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COMBINING ABILITY ANALYSIS FOR YIELD AND YIELD TRAITS USING 'WA' CYTOPLASM IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

Combining ability analysis for yield and yield traits was carried out in rice (*Oryza sativa* L.) through line × tester analysis during the wet season of 2011 involving three Cytoplasmic Male Sterile (CMS) lines used as lines, 10 male genotypes as testers and their 30 F_1 hybrids (generated in *Kharif* 2010) along with two checks (BPT5204 and PHB71). All the materials were grown in *Kharif* 2011 in a randomized block design with three replications under recommended cultural practices and were evaluated for yield and yield traits. Only 15 F_1 hybrids (full fertile common hybrids) were taken for analysis of combining ability. The analysis of variance for combining ability revealed that the variation among lines were only for grain weight / panicle; whereas, contribution of testers towards combining ability was significant in respects of majority of the traits. Among the female parental lines, IR68897B was found to be good general combiner for number of spikelets per panicle. Among the male parental lines, BPT 5204 was found to be the best parental line based on *per se* performance and gca effects for most of the traits. The present finding revealed that cross combinations IR58025 × GR-32, IR58025A × MTU-7029 and Pusa6A × Type-3 exhibited high sca effects for grain yield/plant. None of the cross combinations showed high sca effect for all the characters.

INTRODUCTION

The success of any plant breeding method depends on the choice of appropriate genotypes as parents in the hybridization programme. The combining ability studies of the genotypes provide information which helps in the selection of better parents for effective breeding. Its role is important to decide parents, crosses and appropriate breeding procedure to be followed to select desirable segregants (Salgotra *et al.*, 2009). Good general combining parent result in higher frequency of heterotic hybrids than poor combining parent. From the genetic point of view, general combining ability measures additive gene effects and specific combining ability measures non-additive gene effects, depending on genes with dominance (intra-allelic interactions) and epistasis (inter-allelic interactions). In a hybrid breeding programme, plant breeder generally identify parental lines with good general combining ability, and crosses with high specific combining ability effect. Several workers like, Ramalingam *et. al*. (1997), Ganeshan *et. al*. (1997) and Pradhan *et. al*. (2006) have reported combining ability and gene action on several traits including yield. These studies on several genotypes and on their combinations have not been done earlier in the present environment. Therefore, the present investigation was carried out to estimate combining ability effects for yield and its components involving CMS lines and restorer lines in rice in the present environment.

MATERIAL AND METHODS

The present study was conducted at the Agricultural farm, Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the wet season of 2010 and 2011. The biological material in the study comprised of three CMS lines (IR58025A, IR68897A and Pusa 6A) being properly maintained at the centre through hand pollination were used as lines, ten promising genotypes (BPT-5204, GR-32, CR2496, MTU-7029, Type-3, HUR 105, Kalanamak, HUR-3022, Anjali and Sonachoor) as testers and their 30 F_1 hybrids. Thirty F_1 hybrids generated in *Kharif* season of 2010 by "line x tester" mating design. Out of 30 hybrids, only 15 F_1 hybrids (full fertile common hybrids) were taken for analysis of combining ability. All the materials were grown During *Kharif* Season, 2011 along with 2 checks (BPT5204 and PHB-71) in single row of 5 meter length in a Randomized Block Design with three replications and spacing of 20cm x 15 cm.

Data was recorded for the characters *viz.*, days to 50 % flowering, days to maturity, plant height (cm), tillers / plant, effective tillers / plant, panicle length (cm), spikelets / panicle, sterile spikelets / panicle, grains / panicle, grain weight / panicle (g), grain yield / plant, 1000 grain weight (g), pollen fertility (%), spikelet fertility (%), kernel length (mm), kernel breadth (mm) and kernel L / B ratio. The combining ability analysis was performed following the method Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance for combining ability (Table 1) revealed that the mean squares for grain yield due to females (lines) were significant only for grain weight per panicle. The variance due to hybrids differed significantly for all the characters. The mean squares due to males (testers) were found significant for most of the traits including grain yield per plant. Combining

Table 1: Analysis of variance (mean squares) for combining ability for seventeen characters in rice

	d.f.	Days to 50% Flowering	Days to Maturity	Plant Height	Tillers/ Plant	Effective Tillers/ Plant	Panicle Length	Spikelets/ Panicle	Sterile Spikelets/ Panicle	Grains/ Panicle
Replicates	2.00	0.95	2.63	4.37	0.79	0.02	3.97*	326.22	5.76	242.60*
Crosses	14.00	243.54***	243.40***	1340.74***	32.05***	34.67***	34.37***	18736.03***	869.25***	11787.64***
Line Effect	2.00	38.02	99.99	316.33	9.78	8.27	10.62	2156.16	449.62	724.76
Tester Effect	4.00	628.97*	612.86*	3990.17***	86.54**	94.32**	55.96	55952.29**	2497.91***	34849.61**
Line * Tester Eff.	8.00	102.20***	94.52***	272.12***	10.37***	11.45***	29.51***	4272.87***	159.83***	3022.37***
Error	28.00	2.43	2.39	10.58	0.44	0.47	1.10	117.45	26.80	61.08
Total	44.00	79.08	79.09	433.53	10.51	11.33	11.81	6051.03	293.89	3800.51

Table 1: Cont.....

	d.f.	Grain Weight/ Panicle	Grain Yield/ Plant	1000 Grain Weight	Pollen Fertility %	Spikelet Fertility %	Kernel Length	Kernel Breadth	Kernel L/B Ratio
Replicates	2.00	0.02	6.42	1.19	1.14	0.38	0.07	0.00	0.02
Crosses	14.00	2.34***	425.40***	11.26***	8.27**	9.70***	2.90**	0.07***	0.65***
Line Effect	2.00	3.84*	112.97	1.97	13.92	19.86	1.18	0.04	0.83
Tester Effect	4.00	4.62*	1086.85*	21.31	5.94	7.87	5.66	0.17**	0.89
Line * Tester Eff.	8.00	0.83***	172.78***	8.56***	8.03*	8.08**	1.95***	0.02***	0.48***
Error	28.00	0.02	3.64	0.43	2.93	2.05	0.03	0.00	0.02
Total	44.00	0.76	137.96	3.91	4.55	4.41	0.95	0.02	0.22

* Significant at 5% level, ** significant at 1% level and *** significant at 0.1% level

Table 2: Estimates of general combining ability (gca) effects of parents (males and females) for different characters in rice

Parents	Days to 50% Flowering	Days to Maturity	Plant Height	Tillers/ Plant	Effective Tillers/ Plant	Panicle Length	Spikelets/ Panicle	Sterile Spikelets/ Panicle	Grains/ Panicle
Pusa 6 B	1.09**	1.53***	-4.41***	0.89***	0.82***	0.97**	-13.54***	-5.54***	-8.02**
IR 58025 B	-1.83***	-2.98***	-0.34	-0.69***	-0.62**	-0.48	4.28	0.14	4.15
IR 68897 B	0.73	1.45***	4.75***	-0.19	-0.21	-0.49	9.26**	5.41***	3.88
S.E	.36	.35	.80	.17	.20	.26	2.72	1.22	2.28
BPT 5204	5.94***	7.75***	-19.27***	-2.01***	-1.67***	-1.49***	85.48***	17.64***	67.86***
GR-32	4.94***	6.84***	15.35***	3.28***	3.60***	3.62***	23.53***	5.69**	17.87***
CR2496	-13.78***	-12.11***	4.74***	2.26***	2.45***	-0.54	56.18***	11.88***	44.32***
MTU-7029	5.03***	1.57**	-24.33***	-4.25***	-4.49***	-2.79***	-92.72	-19.26***	-73.48***
Type-3	-2.14***	-4.05***	23.50***	0.72	0.11	1.20**	-72.48***	-15.96***	-56.58***
S.E	.47	.45	1.04	.22	.26	.34	3.51	1.57	2.94

Table 2: Cont.....

Parents	Grain Weight/ Panicle	Grain Yield/ Plant	1000 Grain Weight	Pollen Fertility (%)	Spikelet Fertility (%)	Kernel Length	Kernel Breadth	Kernel L/B Ratio
Pusa 6 B	-0.57***	-1.10	0.32	0.63	1.07*	0.31***	-0.04*	0.27***
IR 58025 B	0.18**	-2.03**	0.08	0.48	0.15	-0.07	0.06**	-0.17***
IR 68897 B	0.39***	3.12***	-0.40*	-1.11*	-1.22**	-0.24***	-0.02	-0.09*
S.E	.052	.56	.19	.42	.38	.039	.016	.038
BPT 5204	0.48***	3.44***	-0.80**	-1.05	-0.69	-0.10*	-0.14***	0.32***
GR-32	0.19**	1.89*	-1.12***	-0.26	-0.64	-0.34***	-0.01	-0.18***
CR2496	0.78***	15.00***	0.20	-0.24	-0.71	-1.03***	-0.08***	-0.45***
MTU-7029	-0.97***	-14.41***	-0.88**	1.09	0.96	0.39***	0.01	0.21***
Type-3	-0.49***	-5.92***	2.60***	0.46	1.09*	1.08***	0.22***	0.10
S.E	.067	.72	.24	1.11	.50	.0.051	.020	.049

Table 3: Estimates of specific combining ability (sca) effects of 15 hybrids for different characters in rice

Characters Cross	Days to 50% Flowering	Days to Maturity	Plant Height	Tillers/ Plant	Effective Tillers/ Plant	Panicle Length Spikelets/ Panicle	Panicle	Sterile Spikelets/ Panicle	Grains/
Pusa 6 A*BPT 5204	9.83***	9.40***	-11.08***	1.78***	2.08***	3.21***	-58.07***	-10.34***	-47.70***
Pusa 6 A*GR-32	-1.47	-2.01*	9.46***	0.06	0.34	-0.74	-0.42	-0.86	0.46
Pusa 6 A*CR2496	-5.15***	-5.42***	4.34*	-0.26	-0.51	1.60*	51.24***	9.33**	41.94***
Pusa 6 A*MTU-7029	-1.93*	0.60	5.52**	-2.65***	-2.77***	-4.11***	-15.94*	2.25	-18.13**
Pusa 6 A*Type-3	-1.28	-2.58**	-8.24***	1.08*	0.86	0.05	23.19***	-0.38	23.44***
IR 58025 A*BPT 5204	-7.12***	-6.00***	7.85***	-1.24**	-0.92	-2.04**	32.04***	2.42	29.62***
IR 58025 A*GR-32	3.88***	4.77***	-14.26***	1.57***	0.98*	0.82	0.79	0.00	0.79
IR 58025 A*CR2496	-1.66	-0.61	0.98	-0.02	-0.01	-0.55	-26.70***	-2.63	-24.07***
IR 58025 A*MTU-7029	2.33**	-0.92	-1.52	1.76***	2.20***	4.77***	23.915***	4.47	19.36***
IR 58025 A*Type-3	2.57**	2.76**	6.95***	-2.07***	-2.26***	-3.00***	-30.04***	-4.26	-25.70***
IR 68897 A*BPT 5204	-2.71**	-3.40***	3.22	-0.54	-1.16*	-1.17	26.03***	7.93**	18.08**
IR 68897 A*GR-32	-2.41**	-2.76**	4.80*	-1.63***	-1.33**	-0.08	-0.37	0.86	-1.25
IR 68897 A*CR2496	6.81***	6.03***	-5.32**	0.28	0.52	-1.04	-24.54***	-6.70*	-17.87**
IR 68897 A*MTU-7029	-0.40	0.31	-4.00*	0.89*	0.56	-0.65	-7.97	-6.73*	-1.23
IR 68897 A*Type-3	-1.29	-0.17	1.29	0.99*	1.40**	2.95**	6.85	4.64	2.27
CD 95% SCA	1.67	1.61	3.70	0.80	0.93	1.21	12.49	5.59	10.46

Table 3: Cont.....

Characters Cross	Grain Weight/ Panicle	Grain Yield/ Plant	1000 Grain Weight	Pollen Fertility (%)	Spikelet Fertility (%)	Kernel Length	Kernel Breadth	Kernel L/B Ratio
Pusa 6 A*BPT 5204	-0.64***	-1.53	-0.51	-0.37	-0.32	0.07	0.11**	-0.22*
Pusa 6 A*GR-32	-0.10	-8.64***	0.33	0.33	0.23	0.92***	0.02	0.53***
Pusa 6 A*CR2496	-0.04	1.91	0.47	-0.16	-0.18	-0.54***	-0.05	-0.20*
Pusa 6 A*MTU-7029	0.14	-0.31	-1.01*	-2.04*	-2.10*	-0.74***	-0.06	-0.28**
Pusa 6 A*Type-3	0.65***	8.57***	0.72	2.24*	2.37*	0.28**	-0.01	0.17
IR 58025 A*BPT 5204	0.46***	2.09	2.20***	0.50	0.86	0.57***	0.05	0.19*
IR 58025 A*GR-32	-0.25*	4.66***	-1.76***	0.06	0.08	-0.99***	-0.03	-0.53***
IR 58025 A*CR2496	-0.01	-1.13	-0.14	-0.89	-0.63	0.79***	-0.01	0.51***
IR 58025 A*MTU-7029	0.43***	6.88***	1.59***	0.14	-0.05	0.36***	0.03	0.13
IR 58025 A*Type-3	-0.64***	-12.51***	-1.89***	0.19	-0.26	-0.73***	-0.04	-0.29**
IR 68897 A*BPT 5204	0.19	-0.57	-1.68***	-0.13	-0.55	-0.64***	-0.16***	0.04
IR 68897 A*GR-32	0.34**	3.98**	1.43**	-0.39	-0.31	0.06	0.01	0.00
IR 68897 A*CR2496	0.05	-0.78	-0.34	1.05	0.80	-0.25**	0.06	-0.31**
IR 68897 A*MTU-7029	-0.57***	-6.57***	-0.58	1.91	2.16*	0.38***	0.03	0.15
IR 68897 A*Type-3	-0.01	3.94**	1.17*	-2.44*	-2.11*	0.45***	0.06	0.12
CD 95% SCA	0.24	2.58	0.87	1.93	1.78	0.18	0.07	0.18

ability analysis revealed that both gca and sca variances were important for inheritance of various traits studied. It further suggests the importance of additive and non-additive types of gene actions. The sca variances were higher than the gca variances for all the characters. Predominance of non-additive gene action for grain yield and its components was also reported by Satyanarayanan *et. al*. (2000), Singh *et. al*. (2005) Venkatesan *et. al*. (2007) and Saidaiah *et. al*. (2010).

An overall appraisal of gca effects (Table 2) revealed that among female parental lines, IR68897B having 'WA' type of cytoplasm was observed as a good general combiner for grain yield per plant, grain weight per panicle and number of spikelet per panicle, whereas, Pusa6B as good general combiner for plant height, number of tillers / plant number, number of effective tillers / plant, panicle length, number of sterile spikelets / panicle, spikelet fertility %, kernel length, kernel breadth and kernel L/B ratio. The female line IR58025B was good general combiner for days to 50 % flowering (earliness), days to maturity (earliness), grain weight per panicle and kernel breadth. The data fairly showed that none of the parent was good general combiner for all the characters. However, it was noted that top two males (testers), BPT 5204 and CR2496 proved to be the best general combiners for grain yield/plant, number of grains /panicle, grain weight / panicle and number of spikelets / panicle. Whereas Type-3 was best general combiner for days to 50% flowering (earliness) and days to maturity, MTU-7029 for plant height (dwarf stature) , GR-32 for number of tillers / plant and number of effective tillers / plant, and Type-3 for panicle length.

High sca effect results (Table 3) mostly from dominance and interaction effects existed between the parents used in hybridization. In the present study positive significant sca effects for grain yield per plant was exhibited by 5 crosses *viz*., Pusa6A x Type-3, IR58025A x MTU-7029, IR58025 x GR-32, IR68897A x GR-32 and IR68897A x Type 3 indicated the preponderance of non additive gene action involving good x good and good x poor and poor x poor combining parents. Shivani *et. al*. (2009) and Saidaiah *et. al*. (2010) also reported about interaction between positive and positive alleles in crosses involving high x high combiners which can be fixed in subsequent generations, if no repulsion phase linkages are involved. The desirable performance of combinations like high x low may be ascribed to the interaction between dominant alleles from good combiners and recessive alleles from poor combiners (Dubey 1975). Involvement of both poor combiners also produced superior specific combining hybrids has been attributed to over dominance and epistasis interaction which has been suggested by Singh *et. al*. (2005) and Dalvi and Patel (2009). The desirable sca effect of Pusa6A x Type-3 for grain yield / plant was accompanied by desirable sca effects for plant height, grain weight/panicle, pollen fertility % and spikelet fertility %. Desirable sca effect of IR58025A X MTU-7029 for grain yield /plant was found to be related with number of effective tillers / plant, panicle length, grain weight/panicle. Similar pattern of association between sca effects for grain yield / plant with other yield attributing traits were reported by Singh (2002), Kumar *et. al*. (2007) and Thakare *et. al*. (2011).

From the present study it is reflected that parental lines among females, IR68897A and Pusa6A; among males, BPT 5204 and CR2496 and combinations, Pusa6A x Type-3, IR58025A x MTU-7029, IR58025 x GR-32, IR68897A x GR-32 and IR68897A x Type 3 could be exploited in future rice breeding programme by adopting appropriate breeding approach in order to develop high yielding hybrid varieties.

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