	0.02**	1.83**	12.49**	0.98**	594.93**	18.35**	14.04**
Error	0.06	0.19	0.17	0.00	0.01	0.00	0.01	0.03	0.01	1.43	0.21	0.45
ó^2 gca	0.25	2.37	5.46	0.017	0.054	0.007	0.161	1.176	0.134	15.435	1.305	0.719
ó^2 sca	2.17	54.52	11.49	0.052	0.635	0.023	1.819	12.46	0.968	593.5	18.14	13.6
ó^2 gca/ ó^2 sca	0.114	0.043	0.475	0.34	0.085	0.291	0.088	0.094	0.139	0.026	0.072	0.053

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

Table 2. Estimates of general combining ability effects for physical and cooking quality characters of parents

Genotype	Hulling (%)	Milling (%)	Head rice recovery (%)	L/B ratio	Volume expansion ratio	Elongation ratio	Gelatinization temperature
Samba Mahsuri	-0.265**	2.557**	2.186**	0.026	0.061	0.139**	-145**
Polasa Prabha	0.452**	0.845**	0.016	0.117**	0.285**	0.031**	-0.208**
Jagtial Samba	-0.833**	-0.481**	-2.921**	0.013	-0.117**	0.043**	-0.248**
Nellore Mahsuri	0.256**	-0.753**	1.263**	0.054**	-0.048	0.003	0.228**
Indra	0.309**	1.00**	2.234**	0.099**	-0.412**	-0.093**	0.126**
Vijetha	-0.407**	-1.232**	-3.491**	-0.031	-0.011	-0.093**	0.736**
Prabhat	0.489**	-1.936**	0.623**	-0.271**	0.243**	-0.031*	-0.488**
SE±	0.063	0.192	0.169	0.003	0.011	0.001	0.012

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

combiners with significant positive gca effect (Table 2). The parents Samba Mahsuri and Indra were identified as good general combiners and could be used as potential donors to improve milling recovery. Samba Mahsuri/ Nellore Mahsuri (H x L) and Jagtial Samba/Prabhat (L x L) were the best specific crosses for milling recovery. The parents Samba Mahsuri, Indra, Nellore Mahsuri and Prabhat were found to be potential donors for head rice recovery owing to their highly positive gca values. An appraisal of sca effects for head rice recovery in F_1 indicated that Samba Mahsuri/Polasa Prabha (H x H), Samba Mahsuri /Prabhat (H x H), and Nellore Mahsuri/Vijetha (H x L) possessed highest sca effects and all these crosses consisted of one of the parent with high gca. However crosses like Samba Mahsuri/Nellore Mahsuri and Samba Mahsuri/Indra offered maximum scope for isolating segregates with good head rice recovery since both these specific crosses possessed high gca parents.

Jagtial Samba, Nellore Mahsuri and Indra were the good general combiners for L/B ratio. These parents also contributed maximum favourable genes and were identified as potential donors to improve L/B ratio. Among the crosses the best specific crosses were Nellore Mahsuri /Indra (H x H) and Samba Mahsuri/Polasa Prabha (H x L). Among the parents used in the study Jagtial Samba, Nellore Mahsuri and Indra appeared to contribute maximum favourable genes for L/B ratio (Krishna Veni et al 2006).

Among the parents studied Vijetha, Prabhat and Polasa Prabha were the best parents for volume expansion whereas Prabhat and Polasa Prabha were good general combiners with desirable gca effects. Cross Polasa Prabha/Prabhat (H x L), Samba Mahsuri/Nellore Mahsuri (L x H) and Samba Mahsuri/Jagtial Samba (L x L) were the best specific crosses.

In the present study Samba Mahsuri and Jagtial Samba which are known for their excellent cooking quality could be used in the breeding schemes. Among the crosses Samba Mahsuri/Polasa Prabha (H x H), Nellore Mahsuri/Prabhat (L x L) and Indra/Vijetha (L x L) were the best specific crosses for elongation ratio.

In the present study Vijetha, Nellore Mahsuri and Indra were good general combiners for gelatinization temperature and these parents were found to possess a high degree of prepotency and transmitted this trait to crosses which turned out to be best specific crosses. Among them Polasa Prabha/Vijetha (L x H) and Samba Mahsuri/Nellore Mahsuri (L x H) were the top ranking specific crosses (Mandal and Sunil Saran 1989).

Table 3. Estimates of general combining ability effects for chemical and nutritional quality characters of parents

Genotype	Amylose content (%)	Protein content (%)	Iron (ppm)	Zinc (ppm)	Grain yield/ plant (g)
Samba Mahsuri	1.745**	-0.246**	-2.316**	2.107**	0.520*
Polasa Prabha	0.848**	0.332**	-1.733**	0.510**	-1.117**
Jagtial Samba	-1.492**	0.300**	1.937**	-1.017**	-0.941**
Nellore Mahsuri	-1.036**	0.260**	-7.038**	-1.079**	-0.345
Indra	0.004	-0.206**	1.514**	-0.902**	1.396**
Vijetha	0.022	0.197**	3.333**	0.494**	0.336
Prabhat	-0.092	-0.636**	4.303**	-0.113	0.150
SE±	0.030	0.014	1.430	0.210	0.496

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

Table 4a. Estimates of specific combining ability effects for physical and cooking quality characters of 21 F_1 hybrids

Cross	Hulling (%)	Milling (%)	Head rice recovery (%)	L/B ratio	Volume expansion ratio	Elongation ratio	Gelatinization temperature
Samba Mahsuri/Polasa Prabha	1.445**	0.807	3.246**	0.364*	-0.263**	0.238**	0.322**
Samba Mahsuri/Jagtial Samba	-0.607*	-2.876**	-1.531**	0.001	1.205**	-0.093**	-1.504**
Samba Mahsuri/Nellore Mahsuri	2.805**	11.045**	2.539**	-0046	1.35**	0.124**	0.854**
Samba Mahsuri/Indra	0.815**	0.233	2.481**	-0.128*	-0.103	-0.094**	-1.658**
Samba Mahsuri/Vijetha	1.141**	-2.258**	2.573**	-0.061	-0.234*	-0.13**	-0.754**
Samba Mahsuri/Prabhat	0.489**	3.992**	3.733**	0.044	0.851**	-0.073*	-0.08
Polasa Prabha/Jagtial Samba	-0.204	-2.441	-0.384	-0.099	0.138	0.108**	-0.442**
Polasa Prabha/Nellore Mahsuri	-0.173	0.867*	-1.828**	0.06	-0.35	-0.122**	-1.607**
Polasa Prabha/Indra	-0.229	1.375**	2.095**	-0.032	-0.076	-0.113**	0.117**
Polasa Prabha/Vijetha	-0.620*	-1.176**	-3.864**	-0.178**	0.166	0.114**	1.308**
Polasa Prabha/Prabhat	-1.389**	-1.71**	-4.044**	0.01	1.545**	-0.125**	-0.535**
Jagtial Samba/Nellore Mahsuri	0.719**	-0719	-1.785**	0.164**	0.111	-0.110**	-0.044
Jagtial Samba/Indra	0.476*	-1.339**	1.878**	-0.081	-0.308	-0.091**	-0.996**
Jagtial Samba/Vijetha	1.765**	-0.53	-2.078**	-0.134*	0.024	0.116**	-0.418**
Jagtial Samba/Prabhat	1.786**	6.734**	3.349**	0.047	0.116	-0.056	0.606**
Nellore Mahsuri/Indra	0.22	1.779**	-0.96*	0.458*	0.137	0.022	0.265*
Nellore Mahsuri/Vijetha	1.309**	5.768**	6.631**	0.109*	-0.668	-0.217**	-2.094**
Nellore Mahsuri/ Prabhat	-0.726**	-27.825**	0.855*	-0.280	-1.359	0.284**	-0.003
Indra/Vijetha	-0.150**	-3.604**	-3.866**	0.576	0.306	0.322**	-1.893**
Indra/Prabhat	0.268	2.549**	-0.216	-0.199**	0.602	0.053	-0.735**
Vijetha/Prabhat	-1.37**	2.745**	2.892**	0.089	-0.666	-0.203**	-0.478**

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

Table 4b. Estimates of specific combining ability effects for chemical and nutritional quality characters of 21 F_1 hybrids

Genotype	Amylose content (%)	Protein content (%)	Iron (ppm)	Zinc (ppm)	Grain yield/ plant (g)
Samba Mahsuri/Polasa Prabha	-1.272**	0.445**	-13.785**	2.359**	5.174**
Samba Mahsuri/Jagtial Samba	0.968**	0.367**	41.512**	3.212**	1.364*
Samba Mahsuri/Nellore Mahsuri	0.48**	-0.468**	-11.947**	5.914**	5.892**
Samba Mahsuri/Indra	4.572**	1.048**	-18.332**	-5.103**	-0.466
Samba Mahsuri/Vijetha	2.521**	0.47**	11.949**	-5.499**	2.434**
Samba Mahsuri/Prabhat	0.868**	-0.306**	-11.488**	-3.659**	-0.964
Polasa Prabha/Jagtial Samba	0.932**	-0.34**	11.563**	-1.924**	-2.935**
Polasa Prabha/Nellore Mahsuri	1.976**	-0.038**	-8.097**	7.938**	0.869
Polasa Prabha/Indra	0.602**	0.662**	-7.448**	-0.573	4.031**
Polasa Prabha/Vijetha	-2.553**	-0.485**	-22.4**	-1.536**	-0.875
Polasa Prabha/Prabhat	-0.402**	0.475**	-22.637**	-3.628**	-0.98
Jagtial Samba/Nellore Mahsuri	0.817**	-0.081	-13.566**	-1.669**	-1.15
Jagtial Samba/Indra	0.099	0.527**	-20.518**	-1.913**	-0.658
Jagtial Samba/Vijetha	0.024	1.353**	-7.27**	2.391**	4.596**
Jagtial Samba/Prabhat	-5.895**	-1.934**	-21.707**	-0.568	-0.189
Nellore Mahsuri/Indra	-6.98**	0.925**	-16.344**	-3.05**	4.019**
Nellore Mahsuri/Vijetha	-1.03**	0.372**	-11.862**	-3.113**	-0.187
Nellore Mahsuri/ Prabhat	1.617**	-0.509**	-8.000**	-2.139**	-2.478**
Indra/Vijetha	-7.505**	0.642**	10.286**	-1.924**	2.258**
Indra/Prabhat	0.409**	0.946**	65.949**	8.35**	2.667**
Vijetha/Prabhat	-1.542**	-1.007**	-6.903**	7.187**	2.944**

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

Parental lines Samba Mahsuri and Polasa Prabha were identified as outstanding general combiners (Table 3) for amylose content. Among the crosses Polasa Prabha/Jagtial Samba (H x L) and Jagtial Samba/Nellore Mahsuri (L x L) were the best specific crosses (Table 4). In the present study also out of the best general combiners Polasa Prabha, Jagtial Samba and Nellore Mahsuri were isolated. Samba Mahsuri/Indra (L x L) and Jagtial Samba/Vijetha (H x H) were the best specific crosses for protein content. The parents viz Prabhat and Vijetha for iron and Samba Mahsuri for zinc were the good general combiners. Among the crosses Indra/Prabhat was the best specific cross for both iron and zinc contents.

For grain yield Indra was the best general combiner followed by Samba Mahsuri. Crosses Samba Mahsuri/Polasa Prabha (L x L) and Samba Mahsuri/Nellore Mahsuri (L x H) were the best specific crosses.

Though different parents had been found to be good general combiners for different characters the results indicated that there was close relationship between mean performance of the parents and their gca effects in most of the cases studied. Based on gca effects Indra was the best parent among all the seven parents studied as it recorded positive gca effects for hulling, milling, head rice recovery, L/B ratio and grain yield per plant. Swain and Nagaraju (2004) reported preponderance of additive gene action for amylose content in rice.However the role of additive component of gene action appears to be considerable along with non-additive effect in the case of head rice recovery, L/B ratio and elongation ratio. It was observed that crosses with significant sca effects were due to the combination of parents both of which were good or poor general combiners or any one was a good general combiner. Depending upon the nature of gene actions and the combining abilities of parents and crosses suitable breeding procedure such as pedigree or heterosis breeding or biparental mating in F2 and selection in later generation will have to be adopted in selecting crosses or for characters in varietal improvement work.

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