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Estimation of Combining Ability for Yield and its Contributing Traits in Rice (*Oryza sativa* L.)

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A B S T R A C T

Combining ability analysis was done for thirteen parents including three cytoplasmic male sterile (CMS) lines and ten testers along with their thirty crosses. IR 58025A (CMS line) was conferred as the great general combiner distinguished for "grain yield per plant" because of its positive GCA impact. Among the ten testers, B.D. Safri, ARC 10550, R1892-486-1-151-1, IC 540584 and CR-3848-2-1-1-2 were distinguished as great combiner for the same trait and other related characteristics. "B.D. Safri" was recognized as great general combiner for the greater part of the yield related attributes. IR 58025A/ CR-3848-2-1-1-2 showed the highest SCA value followed by IR 68888A/ IC 540584 and IR 68888A/ R1892-486-1-151-1 for "grain yield per plant". IR 58025A/ CR-3848-2-1-1-2, IR 68888A/ IC 540584, IR 68888A/ R1892-486-1-151-1 and IR 79156A/ R1892-486-1-151-1 were recognized as promising crosses for pollen fertility per cent and spikelet fertility per cent on the basis of SCA effect.

Introduction

Rice (*Oryza sativa* L.) is being referred to as "Global Grain" in view of the fact that it is of prime importance as staple food (Anonymous, 2012). With a total production of 476 MT and productivity 29.49 qt/ha, rice covered an area of 154 Mha in the world (Anonymous, 2012). Over 95% of global rice is produced solely by Asia with China 194.3 MT and India 106.54 MT, ranking first and second respectively (Anonymous, 2015). According to data published in Indiastat, India has an acreage of 42.95 Mha under rice with production of 111.01 MT in 2017-18 (Anonymous, 2018). In plant breeding programme, it is essential to select parents with desirable characteristics with good general combining ability (GCA) effects for yield and high estimates of specific combining ability (SCA) effects of hybrids. A very powerful tool to estimate combining ability effects is Line x Tester analysis

introduced by Kempthorne (1957). It imparts information on GCA and SCA effects of parents. It also helps in estimation of various types of gene actions governing the inheritance of characters and thereby, helps to select parents and crosses which are more desirable and superior in performance.

Materials and Methods

Using three CMS lines *viz.* IR 58025A, IR 79156A and IR 68888A as female parents and ten testers *viz.* IC 540584, CR-3998-2-IR99784-188-202-1-1, ORJ-1331(IR 13L406), ORJ-1327(IR 13L382), CR-3848-2-1-1-2, R1892-486-1-151-1, ARC-10550, Swarna, Bathras and B.D. Safri as male parents, thirty crosses were produced through L x T mating design at "Research cum Instructional Farm of College of Agriculture, IGKV, Raipur (C.G.) during *Rabi* 2017-18 and *Kharif* 2018.

Three checks namely Indira Sona, Arize 6444 Gold and Mahamaya were also planted. For the development of F_1 hybrids, staggered sowing of the three CMS lines and ten testers was done in a nursery bed during during *Rabi* 2017-18 to synchronise the flowering which is suitable for crossing. The transplantation of twenty one days old seedlings of parents from the nursery to the crossing block was done in five rows of 1m length maintaining a spacing of 20 x 15 cm. To avoid out crossing with the male parents, the transplantation of the three CMS lines was done in separate blocks. Observations were recorded for seven yield parameters "Days to 50% flowering, Plant height (cm), Spikelet fertility percent, Pollen fertility percent, Grain Yield per plant (g), Biological Yield per plant (g) and Harvest index."

Results and Discussion

The results of L x T analysis for assessment of combining ability are discussed under the following sub-heads:

ANOVA for Line x Tester Analysis

Table 2 presenting ANOVA for Line x Tester Analysis shows highly significant was observed among treatments for all the characters under study. The differences were found to be highly significant also for both "parents and hybrids" for all the characters under study.

Combining ability analysis for GCA and SCA effects

Character wise results of combining ability analysis for GCA and SCA effects are briefly described below.

Among the lines, IR 79156A (-1.61) showed negative highly significant effect. Among the testers, both Swarna and Bathras showed -4.30 and CR-3998-2-IR99784-188-202-1-1 (-2.74) showed negative highly significant GCA effects.

The highest negative significant SCA effects has been shown by the cross IR 68888A/ ARC 10550 (-3.56) followed by IR 58025A/ IC 540584 (-2.28), IR 68888A/ ORJ-1331 (IR13L406) (-1.67) being followed by both IR 58025A/ Bathras (-1.50) and IR 79156A/ B.D. Safri (-1.50) in terms of earliness (Days to 50% flowering).

IR 58025A/ CR-3848-2-1-1-2, IR 68888A/ IC 540584, IR 68888A/ R1892-486-1-151-1 and IR 79156A/ R1892-486-1-151-1 were recognized as promising crosses for pollen fertility percent and spikelet fertility percent on the basis of SCA effect and values have been depicted in Table 4.

Among lines, positive significant GCA value for IR 58025A (0.82) and IR 68888A (0.66) for grain yield per plant makes them good general combiners. Similar finding have been

reported by Verma (2010) and Sharma *et al.*, (2015). Among the testers, B.D. Safri (8.38), ARC 10550 (7.25), R1892-486-1-151-1(3.73), IC 540584 (2.06) and CR-3848-2-1-1-2 (0.30) were found to be good combiners for the same trait. The hybrids, IR 58025A/ CR-3848-2-1-1-2 (9.74) showed the highest SCA value followed by IR 68888A/ IC 540584 (9.45) and IR 68888A/ R1892-486-1-151-1(4.83) for "grain yield per plant."

Table.1 Details of genotypes used in investigation

Genotypes	Source
Female Parents	
IR 58025A (WA)	IRRI, Manila, Philippines
IR 79156A (WA)	IRRI, Manila, Philippines
IR 68888A (WA)	IRRI, Manila, Philippines
Male Parents	
IC 540584	Core Collection, CRP on Agro-biodiversity Project, India
CR-3998-2-IR99784-188-202-1-1	NRRI, Cuttack (Odisha), India
ORJ-1331 (IR13L406)	OUAT, Bhubaneshwar (Odisha), India
ORJ-1327 (IR13L382)	OUAT, Bhubaneshwar (Odisha), India
CR-3848-2-1-1-2	NRRI, Cuttack (Odisha), India
R1892-486-1-151-1	IGKV, Raipur (C.G.), India
ARC 10550	Assam Rice Collection, Assam, India
Swarna	ANGRAU, Hyderabad, India
Bathras	IGKV, Raipur (C.G.), India
B.D. Safri	IGKV, Raipur (C.G.), India
Checks	
Indira Sona	IGKV, Raipur (C.G.), India
Arize 6444 Gold	Bayer Crop Science
Mahamaya	IGKV, Raipur (C.G.), India

Table.2 Analysis of Variance for L X T

Source of Variation	df	Mean Squares						
		Days to 50% Flowering	Plant Height (cm)	Spikelet Fertility Percent	Pollen Fertility Percent	Grain Yield per plant (g)	Biological yield per plant (g)	Harvest Index
Replication	2	0.9845	3.3147	1.2422	0.8671	0.0289	0.0601	0.2869
Treatments	42	112.1794**	207.6665**	2277.0282**	5261.8709**	136.725**	189.2382**	1189.3239**
Parents	12	282.3034**	192.667**	2643.4445**	4102.1127**	100.109**	87.2456**	893.2312**
Parents(Lines)	2	70.3333**	202.4533**	34.0564*	0.1121	2.0344	107.5511**	8.9099
Parents(Testers)	9	204.2074**	164.3769**	864.6573**	203.5598**	35.2685**	33.8764**	251.73**
Parents(L v/s T)	1	1409.1077*	427.7051*	23871.3059**	47393.0901**	879.823*	526.9564*	8435.384**
Parents v/s Crosses	1	1.4383	31.4607	17780.7482**	33579.1165**	1049.0538*	59.3311	7510.8957**
Crosses	29	45.6019**	219.9492**	1590.7966**	4765.3141**	120.4168**	235.9217**	1093.8597**
Line Effect	2	105.2778**	80.1113*	696.9205**	1196.4484**	49.5671*	247.084**	129.2277**
Tester Effect	9	101.9025**	620.6456**	3631.6922**	11532.0937**	237.3095**	200.2297**	2421.3939**
Line * Tester Effect	18	10.821**	35.1386**	669.6683**	1778.4649**	69.8427**	252.5273**	537.274**
Error	84	0.7702	2.4481	0.5869	1.104	0.1215	0.4123	1.5498
Total	128							
***Significant at p=0.05% level, **Significant at p=0.01% level**								

Table.3 General combining ability effects of parents for different characters

	Days to 50%	**Plant**	**Spikelet**	**Pollen**	**Grain**	**Biological**	**Harvest**
Characters	Flowering	Height	Fertility	Fertility	yield per	yield per	Index
		(cm)	Percent	Percent	plant (g)	plant (g)	
Parents							
Lines/ Females							
IR 58025A	2.06**	1.84 **	5.47 **	-4.84 **	0.82 **	2.47 **	0.57 **
IR 79156A	-1.61**	-0.56	-1.84 **	-2.30 **	-1.48 **	-3.15 **	-2.30 **
IR 68888A	-0.44**	-1.28 **	-3.63 **	7.14 **	0.66 **	0.67 **	1.73 **
SE (Lines)	0.147	0.3151	0.1126	0.1909	0.0643	0.0954	0.2101
Testers/ Males							
IC 540584	-1.86**	-11.30 **	12.78 **	2.66 **	2.06 **	-4.91 **	6.98 **
CR-3998-2-IR99784-188-202-1-1	-2.74**	-9.50 **	-19.07 **	-28.56 **	-4.21 **	-1.43 **	-12.58 **
ORJ-1331 (IR13L406)	2.03**	3.11 **	-11.12 **	-28.31 **	-4.07 **	4.91 **	-13.53 **
ORJ-1327 (IR13L382)	3.92**	7.98 **	-23.41 **	-28.74 **	-4.97 **	8.83 **	-16.11 **
CR-3848-2-1-1-2	4.37**	0.10	-8.83 **	-13.59 **	0.30 **	4.24 **	-3.11 **
R1892-486-1-151-1	-1.41**	4.75 **	18.77 **	25.06 **	3.73 **	-4.41 **	15.30 **
ARC 10550	3.59**	13.25 **	24.12 **	60.62 **	7.25 **	-0.69 **	20.86 **
Swarna	-4.30**	-4.08 **	-13.92 **	-22.30 **	-3.42 **	1.43 **	-10.25 **
Bathras	-4.30**	-9.42 **	-12.19 **	-25.54 **	-5.04 **	-4.28 **	-15.12 **
B.D. Safri	0.70*	5.10 **	32.85 **	58.69 **	8.38 **	-3.69 **	27.56 **
SE (Testers)	0.2683	0.5753	0.2055	0.3485	0.1173	0.1742	0.3836
***Significant at p=0.05% level, **Significant at p=0.01% level**							

Table.4 Specific combining ability effects of hybrids for different characters

Characters	Days to 50% flowering	Plant height (cm)	Spikelet fertility percent	Pollen fertility percent	Grain yield per plant (g)	Biological yield per plant (g)	Harvest Index
IR 58025A/ IC 540584	-2.28 **	-5.02 **	-20.09 **	-26.52 **	-5.45 **	3.82 **	-16.50 **
IR 58025A/ CR-3998-2-IR99784-188-202-1-1	-0.39	4.62 **	7.45 **	4.92 **	0.71 **	16.40 **	-0.22
IR 58025A/ ORJ-1331 (IR13L406)	2.83 **	3.18 **	10.36 **	4.70 **	0.37 *	2.83 **	1.38 *
IR 58025A/ ORJ-1327 (IR13L382)	-1.06 *	-0.54	0.29	4.97 **	-0.21	-2.06 **	0.8
IR 58025A/ CR-3848-2-1-1-2	-0.5	2.16 *	30.97 **	35.23 **	9.74 **	-0.14	24.56 **
IR 58025A/ R1892-486-1-151-1	0.61	3.82 **	-25.78 **	-48.61 **	-7.19 **	1.55 **	-24.51 **
IR 58025A/ ARC 10550	0.94 *	-2.20 *	-14.69 **	4.90 **	-2.73 **	-10.64 **	3.71 **
IR 58025A/ Swarna	-0.83	-2.46 *	9.68 **	17.26 **	2.41 **	-9.06 **	10.88 **
IR 58025A/ Bathras	-1.50 **	-1.94	-1.98 **	1.82 **	-1.00 **	-8.52 **	-0.33
IR 58025A/ B.D. Safri	2.17 **	-1.61	3.80 **	1.34 *	3.36 **	5.83 **	0.22
IR 79156A/ IC 540584	0.72	-0.44	6.49 **	-26.37 **	-4.00 **	-7.30 **	-9.42 **
IR 79156A/ CR-3998-2-IR99784-188-202-1-1	-1.39 **	-0.61	-1.48 **	2.38 **	1.29 **	-12.58 **	6.10 **
IR 79156A/ ORJ-1331 (IR13L406)	-1.17 *	-1.6	-5.83 **	2.27 **	1.28 **	-5.52 **	3.10 **
IR 79156A/ ORJ-1327 (IR13L382)	0.61	0.79	-1.90 **	2.22 **	1.44 **	14.92 **	1.62 **
IR 79156A/ CR-3848-2-1-1-2	0.83	-0.05	-12.97 **	-12.92 **	-3.75 **	-0.52	-9.93 **
IR 79156A/ R1892-486-1-151-1	-0.06	-2.17 *	10.21 **	24.60 **	2.36 **	-4.90 **	15.99 **
IR 79156A/ ARC 10550	2.61 **	4.38 **	7.20 **	6.69 **	0.87 **	8.45 **	-5.12 **
IR 79156A/ Swarna	-0.17	2.24 *	-1.07 **	-4.12 **	-0.16	5.59 **	-3.43 **
IR 79156A/ Bathras	-0.5	-0.37	7.09 **	-0.62	1.26 **	1.27 **	1.81 **
IR 79156A/ B.D. Safri	-1.50 **	-2.16 *	-7.73 **	5.86 *	-0.59 **	0.58	-0.71
IR 68888A/ IC 540584	1.56 **	5.46 **	13.60 **	52.89 **	9.45 **	3.48 **	25.92 **
IR 68888A/ CR-3998-2-IR99784-188-202-1-1	1.78 **	-4.01 **	-5.97 **	-7.30 **	-2.00 **	-3.83 **	-5.88 **
IR 68888A/ ORJ-1331 (IR13L406)	-1.67 **	-1.58	-4.53 **	-6.97 **	-1.65 **	2.69 **	-4.48 **
IR 68888A/ ORJ-1327 (IR13L382)	0.44	-0.25	1.61 **	-7.19 **	-1.23 **	-12.86 **	-2.42 **
IR 68888A/ CR-3848-2-1-1-2	-0.33	-2.11 *	-18.00 **	-22.31 **	-5.98 **	0.66 *	-14.63 **
IR 68888A/ R1892-486-1-151-1	-0.56	-1.65	15.58 **	24.01 **	4.83 **	3.35 **	8.52 **
IR 68888A/ ARC 10550	-3.56 **	-2.18 *	7.49 **	-11.59 **	1.87 **	2.19 **	1.41 *
IR 68888A/ Swarna	1.00 *	0.23	-8.60 **	-13.13 **	-2.25 **	3.47 **	-7.44 **
IR 68888A/ Bathras	2.00 **	2.31 *	-5.11 **	-1.21 *	-0.26	7.25 **	-1.48 *
IR 68888A/ B.D. Safri	-0.67	3.77 *	3.93 **	-7.20 *	-2.77 **	-6.41 **	0.49
SE	0.4647	0.9964	0.3559	0.6036	0.2032	0.3017	0.6644

***Significant at p=0.05% level, **Significant at p=0.01% level**

In conclusions, IR 58025A (CMS line) was identified as good general combiner for "Days to 50% flowering, spikelet fertility percent and grain yield per plant (g)" and may be utilized in hybrid rice seed production as parent. Among the testers, B.D. Safri, ARC 10550, R1892-486-1-151-1, IC 540584 and CR-3848-2-1-1-2 were spotted as good combiners for grain yield per plant and other related traits. Some hybrids *viz.* IR 58025A/ B.D. Safri, IR 68888A/ IC 540584, IR 58025A/ CR-3848-2-1-1-2, IR 68888A/ ARC 10550 and IR 68888A/ R1892-486-1-151-1 were conferred as promising hybrids based on SCA effects and GCA effects (of their corresponding parents) for grain yield per plant.

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