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COMBINING ABILITY ANALYSIS FOR GRAIN YIELD AND ITS ATTRIBUTES IN RICE (*Oryza sativa* L.)

B. P. Mallikarjuna*, N. Shivakumar[1], J. Devendrappa[2], V.D. Sheela[2], G. Bharamappa[3], and Ganesh Halikatti[4]

Department of Genetics and Plant Breeding, UAS, Raichur, Karnataka, India

ABSTRACT

Combining ability on grain yield and its components from line × tester analysis of thirty rice hybrids (*Oryza sativa* L.) produced by crossing three newly developed CMS lines and ten testers of local origin were studied. The analysis revealed higher SCA variance than GCA variance for all the characters except plant height indicating the prevalence of non-additive gene action. The line KCMS 45A and testers MSN 36 and KMR 3 were the good general combiners for yield and its major contributing characters. MSN 99 was the only good general combiner among the male parents for earliness and dwarfness. The hybrids KCMS 46A × MSN 75, KCMS 44A × KMR 4 and KCMS 45A × KMR 3 were identified as potential hybrids for yield contributing characters based on SCA effects which could be exploited in future rice breeding programme by adopting heterosis breeding strategy. The contribution of testers towards the total variance was found higher than lines and line x tester interaction suggesting predominant of testers influence for these characters.

Keywords: Combining ability, CMS line, Hybrid rice, Yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is the principal food crop of India and Asia. The over growing population, demanded the need to increase the productivity of rice crop. Successful use of hybrid rice technology to increase yield through exploitation of heterosis enabled China to increase total production. Success of any plant breeding programme depends on the choice of appropriate genotypes as parents in the hybridization programme. In hybrid programme, choice of suitable parents is of primary

*Corresponding author email: malli3842@gmail.com

[1]Zonal Agriculture Research Station, V.C.Farm, Mandya, Karnataka, India

[2]Department of Genetics and Plant Breeding, UAS, GKVK, Bengaluru, Karnataka, India.

[3]Department of Agricultural Microbiology, UAS, GKVK, Bengaluru, Karnataka, India.

[4] Department of Agricultural Entomology, UAS, Dharwad, Karnataka, India

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importance since *per se* performance of parents is not always a true indicator of its combining ability in hybrid combination (Swamy et al., 2003). Therefore performance of a F_1 hybrid depends on choice of parents. Several methods like *per se* performance, genetic diversity, combining ability etc., have been attempted to select the parents. Among them combining ability analysis offers a powerful tool for estimating the value of a parent to produce superior hybrid.

The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding strategies. Combining ability analysis also provides information on additive and dominance variance. Its role is important to decide parents, crosses and appropriate hybrid breeding procedure to be followed to exploit heterosis (Salgotra et al., 2009). Keeping this in view, the present investigation was carried out to study the combining ability in order to identify good combiners and superior hybrid combinations.

MATERIAL AND METHODS

The experimental materials for the present study comprised of three newly developed CMS lines *viz.,* KCMS 44A, KCMS 45A possessing WA type of cytoplasm and KCMS 46A having Kalinga type of cytoplasm and ten testers *viz.,* Thanu, KMR-3, KMR-4, KMR-12, MSN-36, MSN-75, MSN-91, MSN-93, MSN-98 and MSN-99. The testers used for the study was of Indian origin and were well adapted to local condition.

The three lines and ten testers were crossed in a line x tester manner by spikelet clipping method during summer 2010. Three lines and 10 testers were sown in three staggered fashions keeping five days interval between them so as to synchronize properly for crossing lines with testers. The resulted thirty hybrids along with the parents (B-lines of corresponding A lines and testers) were grown in randomized block design with two replications during summer 2011 at ZARS, V.C., Farm, Mandya, India. Twenty five day old seedlings of hybrids and their parents were transplanted with single seedling per hill with a spacing of 15 cm between rows and 15 cm between plants. Each entry was transplanted in two rows of 4 meter length. All the recommended package of practices was followed to ensure good crop growth and development. Five competitive plants were randomly selected to record the observations on grain yield and yield contributing characters viz., plant height (cm), no. of tillers per plant, no. of panicles per plant, panicle length (cm), spikelet fertility (%), days to 50% flowering, no. of spikelets per panicle, yield per plant (g), 1000 grain weight (g) and L/B ratio. Combining ability analysis was done using line x tester method (Kempthorne, 1957).

RESULTS AND DISCUSSION

Analysis of variance for combining ability revealed the significant differences among the genotypes (Table 1). Variance due to males (testers) was significant for all the characters except for number of tillers per plant and number of panicles per plant while for females (lines) it was significant only for panicle length and days to 50% flowering. However variance due to lines x testers interaction were highly significant for all the characters except for plant height and number of days to 50% flowering. The variance due to crosses differed significantly for all the characters. Thus, suggesting the importance of heterosis breeding for improvement of rice. Combining ability analysis revealed that SCA variance was predominant in the inheritance of various characters studied, indicating predominance of non-additive gene action. The SCA variances were higher than the GCA variances for all the characters except plant height, which is in corroboration with earlier findings of Saravanan et al. (2006) and Anandkumar et al. (2004). The proportional contribution of lines, testers and their interactions to total variances showed that testers played dominant role indicating predominant testers influence for these characters (Table 1). The smaller contribution of interactions of the line x tester than testers, and higher than lines indicated higher estimates of variances due to general combining ability. Nadali (2010) observed higher estimates of GCA variances due to testers in rice.

The estimates of GCA effects of three lines and ten testers with the corresponding standard errors for all the characters are presented in table 2. Among the CMS lines, KCMS 45A was the best general combiner as it showed highly significant GCA effects for number of tillers per plant, number of panicles per plant and yield in desirable (positive) direction but non-significant. Also the KCMS 46A line was very good general combiner for earliness as it had highly negative significant GCA effect for days to 50% flowering. This line also had high positive significant GCA effect for panicle length and number of spikelets per panicle. Among the testers, MSN 36 was the best general combiner for important characters like number of spikelets per panicle and yield per plant. While KMR-3 was best general combiner for number of tillers per plant, number of panicles per plant, spikelet fertility and 1000 grain weight which showed highly significant GCA effects in desirable direction. Another tester, MSN 99 had highest significant negative GCA effects for days to 50% flowering and plant height indicating as a good combiner in desired direction for earliness and plant height. The tester MSN 93 had highest positive significant GCA value for panicle length and the tester MSN 91 showed good general combining ability for L/B ratio. Higher GCA effects in parents was also reported earlier by Swamy et al. (2003), Anandkumar et al. (2004), Jagadeeasan and Ganesan (2006) and Saidaiah et al. (2010).

The overall GCA status of parents was calculated based on the method suggested by Mohan Rao (2001). From the results, it was evident that the lines KCMS 45A and KCMS 46A had high (H) overall GCA status (Table.2). Whereas, among the testers, Thanu, KMR-3, KMR-4, MSN-36, MSN-93 and MSN 98 possessed high (H) overall GCA status. These results are in line with earlier reports of Swamy et al. (2003), Saidaiah et al. (2010).

The estimate of SCA effects with their respective standard error for each character in thirty cross combinations are presented in table 3. None of the crosses exhibited high SCA effects for all the characters studied. The majority of the crosses showed significant SCA effects, which involved at least one parent having high GCA effects. Only two out of thirty crosses, having positively significant SCA effects for grain yield per plant of which the highest being KCMS 46A × MSN 75, this hybrid also had highly significant SCA values for spikelet fertility and highly negative significant SCA effect for earliness indicating this cross is good specific combiner for earliness.

Another hybrid KCMS 45A × KMR 3 was found superior for number of tillers per plant and number of panicles per plant. None of the hybrids showed significant SCA effects for plant height. The cross KCMS 44A × KMR 4 had high positive significant SCA values for panicle length and numberr of spikelets per panicle. The hybrids, KCMS 45A × MSN 75 and KCMS 46A × MSN 93 were good specific combiners for 1000 grain weight and L/B ratio respectively. These results are in conformity with the earlier findings of Jagadeeasan and Ganesan (2006) and Saidaiah et al. (2010).

Out of thirty hybrids studied fifteen hybrids exhibited high (H) overall GCA status and fifteen crosses exhibited low (L) overall GCA status. All the fifteen crosses with high overall SCA effect has parents with all types of combination of GCA effect viz., H ×H, H × L and L × L suggesting the action of additive, non additive gene action and also overdominance and epistasis, respectively. These results are in agreement with the earlier reports of Mohan Rao (2001), Swamy et al. (2003), Saidaiah et al. (2010).

CONCLUSION

The present study on combining ability analysis revealed the preponderance of non additive gene action for all the characters studied. Hence this study insisted that heterosis breeding is more suitable for all the characters. Among the lines KCMS 45A and among the testers MSN 36 and KMR 3 were the good general combiners for majority of yield attributing characters. These best combiners could be utilized in hybrid development breeding programme. The crosses KCMS 46A × MSN 75, KCMS 44A × KMR 4 and KCMS 45A×KMR 3 were identified as most promising for yield based on *SCA* effects. Hence these could be used for the exploitation of heterosis for yield and related characters.

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Table1. Analysis of variance for yield and yield contributing characters and its propotional contribution to the total variance

Source of variation	Df	Plant height (cm)	No. of tillers per plant	No. of panicles per plant	Panicle length (cm)	Spikelet fertility (%)	Days to 50% flowering	No. of spikelets per panicle	Yield per plant (g)	1000 grain weight(g)	L/B ratio
Replication	1	140.77*	2.58	11.75*	0.004	144.41	1.16	1180.30*	2.54	0.007	0.0009
Genotype	42	193.55**	11.41**	14.89**	1.92**	427.16**	62.28**	2213.12**	182.79**	4.98**	0.24**
Parent	12	315.58**	12.13**	10.14**	1.65**	178.39**	51.30**	2981.51**	73.40**	8.44**	0.65**
Cross	29	107.10**	7.66**	6.68**	2.05**	538.36**	51.94**	1909.77**	177.99**	3.40**	0.08**
Parent vs Cross	1	1236.02**	111.63**	309.99**	1.30	187.51	494.12**	1789.61*	1634.79**	9.23**	0.007
Line(c)	2	13.87	17.84	18.38	3.57*	36.40	36.15*	1363.97	11.58	0.05	0.07
Test(c)	9	305.73**	5.62	4.61	3.87**	1384.65**	139.48**	4288.82**	487.30**	9.9004**	0.14**
LxT (c)	18	18.14	7.55**	6.41**	0.96*	170.99**	9.93	780.88**	41.83**	0.52**	0.05*
Error	42	17.78	2.43	2.37	0.44	62.98	0.31	256.77	10.49	0.07	0.021
GCA		9.98	0.01	0.03	0.12	41.21	4.71	126.64	15.28	0.32	0.00
SCA		-0.93	12.06	8.72	0.83	174.92	19.09	1157.30	68.29	1.02	0.05
GCA/SCA variance		-0.09	988.36	290.73	6.79	4.244	4.049	9.138	4.470	3.14	15.38
Proportional contribution of lines, testers and line × tester interaction to total variance											
Line		0.89	16.05	18.97	12.01	0.47	4.8	4.93	0.45	0.1	6.44
Tester		88.59	22.76	21.44	58.74	79.82	83.34	69.69	84.96	90.24	55.33
Line × Tester		10.52	61.19	59.59	29.25	19.71	11.86	25.38	14.59	9.66	38.23

*, ** Significant at 5 % and 1 % probability levels, respectively

Table2. Estimates of general combining ability effects of lines and testers for yield and yield contributing characters

	Plant height (cm)	No. of tillers per plant	No. of panicles per plant	Panicle length (cm)	Spikelet fertility (%)	Days to 50% flowering	No. of spikelets per panicle	Yield per plant (g)	1000 grain weight(g)	L/B ratio	overall GCA status
Lines											
KCMS 44A	-0.76	-0.09	-0.03	-0.00	-0.10	1.55 **	-4.28	-0.82	0.04	-0.02	L
KCMS 45A	0.89	0.99 **	0.97 **	-0.42 *	1.40	-0.70 **	-5.24	0.69	-0.05	-0.05	H
KCMS 46A	-0.13	-0.90 **	-0.94 **	0.42 *	-1.30	-0.85 **	9.52 **	0.13	0.01	0.07	H
SEm±	**0.9646**	**0.2764**	**0.3204**	**0.1663**	**2.0437**	**0.1387**	**3.1799**	**0.6199**	**0.0333**	**0.034**	
Testers											
Thanu	7.31 **	-0.02	-0.05	0.31	10.78 **	1.45 **	21.83 **	7.14 **	-0.29 **	-0.14 *	H
KMR-3	-4.35 *	1.79 **	1.61 *	0.14	10.46 **	-5.38 **	-13.57 *	2.91 *	2.21 **	0.08	H
KMR-4	-3.63 *	0.35	0.06	0.53	11.37 **	-0.72 **	-33.34 **	-0.07	1.70 **	0.08	H
KMR-12	7.87 **	-1.37 *	-1.28 *	-0.76 *	-2.00	8.62 **	-6.04	-6.73 **	-0.71 **	-0.07	L
MSN-36	3.87 *	-0.10	0.22	0.53	0.73	1.28 **	58.84 **	11.10 **	-0.78 **	-0.12	H
MSN-75	-8.02 **	0.01	0.00	-1.54 **	-40.06 **	-0.38	-25.27 **	-21.70 **	0.17 **	0.06	L
MSN-91	2.09	-1.10 *	-1.00	0.56	5.81	3.28 **	-11.34	4.21 **	-0.99 **	0.36 **	L
MSN-93	8.42 **	0.79	0.70	1.09 **	7.16	3.95 **	10.06	1.75	-0.13 *	0.00	H
MSN-98	-1.08	-0.98	-0.88	-0.04	-5.16	-5.05 **	11.52	3.00 *	0.85 **	-0.11	H
MSN-99	-12.46 **	0.63	0.62	-0.83 *	0.90	-7.05 **	-12.67 *	-1.61	-2.03 **	-0.14 *	L
SEm±	**1.7612**	**0.5046**	**0.5849**	**0.3036**	**3.7313**	**0.2531**	**5.8057**	**1.1318**	**0.0608**	**0.062**	

** Significant at 5 % and 1 % probability levels, respectively.

Table 3. Estimates of specific combining ability effects in crosses for yield and yield contributing characters

Crosses	Plant height (cm)	No. of tillers per plant	No. of panicles per plant	Panicle length (cm)	Spikelet fertility (%)	Days to 50% flowering	No. of spikelets per panicle	Yield per plant (g)	1000 grain weight(g)	L/B ratio	Overall SCA status
KCMS 44A × Thanu	0.37	-0.60	-0.69	0.27	-0.65	1.95 **	-5.31	-3.24	-0.21	0.11	L
KCMS 44A × KMR 3	0.71	-3.63 **	-3.52 **	-0.47	1.66	0.78	14.28	0.16	-0.20	-0.11	L
KCMS 44A × KMR 4	6.15	3.32 **	3.37 **	1.10 *	2.08	-2.88 **	23.85 *	1.43	-0.32 **	0.07	H
KCMS 44A × KMR 12	-2.68	-1.13	-0.97	-1.12 *	11.44	-1.22 **	-15.95	0.60	0.22 *	-0.11	L
KCMS 44A × MSN 36	-3.68	0.76	0.37	-0.15	1.49	-1.88 **	-21.83 *	-2.54	0.43 **	0.01	H
KCMS 44A × MSN 75	-0.79	1.81 *	1.75	0.17	-13.61 *	1.78 **	-0.72	-6.38 **	-0.47 **	-0.13	L
KCMS 44A × MSN 91	-3.07	0.26	0.09	-0.03	0.55	0.12	-16.25	0.72	0.10	0.09	H
KCMS 44A × MSN 93	1.26	-0.30	0.15	0.28	-0.74	2.95 **	14.35	3.96	0.60 **	-0.00	H
KCMS 44A × MSN 98	0.43	0.48	0.32	0.12	6.08	-1.55 **	13.58	7.05 **	-0.63 **	0.03	H
KCMS 44A × MSN 99	1.32	-0.97	-0.86	-0.17	-8.31	-0.05	-6.02	-1.74	0.47 **	0.03	L
KCMS 45A × Thanu	0.39	0.94	0.64	-0.26	0.01	-2.30 **	8.53	0.97	0.03	-0.10	H
KCMS 45A × KMR 3	-1.94	4.12 **	3.80 **	-0.09	1.59	-2.97 **	-18.97	2.94	0.13	0.10	H
KCMS 45A × KMR 4	-2.00	-2.77 **	-2.64 *	0.22	-3.07	0.37	18.30	-0.93	-0.34 **	-0.07	L
KCMS 45A × KMR 12	-0.17	-0.38	0.03	0.86	-5.03	1.03 *	11.60	2.36	0.03	0.13	H
KCMS45A × MSN 36	0.17	0.35	0.19	-0.03	3.33	0.37	4.92	1.07	-0.32 **	0.10	H
KCMS 45A × MSN 75	-0.78	-0.93	-0.75	0.19	-9.63	2.03 **	-3.86	-3.31	1.09 **	0.13	L
KCMS 45A × MSN 91	-0.22	0.51	0.08	-0.56	1.89	0.37	-4.70	2.58	-0.17	-0.02	L
KCMS 45A × MSN 93	0.61	-1.04	-0.62	-0.89	-1.36	-0.30	-27.30 *	-5.39 *	-0.58 **	-0.29 *	L
KCMS 45A × MSN 98	1.78	-0.76	-1.20	-0.11	8.76	0.70	2.54	-0.16	0.51 **	-0.16	L
KCMS 45A × MSN 99	2.17	-0.04	0.47	0.68	3.51	0.70	8.94	-0.12	-0.37 **	0.17	H
KCMS 46A × Thanu	-0.76	-0.34	0.05	-0.01	0.63	0.35	-3.22	2.27	0.18	-0.01	H
KCMS 46A × KMR 3	1.24	-0.49	-0.28	0.56	-3.25	2.18 **	4.68	-3.10	0.07	0.01	L
KCMS 46A × KMR 4	-4.15	-0.55	-0.72	-1.32 *	0.99	2.52 **	-42.15 **	-0.50	0.67 **	-0.01	L
KCMS 46A × KMR 12	2.85	1.51	0.94	0.26	-6.41	0.18	4.35	-2.96	-0.25 *	-0.02	L
KCMS 46A × MSN 36	3.52	-1.10	-0.56	0.18	-4.81	1.52 **	16.91	1.48	-0.10	-0.12	L
KCMS 46A × MSN 75	1.57	-0.88	-1.00	-0.36	23.24 **	-3.82 **	4.58	9.69 **	-0.61 **	0.01	H
KCMS 46A × MSN 91	3.29	-0.77	-0.17	0.59	-2.45	-0.48	20.95 *	-3.30	0.07	-0.07	H
KCMS 46A × MSN 93	-1.87	1.34	0.47	0.61	2.10	-2.65 **	12.95	1.43	-0.02	0.30 **	H
KCMS 46A × MSN 98	-2.21	0.28	0.88	-0.01	-14.85 *	0.85	-16.12	-6.88 **	0.12	0.12	L
KCMS 46A × MSN 99	-3.48	1.01	0.39	-0.51	4.80	-0.65	-2.92	1.86	-0.10	-0.21	H
SEm±	**3.051**	**0.874**	**1.013**	**0.526**	**6.463**	**0.439**	**10.056**	**1.960**	**0.105**	**0.107**	

** Significant at 5 % and 1 % probability levels, respectively