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Combining Ability for Yield, Components and Quality Traits in Hybrid Rice (*Oryza sativa* L.)

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ABSTRACT

Ninty six hybrids generated from crossing four CMS lines and twenty four testers were studied along with parents for combining ability for yield, yield components and quality characters. Predominance of non-additive gene action was recorded for days to 50% flowering, plant height, number of panicles, panicle length, number of fertile spikelets, 100-grain weight, grain yield plant^{-1}, grain length, grain length/breadth ratio, While additive type of gene action was predominant for the spikelet fertility percent and harvest index. Among the parents PMS3A, MTU1064 and MTU II 61-28-1-1 were found to be good general combiners for yield and yield components. The line IR58025A and tester MTU II 161-28-1-1 was found to be good general combiners for grain quality characters. Crosses PMS10A X MTU II 161-28-1-1 and PMS10A X MTU II 193-23-1 were identified as most promising crosses for yield based on sca effects, per se performance and with more than 55% standard heterosis.

Key words : Cytoplasmic Male Sterility, General Combining Ability, Heterosis, Rice, Specific Combining Ability

The combining ability studies of parents and hybrids provide useful information for the selection of high order parents for effective breeding and also elucidate the nature and magnitude of gene action involved in the inheritance of various characters.The present investigation was undertaken to assess the nature of combining ability of four lines and 24 testers for yield, yield components and quality characters in rice.

MATERIAL AND METHODS

The experimental material comprised 96 rice hybrids derived from line x tester mating of four wild abortive CMS lines *viz.,* (IR58025A (A1), PMS3A (A2), PMS10A (A3), and APMS6A (A4)) with twenty four elite testers (DA313-1 (R1), MTU II 1719-5-1-1 (R2), MTU II 1686-8-1-1-11 (R3), MTU ITJ 226-18-1-1-2 (R4), MTU II 112-62-1-4 (R5), MTU ITJ 226-18-1-1-2 (R6), MTU II 112-62-1-4 (R7), MTU ITJ 218-5-1 (R8), MTU II 139-1-1-1-1-1 (R9), MTU II 178-20-2-2-1 (R10), MTU II 187-6-1-1 (R11), MTU II 193-23-1 (R12), MTU II 161-28-1-1 (R13), MTU II 143-26-2 (R14), MTU II 161-22-1 (R15), MTU II 156-13-1-2 (R16), MTU II 127-95-1-1 (R17), MTU PS 194-1-1 (R18), MTU ITJ 201-12-1 (R19), MTU II 124-41-1-1 (R20), MTU II 124-41-1-1 (R21), MTU II 134-6-1-1 (R22), MTU II 110-11-1-1-1-15 (R23), MTU 1064 (R24).) .The hybrids along with parents and one popular hybrid check APHR-2 were grown in a randomized block design with two replications at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station, Maruteru during Rabi 2006-2007 .Twenty eight days old seedlings were transplanted at inter- and intra-row spacing of 20x15 cm. The standard agronomic practices were followed while raising the crop. Plants were selected randomly from each replication and observations were recorded on five randomly selected plants for plant height, number of panicles, panicle length, number of fertile spikelets, spikelet fertility percent, harvest index, grain length, grain length/breadth ratio and garin yield plant^{-1}. Where as days to 50% flowering and 100-grain weight were recorded on plot basis. Line x tester analysis was performed as per Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed highly significant differences among the hybrids with respect to all the characters (Table 1). The significance of mean squares due to lines and testers indicated prevalence of additive variance for most of the characters. The significance of mean squares due to line × tester for all the characters indicated that non-additive variance was important for majority of the characters. Days to 50% flowering, plant height, number of panicles, panicle length, number of fertile spikelets, 100 grain weight, grain yield plant^{-1}, grain length, grain breadth and grain length/breadth ratio showed greater SCA variances than GCA variances indicating the

Table 1. Analysis of variance of combining ability for different characters in rice (Oryza sativa L.)

Source	df	Days to 50% flowering	Plant height	Number of panicles	Panicle length	Number of fertile spikelets	Spikelet fertility %	100 grain weight	Grain yield plant^{-1}	Harvest index	Grain length	Grain breadth	Grain length / breadth
Replications	1	0.08	0.17	1.10	0.28	1.10	0.01	0.121*	1.86	0.007	0.161	0.039	0.015
Treatments	124	38.84**	153.54**	6.11*	6.23**	11295.46**	1497.53**	0.095**	137.45**	0.0253**	0.463**	0.018**	0.128**
Parents	27	46.45**	100.41**	2.43**	4.30**	2824.45**	167.22**	0.155**	7.51**	0.001*	0.959**	0.025**	0.262**
Parents vs. crosses	1	156.56**	245.85**	56.46**	99.49**	17836.03**	23107.59**	0.863**	4.55	0.177**	0.927**	0.018	0.520**
Crosses	95	35.44**	167.66**	6.63**	5.80**	13634.16**	1648.15**	0.070**	175.78**	0.0308	0.318**	0.017**	0.086**
Lines	3	24.31	174.78*	12.36	13.48	6084.14	295.97	0.090	034.81	0.0056	1.107**	0.019	0.455**
Testers	23	110.85**	541.58**	11.93*	10.34*	48852.01**	6348.45**	0.157**	595.72**	0.1175	0.677**	0.022	0.141**
Lines × Testers	69	10.79**	42.72**	4.61**	3.95**	2223.13**	140.17**	0.040**	41.93**	0.0031	0.163**	0.015**	0.051**
Error	95	2.23	3.57	0.58	1.42	7.08	3.06	0.016	2.22	0.0002	0.031	0.007	0.011
σ^2GCA		2.33	12.68	0.42	0.38	980.76	118.55	0.004	11.19	0.0022	0.031	0.001	0.010
σ^2SCA		4.28	19.79	2.06	1.34	1108.21	68.74	0.013	19.96	0.0014	0.066	0.005	0.019
σ^2GCA/ SCA		0.55	0.64	0.20	0.28	0.89	1.72	0.297	0.56	1.517	0.465	0.115	0.534

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

Table 2. Combining ability effects of important parents and the best crosses for grain yield, yield components and quality traits with economic heterosis and *per se* performance in rice (Oryza sativa L.)

	Days to 50 % flowering	Plant height	No of panicles	Panicle length	No of fertile spikelets	Spikelet fertility percent	100 grain weight	Grain yield plant^{-1}	Harvest index	Grain length	Grain breadth	Grain length/ breadth ratio	Per se perfor-mance	gca effects of females	gca effects of	Heterobel-tiosis	Standard heterosis
Lines																	
IR58025A (A1)	-0.91**	0.14	0.64**	0.22	-14.54**	-2.72**	0.02	-1.07**	-0.02**	0.23**	-0.03*	0.15**					
PMS3A (A2)	0.47	1.68**	-0.52**	0.64**	12.91**	2.98**	-0.05*	0.96**	0.00	-0.10**	0.01	-0.06**					
PMS10A (A3)	0.66*	0.89**	0.14	-0.32	1.41**	-1.17**	-0.02	0.29	0.00	-0.06	0.01	-0.04					
APMS6A (A4)	-0.22	-2.70**	-0.27*	-0.53*	0.21	0.92**	0.05*	-0.19	0.01**	-0.06	0.01	-0.05*					
SE(gi)	0.22	0.26	0.10	0.16	0.37	0.24	0.02	0.20	0.00	0.03	0.01	0.02					
SE(gi-gj)	0.30	0.36	0.14	0.23	0.53	0.34	0.02	0.29	0.00	0.04	0.02	0.02					
Teaters																	
DA 313-1 (R1)	-5.89**	4.30**	0.45	0.51	74.77**	16.93**	-0.02	9.47**	0.10**	-0.17*	0.16**	-0.26**					
MTU Ⅱ 178-20-2-2-1(R10)	1.49*	-6.69**	-0.10	-0.25	65.79**	14.41**	0.07	9.97**	0.07**	-0.39**	-0.04	-0.11*					
MTU II 193-23-1(R12)	-3.64**	12.69**	-0.45	1.53**	52.56**	17.96**	0.01	7.67**	0.09**	-0.27**	-0.06	-0.03					
MTU Ⅱ 161-28-1-1(R13)	-2.14**	6.68**	0.37	1.30**	82.60**	23.42**	-0.01	11.47**	0.09**	0.29**	0.00	0.13*					
MTU II 143-26-2 (R14)	-5.14**	8.80**	-0.98**	0.05	61.21**	20.59**	-0.10	5.56**	0.07**	-0.05	0.02	-0.06					
MTUII 156-13-1-2 (R16)	-1.39*	9.75**	-1.10**	1.38**	75.53**	21.22**	-0.02	6.42**	0.09**	-0.17*	-0.02	-0.04					
MTU 1064 (R 24)	-6.76**	-3.99**	-0.67*	2.52**	95.84**	23.76**	0.21**	11.75**	0.10**	-0.09	0.02	-0.07					
SE(gi)	0.53	0.63	0.25	0.40	0.92	0.58	0.04	0.51	0.01	0.06	0.03	0.04					
SE(gi-gj)	0.75	0.89	0.35	0.56	1.30	0.82	0.06	0.71	0.01	0.09	0.04	0.06					
Best Crosses																	
PMS10A X MTU Ⅱ 161-28-1-1 (A3R13)	0.22	0.42	2.12**	1.61	28.85**	7.15**	0.15	9.24**	0.01	-0.21	-0.18*	0.21*	41.59	0.29 A	11.47**H	87.24**	69.43**
PMS3A X MTU II 178-20-2-2-1 (A2R10)	-0.22	-4.15*	0.30	1.54	49.87**	6.55**	0.01	9.17**	0.03*	-0.03	-0.04	0.05	40.69	0.96**H	9.97**H	89.83**	65.74**
PMS10A X MTU Ⅱ 178-20-2-2-1 (A3R10)	0.09	4.05*	1.74**	1.69	56.49**	11.33**	-0.06	8.63**	0.04**	-0.03	0.05	-0.08	39.48	0.29 A	9.97**H	83.33**	60.81**
PMS10A X MTU Ⅱ 193-23-1 (A3R12)	-0.78	1.29	-0.71	1.49	82.73**	8.49**	0.14	10.09**	0.02	-0.21	-0.06	0.02	38.64	0.29 A	7.67**H	68.81**	57.39**
APMS6A X MTU 1064 (A4R24)	1.22	0.19	-0.23	0.81	49.78**	4.31**	0.19	6.33**	0.00	0.05	-0.10	0.19	38.48	-0.19 A	11.75**H	71.46**	56.72**
IR58025A X MTU 1064 (A1R24)	-0.59	-3.74*	0.81	0.58	41.99**	4.68**	-0.03	7.06**	0.02	0.13	0.02	0.02	38.32	-1.07**L	11.75**H	70.79**	56.11**
IR58025A X DA 313-1 (A1R1)	-0.47	7.88**	0.80	1.47	15.15**	8.17**	-0.04	6.39**	0.03	0.09	-0.05	0.06	35.39	-1.07**L	9.47**H	52.32**	44.13**
IR58025A X MTU II 143-26-2 (A1R14)	-0.72	-0.06	-0.23	1.70	39.26**	8.90**	-0.11	9.61**	0.05**	0.03	-0.06	0.12	34.69	-1.07**L	5.56**H	50.16**	41.32**
PMS3A X MTUII 156-13-1-2 (A2R16)	2.16	1.88	0.75	-0.04	54.65**	3.10*	-0.22*	6.53**	0.02	0.12	0.05	-0.04	34.50	0.96**H	6.42**H	59.66**	40.51**
PMS3A X DA 313-1 (A2R1)	0.16	7.17**	-1.50*	0.63	48.25**	5.54*	0.00	0.81	0.01	-0.02	0.18*	-0.14	31.83	0.96**H	9.47**H	37.02**	29.65**
SE(sij)	1.05	1.25	0.49	0.79	1.83	1.16	0.04	1.00	0.01	0.13	0.05	0.08					
SE(sij-skl)	1.49	1.77	0.69	1.12	2.59	1.64	0.06	1.41	0.01	0.18	0.08	0.11					

* = and ** = Significant at P=0.05 and 0.01, respectively

predominance of non-additive gene action for these traits. Similar results were reported by earlier workers for days to 50% flowering, plant height, number of panicles, panicle length, 100-grain weight and grain yield plant^{-1} (Satyanarayana *et al.,* 2000, and Pradhan and Singh 2008); for fertile spikelets (Gnanasekaran *et al.,* 2006) and for grain length, grain breadth and grain length/breadth ratio (Sarvanan *et al.,* 2006). Spikelet fertility per cent and harvest index had higher GCA variances than SCA variances, indicating the predominance of additive gene action. Swain *et al.,* (2003) also reported that additive gene effects were predominant than non-additive gene effects for spikelet fertility % and harvest index.

General combining ability effects

The estimates of gca effects revealed significant differences among the parental lines for different traits. Among lines PMS3A was found to be the best combiner for grain yield plant^{-1} and also for tallness, panicle length, number of fertile spikelets and spikelet fertility per cent. The other lines, IR 58025A for early flowering, number of panicles, grain length, grain breadth and grain length /breadth ratio; APMS6A for dwarfness, 100-grain weight and harvest index and PMS10A for late maturity and tallness were found to be best combiners. Among the testers, 13 parents had recorded significant and positive gca effects for grain yield plant^{-1}. The testers MTU 1064 and MTU II 161-28-1-1 were found to be good general combiners for grain yield plant^{-1} and also for number of fertile spikelets and spikelet fertility per cent and harvest index.The testers MTU1064 and MTU II 187-6-1-1 for early flowering ; MTU II 1719-5-1-1 and MTU II 124-41-1-1 for dwarfness ; MTU II 1719-5-1-1 and MTU II 134-6-1-1 for number of panicles; MTU 1064 and MTU II 193-23-1 for panicle length; MTU ITJ 226-18-1-1-2 and MTU II 112-62-1-4 for 100-grain weight; DA313-1 for harvest index; MTU II 112-62-1-4 and MTU ITJ 226-18-1-1-2 for grain length and grain length/breadth ratio were found to be best combiners.

Specific combining ability effects

In the present study, positive significant sca effects for grain yield plant^{-1} were exhibited by 17 crosses.The promising specific crosses along with high *per se* performance for grain yield were PMS 10A X MTU II 193-23-1, IR58025A X MTU II 143-26-2, PMS10A X MTU II 161-28-1-1, PMS3A X MTU II 178-20-2-2-1, PMS10A X MTU II 178-20-2-2-1, IR58025A X MTU1064, PMS3A X MTU II 156-13-1-2, IR 58025A X DA313-1, APMS6A X MTU1064, PMS10A X MTU II 161-22-1 and PMS 10A X MTU II 127-95-1-1.These promising crosses involved one parent with high gca effects and other having either high, average or low combining ability effect, indicating the presence of additive x additive and / or additive x dominance genetic interaction in sizeable amount in these crosses.Similar results were reported by earlier workers Kalitha and Upadhyaya (2000), Anand Kumar *et al.,* (2006) and Pradhan and Singh (2008).

The *per se* performance, sca effects of crosses, gca effects of parents, heterobeltiosis and standard heterosis in superior hybrid combinations (Table 2) indicated that the high performance hybrids need not be the ones with high sca effects and *vice - versa*. These results are in conformity with the earlier findings of Satyanarayana *et al.,* (2000) and Anand Kumar *et al.,* (2006).The promising specific combinations for grain yield along with other traits were PMS10A X MTU II 193-23-1 and PMS10A X MTU II 161-28-1-1

The cross combinations IR 58025A X MTU PS 194-1-1 and APMS 6A X MTU II 127-95-1-1 had exhibited low sca effects for days to 50% flowering. Negative estimates of sca are desirable for plant height, the crosses PMS10A X DA313-1 and PMS10A X MTU II 686-8-1-1-11 exhibited low sca effects for plant height. Crosses PMS10A X MTU II 134-6-1-1 and IR58025A X MTU II 1719-5-1-1 had exhibited high sca effects for number of panicles. Promising specific combiners for panicle length were APMS6A X MTU II 112-62-1-4 and PMS10A X MTU II 161-22-1.The cross combinations PMS 10A X MTU II 193-23-1 and PMS 10A X MTU II 161-22-1 exhibited high sca effect for number of fertile spikelets.The hybrid APMS10 X MTU II 112-62-1-4 had exhibited high sca effects for spikelet fertility per cent and harvest index. Further, the hybrids APMS6A X MTU ITJ 226-18-1-1-2 for spikelet fertility percent and APMS6A X MTU II 112-62-1-4 for harvest index had exhibited high sca effects. The crosses IR58025A X MTU II 161-28-1-1 and IR58025A X MTU II 187-6-1-1 had exhibited high sca effects for grain length. The promising specific combiners for grain breadth were PMS10A X MTU II 161-28-1-1 and IR58025A X MTU ITJ 226-18-1-1-2 while APMS6A X MTU II 124-41-1-1 and IR58025A X MTU ITJ 226-18-1-1-2 for grain length / breadth ratio.

Combining ability analysis revealed that the parents PMS3A, MTU1064 and MTU II 161-28-1-1 were found to be good general combiners for yield and yield components. The line IR58025A and tester MTU II 161-28-1-1 were found to be good general combiners for grain quality characters. . Crosses PMS10A X MTU II 161-28-1-1 and PMS10A X MTU II 193-23-1 were identified as most promising crosses for yield based on sca effects, *per se* performance and with more than 55% standard heterosis could be profitably exploited for the production of hybrids in rice.

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