

Combining ability and gene action studies for yield and yield attributing traits in rice (*Oryza sativa* L.)

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Abstract

The aim of the present study was to determine the best combining parents, hybrids and nature of gene action in relation to yield and its component traits in rice using 3 lines (Samleshwari, Indira Aerobic Dhan-1 and Chandrahasini) and 3 testers (R 2341-325-2-165-1, R 2406-673-2-397-1 and R 1641-914-1-400-1). The parents were mated in the Line × Tester design. The resultant 9 F1s were evaluated along with their parents and check varieties (IGKV R1 and IGKV R2) for eleven characters. The lines Samleshwari, Chandrahasini and testers R2406-673-2-397-1, R2341-325-2-165-1 were reported as good general combiners for yield and majority of the yield attributing traits. There is predominance of non additive gene action was seen for most of the traits. Chandrahasini/ R1641-914-1-400-1, Indira Aerobic Dhan-1 / R2406-673-2-397-1, Samleshwari / R2341-325-2-165-1 and Indira Aerobic Dhan-1/ R2341-325-2-165-1 were identified as the best specific combiners for majority of the traits including seed yield per plant.

Keywords: GCA, SCA, gene action, yield and yield attributing traits and rice

Introduction

Rice (*Oryza sativa* L. $2n = 24$), is a major dietary staple food for half of the world's population along with wheat and corn. Rice is grown on 162 million hectares worldwide, yielding 496.40 million tonnes (USDA, 2019-20). Rice is presently farmed in over 100 countries on every continent except Antarctica. India is the world's second-biggest rice producer and the world's largest rice exporter. India is the leading exporter of milled rice, accounting for 13 million tonnes out of 44 million tonnes sold in 2019-20, accounting for 30% of global exports. Rice demand is increasing drastically as the world's population grows, making it a difficult challenge to ensure food and nutritional security for the country and the world. By 2050, the world's rice demand will be 943.6 million tonnes, requiring a 5.8 million tonne increase in annual production from current levels (FAO, 2017). As a result, it was considered that increasing rice output through novel genetic approaches such as hybrid rice was necessary.

Combining ability analysis is a useful approach for measuring a parent's worth in order to develop superior hybrids. The investigations of the parents' combining abilities provide information that aids in the

selection of better parents for productive breeding. Its role is critical in determining parents, crossings, and the proper breeding strategy to use in selecting desired segregates (Salgotra *et al.*, 2009). To discover the possibly effective combination of parental lines for the generation of desired rice hybrids, one must have a thorough understanding of the nature of additive and non-additive gene action that governs rice yield and its components. These are reported to be associated with breeding value. The magnitude of gene action elaborates the inheritance pattern of any trait. Kempthorne's line x tester analysis, introduced in 1957, is one of the most potent techniques for estimating combining ability effects and assisting in the selection of ideal parents and crossings for pedigree breeding. It could provide fascinating information about gene action, which could be useful in determining the sort of gene action involved in the production of a trait in specific situations. Keeping this in view, the present investigation was formulated to study the combining ability and gene action for yield and important yield attributes in rice.

Materials and Methods

The present research was carried out at the

Research and Instructional Farm, Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, C.G. during the *kharif* 2021. Randomized Complete Block Design (RCBD) with three replications were used to the experimental material, which consisted of 6 parents (three lines and three testers), their 9 hybrids, and two standard checks, IGKV R1 and IGKV R2 (Table 1). Recommended agronomic practices were followed to raise a good crop. Observations were recorded by choosing five plants at random from each line P1, P2, and F1 and tagged. For statistical analysis, the average value of five plants was used. Plants were chosen from the centre of each line to reduce inaccuracy due to border effect. The observation recorded were days to 50% flowering, plant height, number of effective tillers per plant, panicle length, number of filled grains per panicle, number of unfilled grains per panicle, spikelet fertility (%), seed yield per plant, 100 seed weight, biological yield per plant and harvest index. Each replication's character means were submitted to an analysis of variance and estimation of both the combining ability *viz.*, general combining ability and specific combining ability.

Table 1: Genotypes used in the study during *kharif* 2021

Genotype	Parentage
Female parents/ Lines	
Samleshwari	R1027-2282-2-1 x R308-6
Indira Aerobic Dhan-1	Swarna x IR 42213
Chandrasahani	Abhaya x Phalguna
Male parents/ Testers	
R 2341-325-2-165-1	Karma Masurix Gunci Jiyang-1
R 2406-673-2-397-1	Swarna sub 1 x Gopal bhog
R 1641-914-1-400-1	MTU1001 x Swarna Checks
IGKV 1	R 320-300 x Chaptigurmatiya
IGKV 2	Mahamaya x MTC-4

Results and Discussion

Analysis of variance

Analysis of variance for line x tester revealed that the variance due to parents were recorded highly significant for all the traits. The variance due to hybrids was also found significant for most of the characters except 100 seed weight. The variance due to parent vs. hybrid was also found highly significant for all of the characters except plant height, number of effective tillers per plant, panicle length, number of unfilled grains per panicle, spikelet fertility and 100 seed weight. The

variance due to lines and was found significant for all of the traits under study. The variance due to testers was found highly significant for all characters except plant height. The variance due to line x tester is also significant for most of the characters except panicle length and 100 seed weight.

Combining ability analysis for GCA and SCA effects

The effect of general combining ability (GCA) identifies superior parents, while specific combining ability (SCA) aids in identification of good hybrid combinations. Regarding GCA and SCA effects, the negative effects for days to 50 % flowering, plant height and number of unfilled grains are considered as desirable, whereas positive effects are desirable for other traits.

General combining ability effects

The GCA effect revealed that for the traits like days to 50% flowering, number of effective tillers per plant and number of filled grains per panicle the line Samleshwari were identified as the best general combiner while the line Chandrasahani showed high GCA values for the traits like plant height, number of unfilled grains per panicle and 100 seed weight and noted as the best general combiner for this traits. For the characters like spikelet fertility, biological yield, seed yield and harvest index the lines Samleshwari and Chandrasahani together showed high significant GCA effects and identified as the best general combiners (Table 3). The line Indira aerobic dhan-1 is identified as the best general combiner for panicle length.

Among the testers R2406-673-2-397-1 were found to be the best general combiner for the traits like number of filled grains per panicle, number of unfilled grains per panicle, spikelet fertility, seed yield, 100 seed weight and harvest index. The tester R2341-325-2-165-1 were found to be the best general combiner for the traits plant height and panicle length. For the traits like days to 50% flowering and biological yield the testers R2406-673-2-397-1 and R2341-325-2-165-1 together showed high GCA values and noted as the best general combiners. The GCA effects are shown in the table 3.

Specific combining ability effects

The SCA effects revealed that among nine hybrids, Chandrasahani /R1641-914-1-400-1 recorded highest significant positive SCA effect for seed yield per plant followed by Indira Aerobic Dhan-1 / R2406-673-2-397-1, Samleshwari / R2341-325-2-165-1 and Indira Aerobic Dhan-1 / R2341-325-2-165-1 were considered as desirable (Table 4). Two hybrids *viz.*,

Table 2: Analysis of Variance for L X T

Source of Variation	DF	1	2	3	4	5	6	7	8	9	10	11
Replicates	2	0.15	0.271	2.568	1.25	5.809	1.12	1.455	5.603	0.087	0.264	15.547
Treatments	14	112.596**	59.576**	7.314**	4.651**	915.955**	233.629**	36.245**	576.100**	0.193**	273.111**	1168.438**
Parents	5	191.244**	101.844**	14.613**	7.951**	1127.904**	337.615**	40.300**	607.459**	0.410**	451.873**	1165.547**
Parents (Line)	2	57.587**	56.488**	32.334**	2.387*	1693.151**	127.072**	23.852**	962.426**	0.534**	812.026**	815.420**
Parents (Testers)	2	385.299**	0.578	2.973*	1.717*	951.619**	21.327**	20.323**	325.129**	0.407**	93.606**	2084.904**
Parents (L vs T)	1	70.448**	395.086**	2.449	31.548**	349.978**	1391.281**	113.151**	462.181**	0.166	448.102**	27.085
Parents vs Crosses	1	8.192*	0.563	0.002	0.422	290.184**	0.031	0.026	16.482**	0.078	10.534**	223.733**
Crosses	8	76.492**	40.536**	3.666**	3.117**	861.709**	197.838**	38.237**	626.453**	0.072	194.207**	1288.333**
Line Effect	2	66.478	40.686	8.167	5.594	2038.441*	105.305	37.543	615.194	0.023	153.147	1171.419
Tester Effect	2	168.116	76.722	0.229	4.487	946.392	123.61	39.435	966.63	0.041	42.85	2781.764
Line * Tester Eff.	4	35.688**	22.367**	3.135*	1.193	231.002**	281.218**	37.986**	461.993**	0.111	290.415**	600.074**
Error	28	1.54	1.275	0.798	0.468	2.801	1.902	0.716	1.872	0.065	0.93	8.303
Total	44	36.813	19.779	2.952	1.834	293.487	75.598	12.055	184.75	0.107	87.503	377.766

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

1 = Days to 50% flowering, 2 = Plant height (cm), 3 = Number of effective tillers per plant, 4 = Panicle length (cm), 5 = Number of filled grains per panicle,

6 = Number of unfilled grain per panicle, 7 = Spikelet fertility (%), 8 = Seed yield per plant (g), 9 = 100 seed weight (g), 10 = Biological yield per plant (g) 11 = Harvest index (%).

Chandahasini / R2406-673-2-397-1 and Indira Aerobic Dhan-1 / R2341-325-2-165-1 recorded significant with negative SCA effects for days to 50% flowering were considered to be highly desirable for earliness. Two hybrids viz., Indira Aerobic Dhan-1 / R2341-325-2-165-1 and Chandahasini / R2406-673-2-397-1 were identified as the best specific combiners for plant height and can be used in developing dwarf and semi dwarf hybrids as they had showed significant negative values. For number of effective tillers per plant only one hybrid Samleshwari / R2406-673-2-397-1 has reported significant positive SCA effect and identified as the best specific combiner. Three hybrids viz., Indira Aerobic Dhan-1 / R2406-673-2-397-1, Chandahasini / R1641-914-1-400-1 and Samleshwari / R2341-325-2-165-1 were the promising specific combiners for number of filled grains per panicle. The best specific combiners for number of unfilled grains per panicle are Indira Aerobic Dhan-1 / R2341-325-2-165-1, Samleshwari / R2406-673-2-397-1 and Chandahasini/R1641-914-1-400-1. The negative significant values for number of unfilled grains per panicle are very important as it decreases the risk of yield loss due to unfilled grains. Three hybrids viz., Indira Aerobic Dhan-1 / R2341-325-2-165-1, Chandahasini/R1641-914-1-400-1 and Samleshwari / R2406-673-2-397-1 showed significant positive SCA effects for spikelet fertility (%), an important parameter to be considered for hybrids. Two hybrids viz., Chandahasini / R1641-914-1-400-1 and Samleshwari / R2341-325-2-165-1 recorded significant positive SCA effects for 100 seed weight. Four hybrids viz., Chandahasini/R1641-914-1-400-1, Indira Aerobic Dhan-1 / R2341-325-2-165-1, Indira Aerobic Dhan-1 / R2406-673-2-397-1 and Samleshwari / R2341-325-2-165-1 were noted as the best specific combiners for biological yield per plant. Three hybrids viz., Chandahasini X R1641-914-1-400-1, Indira Aerobic Dhan-1 / R2406-673-2-397-1 and Samleshwari/ R2341-325-2-165-1 were identified as the best specific combiners for harvest index. The SCA effects are shown in the table 4.

The promising hybrids based on combining ability for seed yield were showed in table 5. For

Table 3: General Combining Ability effects of parents for yield and yield related traits

Characters	1	2	3	4	5	6	7	8	9	10	11
Lines/females											
Samleshwari	-3.04 **	-0.02	1.07 **	0.39	16.81 **	1.30 *	1.03 **	5.25 **	-0.04	1.33 **	9.02 **
Indira Aerobic Dhan-1	0.84	2.13 **	-0.74 *	0.51 *	-12.20 **	2.57 **	-2.35 **	-9.53 **	-0.01	-4.62 **	-12.82 **
Chandrasahini	2.19 **	-2.11 **	-0.32	-0.90 **	-4.60 **	-3.88 **	1.31 **	4.27 **	0.05*	3.29 **	3.80 **
Testers/Males											
R2341-325-2-165-1	-2.75 **	-3.37 **	0.18	0.57 *	-3.70 **	4.00 **	-1.83 **	-8.16 **	-0.04	1.00 **	-13.90 **
R2406-673-2-397-1	-2.23 **	1.72 **	-0.10	0.21	11.59 **	-3.30 **	2.27 **	11.65 **	0.07*	1.49 **	19.76 **
R1641-914-1-400-1	4.98 **	1.64 **	-0.08	-0.78 **	-7.88 **	-0.70	-0.44	-3.49 **	-0.03	-2.50 **	-5.86 **
CD 95% GCA(Line)	0.87	0.79	0.63	0.48	1.18	0.97	0.59	0.96	0.18	0.68	2.03
CD 95% GCA(Tester)	0.87	0.79	0.63	0.48	1.18	0.97	0.59	0.96	0.18	0.68	2.03

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

1= Days to 50% flowering, 2 = Plant height (cm),3 = Number of effective tillers per plant, 4= Panicle length (cm), 5 = Number of filled grains per panicle, 6= Number of unfilled grain per panicle, 7 = Spikelet fertility (%), 8 = Seed yield per plant (g),9= 100 seed weight (g), 10= Biological yield per plant (g) 11 = Harvest index (%)

days to 50% flowering similar findings were reported by Dhanwani *et al.* (2013) and Singh *et al.* (2020). Similar results of SCA effects for plant height were found by Ambikabathy *et al.* (2019) and Singh *et al.* (2020). For panicle length similar findings were reported by Padmavathi *et al.* (2012). For number of filled grains per panicle similar findings were found by Singh *et al.* (2020) and Dhanwani *et al.* (2013). For seed yield per plant similar findings were reported by Parimala *et al.* (2018), Deepika *et al.* (2019) and Lakra *et al.* (2020) Similar findings for 100 seed weight were found by Ambikabathy *et al.* (2019).

Estimation of gene action

In the present study, the characters viz., days to 50% flowering, plant height, effective tillers per plant, number of unfilled grains per panicle, spikelet fertility, biological yield, seed yield per plant and harvest index exhibited greater SCA variance than GCA variance which indicates the predominance of non-additive gene action in the inheritance of above mentioned traits. Therefore the hybrid breeding programme is more useful for the improvement of this traits. GCA variance is greater than SCA variance of some traits viz., panicle length, number of filled grains and 100 seed weight indicating the predominance of additive gene action in the inheritance of above mentioned traits. Similar reports were found by Singh *et al.* (2020).

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Table 4: Specific combining ability effects of hybrids for yield and yield related traits

Characters	1	2	3	4	5	6	7	8	9	10	11
Hybrids											
Samleshwari /R2341-325-2-165-1	-0.48	0.19	-0.14	0.29	5.14 **	9.51 **	-2.91 **	6.87 **	0.12*	2.84 **	7.52 **
Samleshwari /R2406-673-2-397-1	1.86 *	1.03	1.18 *	-0.38	-6.49 **	-8.77 **	2.53 **	-3.91 **	-0.06	-0.97	-7.25 **
Samleshwari /R1641-914-1-400-1	-1.38	-1.22	-1.03	0.09	1.35	-0.74	0.38	-2.96 **	-0.05	-1.87 **	-0.26
Indira Aerobic Dhan-1 /R2341-325-2-165-1	-2.27 **	-3.03 **	0.45	-0.78	-3.07 **	-10.61 **	3.76 **	2.62 **	0.08	6.53 **	0.26
Indira Aerobic Dhan-1 /R2406-673-2-397-1	2.57 **	0.80	-0.79	0.51	10.59 **	5.09 **	-0.68	8.90 **	0.06	3.18 **	13.73 **
Indira Aerobic Dhan-1 /R1641-914-1-400-1	-0.30	2.22 **	0.34	0.26	-7.52 **	5.52 **	-3.08 **	-11.53 **	-0.15	-9.71 **	-13.99 **
Chandahasini /R2341-325-2-165-1	2.75 **	2.83 **	-0.30	0.49	-2.07 *	1.10	-0.85	-9.50 **	-0.21	-9.38 **	-7.79 **
Chandahasini /R2406-673-2-397-1	-4.43 **	-1.84 *	-0.38	-0.13	-4.10 **	3.68 **	-1.84 **	-4.99 **	0.20	-2.20 **	-6.47 **
Chandahasini /R1641-914-1-400-1	1.68 *	-0.99	0.69	-0.36	6.17 **	-4.78 **	2.70 **	14.49 **	0.21 **	11.59 **	14.26 **
CD95% SCA	1.51	1.38	1.09	0.83	2.04	1.68	1.03	1.67	0.31	1.18	3.52

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

1= Days to 50% flowering, 2 = Plant height (cm), 3 = Number of effective tillers per plant, 4= Panicle length (cm), 5 = Number of filled grains per panicle, 6= Number of unfilled grain per panicle, 7 = Spikelet fertility (%), 8 = Seed yield per plant (g), 9= 100 seed weight (g), 10= Biological yield per plant (g) 11 = Harvest index (%)

Table 5: Promising hybrids on the basis of combining ability for seed yield per plant

Crosses	GCA effects			SCA effects		
	Lines	Testers	Hybrids	Lines	Testers	Hybrids
Chandahasini /						
R1641-914-1-400-1	3.80 **	-5.86 **	14.49 **			
Indira Aerobic Dhan-1/						
R2406-673-2-397-1	-12.82 **	19.76 **	8.90 **			
Samleshwari/						
R2341-325-2-165-1	5.25 **	-8.16 **	6.87 **			

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