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Evaluation of Nature and Magnitude of Gene Action in Hybrids of Rice (*Oryza sativa* L.) Throigh Line × Tester Design in Irrigated Conditions

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Abstract The three CMS lines were crossed with eight restorer lines in a line × tester mating design to obtain twenty four F_1 hybrids during *rabi*, 2013-2014 for the identification of best genotypes. The line × tester analysis in rice is used principally to determine the general and specific combining ability of the quantitative properties. Highly significant difference due to specific combining ability was observed for all the traits except plant height. Good specific crosses were obtained from high × high, high × low, low × high and low × low general combiner indicating predominance of non-additive gene action. The ratio of SCA and GCA variances was high for panicle length, number of productive tillers per plant, spikelet fertility preponderance of non-additive gene action over the additive gene action. The smaller contribution of interaction of the line × tester than either lines or testers indicating higher estimates of variances due to general combining ability and higher contribution of interaction of line × tester than either lines or testers indicating higher estimates of variances due to specific combining ability.

Keywords Variance, Gene action GCA, SCA, Line × Tester.

Introduction

Rice (*Oryza sativa* L.) is a self–pollinated cereal crop. It is a perennial, bisexual cereal crop but cultivated as annual crop. The family Gramineae is rich in cereal crops like rice, wheat, maize, barley, sorghum, millet that are grown tropical and temperate countries over a wide range of soil and climatic conditions [1]. It is the leading cereal of the world and it is the staple food for nearly half of the world population. Rice is cultivated in 140 M ha with annual production of 600 MT globally. Rice occupies 77% of total cropped area. At present, rice alone constitutes about 92% of the total food grains produced annually in the country. It provides 75% of the calories and 55% of the proteins in the average daily diet of the perople. The increasing population pressure, the demand of cereal is in-

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creasing day by day. More than 90% of the rice produced and consumed in Asia as a staple food, which provides 35–60% of the required calories. Hybrid rice offers an opportunity to boost the yield potential of rice. It has a yield advantage of 15–20% over conventional high yielding variety. Success of any plant breeding program depends on the choice of appropriate genotypes as parents in the hybridization program. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding [2]. Combining ability is a powerful tool in identifying the best combiners that may be used in crosses either to exploit heterosis or to accumulate fixable genes and obtain desirable segregates. It will help to understand the genetic architecture of various characters that enable the breeder to design effective breeding plan for future up gradation of the existing materials. This information may also be useful to breeders for genetic improvement of the existing genotypes on the basis of the performance in various hybrid combinations. The line × tester analysis in rice is used principally to determine the general and specific combining ability of the quantitative properties. Considering the above idea evaluation and identification of hybrids and their parental lines is the objective by line × tester mating design.

Materials and Methods

Based on the pedigree records, eleven hybrid rice parental lines (Three Cytoplasmic Male Sterile lines and eight restorer lines) were selected which were having ideal characters for restorers and maintainers in addition to yield. The three male sterile lines were crossed with eight restorer lines in line × tester mating design during *rabi* 2013–2014. The resulting twenty four F_1 hybrids along with their eleven parents and two checks were sown during *kharif*, 2014 in flooded conditions at Indian Institute of Rice Research, Rajendranagar, Hyderabad for studying combining ability and heterosis.

The three CMS lines were crossed with eight restorer lines in a line × tester mating design to obtain twenty four F_1 hybrids during *rabi*, 2013–2014 at Research farm, Indian Institute of Rice Research, Rajendranagar, Hyderabad. Unpaired-parent method of planting arrangement was used for making line × tester crosses. Four sowings of the parents were undertaken at an interval of ten days to ensure synchronous flowering to produce adequate crossed seed with a spacing of 20 × 15 cm.

Recording observations

Five plants were tagged at random for each entry in each replication. Observations were recorded for yield and yield attributing characters from these tagged plants in all the genotypes in each replication and the averages were computed. The analysis of variance was carried out. The combining ability analysis was

Table 1. Analysis of variance for combining ability for different characters in rice. *Significant at 5% level of significance and **Significant at 1% level of significance, σ^2 gca = variance of general combining ability and, σ^2 sca = variance of specific combining ability.

	Df	Days to 50% flowering	Plant height (cm)	Number of productive tillers/ plant	Panicle length (cm)	Number of grains/ panicle	Spikelet fertility (%)	Grain yield/plant (gm)	Biomass (gm)	Harvest index (%)
Replication	1	0.188	37.808	0.853	0.120	1725.601*	5.796	0.521	129.988	2.950
Genotypes	23	13.064**	69.856**	2.730	6.048**	2013.523**	177.282**	35.207**	285.711**	40.129
Line	2	30.771*	91.251*	1.441	1.985	1676.607	33.222	87.879	101.735	98.522
Tester	7	19.688	162.441**	3.036	5.358	2042.241	271.240	29.137	327.331	27.397
Line×Tester	14	7.223**	20.508*	2.762	6.974**	2047.295**	150.883**	30.718**	291.183**	38.153*
Error	23	2.144	21.689	1.413	1.758	312.272	4.896	2.826	57.332	6.507
σ^2 gca	10	1.668	9.670	0.067	0.087	133.250	13.198	5.111	15.293	5.143
σ^2 sca	23	0.168	0.014	0.632	2.127	826.812	71.915	14.213	122.437	15.882
σ^2sca/σ^2 gca	–	0.1007	0.0014	9.432	24.448	6.204	5.448	2.780	8.006	3.076
Total	47	7.446	45.603	2.046	3.822	1174.870	89.274	18.623	170.638	22.885

Table 2. Proportional contribution (%) of lines, testers and their interactions to total variance in rice.

Characters	Days to 50% flowering	Plant height (cm)	Number of productive tillers/ plant	Panicle length (cm)	Number of grains/ panicle	Spikelet fertility (%)	Grain yield/plant (gm)	Biomass (gm)	Harvest index (%)
Line	20.4812	11.3588	4.5889	2.8542	7.2406	1.6295	21.7047	3.0963	21.3489
Tester	45.864	70.7715	33.8394	26.9625	30.8689	46.5650	25.1869	34.8683	20.7785
Line×Tester	33.6546	17.8697	61.5717	70.1833	61.8905	51.8055	53.1084	62.0354	57.8726

done by using Line × Tester mating design. However, the data for the character, days to 50% flowering was recorded on plot basis. The method of recording data for each trait is described below character wise.

The total number of days taken from the date of sowing to extrusion of the panicle tip avove the sheath of the flag leaf in 50% of plants in a plot. The plant height was recorded by measuring the total height from the base of the plant to the tip of the main panicle and excluding own if present and is expressed in centimeters. Number of ear bearing tillers per plant was counted at the time of maturity. It was measured in centimeters at the time of plant maturity from the base of panicle to the tip of last spikelet prior to harvesting. Number of filled and unfilled grains were counted from five panicles in each selected plant. Biological yield which refers to the total yield of plant material. Harvest index was a measurement of crop yield as the ratio of economical yield to biological yield. Panicles from a single plant were harvested at maturity, threshed, cleaned and dried to 12–14% moisture content and the weight was recorded in grams.

Results and Discussion

In the present investigation, eleven diverse genotypes (3 CMS and 8 restorer lines) and their 24 crosses were studied. The analysis of variance for combining ability (Table 1) revealed that the variance due to general combining ability (GCA) and specific combining ability (SCA) highly significant for all the characters. The greater magnitude of SCA variance than GCA variance indicated the role of non-additive gene action for characters. Similar results were also reported by Tiwari et al. [3] for days to flowering, Amudha et al. [4] for plant height, Saidaiah et al.[5] for number of productive tillers per plant. Mean square from the analysis of variances for genotypes, general combining ability and specific combing, ratio of SCA and GCA variances, proportional contribution of lines, tester, and interactions of line and tester to the total sum of square due to crosses, general combining ability and specific combining ability effects and mean values of different characters of parents and crosses are shown in Tables 1 and 2.

The analyses of variances of the study are presented in Table 1. The genotypes were found highly significant for all the traits which indicated that the treatments used in this study were significantly varied from each other. The mean sum of squares for crosses was again portioned into lines, testers and line × tester components. Lines are showing significant for only days to 50% flowering and plant height and testers are showing significant for only plant height. Line × tester interactions showing significant for all the traits except number of productive tillers per plant. Ratio of SCA and GCA was high for panicle length, number of productive tillers per plant, biomass, number of grains per panicle, spikelet fertility and harvest index. So this indicates that high ratio of SCA and GCA indicates non additive gene action for these characters. The proportion of contribution of either lines or tester to the total sum of square due to crosses were lower than that of the interactions of line × tester that indicated lower estimates for variances due to general combining ability for all the characters except days to 50% flowering and plant height

(Table 2). These results were in agreement with the earlier findings [6, 7].

Conclusion

The mean square from the combining ability analysis of the variances revealed that highly significant difference due to specific combining ability was observed for all the traits except plant height good specific crosses were obtained from high × high, high × low, low × high and low × low general combiner indicating predominance of non-additive gene action. The ratio of SCA and GCA variances was high for panicle length, number of productive tiller per plant and spikelet fertility preponderance of non-additive gene action over the additive gene action. The contribution of either lines or testers to the total sum square due to crosses was higher than that of interaction of line × tester for plant height and days to 50% flowering. The smaller contribution of interaction of the line × tester than either lines or testers indicating higher estimates of variances due to general combining ability and higher contribution of interaction of line × tester than either lines or testers indicating higher estimates of variances due to specific combining ability.

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