Indian J. Genet., **54** (2): 149–154 (1994)

GENETICS OF YIELD AND ITS COMPONENTS IN RICE (*O. SATIVA* L.)

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(Received: October 28, 1992; accepted: March 29, 1994)

ABSTRACT

The components of gene effect for yield and five yield traits were studied in four crosses using a popular indigenous cultivar as one parent. The character means over six generations were subjected to scaling test. In the presence of epistasis, six-parameter model was used to detect all types of gene effects. The analysis revealed the importance of dominance and epistatic components for yield, tillers/plant, grains/panicle and 100-grain weight in all the crosses. Additive and dominance effects were important for plant height and panicle length. Among the digenic interactions additive x additive and dominance x dominance effects contributed more in most of the characters. Additive x dominance gene effects was important for 100-grain weight in the crosses IR 50 x C 14-8 and C 14-8 x Vijaya, and for plant height in C 14-8 x IR 64 and C 14-8 x Vijaya. In general, most crosses revealed duplicate nonallelic interactions for majority of characters. All the crosses exhibited heterosis in F_1 and inbreeding depression in F_2 generation.

Key words: Rice, generation means, yield components, gene effects.

Rice cultivation in the Andamans is mainly dominated by an indigenous tall, photosensitive, long duration (170 days) cultivar, C 14-8 having tolerance/resistance against multiple diseases but prone to lodging. The farmers of these Islands lope the crop twice during vegetative stage and use the vegetative mass as fodder. Such traditional cultivars with good photosynthetic ability could be of immense value to improve the yield potential besides incorporating pest resistance.

Information on the genetic systems controlling matric traits is important for planning effective selection programmes. Gene action for quantitative traits has been determined in rice using diallel method [1–3] which furnishes information on additive and dominance gene effects. The importance of epistatic gene effects on yield and its components in rice was also reported [3–5]. In view of the limited information available on gene effects, the present

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study aims to estimate the nature and magnitude of additive, dominance and epistatic effects for yield and its components, involving the Andaman landrace C 14-8 in crosses with other commercial cultivars from the mainland which are distinguished for various other traits of economic importance.

MATERIALS AND METHODS

The experimental materials comprised six varieties, viz., C 14-8, IR 64, Pankaj, Mahsuri, IR 50 and Vijaya, which were crossed in four combinations: C 14-8 x IR 64, Pankaj x Mahsuri, IR 50 x C 14-8 and C 14-8 x Vijaya. Six populations (i.e., the two parents, F_1 and F_2, BC_1 and BC_2) of each cross were grown in compact family block design with three replications. The parents, F_1 and backcrosses were transplanted in one row each and F_2 in 10 rows at the research farm of the Central Agricultural Research Institute, South Andaman. The row length was 3.75 m, and distance between rows and plants 20 and 15 cm, respectively. One row of the parent was planted in the beginning of the block as border to avoid border effects. The recommended agronomic and plant protection measures were followed. Observations were recorded on 15 random plants from each parent and F_1; 20 plants from each backcross, and 75 plants from each F_2 population. The individual scaling test [6] was used to detect the presence of nonallelic gene interactions. In the absence of epistasis, the three-parameter model [7] was used to analyse m, (d) and (h) components. In the presence of epistasis, the additive (d), dominance (h) effects, and nonallelic interaction components (i, j and l) and generation means were estimated [8]. Heterosis and inbreeding depressions were also estimated.

RESULTS AND DISCUSSION

The values of individual scaling tests and estimates of m, d, h, i, j and l parameters for six metric traits in four crosses are presented in Table 1. The scaling tests A, B and C revealed significant deviation from zero in all the crosses for all the characters except in Pankaj x Mahsuri for plant height and 100-grain weight; in IR 50 x C 14-8 for plant height; panicle length and 100-grain weight; and in C 14-8 x IR 64 for panicle length. The high estimates of scales suggested inadequacy of simple additive and dominance model as well as presence of nonallelic interactions. Partitioning of the genetic components of variance indicated that mean values were highly significant for all the characters in all crosses.

The estimates of (d) and (h) components were significant for plant height in all the crosses. The additive gene effect was highly significant in all the crosses. The (h) component was positive for all crosses, whereas positive (d) component was observed only in the cross C 14-8 x Vijaya. In all the crosses, the (h) component for plant height was greater than (d). Among the epistatic components, additive x dominance component was significant in the cross C 14-8 x IR 64, and additive x additive and additive x dominance types in C 14-8 x Vijaya. The results suggested that additive, dominance and epistatic components were important for the expression of this character.

Table 1. Gene effects, heterosis, inbreeding depression and type of epistasis for yield and its components in rice crosses

Cross	Scales			Genetic components						Epistasis	Heterosis (%)	Inbreeding depression (%)
	A	B	C	m	d	h	i	j	l			
Plant height												
C 148 x IR 64	59.5*	- 25.7	- 8.5	146.4**	- 20.0**	29.4*	- 0.4	21.3*	9.27	C	22.3	10.3
Pankaj x Mahsuri	4.9	- 2.3	- 5.8	105.6**	- 11.1**	35.9*	—	—	—	—	14.6	7.5
IR 50 x C 14-8	16.4	13.6	- 7.9	96.0**	- 41.0**	129.8*	—	—	—	—	17.8	8.8
C 14-8 x Vijaya	- 28.8	14.5	- 45.4**	138.2**	21.5**	66.6**	31.9*	- 22.4**	- 16.8	D	27.0	17.4
Panicle length												
C 148 x IR 64	- 4.9	- 4.6	8.4	19.6**	- 3.7**	- 24.4*	—	—	—	—	17.5	7.1
Pankaj x Mahsuri	- 1.8	- 0.7	- 6.9**	24.7**	- 0.9	7.9**	10.4**	- 0.6	- 1.9	D	14.2	12.3
IR 50 x C 14-8	- 6.2	- 0.2	- 4.5	27.8**	- 3.5**	- 7.0*	—	—	—	—	11.7	9.1
C 14-8 x Vijaya	- 1.6	- 5.1**	- 6.2**	25.5**	5.3**	2.0	-0.5	1.7	7.3**	C	9.7	9.9
No. of tillers/plant												
C 148 x IR 64	- 3.1*	- 1.3	- 10.9**	4.6**	0.1	7.4**	6.5**	- 0.9	- 2.1	D	13.7	40.8
Pankaj x Mahsuri	2.4	- 0.3	- 5.3**	5.4**	2.3**	8.7**	7.3**	1.4	- 9.4**	D	22.7	27.0
IR 50 x C 14-8	- 0.8	0.3	- 6.6*	5.5**	0.8	5.8*	6.1**	- 0.7	- 5.6	D	- 4.3	21.5
C 14-8 x Vijaya	1.1	1.7	- 4.2*	6.8**	- 1.0	8.5**	7.0**	- 0.3	- 9.8**	D	21.3	21.0
No. of grains/panicle												
C 148 x IR 64	64.9**	- 4.7	- 88.2**	174.7**	- 62.3**	205.0**	148.4**	34.8**	- 208.6**	D	32.9	22.2
Pankaj x Mahsuri	- 64.8**	2.2	- 216.0**	163.9**	- 88.1**	227.0**	155.4**	- 32.5**	- 94.8**	D	39.3	35.4
IR 50 x C 14-8	- 27.6	33.1*	- 206.7**	140.9**	- 113.3**	251.5**	413.1**	- 30.4**	- 218.7**	D	22.1	33.6
C 14-8 x Vijaya	- 21.2	- 19.8	- 289.3**	141.6**	52.9**	269.4**	248.3**	- 0.7	- 207.3**	D	10.3	37.0
100-grain weight												
C 148 x IR 64	- 0.3**	- 0.4**	- 0.7**	2.4**	0.1**	0.2*	- 0.1	0.1	0.7**	C	10.3	10.9
Pankaj x Mahsuri	0.1	0.1	- 0.5	1.5**	0.5**	1.6*	—	—	—	—	3.5	6.7
IR 50 x C 14-8	0.5**	- 0.01	- 0.7**	1.9**	- 0.1	1.2**	1.1**	- 0.2**	1.6**	D	4.4	9.8
C 14-8 x Vijaya	- 0.4**	0.1	- 0.2	2.3**	0.1	0.1	0.1	0.2**	0.4	—	7.9	5.3
Grain yield/plant												
C 148 x IR 64	- 1.2	8.3**	- 12.0*	16.1**	-8.8**	30.5**	19.2**	- 9.5**	- 26.3**	D	84.0	35.0
Pankaj x Mahsuri	10.8**	9.3**	- 12.9*	16.2**	- 1.1	41.5**	33.1**	0.7	- 53.2**	D	55.1	31.4
IR 50 x C 14-8	1.6	9.0**	- 13.5**	15.9**	- 5.5**	33.0**	24.1**	- 3.7**	- 34.7**	D	60.1	33.0
C 14-8 x Vijaya	3.6	1.0	- 17.9**	19.0**	0.5	32.9**	22.4**	1.3	- 26.9*	D	58.0	33.9

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

Note. C—complementary and D—duplicate epistasis.

The cross C 14-8 x IR 64 showed complementary and C 14-8 x Vijaya duplicate type of nonallelic interaction. Similar results were also reported by [4, 5]. Maximum heterosis was observed in the cross C 14-8 x Vijaya, which was followed by highest inbreeding depression among all the crosses. The crosses C 14-8 x IR 64; IR 50 x C 14-8 and Pankaj x Mahsuri were next in order. The two crosses which showed higher heterosis had also significant epistatic effects.

For panicle length, the crosses C 14-8 x IR 64 and IR 50 x C 14-8 revealed significant additive and dominance components. These two crosses showed negative estimates of both additive and dominance effects which indicates that these gene effects could reduce character expression. The cross Pankaj x Mahsuri showed significant positive dominance and additive x additive gene effects along with duplicate type of nonallelic interaction. On the other hand, additive and dominance x dominance gene effects with complementary type epistatic interaction were important in the cross C 14-8 x Vijaya. The importance of epistatic interactions in rice was reported earlier [5, 9].

Number of tillers/plant was mainly influenced by dominance and epistatic gene effects in most crosses. Only the cross Pankaj x Mahsuri expressed significant additive as well as nonadditive effects. The significant positive (h) component in all the crosses indicates the importance of dominance type gene effect. All the crosses showed significant positive additive x additive gene action. Cross Pankaj x Mahsuri and C 14-8 x Vijaya expressed negative dominance x dominance gene effect. All the crosses showed duplicate type of nonallelic interaction for tiller number. Similar results were also reported by earlier workers [5, 10, 11] using entirely different set of parents. Higher estimates of heterosis were observed in the crosses where dominance and dominance x dominance type of gene effects were more important. The highest inbreeding depression was observed in the cross C 14-8 x IR 64, followed by Pankaj x Mahsuri.

It was observed that additive and all types of nonadditive components played important role in the inheritance of grains/panicle. The dominance and epistatic components were more important than the additive component in all the crosses. Among the epistatic components additive x additive and dominance x dominance components had more effect than additive x dominance. Duplicate type of nonallelic interaction was observed in all crosses.

The results indicate that nonfixable type of gene effects were more important for grain filling than the fixable type. Kalaimani and Sundaram [11] reported the importance of nonadditive components while Sharma [12] reported epistasis of low magnitude for this character. Greater heterosis was observed in the crosses Pankaj x Mahsuri and C 14-8 x IR 64. All the crosses showed high inbreeding depression, which again confirms the importance of epistatic gene effect.

In case of 100-grain weight, additive type of effect was important in the crosses C 14-8 x IR 64 and Pankaj x Mahsuri. Dominance and all types of epistatic components along with duplicate type of nonallelic interaction played important role in the expression of this character in the cross IR 50 x C 14-8. In the cross C 14-8 x Vijaya, only additive x dominance type of gene action was significant. The cross C 14-8 x IR 64 showed significant dominance x dominance type of gene effect along with complementary type of nonallelic interaction. The importance of epistatic gene effects in the expression of this character has been emphasized earlier [12, 13].

The gene effects for grain yield in the four crosses revealed that the cross C 14-8 x IR 64 and IR 50 x C 14-8 showed significant estimates of all kinds of (d, h, i, j and l) genetic components with duplicate type of nonallelic gene interaction. Nonadditive gene effects were more important than additive type in these crosses. At the same time, dominance, additive x additive and dominance x dominance type of gene effects were important for the expression of grain yield in the crosses Pankaj x Mahsuri and C 14-8 x Vijaya. The present findings are in agreement with the earlier results [4, 5, 10, 12].

In general, almost all the hybrids had significant positive dominance effect. The duplicate type of epistatic interaction further confirms the prevalence of dominance effect. All the crosses showed high degree of heterosis. Maximum heterosis was observed in the cross C 14-8 x IR 64 followed by IR 50 x C 14-8, C 14-8 x Vijaya and Pankaj x Mahsuri. All the crosses expressed inbreeding depression.

The additive effect and gene interaction (i) or any other digenic complementary gene interaction are fixable and thus can be exploited effectively for the improvement of characters through pedigree method of selection. Use of reciprocal recurrent selection has been suggested to improve the characters when both additive and nonadditive gene effects are involved in the expression of traits [14]. In the self-fertilized crops, where pronounced nonadditive gene effect along with some additive effects are observed, heterosis breeding programme (if commercial seed production is feasible) would be more rewarding. However, for development of lines, biparental approach, inter se crossing and/or reciprocal recurrent selection could be useful to increase the frequency of desirable recombinants.

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