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Assessment of Combining ability for Grain Yield and its Related Contributing Traits in Rice (*Oryza sativa* L.)

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ABSTRACT: Assessment of combing ability in rice genotype is important role for increasing grain yield to develop new or improved varieties. In present investigation these parameters have been selected for these genotypes which have not been made earlier. It requires proper study about these characters which fascinated me to study about these parameters in the respected genotypes. This study aimed to determine the effects of combining ability in rice (*Oryza sativa* L.). Ten parental lines and their 45 F_1 progenies were evaluated in Kharif 2020-21 in randomized block design with three replications at CRC of SVPUAT, Meerut using a half-diallel mating design. The analysis of variance for the treatments (parents and hybrids) revealed that all genotypes had highly significant differences for both yield and quality traits indicating sufficient variability among the material studied. The mean sum of squares due to general combining ability were highly significant for all traits under study, indicating that these characters are governed by additive gene action. While the mean sum of squares due to specific combining ability were observed to be highly significant for all the characters, excluding days to maturity, plant height, L/B ratio and kernel length after cooking, which indicates that those traits are expressed by non-additive gene action. The variance of the GCA/SCA ratio was less than unity for days to maturity, panicle length, grains per panicle, 1000 grain weight, biological yield, harvest index, hulling percentage and grain yield per plant revealed preponderance of non-additive gene action, while all the remaining character like days to 50% flowering, plant height, spikelet's per panicle, gel consistency, L/B ratio and kernel length after cooking were more than unity, revealed additive gene action. The significant GCA effects for parents Vallabh Basmati 23, Pant Basmati 2, Pusa Basmati 1718, Pusa Basmati 1637 and Pusa Basmati 1509 were found to be good general combiners for grain yield per plant. The best significant SCA effect crosses *viz*., Vallabh Basmati 23 × Pusa Basmati 1121, Pusa Basmati 1637 × Pusa Basmati 1718, Pusa Basmati 1509 × Vallabh Basmati 24, Pant Basmati 2 × Pusa Basmati 1121, Pusa Basmati 1 × Basmati CSR 30, were found to be good specific combiners for grain yield per plant. In present study outcomes based on combing ability which revealed that the grain yield can be enhanced by improving these traits through heterosis breeding followed by recurrent selection methods.

Keywords: Combining ability, GCA, SCA, and Basmati rice.

INTRODUCTION

Rice is the basic food that contributes approximately 40% to the total food grain production for more than 65% of the Indian population. Thereby, it occupies a pivotal role in the livelihood and food security of people. In India, under varying agro-ecological zones, rice is grown under highly diverse conditions with area expansion from 79° to 90°E longitude and 16° to 28° N latitude. It is cultivated mostly in the muddy season with undeterminable rainfall distribution. It is also grown in areas where the water level reaches 23 m or more (Pathak *et al.* 2020). The study based on combining ability proposed by Sprague and Tatum (1942). Combining ability is two type; general combining ability (GCA) and specific combining ability (SCA). General combining ability results in additive gene effects, whereas specific combining ability results in non-additive gene effects. The general combining ability (GCA) refers to an average performance of parents, whereas specific combining ability (SCA) refers to best specific cross combinations. In present study, the genotypes of parental lines were generally identified with good general combining ability and crosses with high specific combining ability effects in the hybrid breeding programme.

MATERIALS AND METHODS

The present field experiment was conducted at the CRC of SVP University of Agriculture and Technology, Meerut (Uttar Pradesh), India during *kharif* 2019-20 and 2020-21 for attempting of crossing programme in a half diallel (10 Parents) and develop 45 F_1 were laid out in Randomized Block Design with three replications. The parents and the crosses are presented in Table 1. These genotype were sown in a 3 m row with 20 cm row spacing and 10 cm plant spacing. The data were recorded on average of five selective plants taken from each replication for fourteen traits *viz.*, days to 50% flowering, days to maturity, plant height at maturity (cm), panicle length (cm), spikelet's per panicle, grains per panicle, 1000 grain weight, biological yield per plant, harvest-index, gel consistency, hulling percentage, L/B ratio, kernel length after cooking and grain yield per plant. Analysis of variance was done by using the method of Panse and Sukhatme (1967) and combining ability analysis was done using Griffing's method II, model I (1956).

Table 1: A list of parents and F1 hybrids used in present investigation.

Sr. No.	Genotypes	Sr. No.	Name of crosses
1.	Vallabh Basmati - 23	28.	Pusa Basmati - 1509 × Basmati CSR - 30
2.	Pusa Basmati - 1	29.	Pusa Basmati - 1509 × Vallabh Basmati - 24
3.	Pusa Basmati - 1509	30.	Pusa Basmati - 1509 ×Basmati - 386
4.	Basmati CSR - 30	31.	Pusa Basmati - 1509 × Pant Basmati - 2
5.	Vallabh Basmati - 24	32.	Pusa Basmati - 1509 × Pusa Basmati - 1121
6.	Basmati - 386	33.	Pusa Basmati - 1509 × Pusa Basmati - 1637
7.	Pant Basmati - 2	34.	Pusa Basmati - 1509 × Pusa Basmati - 1718
8.	Pusa Basmati - 1121	35.	Basmati CSR - 30 × Vallabh Basmati - 24
9.	Pusa Basmati - 1637	36.	Basmati CSR - 30 × Basmati - 386
10.	Pusa Basmati - 1718	37.	Basmati CSR - 30 × Pant Basmati - 2
	F1 Hybrids	38.	Basmati CSR - 30 ×Pusa Basmati - 1121
11.	Vallabh Basmati - 23 × Pusa Basmati - 1	39.	Basmati CSR - 30 × Pusa Basmati - 1637
12.	Vallabh Basmati - 23 × Pusa Basmati - 1509	40.	Basmati CSR - 30 × Pusa Basmati - 1718
13.	Vallabh Basmati - 23 × Basmati CSR - 30	41.	Vallabh Basmati - 24 × Basmati - 386
14.	Vallabh Basmati - 23 × Vallabh Basmati - 24	42.	Vallabh Basmati - 24 × Pant Basmati - 2
15.	Vallabh Basmati - 23 × Basmati - 386	43.	Vallabh Basmati - 24 × Pusa Basmati - 1121
16.	Vallabh Basmati - 23 × Pant Basmati - 2	44.	Vallabh Basmati - 24 × Pusa Basmati - 1637
17.	Vallabh Basmati - 23 × Pusa Basmati - 1121	45.	Vallabh Basmati - 24 × Pusa Basmati - 1718
18.	Vallabh Basmati - 23 × Pusa Basmati - 1637	46.	Basmati - 386 × Pant Basmati - 2
19.	Vallabh Basmati - 23 × Pusa Basmati - 1718	47.	Basmati - 386 × Pusa Basmati - 1121
20.	Pusa Basmati - 1 × Pusa Basmati - 1509	48.	Basmati - 386 × Pusa Basmati - 1637
21.	Pusa Basmati - 1 × Basmati CSR - 30	49.	Basmati - 386 × Pusa Basmati - 1718
22.	Pusa Basmati - 1 × Vallabh Basmati - 24	50.	Pant Basmati - 2 × Pusa Basmati - 1121
23.	Pusa Basmati - 1 × Basmati - 386	51.	Pant Basmati - 2 × Pusa Basmati - 1718
24.	Pusa Basmati - 1 × Pant Basmati - 2	52.	Pant Basmati - 2 × Pusa Basmati - 1637
25.	Pusa Basmati - 1 × Pusa Basmati - 1121	53.	Pusa Basmati - 1121 × Pusa Basmati - 1637
26.	Pusa Basmati - 1 × Pusa Basmati - 1637	54.	Pusa Basmati - 1121 × Pusa Basmati - 1718
27.	Pusa Basmati - 1 × Pusa Basmati - 1718	55.	Pusa Basmati - 1637 × Pusa Basmati - 1718

RESULT AND DISCUSSION

In present investigation, half diallel design is used to work out the combining ability variance and their effect of parents and their hybrids were discussed below.

Analysis of variance for Parents and hybrids. The analysis of variance for parents and hybrids are presented in Table 2. An effort was made in the current investigation to obtain information on the estimates of GCA and SCA variances and their effects of parents and their hybrids for different morphological traits through combining ability analysis. The analysis of variance for the treatments (parents and hybrids) revealed that all genotypes had highly significant differences (at the 1% level of significance) in both yield and quality traits.

Analysis of variance for combining ability. The total genetic variance is divided into general combining ability variance and specific combining ability variance are presented in Table 3. According to the assessments of all traits, mean squares due to general combining ability were highly significant, while the mean squares due to specific combining ability were observed highly significant for all the traits under consideration except days to maturity, plant height, L/B ratio and kernel length after cooking. The ratio of estimates of variances of GCA/SCA is less than unity for characters namely, days to maturity, panicle length, grain per panicle, 1000 grain weight, biological yield per plant, harvest index, hulling percentage and grain yield per plant revealed preponderance of non-additive gene action. While the variance ratio of GCA/SCA was more than unity for character namely, days to 50% flowering, plant height, spikelet's per panicle, gel consistency, L/B ratio and kernel length after cooking revealed preponderance of additive gene action. Almost similar result were found in Vange *et al.* (2020); Singh *et al.* (2019); Pon *et al.* (2019).

Table 2: Analysis of variance of parent and hybrids for 14 characters in rice.

Sourced of variation	df	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Spikelet's per panicle	Grains per panicle	1000 Grain weight (g)	Biological yield per plant (g)	Harvestindex (%)	Gel consistency (mm)	Hulling (%)	L/B ratio	Kernel length after cooking (mm)	Grain yield per plant (g)
Replication	2	9.79	1.90	18.46	0.26	3.04	6.24	0.20	1.49	0.62	3.25	1.53	0.06	1.01	0.09
Treatment	54	161.76**	84.10**	39.54**	5.17**	166.41**	107.01**	6.10**	44.36**	43.17**	19.62**	12.44**	0.13**	2.97**	10.31**
Parent	9	180.00**	166.19**	50.87**	3.77**	221.62**	361.95**	7.97**	34.16**	48.30**	51.41**	30.92**	0.25**	7.32**	2.99**
F1	44	138.42**	59.86**	33.88**	2.56**	139.20**	17.43**	4.04**	37.22**	43.00**	10.74**	5.75**	0.10**	1.93**	9.58**
PVsF1	1	1024.89**	411.12**	186.72**	132.49**	866.08**	1755.12**	79.93**	449.94**	4.59	123.84**	140.12**	0.43**	9.99**	108.07**
Error	108	11.11	19.11	10.52	0.98	23.86	22.56	1.14	3.54	5.14	0.88	2.80	0.03	0.54	0.82

*, ** significant at 5% and 1% level, respectively

Table 3: Analysis of variance of combing ability for 14 characters in rice.

Source of variation	DF	Days to 50% flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Spikelet's per panicle.	Grains per panicle.	1000grain weight (g).	Biological yield per plant (g)	Harvestindex (%)	Gel consistency (mm)	Hulling percentage	L/B ratio	Kernel length after cooking (mm)	Grain yield per plant (g)
GCA	9	235.83**	142.31**	51.47**	4.14**	276.51**	101.56**	7.00**	26.95**	40.62**	31.17**	13.55**	0.193**	5.03**	5.10**
SCA	45	17.54**	5.18	5.52	1.24**	11.26**	22.50**	1.04**	12.36**	9.14**	1.61**	2.26**	0.012	0.18	3.10**
Error	108	3.71	6.38	3.51	0.33	7.96	7.53	0.38	1.18	1.71	0.29	0.93	0.010	0.18	0.27
GCA Variance		19.34	11.33	4.00	0.32	22.38	7.84	0.55	2.15	3.24	2.57	1.05	0.015	0.40	0.40
SCA Variance		13.83	-1.20	2.01	0.91	3.30	14.98	0.66	11.17	7.43	1.32	1.33	0.002	0.00	2.83
GCA/SCA		1.40	-9.45	1.99	0.35	6.78	0.52	0.83	0.19	0.44	1.95	0.79	6.955	84.25	0.14

*, ** significant at 5% and 1% level, respectively

General combining ability effects. Parents with significant GCA effects in the desired direction were categorized as good general combiners and those with significant GCA effects in undesirable direction were poor general combiners. The GCA effects of the parents for different traits obtained from the diallel analysis are given in Table 3. The significant GCA effect for parents Vallabh Basmati 23, Pant Basmati 2, Pusa Basmati 1718, Pusa Basmati 1637, Pusa Basmati 1509 and Pusa Basmati 1 were found good general combiners for grain yield per plant. Similar results have also been reported by Dadilakshmi and Upendra (2014); Rahaman (2016); Sudeepthi *et al.* (2018); Ambikabathy *et al.* (2019); Deepika *et al.* (2019).

Specific combining ability effects. Specific combining ability is deviation in a performance of hybrid from expected value on the basis of general combining ability effect of lines involved, and can be regarded as a measure of non–additive gene action.

The significant SCA effect, fifteen crosses *viz.*, Vallabh Basmati 23 × Pusa Basmati 1121, Pusa Basmati 1637 × Pusa Basmati 1718, Pusa Basmati 1509 × Vallabh Basmati 24, Pant Basmati 2 × Pusa Basmati 1121, Pusa Basmati 1 × Basmati CSR 30, Pusa Basmati 1 × Pusa Basmati 1718, Vallabh Basmati 23 × Basmati 386, Vallabh Basmati 23 × Pant Basmati 2, Vallabh Basmati 23 × Pusa Basmati 1, Pusa Basmati 1 × Pusa Basmati 1637, Pusa Basmati 1509 × Basmati CSR 30, Pusa Basmati 1 × Pusa Basmati 1509, Pusa Basmati 1509 × Pusa Basmati 1718, Pusa Basmati 1509 × Pant Basmati 2, Vallabh Basmati 23 × Pusa Basmati 1637, Basmati CSR 30 × Basmati 386, Basmati CSR 30 × Pant Basmati 2, Pant Basmati 2 × Pusa Basmati 1718, Pusa Basmati 1509 × Basmati 386, and Vallabh Basmati 24 × Basmati 386, out of forty five crosses were found good specific combiners for grain yield per plant. Kolom *et al.,* (2014); Prasad *et al.* (2015); Sala *et al.*, (2016); Bano and Singh (2019); Lal *et al.,* (2021)have also reported similar findings.

Table 4. Estimate General combing ability (GCA) effects of parents for 14 characters in rice.

S.No.	Parents	Days to 50% Flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Spikelet's per panicle.	Grains per panicle.	1000 grain weight (g).	Biological yield per plant (g)	Harvest index (%)	Gel consistency (mm)	Hulling percentage	L/B ratio	Kernel length after cooking (mm)	Grain yield per plant (g)
1.	**P1**	0.84	3.16 **	1.47 **	0.02	2.53 **	0.52	-0.06	0.02	1.96 **	0.36 *	-0.52 *	-0.07 *	0.20	1.13 **
2.	**P2**	1.87 **	1.26	-3.16 **	0.69 **	-7.10 **	-0.77	0.22	0.29	0.02	1.45 **	-0.78 **	0.10 **	-0.40 **	0.20
3.	**P3**	-0.68	4.20 **	2.12 **	0.58 **	-1.70 *	1.80 *	1.43 **	0.83 **	-0.32	0.32 *	-1.74 **	0.04	0.92 **	0.23
4.	**P4**	2.15 **	0.98	-0.60	-0.19	-1.49	-0.66	0.25	0.09	-2.19 **	0.72 **	-0.18	-0.19 **	-0.37 **	-1.12 **
5.	**P5**	-1.34 *	-5.35 **	3.62 **	-0.10	-3.68 **	0.93	-1.22 **	2.31 **	-3.27 **	-0.06	-0.79 **	-0.06 *	-0.87 **	-0.81 **
6.	**P6**	10.06 **	4.81 **	-0.42	0.86 **	-3.71 **	-3.13 **	-0.42 *	-3.53 **	2.56 **	-3.92 **	1.29 **	0.07 **	-0.69 **	-0.23
7.	**P7**	-2.13 **	-3.72 **	-2.10 **	-0.91 **	-2.88 **	-5.63 **	-0.72 **	0.51	0.27	-0.60 **	-0.18	-0.18 **	0.10	0.39 **
8.	**P8**	0.18	-0.79	0.00	-0.03	6.48 **	5.23 **	0.90 **	0.57	-1.24 **	1.29 **	1.81 **	0.18 **	0.88 **	-0.40 **
9.	**P9**	-5.76 **	-2.43 **	-1.80 **	-0.82 **	6.55 **	0.39	-0.29	-1.00 **	1.60 **	-1.01 **	0.38	0.13 **	-0.40 **	0.28 *
10.	**P10**	-5.19 **	-2.12 **	0.86	-0.11	4.99 **	1.33	-0.09	-0.09	0.61	1.45 **	0.71 **	-0.01	0.64 **	0.32 *
	SE (gi)	0.53	0.69	0.51	0.16	0.77	0.75	0.17	0.30	0.36	0.15	0.26	0.03	0.12	0.14

*, ** significant at 5% and 1% level, respectively

Table 5: Estimate Specific combined ability (SCA) effect of hybrids for 14 characters in rice.

S.No.	Hybrids	Days to 50% Flowering	Days to maturity	Plant height (cm)	Panicle length (cm)	Spikelet's per panicle.	Grains per panicle	1000 grain weight (g).	Biological yield per plant (g)	Harvest index (%)	Gel consistency (mm)	Hulling percentage	L/B ratio	Kernel length after cooking (mm)	Grain yield per plant (g)
1.	**P1xP2**	-0.38	-2.36 *	-0.27	0.22	-1.68	1.21	0.00	0.44	2.26 **	-0.05	-0.23	-0.08 *	-0.15	1.45 **
2.	**P1xP3**	-1.22	0.02	-1.41 *	-0.56 **	3.29 **	1.26	-0.08	3.49 **	-3.11 **	0.08	1.43 **	-0.11 **	0.07	-0.26
3.	**P1xP4**	8.23 **	-2.11 *	2.70 **	0.76 **	4.36 **	1.91	0.87 **	2.34 **	-3.61 **	0.46 *	1.79 **	0.35 **	-0.04	-1.06 **
4.	**P1xP5**	-4.78 **	-2.82 **	0.11	0.25	0.54	2.22 *	0.72 **	0.80 *	0.00	0.27	0.37	-0.02	0.29	0.36
5.	**P1xP6**	-4.81 **	-0.37	0.03	1.21 **	4.49 **	2.15 *	0.85 **	-0.52	3.65 **	1.99 **	1.25 **	-0.10 **	0.28	1.59 **
6.	**P1xP7**	-2.42 **	-1.23	-0.36	0.17	0.86	6.25 **	0.06	-1.12 **	3.66 **	-0.06	1.31 **	0.14 **	0.34 *	1.52 **
7.	**P1xP8**	-0.88	-1.40	-1.05	1.39 **	3.03 **	0.09	0.53 *	1.98 **	6.08 **	0.94 **	-0.42	0.14 **	0.24	4.37 **
8.	**P1xP9**	-4.21 **	-0.87	-0.45	-0.41	3.16 **	1.14	1.15 **	0.84 *	1.16 *	0.40 *	0.17	-0.04	0.62 **	1.20 **
9.	**P1xP10**	-2.07 **	-0.04	-3.56 **	0.57 **	3.20 **	-0.06	-0.51 *	0.42	-2.19 **	0.85 **	0.67	-0.06	-0.39 *	-1.07 **
10.	**P2xP3**	2.52 **	0.42	1.19	0.41	1.64	1.02	1.39 **	0.56	1.89 **	1.81 **	-0.03	-0.02	-0.02	1.28 **
11.	**P2xP4**	1.68 *	-1.34	-0.60	0.45 *	2.11 *	2.64 **	0.25	2.03 **	2.08 **	-0.32	1.43 **	0.09 *	0.26	1.98 **
12.	**P2xP5**	-2.16 **	-1.53	0.51	0.14	0.95	1.42	0.54 *	2.80 **	-2.26 **	-0.33	1.25 **	0.07	-0.09	-0.30
13.	**P2xP6**	-9.27 **	0.93	-1.45 *	0.57 **	1.38	2.52 *	0.09	0.20	-3.26 **	0.18	0.69	-0.03	0.28	-1.57 **
14.	**P2xP7**	0.36	0.08	-4.40 **	0.53 *	0.53	2.39 *	0.30	-1.40 **	0.32	1.36 **	0.45	0.04	0.20	-0.46 *

15.	**P2xP8**	1.18	-1.68	-1.68 *	0.18	4.08 **	-1.60	-0.41	-0.86 *	1.11 *	0.89 **	1.11 **	-0.09 *	0.46 **	0.21
16.	**P2xP9**	-3.52 **	-1.67	-5.22 **	0.56 **	2.37 *	1.74	-0.07	1.88 **	0.67	-0.33	0.04	-0.04	0.72 **	1.37 **
17.	**P2xP10**	1.03	0.62	-2.21 **	0.68 **	-4.06 **	1.11	0.38	0.02	2.91 **	-1.52 **	0.99 **	0.03	0.31 *	1.60 **
18.	**P3xP4**	-1.56 *	0.25	-1.68 *	0.78 **	-0.60	-1.44	0.08	0.55	2.07 **	0.60 **	2.88 **	0.01	-0.18	1.36 **
19.	**P3xP5**	-4.43 **	1.15	0.41	0.23	-0.56	0.98	1.50 **	1.17 **	3.04 **	0.45 *	-0.17	-0.02	0.42 **	2.23 **
20.	**P3xP6**	-2.15 **	-4.58 **	-0.19	0.58 **	0.87	3.01 **	0.00	-3.14 **	4.11 **	0.71 **	-0.35	-0.01	0.11	0.64 **
21.	**P3xP7**	-2.11 **	-0.29	-1.19	0.96 **	-1.18	5.87 **	0.83 **	1.79 **	0.72	0.73 **	-1.17 **	0.10 **	0.32 *	1.20 **
22.	**P3xP8**	-0.97	-1.84 *	-1.82 **	-0.14	1.65	-1.01	0.52 *	3.38 **	-1.85 **	0.09	1.10 **	0.12 **	0.02	0.29
23.	**P3xP9**	-3.27 **	-0.08	0.49	1.06 **	-1.22	-0.59	0.39	1.09 **	-4.36 **	-0.12	1.27 **	-0.01	-0.07	-1.75 **
24.	**P3xP10**	-0.15	0.91	-1.54 *	0.48 *	0.53	-0.73	1.23 **	2.26 **	0.50	-0.26	0.19	0.03	-0.51 **	1.28 **
25.	**P4xP5**	-1.42 *	-1.50	-1.78 *	0.07	-1.41	2.84 **	0.36	0.49	-0.57	0.42 *	1.52 **	0.01	0.38 *	-0.20
26.	**P4xP6**	-0.36	-0.59	-3.46 **	0.14	1.08	3.23 **	0.15	3.54 **	-1.45 **	1.11 **	1.42 **	0.01	0.39 *	0.89 **
27.	**P4xP7**	-0.09	0.84	3.61 **	0.01	-0.06	6.09 **	0.36	0.22	1.56 **	0.78 **	1.60 **	-0.07	-0.40 *	0.87 **
28.	**P4xP8**	-0.57	2.27 *	-2.11 **	0.61 **	2.59 *	-0.36	0.25	1.22 **	-1.47 **	-0.47 *	-0.89 *	0.03	-0.26	-0.33
29.	**P4xP9**	-6.13 **	-3.06 **	0.51	0.08	-0.79	1.33	0.05	0.96 *	-3.63 **	0.95 **	0.61	0.02	0.36 *	-1.39 **
30.	**P4xP10**	-3.84 **	-1.79	-0.80	0.67 **	2.61 *	-0.32	-1.42 **	0.93 *	-2.26 **	0.07	0.47	-0.04	0.22	-0.88 **
31.	**P5xP6**	2.27 **	-0.91	-1.18	0.31	-0.07	2.80 **	0.22	2.92 **	-1.60 **	1.41 **	-0.08	0.01	0.18	0.54 **
32.	**P5xP7**	-2.58 **	0.36	0.17	0.82 **	0.40	2.67 **	1.06 **	-0.02	-1.89 **	-0.44 *	-0.01	0.03	0.01	-1.11 **
33.	**P5xP8**	-3.16 **	0.72	1.16	-0.25	0.40	-0.12	1.37 **	0.87 *	-2.20 **	-0.22	0.82 *	0.10 **	0.34 *	-1.02 **
34.	**P5xP9**	0.41	-1.15	1.46 *	0.98 **	1.51	0.76	-0.38	2.20 **	-2.48 **	-0.43 *	-0.93 **	0.08 *	0.02	-0.30
35.	**P5xP10**	-3.72 **	-0.30	-0.51	0.14	1.49	-1.87	0.02	-1.14 **	-1.85 **	0.34	0.03	0.04	0.78 **	-1.46 **
36.	**P6xP7**	0.46	0.10	-1.11	1.45 **	0.49	5.69 **	0.32	-3.50 **	0.70	1.22 **	-0.19	0.03	0.20	-1.27 **
37.	**P6xP8**	5.02 **	-1.63	-1.77 *	0.87 **	-0.01	1.46	0.28	-3.09 **	2.84 **	-0.21	0.08	0.14 **	0.06	0.12
38.	**P6xP9**	2.13 **	-1.28	0.67	0.64 **	1.18	2.19 *	-0.54 *	-1.97 **	-0.17	1.57 **	-0.10	-0.02	-0.59 **	-0.88 **
39.	**P6xP10**	0.94	-0.99	-0.82	0.06	3.25 **	1.30	0.95 **	-4.00 **	3.94 **	-0.04	-1.33 **	0.03	0.07	0.04
40.	**P7xP8**	-0.94	-0.23	1.74 *	1.15 **	1.38	3.17 **	-0.48 *	3.08 **	1.20 *	1.06 **	0.24	-0.15 **	-0.18	2.01 **
41.	**P7xP9**	-3.03 **	-2.64 **	0.53	-0.37	0.09	2.73 **	0.16	5.92 **	-3.42 **	0.29	0.77 *	0.01	-0.02	0.85 **
42.	**P7xP10**	-2.04 **	-2.04 *	1.90 **	0.30	0.96	2.26 *	-0.07	-1.89 **	1.05 *	0.42 *	-0.02	0.08 *	0.18	-0.22
43.	**P8xP9**	-0.65	-0.78	0.87	0.02	1.93	-0.14	0.43	-1.83 **	-0.16	0.59 **	-0.63	0.05	-0.06	-0.76 **
44.	**P8xP10**	-1.65 *	-0.75	0.21	-0.07	2.74 **	-0.82	0.33	-1.06 **	0.69	0.04	0.47	0.19 **	-0.17	-0.06
45.	**P9xP10**	1.43 *	1.71	1.79 **	0.32	-0.89	0.79	0.74 **	10.19 **	-0.86	1.09 **	-0.32	0.01	0.25	4.25 **
	sca(ii)	1.77	2.33	1.72	0.53	2.60	2.53	0.57	1.00	1.21	0.50	0.89	0.09	0.39	0.48
	sca(ij)	0.71	0.93	0.69	0.21	1.04	1.01	0.23	0.40	0.48	0.20	0.36	0.04	0.16	0.19

*, ** significant at 5% and 1% level, respectively

CONCLUSION

The general combining ability is associated with fixable gene action (additive and additive × additive gene action). In contrast, the specific combining ability is attributed to non-fixable gene action (non-additive genes). The existence of additive gene action can be used in pure line selection, mass selection, and progeny selection, whereas the presence of non-additive gene action can be used to initiate a hybrid breeding programme. Based on the findings, we may conclude that both additive and non-additive gene action significantly impact on grain yield and the yield contributing features. As a result, it is suggested that pure line and heterosis breeding could be used to improve the yield of these rice genotypes.

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Conflict of Interest. None.

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