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Combining ability effects for yield traits in rice (*Oryza sativa* L.) under sodic soil

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Abstract
The present study was conducted to analyze the combining ability for yield and its contributing traits in rice (*Oryza sativa* L.). Rice, being a staple food for more than 70 per cent of national population is the source of livelihood for 120-150 million rural households. The major objective of a plant breeder is to create genetic variability upto maximum extent possible in the existing germplasm because the genetic variability and combining ability estimates provide the basis for selection of suitable genotypes in any breeding programme. The combining ability effects, which are supposed to be manifestation of non-additive components of genetic variance, are valuable for discrimination of superior crosses for their genetic worth as breeding materials. The estimates of combining ability of 39 crosses for 12 characters were analyzed during the experiment. Six crosses, NDRK 2011-18 x Gujarat 70, CSR 36 x CSR 43, Sarjoo 52 x Pusa Sugandha 4, NDRK 2011-19 x Pusa Sugandha 4, NDRK 2011-17 x CSR 43 and Sarjoo 52 x CSR 43 showed significant and positive combining ability effects for grain yield per plant as well as some other yield components. In general, the crosses showing significant and desirable combining ability effects were associated with better *per se* performance for the respective traits.

Keywords: Rice, combining ability, sodic soil, traits, yield

Introduction
Rice is most important food crop of the world and it has been estimated that half the world's population subsists wholly or partially on rice [1]. Ninety percent of the world crop is grown and consumed in Asia [2]. The available information regarding genetic behavior of different agro-physiological traits of rice is limited [3]. The feasibility of breeding of salt-tolerance in rice, as there was no antagonism between high yield and salt tolerance [4]. Salinity is an environmental condition which adversely affects the physiological processes of crop plants and severely affects crop production [1]. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis. The combining ability analysis gives an indication of the variance due to general and specific combining ability which represents a relative measure of additive and non additive gene actions, respectively. Breeders use these variance components to measure the gene action and to assess the genetic potentialities of parents in hybrid combinations. Line x tester analysis is one of the most powerful tools for estimating the general combining ability (GCA) of parents and selecting of desirable parents and crosses with high SCA for the exploitation of heterosis. Significant GCA and SCA for yield and yield components were also reported [5]. Therefore, the present study was conducted to assess the gene action, general combining ability and specific combining ability for yield and its contributing traits in rice (*Oryza sativa* L.).

Material and Methods
The present experiment was conducted at Department of Genetics and Plant Breeding Research Farm of N.D. University of Agriculture and Technology, Kumarganj, Faizabad, during Kharif, 2012 and 2013. Twelve plant characters *viz*., days to 50% flowering, days to maturity, plant height (cm), panicle bearing tillers plant-1, panicle length (cm), spikelet panicle-1, spikelet fertility (%), test weight (g), biological yield plant-1 (g), harvest index (%), grain yield plant-1 and length: breadth ratio were studied in the experiment.

Combining Ability Analysis
The combining ability analysis was carried out following line × tester mating design outlined by Kempthorne (1957) and further elaborated by Arunachalam (1974) [6, 7]. Line × tester analysis was used to estimate general combining ability (gca) and specific combining ability

(sca) variances and their effects using the observations taken on F_1 generation of the line × tester sets of crosses. In this mating system, a random sample of 'l' lines is taken and each line is mated to each of the 't' testers [8].

Results

Combining Ability Analysis

Analysis of variance for line × tester set

The analysis of variance for fifty five genotypes of line × tester set comprising thirty nine crosses and sixteen parents is presented in Table 1. The analysis of variance revealed that mean squares due to lines × testers were highly significant for all the twelve characters. The variance due to lines was highly significant for spikelets per panicle, spikelet fertility, 1000 grain weight and harvest index, while significant for biological yield per plant. The mean square due to testers was non-significant in case of all the twelve characters.

Estimates of components of variance

The estimates of general combining ability (gca) and specific combining ability (sca) variances, degree of dominance, predictability ratio, additive and dominance variance have been presented in Table 1.

Estimates of sca variance were higher than the corresponding estimates of gca variance for majority of the traits except for spikelet per panicle. The values of degree of dominance were more than unity (>1) revealing over dominance for all the characters except for spikelets per panicle. The predictability ratio was lesser than one for all the characters studied. For days to 50% flowering, panicle length, grain yield per plant and panicle bearing tillers per plant; the predictability ratio could not be estimated due to negative value of gca variance for those characters. The estimates of heritability in narrow sense (h^2n) have been classified by Robinson (1966) into three categories *viz.*, high (> 30%), medium (10-30%) and low (<10%). Low estimates of heritability in narrow sense were recorded for plant height (6.04%) and biological yield per plant (4.53%). Moderate estimates of heritability in narrow sense were recorded for days to maturity (14.22%) and spikelet fertility (27.32%). Rest of the characters showed high estimate of heritability in narrow sense.

Table 1: Analysis of variance for combining ability and genetic components of variance for 12 traits in rice under sodic soil

Source of variation	df	D50F	DM	PH	PBTP	PL	SP	SF	TW	BYP	H.I.	GYP	LBR
Lines	12	37.59	37.53	91.52	3.14	3.08	6208.21**	55.07**	1.92**	183.64*	22.61**	8.93	0.30
Testers	2	22	57.62	116.11	1.99	0.98	119.32	3.13	1.40	5.52	4.84	1.23	0.06
Lines × Testers	24	50.84**	28.60**	82.56**	2.57**	3.11**	243.95**	11.62**	0.58*	79.47**	4.96**	8.38**	0.19**
Error	76	1.03	1.24	1.70	0.52	0.80	5.18	2.37	0.31	3.31	1.41	0.97	0.02
Varaince GCA		-0.86	0.79*	0.88*	-0.00	-0.04	121.65**	0.72**	0.04**	0.62*	0.36**	-0.13	-0.00
Varaince SCA		16.58**	9.15**	26.97**	0.62**	0.72**	79.30**	2.80**	0.09*	25.30**	1.12**	2.43**	0.05**
Degree of Dominance		3.10	2.40	1.77	32.72	2.84	0.57	1.38	1.01	4.48	1.23	2.98	8.74
Predictibility Ratio		@	0.15	0.06	0.00	@	0.75	0.34	0.47	0.05	0.39	@	0.00
Additive variance		0.36	1.58	1.77	0.00	@	243.31	1.45	0.08	1.25	0.73	@	0.00
Dominance variance		@	9.15	26.97	0.62	0.72	79.30	2.80	0.09	25.30	1.12	2.43	0.05
Heritability in Narrow sense		@	14.22	6.04	@	@	74.95	27.32	31.43	4.53	30.65	@	@

Traits: D50F=Days to 50% flowering, DM=Days to maturity, PH=Plant height (cm), PBTP=Panicle bearing tillers plant^{-1}, PL=Panicle length (cm), SP=Spikelets panicle^{-1}, SF=Spikelet fertility (%), TW=Test weight (g), BYP= Biological yield plant^{-1} (g), HI=Harvest index (%), GYP= Grain yield plant^{-1} and LBR=Length: breadth ratio

@= Negative value

*,**. Significant at 5% and 1% probability level, respectively.

Proportional contribution of lines, testers and line × tester interactions

Proportional contribution of lines, testers and lines × testers interaction for twelve characters have been presented in Table 2. The maximum contribution of females (lines) was recorded for spikelets per panicle (92.43%), followed by spikelet fertility (69.85%), harvest-index (67.82%), 1000 grain weight (57.80%), biological yield per plant (53.45%),L:B ratio (43.00%), panicle bearing tillers per plant (36.44%), days to maturity (35.97%), grain yield per plant (34.49%), plant height (33.16%), panicle length (32.57%). Lowest contribution of lines was recorded for days to 50% flowering (26.27%).

Maximum contribution of males (testers) was recorded for days to maturity (9.20%) followed by plant height (7.01%), 1000-grain weight (6.99%), panicle bearing tillers per plant (3.85%), days to 50% flowering (2.64%), harvest-index (2.42%), panicle length (1.73%), L:B ratio (1.62%), grain yield per plant (0.79%), spikelet fertility (0.66%) and spikelets per panicle (0.29%). The lowest contribution of males was recorded for biological yield per plant (0.26%).

Proportional contribution of lines × testers was found maximum for the character days to 50% flowering (71.07%) followed by panicle length (65.69%), grain yield per plant (64.70%), plant height (59.82%), panicle bearing tillers per plant (59.70%), L:B ratio (55.36%), days to maturity (54.82%), biological yield per plant (46.27%), 1000-grain weight (35.20%), harvest-index (29.74%), spikelet fertility (29.74%), The lowest contribution of lines × testers interaction was recorded for spikelets per panicle (7.26%).

Table 2: Contribution of lines, testers and their interaction to the total variance for 13 traits in rice under sodic soil

Trait	Contribution (%)		
	Line	Tester	Line × Tester
D50F	26.27	2.64	71.07
DM	35.97	9.20	54.82
PH	33.16	7.01	59.82
PBTP	36.44	3.85	59.70
PL	32.57	1.73	65.69
SP	92.43	0.29	7.26
SF	69.85	0.66	29.48
TW	57.80	6.99	35.20
BYP	53.45	0.26	46.27
HI	67.82	2.42	29.74
GYP	34.49	0.79	64.70
LBR	43.00	1.62	55.36

Traits: D50F=Days to 50% flowering, DM=Days to maturity, PH=Plant height (cm), PBTP=Panicle bearing tillers plant^{-1}, PL=Panicle length (cm), SP=Spikelets panicle^{-1}, SF=Spikelet fertility (%), TW=Test weight (g), BYP= Biological yield plant^{-1} (g), HI=Harvest index (%),GYP= Grain yield plant^{-1} and LBR=Length: breadth ratio

Discussion

The understanding of inheritance of various characters and identification of superior parents are important pre-requisites for launching an effective and efficient breeding programme [9]. It is not always necessary that parents with high mean performance for yield and other traits would produce desirable F_1s and/or segregants. The selection of a few parents having high genetic potential as per breeding objectives is essential because analyzing and handling of very large number of crosses resulting from numerous parents available in collections of a crop would be an impractical and perhaps impossible task. Among the various techniques of combining ability analysis, line × tester analysis [6] has been widely utilized for screening of germplasm to identify valuable donor parents and promising crosses in many crops including rice [10-16].

Conclusion

The concept of combining ability has assumed great importance in plant breeding as an effective means of selecting potential parents for hybridization and specific crosses for further exploitation. From the genetic view point, GCA measures additive gene effects and the SCA measures non additive gene effects including dominance and epistasis. This information on the nature of the gene action present in the population would help to determine an appropriate breeding strategy.

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