Research Paper

ADVANCE RESEARCH JOURNAL OF
C R P
IMPROVEMENT
Volume 5 | Issue 2 | Dec., 2014 | 105-108
e ISSN-2231-640X

DOI :
10.15740/HAS/ARJCI/5.2/105-108
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Study of combining ability to develop hybrids in rice (*Oryza sativa* L.)

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ABSTRACT : The GCA variances of parents and SCA variances of hybrids produced for thirteen different yield and yield contributing characters are the basic criteria for selection or hybridization programme. The study for combining ability analysis of 15 F1's produced under (L × T) manner by 3 lines and 5 testers are studied in RBD fashion with two checks *viz.*, Mahamaya and Indira sona.

Key **W**ords : Combining ability, Line x tester, Rice

How to cite this paper : Bedi, Samrath and Sharma, Deepak (2014). Study of combining ability to develop hybrids in rice (*Oryza sativa* L.). *Adv. Res. J. Crop Improv.,* **5** (2) : 105-108.

Paper **H**istory : **Received :** 03.06.2014; **Revised :** 21.10.2014; **Accepted :** 05.11.2014

Rice belongs to the genus *Oryza*, of the tribe Oryzeae of the family Poaceae. It is one of the few crop species endowed with richest genetic diversity. There are 24 recognized species in the genus *Oryza* both wild and cultivated. The cultivated species *viz.*, the Asian *O. sativa* and African *O. glaberrima*. The sub species or varietal groups of *O. sativa*, are *indica*, *japonica* and *javanica*. In general the out-cross ability is more in *japonica* followed by *javanica* and less in *indica* but compatibility is more in *indica*. Magnitude of heterosis is determined by the combining ability of the parents and crosses in hybrids. There are two types of combining ability *viz.*, general combining ability (GCA) and specific combining ability (SCA). Sprague and Tatum (1942) defined GCA as the average performance of a line in hybrid combinations and specific combining ability as those cases in which certain combinations are relatively better or worse than would be expected on the basis of the GCA for the parents. Good combing parents result in higher frequency of heterotic hybrids than poor combining parents (Jayasudha and Sharma, 2009). From the genetic viewpoint, GCA measures additive gene effect and SCA measures non-additive gene effects, including dominance and epistasis. In a hybrid breeding programme plant breeders aim to identify parental lines with good general combining ability, and crosses showing high specific combining ability. Line x tester analysis (Kempthorne, 1957) is the most popular method for self-fertilized crops especially in rice breeding programme (Peng and Virmani, 1990). In general, GCA is less and SCA is more influenced by environment (Singh and Richharia, 1977).

RESEARCH PROCEDURE

The present study was conducted at the Research cum Intuitional Farm, and laboratories of the Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Rabi* season 2010-2011 and *Kharif* 2011. The biological material used in the present study comprised of three CMS lines *viz.*, CRMS 31A, IR 58025A and IR79156A and five testers *viz.*, NPT 453-2, NDR 8054 (IR 77768-25-NDR-B-108-14) , CR 2330-3-3-2-1-1, NPT 76-8 and PR-115. The crosses were attempted during *Rabi* 2010-11 with line × tester mating design. The evaluation of 15 F1's along with there parents and two checks *viz.*, Indira Sona (hybrid) and Mahamaya (commercial cultivar) were done at *Kharif* 2011 with two replications. The distance between row to row and plant to plant was 20 cm and 15 cm, respectively. A standard agronomic package of practices was adopted. Five plants of each line from each replication were randomly selected for observations for the fifteen characters *viz.*, days to 50 per cent

flowering, plant height (cm), number of productive tillers per plant, flag leaf length (FLL), flag leaf width (FLW), leaf area index (LAI), number of filled spikelets per panicle, number of sterile spikelets per panicle, spikelet fertility percentage, pollen fertility percentage, 1000 grain weight, grain yield per plant, harvest index, chlorophyll content.

In the present study GCA / SCA variance are less then unity. Along with the GCA variance of parents and SCA variance of hybrids, the GCA effects of eight parentages *i.e.* three lines and five testers and the SCA effects of fifteen one hybrids combinations were estimated according to Kempthorne (1957) into L × T mating design. The variances for general combining ability (GCA) and specific combining ability (SCA) were tested against their respective error of variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were performed using t-test.

Significance of GCA effects of lines was tested as :

$$t = \frac{g_i}{SE(g_i)}$$

Signicance of GCA effects of testers was tested as :

$$t = \frac{g_i}{SE(g_i)}$$

Signicance of SCA effects of testers was tested as :

$$t = \frac{S_{ij}}{SE(S_{ij})}$$

The standard errors pertaining to GCA and SCA effects were worked out from the square root of error variance effects as given below :

– Standard error for testing the GCA effects of lines :

$$SE(g_i) = \frac{\sqrt{Me}}{rt}$$

– Standard error for testing the significance of difference between GCA effects of two lines :

$$SE(g_i - g_j) = \frac{\sqrt{2Me}}{rt}$$

– Standard error for testing the GCA effects of testers

$$SE(g_i) = \frac{\sqrt{Me}}{rt}$$

RESEARCH ANALYSIS AND REASONING

The findings of the present study as well as relevant discussion have been presented under the following heads :

The GCA and SCA variance :

The GCA variance was found highest for number of fertile spikelets per panicle, followed by number of sterile spikelets per panicle, spikelets fertility per cent, pollen fertility per cent, leaf area index, grain yield per plant, plant height, harvest index, chlorophyll content, flag leaf length, days to 50 per cent flowering. The SCA variance was found highest for number of sterile spikelets per panicle followed by number of fertile spikelets per panicle, pollen fertility per cent, spikelets fertility percentage, leaf area index, harvest index, grain yield per plant, plant height, chlorophyll content, flag leaf length, days to 50 per cent flowering, 1000 seed weight, productive tillers and panicle length (Table 1).

All the characters had greater SCA variance than GCA variance. The character number of sterile spikelets per panicle

Table 1 : GCA and SCA variance

Sr. No.	Character	GCA variance	SCA variance	GCA / SCA ratio
1.	Days to 50 % flowering	3.0389	16.9155	0.1796
2.	Flag leaf length	3.4351	25.6919	0.1337
3.	Flag leaf width	0.0443	0.2512	0.1765
4.	Leaf area index	61.882	333.3	0.1856
5.	Plant height	45.66	106.21	0.4298
6.	Productive tillers	0.31	4.7799	0.0649
7.	Pollen fertility	306.0465	1045.76	0.2926
8.	Number of fertile spikelet / panicle	2389.997	3457.974	0.6911
9.	Number of sterile spikelet / panicle	1317.334	13252.2	0.0994
10.	Spikelet fertility	309.9868	1008.912	0.3072
11.	Panicle length	0.448	3.6595	0.1225
12.	1000 grain weight	0.205	10.5836	0.0194
13.	Grain yeild/plant	59.359	197.9431	0.2998
14.	Chlorophyll content	8.741	77.6173	0.1126
15.	Harvest index	12.889	198.8861	0.0648

Table 2 : General combining ability (GCA) effects of different parents under study

Parents	Days to 50 (%) flowering	Flag leaf length (cm)	Flag leaf width (cm)	Leaf area index	Plant height (cm)	Productive tillers	Pollen fertility	Total empty spikelet	Total filled spikelet	Spikelet fertility	Panicle length (cm)	1000 grain weight (g)	Grain yield/ plant (g)	Chlorophyll content	Harvest index
Lines															
58025 A	-1.30**	0.45	0.07**	3.95**	0.55	-0.3	17.94**	-44.51**	22.44**	16.10**	0.22	0.16	-3.05**	-2.62**	2.55**
79156 A	1.00**	-0.47	0.15**	3.91**	3.85**	-0.56*	-6.96**	13.96**	-17.49*	-9.27**	-0.07	0.21	3.61**	0.24	-2.00**
CRMS 31A	0.3	0.02	-0.22**	-7.86**	-4.40**	0.85**	-10.98**	30.54**	-4.95**	-6.83**	-0.15	-0.37	-0.56	2.38**	-0.55
Testers															
NPT 453-2	0.4	-1.17*	-0.01	-3.14**	-11.16**	0.65	-4.70**	18.31**	-39.54**	-6.41**	-1.36**	-0.5	-8.05**	2.08*	-5.07**
NDR 8054 (IR 77768-25-NDR-B-108-14)	3.90**	-2.46**	-0.36**	-17.12**	13.41**	0.05	-6.61**	26.50**	-38.89**	-9.71**	0.83	0.21	-9.55**	3.87**	0.23
CR 2330-3-3-2-1-1	-2.10**	1.90**	0.11**	8.52**	6.67**	-0.89*	14.33**	-44.62**	45.44**	20.65**	0.64	-0.48	0.05	2.14*	-3.82**
NPT 76-8	0.23	-2.39**	0.39**	9.03**	-2.16*	0.08	29.85**	-49.91**	108.22**	28.35**	-0.89	1.05**	19.86**	-1.81*	8.39**
PR-115	-2.43**	4.12**	-0.13**	2.70**	-6.76**	0.11	-32.87**	49.72**	-75.22**	-32.88**	0.78	-0.28	-2.33**	-6.28**	0.27

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

Table 3 : Specific combining ability (SCA) effects of different parents under study

Hybrids	Day's to 50 (%) flowering	Flag leaf length (cm)	Flag leaf width (cm)	Leaf area index	Plant height (cm)	Productive tillers	Pollen fertility	Total empty spikelet	Total filled spikelet	Spikelet fertility	Panicle length (cm)	1000 grain weight (g)	Grain yield/ plant (g)	Chlorophyll content	Harvest index
58025 A															
25A*NPT 453-2	0.8	2.22**	-0.44**	-12.51**	8.95	-1.44*	1.28*	-27.99**	-0.89	2.88**	0.57	1.42**	1.59*	-2.31*	13.78**
25A*IVT-SDW-70	0.8	-0.44	-0.13**	-6.78**	-5.92	-0.04	12.66**	-37.18**	33.15**	17.09**	0.59	0	7.99**	1.82	-1.22
25A*IVT-SDW-70	-3.70**	3.17**	-0.05	5.57**	-7.29	1.1	-10.95**	38.54**	-45.88**	-17.76**	-1.05	-1.34**	5.28**	-1.83	1.07
25A*NPT 76-8	1.97**	-0.44	0.18**	5.14**	-3.59	-0.12	-17.69**	46.33**	-17.26**	-16.37**	-1.46	-1.81**	-14.57**	9.24**	-15.69**
25A*PR-115	0.13	-4.50**	0.45**	8.57**	7.85	0.5	14.70**	-19.70**	30.88**	14.16**	1.36	1.72**	-0.28	-6.93**	2.05
79156 A															
56A*NPT 453-2	0.5	-0.07	0.54**	20.39	-6.25**	2.22**	-31.47**	126.24**	-30.31**	-28.65**	-0.28	-0.11	-2.08**	2.34*	-12.01**
56A*IVT-SDW-70	-2.00**	2.06*	0.01	4.11	2.89*	0.82	11.55**	-65.85**	3.49**	8.59**	-1.06	-0.77	-8.18**	1.01	2.88*
56A*IVT-SDW-70	4.50**	-5.55**	-0.10**	-15.89	6.32**	-0.44	13.80**	-24.83**	-6.24**	9.62**	0.81	0.98*	5.72**	3.38**	-1.24
56A*NPT 76-8	-0.33	0.18	-0.14**	-4.24	3.19*	-0.66	12.18**	-24.22**	37.11**	13.48**	0.04	3.20**	10.73**	-9.63**	10.77**
56A*PR-115	-2.67**	3.38**	-0.32**	-4.37	-6.15**	-1.94**	-6.06**	-11.34**	-4.06**	-3.04**	0.5	-3.31**	-6.20**	2.90*	-0.4
CRMS 31 A															
31A*NPT 453-2	-1.30*	-2.15**	-0.10**	-7.88	-2.70*	-0.79	30.20**	-98.24**	31.20**	25.77**	-0.29	-1.31**	0.49	-0.04	-1.77
31A*IVT-SDW-70	1.208	-1.62**	0.12**	2.67	3.03*	-0.79	-24.21**	103.02**	-36.65**	-25.68**	0.48	0.77	0.19	-2.83*	-1.66
31A*IVT-SDW-70	-0.8	2.39**	0.15**	10.33	0.97	-0.65	-2.86**	-13.71**	52.12**	8.14**	0.25	0.35	-11.01**	-1.54	0.17
31A*NPT 76-8	-1.63**	0.26	-0.04	-0.9	0.4	0.78	5.51**	-22.12**	-19.86**	2.88**	1.42	-1.39**	3.84**	0.39	4.92**
31A*PR-115	2.53**	1.12*	-0.13**	-4.21	-1.7	1.45*	-8.63**	31.05**	-26.82**	-11.12**	-1.86*	1.58**	6.48**	4.02**	-1.65

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

registered highest SCA variance followed by number of fertile spikelets per panicle, pollen fertility per cent, spikelets fertility per cent, leaf area index, harvest index, grain yield per plant, plant height, chlorophyll content, flag leaf length, days to 50 per cent flowering, 1000 grain weight, productive tillers and panicle length which indicated the predominance of non-additive gene action in the inheritance of traits.

Therefore, the hybrid breeding programme will be more useful for improvement of these traits.

Similar finding (SCA > GCA) has been reported by, Bagheri and Jelodar (2010) for grain yield, productive tillers per plant, filled spikelets per panicle and Saidaiah *et al.* (2010) for grain yield per plant.

General and specific combining ability :

The results obtained so far concluded that none of the parents showed significant GCA effects regarding the traits under study, in order to analyze, the desirable parent for subsequent hybrid rice development, variation in the GCA effect has been estimated among lines and testers for all traits. Negative GCA effect of plant height and days to 50 per cent flowering were desirable. While positive GCA for other characters is needed. Character wise analysis of GCA effect of lines and testers (Table 2) reveled that line 58025 A was good combiner for pollen and spikelet fertility and panicle length, leaf area index, days to 50 per cent flowering. Line 79156 A was good general combiner for grain yield, 1000 grain weight, spikelet fertility, while line CRMS 31A performed well for productive tillers, plant height. GCA effect of tester CR 2330-3-3-2-1-1 was good combiner for pollen fertility, spikelet fertility, grain yield and days to 50 per cent flowering. Tester NPT 76-8 was also good general combiner for grain yield, 1000 grain weight spikelet fertility, and plant height and harvest index.

Based on the estimates of SCA effects none of the cross combination (L × T) exhibited significant and desirable SCA effect for all the parameters under study (Table 3). Concluding that no specific combination was appropriate for all characters. These results are in complete agreement with the earlier findings (Mirarab *et al*., 2011 and Pradeep Kumar and Reddy, 2011). Yield is a desired and most important character under consideration in rice breeding and hybrid rice development programme. Character wise estimation of SCA effect of hybrids (Table 3) reveled that highest SCA effect had shown by 79156 A / NPT 76-8 for grain yield and other important characters like pollen fertility, spikelet fertility and biological yield.58025 A / NDR 8054 (IR 77768-25-NDR-B-108-14) was specific combiner for character like plant height, pollen fertility, spikelet fertility, spikelet fertility and grain yield. Similar findings were reported earlier by (Toppo, 2010 and Verma, 2010).

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