COMBINING ABILITY ANALYSIS TO IDENTIFY SUITABLE PARENTS FOR HETEROTIC RICE HYBRID BREEDING

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KEYWORDS

Combining ability
line x tester
GCA
SCA
Hybrid rice
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INTRODUCTION
Success of any plant breeding programme depends on the choice of appropriate genotypes as parents in the hybridization programme. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding. Combining ability analysis also provides information on additive and dominance variance. Its role is important to decide parents, crosses and appropriate breeding procedure to be followed to select desirable segregants (Salgotra et al., 2009). Semi-dwarft high yielding modern varieties though has increased yield drastically in many rice-growing countries, yield plateaus have been achieved in most of the areas. In such a situation, hybrids can break through the yield ceilings of semi-dwarf rice began in early 60's. India is the second country to commercially exploit heterosis in rice after China. The discovery of CMS in rice (Athwal and Virmani, 1972) suggested that breeding could develop a commercially viable F₁ hybrid. The promising hybrids yielded 20-30% (Lin and Yuan, 1980) and 15-20% (Yuan, 1998) higher than the best hybrids and conventional rice varieties, respectively.

Line × tester technique (Kempthorne, 1957) is useful in deciding the relative ability of female and male lines to produce desirable hybrid combinations. It also provides information on genetic components and enables the breeders to choose appropriate breeding methods for hybrid variety or cultivar development programmes. Lot of research work is available on combing ability analysis in rice; however there is need to analyze combining ability in relation to mean performance, heterosis and other genetic parameters in rice where the improvement has been slow over the world due to various genetic barriers. Hybrid rice includes three line and two line hybrid rice that is developed via cytoplasmic male sterility and photo/thermo sensitive male sterility respectively given by Yuan and Peng (2005). The first approach is called three-line system involving CMS line, a maintainer line and restorer line. The second approach is called two-line system involving environmentally sensitive male sterility (Sheeba et al., 2009). In 1974, Chinese scientist successfully transferred the male sterility gene from wild rice to create the CMS line and hybrid combination (FAO org., 2004).

The present research work was therefore carried out with the objective to assess combining ability based on mean performance, genetic components and heterosis controlling some economic traits in rice. The information obtained thus will be used in selection of suitable parents and choice of appropriate breeding methods to develop high yielding rice cultivar(s) or hybrid variety(s). Hence, the current investigation was undertaken to find out the best combination with respect to their combining ability effects among the parents and hybrids at IGKV Raipur.

MATERIALS AND METHODS
The present study entitled was conducted at the University Research cum Instructional Farm, Department of Genetics and Plant breeding, College of Agriculture, Indira Gandhi KrishiVishwavidyalaya, Raipur (Chhattisgarh) during wet season 2012. It is situated at 21°16’ N Latitude and 81°36’ E longitude at an
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altitude of 289.60 meters above mean sea level. It comes under sub-humid region receiving an average rainfall of 1400 mm annually, of which about 92 percent is received during rainy season between Junes to September and remaining 8 percent during winter season between October to March. The experimental material comprised of three CMS lines (IR58025A, CRMS31A, and CRMS32A) and 20 testers as varieties including accessions (RRH-1, RRH-2, R1557-1317-1-580-1, Nagina-22, Tarun Bhog, R1659-3629-1-462-1, Mancha, R-1240-927-3-1056-1, Jaldubi, Adhamchini, MTU-1001, TOX 981-11-2-3, Chinikapoor, R1949-1196-2-1, IR73007-44-1-2-3, IR72164-352-2-5-5, IR72910-177-1-1-3, R1213-3, Mahsuri and HR-NPT-6-3) from germplasm. The 3 CMS lines have cytoplasm derived from a WA and Kalinga cytoplasmic source. Lines (CMS) were crossed with 20 testers to generate 60 hybrid combinations in line x tester mating design. The twenty one days old seedlings of 60 F1 hybrids along with their parents were transplanted in the main field during kharif 2012 at Research farm, IGKV, Raipur, Chhattisgarh. The experiment was conducted as randomized complete block design with two replications with inter-row and intra-row spacing of 20 cm having a plot size of 5x1 m². All recommended agronomical practices were followed to raise the ideal crop stand. Observations were recorded on ten agro-morphological characters such as days to 50 percent flowering, plant height (cm), number of tillers per plant, number of productive tillers per plant, panicle length (cm), pollen fertility (%), spikelet fertility (%), biological yield per plant (g) and grain yield per plant (g) and 1000 grain weight (g). The mean data were recorded on five randomly selected plants from parents and F1’s from each replication. Heterosis was estimated from mean values according to the Fehr (1987). The significance of different types of heterosis was carried out by adopting ‘t’ test as suggested by Nadarajan and Gunasekaran (2005). However, combining ability analysis was done using line x tester method (Kempthorne, 1957) for general combining ability (GCA) and specific combining ability (SCA) were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were per-formed using t-test.

Genotype means were used for the analysis of variance (Singh & Chaudhary, 1985). Genotypes with significant and high mean performance than grand mean were adjudged as desirable ones. Combining ability analysis was also performed according to Singh & Chaudhary (1985). Significant and positive general combining ability (GCA) and specific combining ability (SCA) effects were considered as high (h), non-significant as average (a) and significant and negative as low (l). Heritability in broad sense h² b.s was determined as outlined by Lush (1940). Standard error (S.E.) of broad sense heritability was calculated following Lothrop et al. (1985). Heterobeltiosis Ht (bel) was determined as outlined by Falconor and Mackey (1996).

RESULTS AND DISCUSSION

Analysis of variance, estimates of genetic components and contribution of lines, testers and line x tester interaction to the total variance have been shown in Table 1. Mean squares of parents and crosses were significantly different at a 1%
level of probability in all the traits. The difference between parents indicated that they are suitable for genetic studies. Also, the significance of SCA and GCA for all studied traits revealed that both additive and non-additive gene effects contributed in trait control. 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 sums of squares (MSS) of the treatments were further partitioned into parent, cross and parent vs hybrids. The results showed that all the parameters for parent, cross and hybrids were found highly significant except productive tillers for parent vs hybrids (Table 1).

Mean sum of squares for crosses was again partitioned into lines, testers and line x tester components. In case of lines, significant variances were observed in all fourteen characters. On the other hand, tester and line x tester was also found highly significant for all the characters. The results were in confirmation with the findings of Sarker et al. (2002), Roy et al. (2013) and Sharma et al. (2007). A comparison of the magnitude of variance components due to GCA and SCA combined the nature of gene action in controlling the expression of the traits was also reported by Bhadru et al. (2013) and Malik et al. (2013). The value of variance of general combining ability (Va) was less than variance of specific combining ability (Vs) for all traits except days to 50% flowering and plant height respectively which revealed that the preponderance of non-additive gene action governing the traits concerned, conversely, additive gene action might be prevailed for fertile spikelets per panicle.
<table>
<thead>
<tr>
<th>Hybrids</th>
<th>R-58025A</th>
<th>R-58025B</th>
<th>R-81802</th>
<th>R-58026A</th>
<th>R-58025B</th>
<th>R-58026A</th>
<th>R-58026B</th>
<th>R-81802A</th>
<th>R-58026B</th>
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<td>SCA</td>
<td></td>
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<td></td>
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<td>1.44*</td>
<td>-22.51*</td>
<td>-23.27**</td>
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<td>106.15**</td>
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<td>4.26**</td>
<td>3.59**</td>
<td>-1.18</td>
<td>-8.32</td>
<td>7.37</td>
<td>-15.69*</td>
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<td>-115.80**</td>
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<td>3.59**</td>
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<td>-134.08**</td>
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<td>-18.24**</td>
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<td>67.45</td>
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<td>-35.31**</td>
<td>91.14**</td>
<td>-22.12**</td>
<td>-20.33**</td>
</tr>
</tbody>
</table>

Table 3: Specific combining ability (SCA) effect and mean performance of different hybrids for characters under study

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plant height and sterile spikelets per panicle (Table 1). But for plant height and fertile spikelets per panicle both additive and non-additive gene actions suppose to playing the role of controlling the trait. This was also reported by Annadurai and Nadaranjan (2001) and Soni et al. (2013). It was further supported by ratio (s) being less than one and degree of dominance being less than one except days to 50% flowering and panicle length. Several workers have reported preponderance of non-additive gene action for number of tillers per plant, total number of grains per panicle and fertility percentage (Vaithiyalingam & Nadaranjan, 2005), panicle length and 1000-grain weight (Punitha et al., 2004) and yield per plant (Sharma, 2006). The role of additive and non-additive gene effects for controlling these traits were also reported by Hong et al. (2002), Bisneet et al. (2005), Mishra et al. (2015) and Rahimi et al. (2010).

Identification of parents based on mean performance and GCA effects

Mean performance of the parents and GCA effects have been given in Table 2. Significant and positive mean performance and GCA effects are preferable for all traits. It is evident that assessment of parents on the basis of mean performance and GCA effects separately, however, mean performance of the parents with nature of combining ability provides the criteria to select the parents for hybridization as suggested by Harer & Bapat (1982). On this basis, those parents who perform better for both mean performance and GCA effects have been treated as good general combiners in present study. The Table showed that IR-58025A were produced highly

<table>
<thead>
<tr>
<th>Hybrids</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<tbody>
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<td>5.24**</td>
<td>-5.71**</td>
<td>-0.22**</td>
<td>-0.54**</td>
<td>0.01</td>
<td>-50.57**</td>
<td>-36.37**</td>
<td>-14.19**</td>
<td>0.83</td>
<td>-2.57</td>
<td>-12.54**</td>
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</tr>
<tr>
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<td>-1.27**</td>
<td>-1.71**</td>
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<td>-32.20**</td>
<td>-20.49**</td>
<td>-11.70</td>
<td>-1.94</td>
<td>0.53</td>
<td>-34.22**</td>
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<td>10.25</td>
<td>10.10</td>
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<td>146.20</td>
<td>112.35</td>
<td>33.85</td>
<td>76.67</td>
<td>56.00</td>
<td>67.50</td>
<td>31.00</td>
<td>18.25</td>
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<td>HR-NP1-6-3</td>
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<td>-2.48**</td>
<td>-0.15</td>
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<td>-9.06</td>
<td>19.61**</td>
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<td>26.25</td>
<td>87.74</td>
<td>86.75</td>
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<td>21.35</td>
<td>31.30</td>
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<td>53.15</td>
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<td>183.00</td>
<td>52.75</td>
<td>18.55</td>
<td>28.81</td>
</tr>
</tbody>
</table>

-1.29** -3.79** 1.73** 2.7** -0.33 2.48 -5.82 8.30 -0.60 6.53** -0.35 -0.99 1.70** -1.41

-2.04** 2.12 2.41** 2.33** 3.19** 45.67** 33.80 11.87 2.32 -3.94 -39.14** -6.07** 4.17** 7.41**
Identification of hybrids based on mean performance and SCA effects

Marilia et al. (2001) stated that specific combining ability (SCA) effects of hybrids alone had limited value for parental choice in breeding programme and must be used in combination with other parameters such as hybrid means and GCA of the respective parents. The hybrid combinations with high mean performance, desirable SCA estimates and involving at least one of the parent with high GCA would likely to enhance the concentration of favorable alleles (Kenga et al., 2004) and this is what a breeder desires to improve a trait. Similar views have been expressed by various researchers (Thirumeni et al., 2000; Manivannan and Ganesan, 2001; Gnanasekaran et al., 2006) and Bhati et al. (2015) in rice. The identification of good specific combiners (hybrids) has been adjudged on the basis of mean performance, SCA effects estimates (Table 3) in present investigation.

The results of SCA effect of the present study are given in the Table 4. The results showed that out of 60 hybrid combinations three of them viz. CRMS32A x R1949-1196-2-1 (-29.17), CRMS31A x R-1240-927-3-1056-1 (-25.09) and CRMS31A x MTHU1001 (-20.98) produced significant and negative SCA effect for shortening plant height with mean performance (50.60 to 164.84). Similarly, for growth duration seven combinations possessed significant and negative SCA with mean performance ranged from 84.75 to 115 days, which were desirable for early hybrid. In case of number of spikelets per panicle considerable magnitude of SCA effects were observed in five crosses having significant and positive SCA effect ranged from 79.48 to 208.43 where the hybrid combination CRMS31A x MTHU1001 produced the highest SCA effect. This combination could be selected for further evaluation for high yield heterosis. Six combinations possessed significant and positive SCA effect for grain yield per panicle with mean performance ranged from 8.55 to 61.10 g. per panicle. The combination IR-58025A x R-1240-927-3-1056-1 (14.42) produced the highest SCA effect followed by IR-58025A x R-1240-927-3-1056-1 (14.07), CRMS32A x R-1240-927-3-1056-1 (13.11), CRMS31A x R-1240-927-3-1056-1 (11.20), CRMS31A x HR-NPT-6-3 (10.87) and CRMS31A x RRH-1 (10.02) for the trait. Significant and positive SCA effects were observed in nine hybrid combinations for spikelet fertility in which CRMS31A x MTHU1001 gave the highest (216.66) value.

On the other hand, five significant and positive values were found in five combinations for spikelet fertility in which CRMS31A x MTHU1001 gave the highest (216.66) value.
fertility only seven crosses range from 20.28 to 36.98 and for thousand grain weight only five crosses were found to have under significant and positive SCA effect which range from 4.79 to 10.92. The results were confirmed with the findings of Ganesen and Rangaswamy (1997), Roy and Mondal (2001), Singh and Kumar (2004), Sao et al. (2006), Rashid et al. (2007) and Jhajharia et al. (2013).

Specific combining ability refers chiefly to dominance variance and epistatic interaction (dominance × dominance, additive × dominance or additive × additive). It has relationship with heterosis therefore good specific combiners identified in present study for yield and its components are proposed for heterosis breeding. Hybrids which had significant and positive SCA effects (presence of non-additive gene effects) and emerged from parents having significant and positive GCA effects can also be used for cultivar or valuable germplasm development.

REFERENCES


