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PARTIAL DIALLEL CROSS ANALYSIS OF YIELD AND ITS RELATED CHARACTERS IN RICE (*ORYZA SATIVA* L.) UNDER IRRIGATED AND RAINFED SITUATIONS

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ABSTRACT

In partial diallel cross analysis involving 16 parents in rice (*Oryza sativa* L.), both dominant and additive gene actions were found to play important roles in character expression. In the set grown irrigated situation, 9 traits, and in the set grown under rainfed situation, 8 traits were found to be predominantly controlled by nonadditive gene actions. These included important traits like grain yield, tiller number/plant, and No. of fertile spikelets per panicle. Panicle length, grain length, plant height and spikelet density were primarily determined by additive gene actions. Although the relative magnitudes of estimates of additivity and dominance were considerably influenced by growing situations, the direction of change was variable for different traits. In spite of these variations, however, the parents identified to be good general combiners for different traits from two sets generally the same. Important among these were Roti for grain size, IR 52 for harvest index, and IR 50 and IR 36 for tillers/plant.

Key words: Partial diallel, general combining ability.

Combining ability studies are useful in classifying parental lines in terms of their hybrid performance. Partial diallel analysis provides better estimates of general combining ability (gca) than that of specific combining ability (sca). In self-pollinated crops like rice, these studies are useful in assessing the nicking ability of the parents which, when crossed, would give more desirable segregates. This, in turn, helps in choosing the parents for hybridization. Very little information is available on partial diallel analysis in rice. The present study, therefore, has been carried out using partial diallel technique [1] in rice with n=16 and s-9 (where s denotes number of sampled crosses per parent).

MATERIALS AND METHODS

Sixteen diverse rice cultivars and their 72 F_1 hybrids generated by adopting partial diallel design were grown in two environments. These were created at the same location by planting whole material in two sets. The first set was raised under irrigated conditions and the other as rainfed. Twenty-one-day old seedlings were transplanted in randomized block design with three replications per environment. Each replication was spread over two tiers to avoid soil heterogeneity. The row-to-row and plant-to-plant distances were maintained at 20 x 15 cm. Various marphological characters were recorded on five random plants from the middle row of each plot by following standard procedures [2]. Partial diallel analysis to estimate general combining ability was based on the procedure developed by [1].

RESULTS AND DISCUSSION

The variances for gca and sca were significant at 1% level for all the 15 traits in both environments (Tables 1, 2), suggested the presence of both additive and nonadditive (dominance) effects for them. The major role of nonadditive component was evident for tiller number per plant, flag leaf area, fertile spikelets per panicle, spikelet sterility, breadth of grain, length–breadth ratio, biological yield, harvest index, and grain yield/plant. For the

Table 1. Analysis of variance for combining ability analysis in rice (irrigated)

Character	Mean squares			σ^2_A	σ^2_D	σ^2_A/σ^2_D
	gca (15)	sca (56)	error (142)			
Plant height	4636.4**	308.69**	41.03	343.47	89.23	3.85
Tiller number	147.37**	62.65**	10.13	6.77	17.31	0.39
Flag leaf area	192.6**	52.16**	11.53	11.07	13.55	10.82
Panicle length	82.9**	13.07**	6.40	5.54	2.23	2.49
Fertile spikelets/panicle	10887.8**	3605.36**	500.58	577.97	1034.93	0.56
Spikelet sterility	855.6**	654.26**	32.45	15.99	207.28	0.08
Spikelet density	26.8**	3.34**	0.94	1.86	0.79	2.33
Days to 50% flowering	534.0**	73.99**	9.12	36.52	21.63	1.69
Grain length (L)	0.06**	0.006**	0.0007	0.006	0.002	3.16
Grain breadth (B)	0.002**	0.0009**	0.0002	0.00001	0.0002	0.07
L/B ratio	0.72**	0.18**	0.04	0.04	0.05	0.90
Biological yield	1509.5**	588.17**	110.45	73.13	159.25	0.46
100-grain weight	2.21**	0.22**	0.03	0.16	0.07	2.36
Harvest index	430.7**	188.80**	36.20	19.19	50.87	0.38
Grain yield/plant	450.4**	1225.17**	34.68	25.81	30.17	0.86

*,** Significant at 5% and 1% levels, respectively.

Degrees of freedom for sca, gca and error given in parentheses.

remaining characters, the magnitude of additive variance was greater than that of dominance variance.

The present findings regarding grain yield per plant are also in conformity with those of [3,4], who also reported dominance to play a greater role than additive type, but is contrary to the findings of [5,6] who reported additive type to be more important. It is also not in conformity with the findings of [7] that both additive and dominance gene action are important.

The present findings, however, have an important bearing on the future breeding strategies. While additive gene action has already been exploited in several countries and in several ways to develop high yielding rice varieties, the breeding procedures like reciprocal recurrent selection now need to be adopted which can utilize nonadditive variation. So far only the People's Republic of China, which grew hybrid rice on over 7 million ha of land in 1984 [8] has been successful in adopting this approach, and thus need to be followed in other countries.

Table 2. Analysis of variance for combining ability analysis in rice (Rainfed)

Character	Mean squares			σ^2_A	σ^2_D	σ^2_A/σ^2_D
	gca (15)	sca (56)	Error (142)			
Plant height	3712.3	251.30	37.20	231.83	71.37	3.25
Tiller number	41.4	20.69	6.62	1.65	4.69	0.35
Flag leaf area	99.1	58.55	8.19	3.22	16.78	0.19
Panicle length	62.9	9.52	2.96	4.24	2.19	1.93
Fertile spikelets/panicle	8452.3	2139.48	593.27	501.02	515.40	0.98
Spikelet sterility	1193.1	366.12	47.87	65.63	106.09	0.61
Spikelet density	23.6	3.74	0.99	1.58	0.92	1.72
Days to 50% flowering	487.2	66.01	14.86	33.43	17.05	1.96
Grain length (L)	0.05	0.007	0.001	0.003	0.002	1.52
Grain breadth (B)	0.0008	0.0004	0.0001	0.00004	0.0001	0.33
L/B ratio	0.66	0.16	0.03	0.04	0.04	0.92
Biological yield	498.08	297.79	59.13	15.89	79.56	0.19
100-grain weight	1.37	0.26	0.04	0.09	0.07	1.19
Harvest index	522.2	92.72	32.71	34.08	20.004	1.70
Grain yield/plant	146.3	77.61	16.93	5.93	22.23	0.27

Note. All gca and sca values significant at 1% level.
Degrees of freedom for sca, gca and error given in parentheses.

Harvest index and biological yield were better expressed in irrigated conditions. Harvest index is the ratio of economic yield to biological yield, and both components are determined by nonadditive gene action. Moreover, plant height and leaf length, which are closely associated with harvest index, are governed by dominant genes. Also, any independent genes may or may not be existing for such resultant traits, and they may depend more on the environment. Very little information is available on the genetics of harvest index. Sharma [9] reported nonadditive gene action for harvest index and its components. This finding is similar to our results.

Table 3. Ranking of parents on the basis of gca effects for different traits under two situations

Character	Ranks of parents in set I			Ranks of parents in set II		
	I	II	III	I	II	III
Days to 50% flowering	Roti	Mahsuri	Safri 17	Roti	Mahsuri	Safri 17
Plant height	Kalimai	PL 16	R 68-1	Kalimai	Roti	Safri 17
Tillers per plant	IR 50	Early Raskadam	IR 36	Early Raskadam	IR 36	Roti
Flag leaf area	Roti	PL 16	Mahsuri	Roti	Anupama	Kalimai
Panicle length	Kalimai	Roti	IR 54	Kalimai	Roti	IR 52
Fertile spikelets per panicle	Mahsuri	PL 16	Safri 17	Improved sona	Safri 17	Kranti
Spikelet sterility	Kalimai	Samridhi	Jaya	Kalimai	Mahsuri	Jaya
Spikelet density	Mahsuri	PL 16	Improved Sona	Mahsuri	PL 16	Improved Sona
Grain length (L)	Roti	IR 54	IR 52	Roti	IR 52	—
Grain breadth (B)	Roti	IR 68-1	Jaya	Roti	Kranti	—
L/B ratio	Roti	Improved Sona	IR 52	Roti	Improved Sona	IR 50
Biological yield	PL 16	IR 36	R 68-1	Mahsuri	Roti	Kalimai
100-grain weight	Roti	Kranti	IR 54	Roti	Improved Sona	R 68-1
Harvest index	R 68-1	Kranti	IR 52	IR 52	Improved Sona	IR 54
Grain yield/plant	R 68-1	IR 36	Roti	Improved Sona	Roti	Safri 17

Tiller number per plant, flag leaf area, fertile spikelets/panicle, and spikelet sterility appear to be controlled by dominant gene action. This is also in agreement with the findings of [10-13], who reported dominance to be more important for tiller number per plant. Similarly, Chang [14,15] found dominance playing a greater role than additivity, for spikelets/panicle, which is contrary to the findings of [5,13,16,17]. The additive portion has been reported to be more important than dominance [6,18,19]. Similarly, nonadditive gene actions have been reported to be more important for spikelet sterility.

Grain length–breadth ratio was found to be controlled by both additive and dominant gene actions. This was also reported earlier [18,19]. Shrivastava and Seshu [4] reported additive gene action to be predominantly responsible for grain length and spikelet density. The present finding of additivity being more important is not in agreement with the findings of [3] reporting dominance to be more important for this trait. Additivity was found to be more important than dominance for plant height, panicle length, days to 50% flowering and test weight, as was reported earlier.

GENERAL COMBINING ABILITY EFFECTS

The variety Roti proved to be a good general combiner for several morphological, grain and panicle characters, e.g. days to flowering, flag leaf area, grain length, breadth and their ratio, test weight, and grain yield/plant. This need to be exploited in future breeding programmes. This may be a case similar to that of variety Peta of Indonesia which figures the pedigree of almost all the varieties released by IARI till 1980. A tall variety (R 68-1) also unexpectedly proved to be a good general combiner for grain yield, biological yield, and harvest index, especially under irrigated situations. This may be because of its Indica x Japonica origin so to have very dark green, short and erect leaves. In the absence of lodging, these traits make this variety particularly high yielding, resulting in high gca effects for the traits mentioned. The good performance of R 68-1 may be due to its high gca for plant height and positive, although nonsignificant, gca values for harvest index, biological yield, test weight, panicle length, and grain breadth. The good performance of cv. Impoved Sona may be due to its significant gca values for fertile spikelets per panicle and spikelet density. This parent also exhibited positive (but nonsignificant) gca effects for most of the traits. The high general combiner R 68-1 and Improved Sona can form a good agronomic base for developing suitable high yielding varieties. They are likely to combine well to provide good segregates, thereby leading to evolution of good fixed varieties.

The dwarf parents (IR 52, Kranti, IR 54), in general, had high gca effects for harvest index. In fact, IR 52 and Kranti are known for their drought tolerance, exhibiting high production potential under rainfed situations. These varieties may be utilized in breeding dwarf varieties for rainfed situations.

For gca effects, considerable similarity can be observed in the ranking of parents under two situations. Except for biological yield, at least one parent usually occupied one of the first three positions in two sets. Thus, although the estimates of σ^2A for various traits vary considerably under the two situations, the lines identified as good general combining parents remain so in most situations.

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