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Research Article

Combining ability studies for yield and yield components trait in hybrid rice (*Oryza sativa* L.)

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Abstract

Fifty two hybrids were generated from crossing four CMS lines and thirteen restorer lines in line x tester design. Crosses along with parents were evaluated for yield and yield component traits during *rabi,* 2011 at RARS, Jagtial, Andhra Pradesh. Predominance of non additive gene action was recorded for all the characters. Among CMS lines APMS 9A and APMS 10A and in testers *viz.,* MTU II-110-9-1-1-1-1, MTU II -187-6-1-1, MTU II-143-26-2, MTU II-290-42-1 and MTU II-283-7-1-1 were found to be good general combiners for grain yield and yield component traits. The crosses APMS 10A x MTU II-290-42-1, APMS 6A x MTU II -187-6-1-1 and PMS 6A x MTU II-110-9-1-1-1-1 were identified as most promising hybrids for grain yield plant^{-1}. These hybrids can be tested over locations before their commercial cultivation.

Key words: Cytoplasmic male sterility, General combining ability and Specific combining ability.

Rice (*Oryza sativa*) is an important staple food crop providing 43% of calorie requirement for more than 70% of Indian population. Sustainable increase in rice production can be achieved only with the use of suitable hybrids which depends on choice of suitable parents with favourable alleles which on crossing could produce heterotic hybrids. Combining ability studies are to identify superior parents with good combining ability which may be used to build up a population with favourable and fixable genes for effective yield improvement. The present investigation was undertaken with four CMS lines and thirteen testers to assess the nature of combining ability for yield and yield component traits.

Material and Methods

The experimental material comprised of four wild abortive source CMS lines and thirteen elite indica/indica derivates. These were crossed in line x tester design during *kharif,* 2010 at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station, Maruteru. The resultant 52 hybrids along with their parents and three checks (*viz*., MTUHR 2089-hybrid check, MTU 1075 and MTU 1010-varietal checks) were evaluated in a randomized block design with two replications for combining ability at RARS, Jagtial, Andhra Pradesh during *rabi*, 2011. Twenty eight days old seedlings were transplanted at a spacing of 20x15 cm. Observations were recorded on ten randomly selected plants for plant height, number of tillers palnt^{-1}, panicle length, number of filled grains panicle^{-1}, spikelet fertility per cent and grain yield plant^{-1}. Whereas days to 50% flowering and test weight were recorded on plot basis. The mean data were analysed for combining ability following the standard method of 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 studied (Table 1). Partitioning of crosses into lines, testers and line × tester revealed that the variance due to lines was significant for all the characters expect for number of tillers palnt^{-1}, number of filled grains panicle^{-1} and grain yield plant^{-1} whereas in testers, significance was found for days to 50% flowering, plant height, number of filled grains panicle^{-1}, spikelet fertility per cent, test weight and grain yield plant^{-1}. Interaction effect, line x tester was significant for all the characters indicating the genetic difference among them. The estimates of variance due to SCA were higher than GCA variance indicating the predominance of non-additive gene action for all the characters. The influence of non-additive gene action in the control of yield, yield component traits was also reported by Dalvi and Patel (2009), Jayasudhan and Deepaksharma (2009), Kumarbabu e*t al.* (2010), Nadali Bagheri (2010) and Saidaiah e*t al.* (2011).

Two CMS lines *viz.,* APMS 9A and APMS 10A and five testers *viz.,* MTU II-110-9-1-1-1-1, MTU II -187-6-1-1, MTU II-143-26-2, MTU II-290-42-1 and MTU II-283-7-1-1 recorded high *gca* values and were found to be good general combiners for grain yield (Table 2). The line APMS 9A also showed high significant *gca* effects for number of filled grains panicle^{-1} and spikelet fertility. Whereas APMS 10A recorded high significant *gca* effects for number of tillers palnt^{-1}, panicle length and test weight in addition to grain yield plant^{-1}. The line APMS 6A was good for early flowering and dwarf plant stature. The restorer line, MTU II-290-42-1 was found good for number of tillers palnt^{-1}, number of filled grains panicle^{-1}, spikelet fertility and test weight while, MTU II-143-26-2 was good for number of tillers palnt^{-1}. Further, MTU II-283-7-1-1 recorded significant effects for panicle length, number of filled grains panicle^{-1} and spikelet fertility. MTU II -187-6-1-1 tester was significant for spikelet fertility and MTU II-110-9-1-1-1-1 and MTU II-143-26-2 were good combiners for number of tillers palnt^{-1}. Testers *viz.,* MTU II 218-5-1, MTU II-143-26-2, MTU II-124-41-1-1, MTU II-178-28-1-1-1 and MTU II-301-2-1 had *gca* effects in desirable direction for days to 50 % flowering.

Positive significant *sca* effects for grain yield (Table 3) were exhibited by eight crosses *viz.,* APMS 6A x MTU II-110-9-1-1-1-1, APMS 6A x MTU II -187-6-1-1, APMS 6A x MTU II-143-26-2, APMS 9A x MTU 1071, APMS 9A x MTU II-301-2-1, APMS 10A x MTU II 218-5-1, APMS 10A x MTU II-290-42-1 and IR58025A x MTU II-190-1-1-1-1-1. Out of these crosses, all hybrids recorded high *per se* performance and significant *sca* effects except APMS 9A x MTU II-301-2-1 for grain yield plant^{-1}. Among these crosses the promising hybrid, APMS 10A x MTU II-290-42-1 had both the parents with significant positive *gca* effects possessing additive x additive type of gene action. The crosses *viz.,* APMS 6A x MTU II-110-9-1-1-1-1, APMS 6A x MTU II -187-6-1-1, APMS 6A x MTU II-143- 26-2, APMS 9A x MTU 1071 and APMS 10A x MTU II 218-5-1 possessed only one parent with significant positive *gca* effects indicating the involvement of additive and dominance genetic interaction. Whereas IR58025A x MTU II-190-1-1-1-1-1 cross had both parents with low *gca* effects for grain yield plant^{-1} indicating over dominance and epistatic interactions. Similar findings were given by Anandkumar *et al.* (2006), Gnanasekaran *et al.* (2006), Dalvi and Patel (2009), Jayasudhan and Deepaksharma (2009), Kumarbabu e*t al.* (2010), Nadali Bagheri (2010) and Saidaiah e*t al.* (2011).

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The CMS line APMS 9A and testers *viz.,* MTU II -187-6-1-1, MTU II-143-26-2 and MTU II-110-9-1-1-1-1 are good general combiners for grain yield. The crosses APMS 10A x MTU II-290-42-1, APMS 6A x MTU II -187-6-1-1 and APMS 6A x MTU II-110-9-1-1-1-1 were identified as most promising hybrids based on *per se* performance and *sca* effects for grain yield plant^{-1}. These crosses could be profitably exploited for the production of hybrids in rice after thorough testing over locations.

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

Source of variation	df	Days to 50% flowering	Plant height (cm)	Number of tillers $plant^{-1}$	Panicle length (cm)	No. of filled grains $panicle^{-1}$	Spikelet fertility %	Test weight (g)	Grain yield $plant^{-1}$
Replication	1	0.24	0.10	0.48	0.36	509.10	14.18	0.09	3.01
Crosses	51	52.53**	149.26**	4.94**	3.36**	5972.72**	211.42**	6.93**	166.74**
Lines	3	76.55*	180.24*	4.55	16.08**	6392.01	485.75**	52.91**	190.02
Testers	12	127.79**	419.52**	9.40	4.50	14625.98**	477.80**	10.64**	344.47*
Lines ×Testers	36	25.44**	56.59**	3.48**	1.93**	3053.36**	99.76**	1.86**	105.56**
ERROR	51	2.10	10.83	0.83	0.56	629.10	12.81	0.43	14.34
σ^2GCA		0.53	1.81	0.03	0.03	57.04	2.18	0.10	1.20
σ^2SCA		11.67	22.88	1.33	0.68	1212.13	43.48	0.72	45.61
σ^2GCA/ σ^2SCA		0.05	0.08	0.02	0.04	0.05	0.05	0.14	0.03

*significant at 5% level

**significant at 1% level

σ^2GCA = Variance of General combining ability

σ^2SCA = Variance of Specific combining ability

Table 2: General combining ability effects of lines and testers for yield, yield component characters in rice (*Oryza sativa* L.) during *rabi*, 2011

CMS lines	Days to 50% flowering	Plant height (cm)	Number of tillers plant^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Spikelet fertility %	Test weight (g)	Grain yield plant^{-1} (g)
APMS 6A	-2.51**	-2.95**	-0.40*	-1.11**	-5.13	-1.35	-0.77**	-1.08
APMS 9A	0.76**	-1.46*	0.33	0.05	21.16**	5.37**	-1.43**	2.48**
APMS 10A	1.34**	1.85**	0.40*	0.34*	-16.24**	-4.95**	1.82**	1.91*
IR58025A	0.41	2.55**	-0.32	0.72**	0.21	0.93	0.38**	-3.31**
S.E (lines)	0.28	0.65	0.18	0.15	4.92	0.70	0.13	0.74
Restorer lines								
MTU 1071	1.5**	3.09**	0.57	1.23**	17.38	-1.61	-0.58*	2.21
MTU II 218-5-1	-2.88**	-9.48	-0.98**	-0.92**	-34.4**	-0.58	0.65**	-8.09**
MTU II-110-9-1-1-1-1	4.50**	-0.11	1.15**	0.23	8.30	0.40	-1.18**	5.87**
MTU II-110-11-1-1-1-6	2.25**	7.39**	-0.92**	0.03	47.78**	2.09	-1.16**	0.04
MTU II -187-6-1-1	4.00**	-0.98	-0.27	0.38	-4.1	6.18**	2.58**	7.91**
MTU II-190-1-1-1-1-1	0.50	4.81**	0.72*	-0.17	51.1**	4.32**	-1.61**	2.04
MTU II-143-26-2	-1.25*	10.29**	1.35**	0.37	2.93	1.89	-0.03	7.44**
MTU II-124-41-1-1	-7.63**	-6.83**	-1.63**	-1.51**	-6.27	2.77*	0.36	-5.39**
MTU II-178-28-1-1-1	-2.38**	0.42	-0.27	-0.36	-14.77	0.60	0.68**	-4.28**
MTU II-290-42-1	4.75**	2.02	1.80**	-0.12	25.95**	4.17**	1.43**	4.74**
MTU II-301-2-1	-6.25**	-13.96**	-0.65*	-0.57*	-104.82**	-23.68**	-0.11	-13.99**
MTU II-283-7-1-1	3.50**	8.52**	0.42	1.08**	47.2**	7.04**	-0.37	4.16**
WGL 285	-0.63	-5.18**	-1.30**	0.35	-36.31**	-3.59**	-0.66**	-2.66*
S.E (testers)	0.51	1.16	0.32	0.26	8.87	1.27	0.23	1.34

**significant at 1% level   *significant at 5% level

Table 3: Specific combining ability effects of hybrids for yield, yield component characters in rice (*Oryza sativa* L.) during *rabi*, 2011

Hybrids	Days to 50% flowering	Plant height (cm)	No. of tillers plant^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	Spikelet fertility %	Test weight (g)	Grain yield plant^{-1} (g)
APMS 6A x MTU 1071	4.38**	2.45	0.75	-1.14*	-68.37**	-10.31**	0.93*	-10.17**
APMS 6A x MTU II 218-5-1	-0.74	-3.68	0.00	0.51	51.00**	8.05**	0.04	3.33
APMS 6A x MTU II-110-9-1-1-1-1	0.38	6.55**	1.47*	0.96	12.7	0.69	0.31	9.57**
APMS 6A x MTU II-110-11-1-1-1-6	-4.37**	0.25	-1.17	0.76	28.53	10.27**	1.18*	0.71
APMS 6A x MTU II -187-6-1-1	2.38*	4.32	1.78**	-0.29	0.20	5.97*	0.01	10.13**
APMS 6A x MTU II-190-1-1-1-1-1	-6.12**	-5.71*	-1.1	-0.34	41.5*	3.37	0.32	-5.99*
APMS 6A x MTU II-143-26-2	-1.37	0.15	-0.83	-0.98	-33.92	-0.81	-0.57	6.41*
APMS 6A x MTU II-124-41-1-1	4.51**	4.57	0.75	0.39	46.18*	6.25*	-0.02	3.83
APMS 6A x MTU II-178-28-1-1-1	-2.24*	0.62	1.23	-0.06	-6.52	-2.78	-1.05*	-4.28
APMS 6A x MTU II-290-42-1	2.63*	1.12	-2.08**	0.51	-5.65	-3.84	-2.81**	-9.29**
APMS 6A x MTU II-301-2-1	2.63*	-4.40	0.07	0.76	-57.57**	-23.97**	-0.08	-7.77**
APMS 6A x MTU II-283-7-1-1	3.38**	0.82	-0.5	-0.09	14.00	-0.24	0.39	-0.32
APMS 6A x WGL 285	-5.49**	-7.08**	-0.38	-0.97	-22.08	7.35**	1.34**	3.81
APMS 9A x MTU 1071	-0.88	-6.94**	-0.48	0.9	-39.56*	1.06	1.78**	5.97*
APMS 9A x MTU II 218-5-1	-5.51**	-5.56*	0.57	0.05	16.92	0.05	-0.08	3.57
APMS 9A x MTU II-110-9-1-1-1-1	0.62	4.96*	-1.90**	-1.10*	-15.78	0.46	0.06	-2.34
APMS 9A x MTU II-110-11-1-1-1-6	2.37*	3.26	1.06	0.10	28.74	-1.95	-0.91	3.44
APMS 9A x MTU II -187-6-1-1	1.62	3.74	0.51	0.25	25.12	3.01	-0.57	3.37
APMS 9A x MTU II-190-1-1-1-1-1	3.12**	1.55	-0.23	-0.60	-44.68*	-5.95*	-0.04	-5.76*

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Hybrids	Days to 50% flowering	Plant height	No. of tillers plant^{-1}	Panicle length	No. of filled grains panicle^{-1}	Spikelet fertility %	Test weight	Grain yield plant^{-1}
APMS 9A x MTU II-143-26-2	2.87**	-1.04	1.45	0.31	-29.81	1.42	-0.84	-2.96
APMS 9A x MTU II-124-41-1-1	-2.76**	-2.91	1.02	-0.91	-31.41	-3.52	-0.35	-1.33
APMS 9A x MTU II-178-28-1-1-1	3.99**	-0.66	-1.44*	0.74	-12.61	-3.26	0.55	-0.34
APMS 9A x MTU II-290-42-1	1.87	1.44	-0.10	0.05	15.07	-0.10	1.01*	-7.16**
APMS 9A x MTU II-301-2-1	-1.13	-2.99	1.25	-0.60	70.14**	14.68**	-0.91	8.07**
APMS 9A x MTU II-283-7-1-1	-2.88**	5.04*	-0.63	1.25*	45.02*	1.62	0.65	3.92
APMS 9A x WGL 285	-3.26**	0.14	-1.1	-0.43	-27.17	-7.52**	-0.36	-8.46**
APMS 10A x MTU 1071	1.04	6.55**	0.55	1.81**	82.84**	7.11**	-2.3**	4.64
APMS 10A x MTU II 218-5-1	0.91	-3.28	2.20**	0.36	-6.39	-2.28	0.15	6.74*
APMS 10A x MTU II-110-9-1-1-1-1	1.04	0.05	-0.37	0.11	-5.19	1.85	0.10	-12.42**
APMS 10A x MTU II-110-11-1-1-1-6	0.29	-1.25	-0.06	-1.19*	-25.76	-2.29	-0.22	-5.59*
APMS 10A x MTU II -187-6-1-1	-1.46	-2.38	-1.91**	-0.14	-23.09	-5.96*	0.51	-6.06*
APMS 10A x MTU II-190-1-1-1-1-1	2.04*	4.13	0.50	1.11*	-19.59	5.12*	-0.31	5.11
APMS 10A x MTU II-143-26-2	-0.21	-1.85	-0.02	-0.53	8.99	-2.47	0.51	-0.99
APMS 10A x MTU II-124-41-1-1	-0.34	-3.03	-1.85**	0.55	-17.41	-3.57	0.15	-6.56*
APMS 10A x MTU II-178-28-1-1-1	-1.09	-4.28	-0.51	-1.70**	1.09	-3.08	0.33	0.68
APMS 10A x MTU II-290-42-1	0.29	2.02	2.13**	0.26	-2.04	2.06	0.87	15.71**
APMS 10A x MTU II-301-2-1	-0.71	1.60	-0.62	0.41	-6.96	3.49	0.60	-0.36
APMS 10A x MTU II-283-7-1-1	-4.96**	1.62	0.00	-0.34	-31.19	-3.34	0.26	-0.51

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Hybrids	Days to 50% flowering	Plant height (cm)	No. of tillers plant^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	Spikelet fertility %	Test weight (g)	Grain yield plant^{-1} (g)
APMS 10A x WGL 285	3.16**	0.12	-0.07	-0.71	44.72*	3.36	-0.65	-0.39
IR58025A x MTU 1071	-4.54**	-2.05	-0.83	-1.57**	25.09	2.14	-0.41	-0.44
IR58025A x MTU II 218-5-1	5.34**	12.52**	-2.78**	-0.92	-61.53**	-5.83*	-0.11	-13.64**
IR58025A x MTU II-110-9-1-1-1-1	-2.04*	-11.55**	0.80	0.03	8.27	-3.01	-0.47	5.2
IR58025A x MTU II-110-11-1-1-1-6	1.71	-2.25	0.16	0.33	-31.51	-6.02*	-0.05	1.43
IR58025A x MTU II -187-6-1-1	-2.54*	-5.68*	-0.39	0.18	-2.23	-3.03	0.05	-7.44**
IR58025A x MTU II-190-1-1-1-1-1	0.96	0.03	0.82	-0.17	22.77	-2.55	0.03	6.63*
IR58025A x MTU II-143-26-2	-1.29	2.75	-0.60	1.20*	54.74**	1.86	0.9	-2.47
IR58025A x MTU II-124-41-1-1	-1.41	1.37	0.07	-0.03	2.64	0.84	0.21	4.06
IR58025A x MTU II-178-28-1-1-1	-0.66	4.32	0.71	1.02	18.04	9.12**	0.16	3.95
IR58025A x MTU II-290-42-1	-4.79**	-4.58	0.05	-0.82	-7.38	1.88	0.92*	0.73
IR58025A x MTU II-301-2-1	-0.79	5.8*	-0.70	-0.57	-5.61	5.80*	0.40	0.06
IR58025A x MTU II-283-7-1-1	4.46**	-7.48**	1.12	-0.82	-27.83	1.96	-1.3**	-3.09
IR58025A x WGL 285	5.59**	6.82**	1.55*	2.11**	4.53	-3.19	-0.34	5.03
SE (crosses)	1.03	2.33	0.64	0.53	17.74	2.53	0.46	2.68

**significant at 1% level *significant at 5% level