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Combining Ability Analysis to Identify Suitable Parents and Hybrids for Cultivation of Rice Under Alternate Wetting and Drying Conditions

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ABSTRACT

Heterosis breeding is one of the tools in overcoming yield barrier and increasing productivity under both favourable and unfavourable conditions. In the present field study 45 crosses derived from three CMS lines and 15 restorer lines along with parents were evaluated in line x tester design for grain yield and yield components under alternate wetting and drying (AWD) conditions in rice during *kharif* 2008. Predominance of non additive gene action was observed for all the characters, suggesting the development of hybrids in rice. The line IR 58025A was a good general combiner for grain yield per plant, earliness and dwarf plant height, while IR 79156A was good general combiner for 1000 seed weight and short plant height. Among the testers 1096, TG-60 were good general combiners for grain yield per plant. The hybrid combinations APMS6A X TG 21, IR79156A x 1005, IR 79156A x EPLT 109, IR58025A x SG 27-77 and IR 58025A x VG 149 showed to be having good specific combining ability for grain yield and components.

Key words : Alternate wetting and drying, CMS lines, Combining ability, Hybrid rice, Line x Tester.

Rice (*Oryza sativa* L.) is one of the most important crops in the world, providing 35 to 60% of the dietary calories consumed by more than 3 billion people. It is estimated that, by the year 2025, it will be necessary to produce about 60% more than what is currently produced to meet the food needs of a growing world population (Fageria, 2003 and 2007). Decreasing water availability for agriculture threatens the productivity of the irrigated ecosystem, and ways must be sought to increase both grain yield and water use efficiency (WUE) of rice (Belder *et al*., 2004). Growing rice under limited water input conditions is one among the many options available for conservative use of water for rice cultivation. Rice cultivation under aerobic practice saves water up to 30-50% percent with a yield penalty of 10-15 percent only, while the water productivity is up to 60% (Xie Guanghui *et al*., 2008). Alternate wetting and drying (AWD) method is a practice of rice cultivation where high input use efficient cultivars are grown in near or below saturated field conditions (Belder *et al.,* 2007; Zhang *et al.,* 2008). Since AWD situation is a limited water input environment, the genotype targeted to this environment should be able to withstand occasional or intermittent stress for moderate periods. Most of the present available rice hybrids which are in public domain are bred for irrigated ecosystem. In the course of developing hybrids for this new cultivation practice and to exploit heterosis there is an urgent need to test various cytoplasmic male sterile (CMS) lines and restorers for their combining ability. The present study was aimed to develop suitable high yielding early hybrid as well as CMS lines and tester for growing in AWD conditions by assessing the combing ability of promising CMS and newly developed restorer lines under AWD conditions using Line x Tester analysis.

MATERIAL AND METHODS

The experimental material for the present study comprised 45 F_1 s of rice generated by crossing three CMS lines (*viz*., IR58025A, IR79156A and APMS 6A) with 15 restorer lines during *rabi*, 2006-07. The resultant 45 F_1s along with 18 parents and 4 checks of different maturity groups were grown in randomized complete block design with two replications during *khariff,* 2008 at Research Farm, Directorate of Rice Research, Rajendranagar, Hyderabad. Thirty days old seedlings were transplanted with one seedling per hill adopting 20 X 15 cm spacing. Each entry was planted in two rows of 1.8 m length. All the recommended agronomic practices were followed during the crop growth period and the field was maintained in alternate wetting and drying condition. The following observations were taken on randomly selected five plants from each replication of each entry viz., days to 50 percent flowering, plant height, tiller number plant^{-1} , productive tillers plant^{-1} , panicle length, spikelet fertility percent, 1000 grain weight, grain yield plant^{-1}. The mean data were analyzed for combining ability based on the method developed by Kempthorne (1957). The F_1 hybrid performance was evaluated on the basis of estimate of heterosis (Mutzinger, *et al.,* 1952), heterobeltiosis (Fonesca and Patterson, 1968) and standard Heterosis.

RESULTS AND DISCUSSION

The analysis of variance for combining ability revealed that sufficient variability existed in the material for all the traits studied under the AWD experimental conditions. The variance due to lines was significant for days to 50 percent flowering, tiller number plant^{-1}, productive tillers plant^{-1} and 1000 seed weight indicating their contributions to combining ability (Table-1). The variance due to test cross was significant for days to 50 percent flowering plant height, panicle length and 1000 seed weight. L X T component of variances were significant for most of the traits indicating that lines interacted sufficiently with testers. The estimates of variance due to GCA and SCA indicated the predominance of SCA variance for most of the traits studied. Sanjeev Kumar *et al.,* (2007), Sarma *et al.,* (2007), also reported that non- additive gene effect were more predominant than additive gene effects especially for yield and its component characters. The presence of non-additive gene effects was more prominent than additive gene effects especially for yield and its component characteristics. The presence of non- additive genetic variance in this study offer scope for exploitation of heterosis for these characters.

The selection of parents with good general combining ability effects is a prerequisite for a successful hybrid breeding program. Of the CMS lines evaluated IR 58025A was a good general combiner for grain yield per plant, earliness and dwarf plant height, while IR 79156A was good general combiner for 1000 seed weight and short plant height (Table-2). Among the testers 1096, TG-60 were good general combiners for grain yield per plant. The tester TG 60 was also a good combiner for traits like earliness, dwarf status and 1000 seed weight.

The specific combining ability (SCA) effect is an average performance of a cross expressed as deviation from the population mean and is correlated with parental GCA effects. The high SCA effects may be associated with high hybrid vigor. The hybrid APMS6A X TG 21 recorded the highest significant SCA effects for grain yield per plant, % SPF and 1000 seed weight besides short plant height (Table 3). The other hybrids identified as specific general combiners such as IR79156A x 1005, IR 79156A x EPLT 109, IR58025A x SG 27-77, IR 58025A x VG 149, IR 79156A x TG-159 for grain yield per plant could be utilized for heterosis breeding to exploit hybrid vigor. High magnitude of SCA effects in these hybrids resulted from the combination of high x low (IR 58025A with SG27-77 and VG -149), low x high (IR 79156A with 1005 and APMS6A with TG 21) and low x low (IR79156A with 1005) GCA effects of parents. Similarly, Shivani et al., (2009) and Salgotra et al., (2009) also reported about interaction between positive and negative alleles. In crosses with high x low GCA effects the high positive SCA effects may be due to the dominant x recessive interaction expected to produce desirable segregates in subsequent generations.

Grain yield is a cumulative function of various components and the contributions of these components are through component compensation mechanism (Adams, 1967). A meagre hybrid vigor for a component may result in significant hybrid vigor for yield *per se*. In the present study of evaluation under AWD condition the cross combinations viz., APMS6A X TG 21, IR79156A x 1005, IR58025A x SG 27-77, and IR 58025A x VG 149 were identified to be the best and could be exploited further. In these crosses, heterosis was realized for more than one component viz., early maturity and 1000 seed weight, in addition to grain yield per plant.

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Table 1. Analysis of variance for combining ability for grain yield and component traits in rice

Source of variation	d.f	Days to 50% flowering	Plant height	Tillers plant^{-1}	Productive tillers plant^{-1}	Panicle length	Spikelet fertility %	1000 grain weight	Yield plant^{-1}
Treatments	62	31.02**	301.37**	19.64**	7.84**	14.53**	184.12**	12.31**	48.89**
Parents	17	42.03**	483.05**	8.88	4.11	11.97**	205.26**	16.47**	6.12
Parents vs Crosses	1	118.86**	94.46*	0.2	18.82*	209.68**	763.72**	28.49**	547.38**
Crosses	44	24.78**	235.88**	24.24**	9.03**	11.08**	162.78**	10.33**	54.08**
Line	2	61.68*	144.05	134.63**	85.14**	4.48	259.471	12.61*	80.86
Tester	14	38.01*	570.97**	25.67	5.74	21.62**	210.45	23.50**	76
Line * Tester	28	15.52**	74.89**	15.63**	5.24	6.29	132.03**	3.58**	41.20**
Error	62	2.05	15.471	5.3	3.76	3.84	31.57	0.36	7.47
s^2 gca		2.655	19.002	4.158	2.315	0.512	11.300	0.983	3.942
s^2 sca		6.736	29.708	5.165	0.738	1.225	50.232	1.612	16.867
s^2 gca/s^2 gca		0.394	0.640	0.805	3.136	0.418	0.225	0.610	0.234

Table 2. General combining ability effects of parents for grain yield and component traits in rice

Lines	DFF	PH	TNT	NPT	PL	SPF%	1000 GW	GY
IR 58025A	-1.64**	-0.49**	-0.10**	-0.08**	0.19	3.05	-0.52**	1.89**
APMS 6A	0.99**	2.39*	2.17**	1.72**	0.26	-2.82**	-0.20**	-1.09**
IR 79156A	0.66**	-1.91**	-2.07**	-1.64**	-0.44**	-0.23**	0.73**	-0.80**
SE (lines)	0.26	0.72	0.42	0.35	0.36	1.03	0.11	0.5
Testers								
1096	2.29*	20.36**	0.03	-0.24**	2.92*	10.66	-1.31**	6.33*
1005	3.12**	3.86	-0.13**	-0.08**	-0.24**	-2.29**	-3.22**	-1.76**
EPLT-109	-4.38**	-6.14**	-0.80**	0.59	-0.41**	0.06	-0.48**	2.23
SG-27-77	3.96**	6.19	-1.30**	-0.91**	1.76	-3.25**	-4.96**	-0.13**
TG-21	-3.71**	1.53	-2.13**	-1.24**	0.42	9.74	-0.15**	1.1
TG-45	0.62	-3.81**	-3.47**	-1.58**	-3.41**	0.97	0.51**	0.71
TG-60	-0.04**	-4.97**	-1.47**	-0.74**	-1.41**	4.94	1.12**	5.26*
TG-159	0.79	-5.47**	-1.30**	-0.24**	-3.08**	5.52	-0.21**	3.5
TG-179	-1.04**	-2.97**	0.53	1.09	0.09	4.85	0.34*	2.44
VG-93	2.12*	-6.97**	-1.47**	-0.41**	-0.08**	-8.35**	1.14**	-3.76**
VG-149	-1.38**	-8.81**	1.70	1.09	0.76	-2.87**	0.17	0.13
VG-156	-2.21**	-11.81**	1.70	0.26	-0.74**	-4.98**	2.47**	-2.64**
VG-177	-2.54**	8.53	3.87*	1.59	1.42	-7.44**	2.54**	-3.86**
VG-369	0.12	-8.06**	0.53	-0.58**	-1.24**	-3.21**	1.39**	-4.87**
612-1	2.29*	18.53*	3.70*	1.42	3.26*	-4.36**	0.66**	-4.68**
SE(testers)	0.58	1.61	0.94	0.79	0.80	2.29	0.24	1.12

DFF: Days to 505 flowering; PH: Plant height, NTL: number of tillers per plant; NPT: Number of productive tillers per plant;

PL: Panicle length; SPF: Spikelet fertility percent; 1000GW: 1000 grain weight; GY: Grain yield

Table 3. Specific combining ability effects of hybrids and associated traits in rice.

Crosses	DFF	PH	NTL	NPT	PL	SPF	1000 GW	GY
IR 58025A x 1096	-0.02	0.66	5.10**	2.41	1.14	-6.12	0.00	1.89
IR 58025A x 1005	0.64	-10.84**	-3.23	-2.26	-1.19	2.59	-1.76**	-5.48**
IR 58025A x EPLT-109	1.14	-1.84	1.43	0.58	-1.02	-2.71	1.75**	1.04
IR 58025A x SG-27-77	0.81	10.82**	-0.07	-0.92	0.81	13.52**	0.31	5.97**
IR 58025A x TG-21	2.48*	-1.01	1.27	0.91	-0.36	-13.34**	-0.99*	-7.71**
IR 58025A x TG-45	-1.36	-0.68	-0.4	0.24	0.48	0.95	-1.55**	0.70
IR 58025A x TG-60	-3.69**	-4.51	1.1	-0.09	-0.52	0.56	1.93**	-0.24
IR 58025A x TG-159	-2.02	0.99	0.43	-0.59	-0.36	0.06	0.13	0.24
IR 58025A x TG-179	-3.69**	1.49	0.6	0.08	0.48	8.32*	1.50**	1.68
IR 58025A x VG-93	-1.36	-0.51	0.1	-0.42	-0.36	0.31	0.23	-2.59
IR 58025A x VG-149	-0.86	10.82**	-1.07	0.08	0.81	5.76	-1.65**	5.14*
IR 58025A x VG-156	-1.02	4.82	-0.57	0.41	1.81	2.41	-0.14	1.84
IR 58025A x VG-177	3.81**	-3.01	2.77	1.58	1.14	-0.52	0.02	0.42
IR 58025A x VG-369	4.64**	-5.18	-4.40**	-1.76	-2.69	0.55	1.19**	-1.22
IR 58025A x 612-1	0.48	-2.01	-3.07	-0.26	-0.19	-12.33**	-0.98*	-1.69
APMS 6A x 1096	-0.16	-2.23	-4.67**	-1.89	0.58	6.56	1.23**	-1.31
APMS 6A x 1005	-0.99	7.27	0.5	0.94	0.74	-7.90	0.69	-1.72
APMS 6A x EPLT-109	-2.49*	-1.73	-3.83*	-2.72	-0.59	-8.90*	-1.37**	-6.01**
APMS 6A x SG-27-77	-0.32	-11.56**	1.67	1.28	-3.26*	-5.69	-0.47	-1.51
APMS 6A x TG-21	-2.66*	4.11	-0.5	0.11	0.08	12.81**	1.19**	9.85**
APMS 6A x TG-45	6.01**	-4.06	-3.17	-3.06*	-2.09	-9.15*	0.57	-3.12
APMS 6A x TG-60	1.18	5.11	-0.67	0.11	0.91	1.61	-2.16**	3.66
APMS 6A x TG-159	1.34	-1.89	-1.33	0.11	-1.42	-1.76	-1.01*	-5.16*
APMS 6A x TG-179	1.68	3.61	1.33	0.78	-0.09	6.01	-1.80**	3.41
APMS 6A x VG-93	-0.99	2.11	0.83	0.78	3.07*	-0.23	0.85	3.36
APMS 6A x VG-149	-0.49	-10.06**	1.67	1.28	-0.26	-1.76	0.73	-1.99
APMS 6A x VG-156	1.34	-2.06	3.17	1.61	1.24	-4.17	1.21**	-1.5
APMS 6A x VG-177	-0.32	8.60**	-2.00	-0.72	-0.42	3.65	0.62	0.43
APMS 6A x VG-369	-0.99	1.19	3.83*	0.94	1.74	-0.63	-1.34**	0.61
APMS 6A x 612-1	-2.15*	1.61	3.17	0.44	-0.26	9.55*	1.079*	0.99
IR 79156A x 1096	0.18	1.57	-0.43	-0.52	-1.72	-0.44	-1.23**	-0.58
IR 79156A x 1005	0.34	3.57	2.73	1.31	0.44	5.31	1.071*	7.20**
IR 79156A x EPLT-109	1.34	3.57	2.40	2.14	1.61	11.60**	-0.38	4.97*
IR 79156A x SG-27-77	-0.49	0.74	-1.60	-0.36	2.44	-7.84	0.15	-4.46*
IR 79156A x TG-21	0.18	-3.09	-0.77	-1.02	0.28	0.53	0.21	-2.14
IR 79156A x TG-45	-4.65**	4.74	3.56*	2.81*	1.61	8.21*	0.98*	2.42
IR 79156A x TG-60	2.51*	-0.59	-0.43	-0.02	-0.39	-2.17	0.23	-3.42
IR 79156A x TG-159	0.68	0.91	0.90	0.48	1.78	1.70	0.88*	4.92*
IR 79156A x TG-179	2.01	-5.09	-1.93	-0.86	-0.39	-14.33**	0.3	-5.08*
IR 79156A x VG-93	2.34*	-1.59	-0.93	-0.36	-2.72	-0.08	-1.07*	-0.77
IR 79156A x VG-149	1.34	-0.76	-0.60	-1.36	-0.56	-3.99	0.93*	-3.16
IR 79156A x VG-156	-0.32	-2.76	-2.60	-2.02	-3.05*	1.76	-1.06*	-0.35
IR 79156A x VG-177	-3.48**	-5.59	-0.77	-0.86	-0.72	-3.13	-0.64	-0.85
IR 79156A x VG-369	-3.65**	3.99	0.57	0.81	0.94	0.08	0.16	0.61
IR 79156A x 612-1	1.68	0.41	-0.10	-0.19	0.44	2.77	-0.10	0.70
SE(Crosses)	1.01	2.78	1.63	1.37	1.39	3.97	0.42	1.93

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