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Gene effects and selection parameters in rainfed low land rice

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ABSTRACT

The information on the nature and magnitude of gene action controlling important agronomic traits is essential for developing suitable breeding strategy. The present investigation was undertaken on rainfed lowland rice under normal and delayed transplanting conditions. The data were subjected to analysis of variance of compact family Block Design. Simple and joint scaling test and six parameters model of generation mean analysis were carried out to study nature and magnitude of gene effects. Simple and joint scaling tests indicated presence of epistatic gene interactions and fitness of digenic interaction model. Six parameter model of generation mean analysis revealed importance of additive (d) and dominance (h) gene effects as well as one or more of the epistatic gene interaction (I). Biological yield plant^{-1} and plant height having high heritability and genetic advance in both transplanting conditions emerged as ideal traits for selection in both transplanting conditions. Grain plant^{-1}, tiller plant^{-1}, days to fifty per cent flowering in normal transplanting and harvest index in delayed transplanting indicated ideal traits for selection owing to their high estimates for both parameters in respective conditions.

Key words: *Rainfed rice, gene, inheritance*

Rice is the most staple food of the world ensuring a diet fortified with 43% of calorie requirement to more than 70% of Indians to sustain them substantially than any other single crop. The potential impact of rainfed lowland rice research is enormous, given that this ecosystem covers 38% out of 43 million hectares. It is imperative to understand gene by environment interaction and the information on nature and magnitude of gene action in controlling physiological traits associated with productivity under such heterogeneous and diverse conditions. The nature and magnitude of gene effects through simple and joint scaling tests indicated presence of epistatic gene interaction as well as digenic interactions. Secondary traits are considered better targets for selection than yield under stress *per se*.The present investigation was undertaken on rainfed rice under normal and delayed transplanting conditions with the objective to test the adequacy of additive-dominance model inheritance of various characters using simple and joint scaling tests and to study the nature and magnitude of gene effects controlling yield and yield components.

MATERIALS AND METHODS

The experimental materials comprised of the parents (P_1 and P_2), the F_{1s}, F_{2s} and F_3 generation and back crosses with both the parents (B_1 and B_z) of the three crosses viz., SBIR 66366-7-M-l-l-l-l x Rajshree, SBIR 66876-11-M-l-l-l-l x Rajshree and SBIR 67471-8-M-l-l-l-l x Rajshree.

The seven generations (P_1, P_z, F_1, F_z, F_3, B_1, B_z) of all the three cross combinations were evaluated under normal transplanting (NTP) and delayed transplanting (DTP) during wet season 2000 at Crop Research Station, Masodha. The experiments were laid out in compact family Block Design with three replications. Seven generations of the individual cross referred as progenies that constituted a family with different generations of three crosses making three families.

Nursery sowing of all the generations was done on same day. Thirty days old seedlings were transplanted as NTP whereas 60 days old seedlings were transplanted as DTP. Plants were randomly selected from each generation for data. The plot means used for statistical analysis were obtained on the basis of the randomly selected plants.

The four scales for testing the validity of additive-dominance model were applied as suggested by Mather (1949) and Hayman and Mather (1955). Estimation of six parameters, m. (d), (h), (i), (j) and (i) was analysed as given by Jinks and Jones (1958). The test for significance of the gene effects was done by 't' test.

The co-efficient of variation for different characters and heritability in broad sense were (h^2) estimated as suggested by Burton and Vane (1953).

RESULTS AND DISCUSSION

The analysis of variance for compact family Block Design revealed that the three cross families differed significantly for all the characters in both transplanting conditions except harvest index in NTP. This indicated that families had wide spectrum of variation for characters under study.

In the present study, one or more of the four scaling tests (A, B. C and D) were significant in case of all the six characters of three crosses in both the transplanting conditions (Table 1 and 2). This indicated presence of epistasis for five traits. The presence of epistasis indicated inadequacy of additive-dominance model and therefore, need for application of digenic interaction model of generation mean analysis such as six parameter (m, d, h, I, j, 1) Model of Jinks and Jones (1958). The results of joint scaling test (Cavalli 1952) also supported the inferences drawn from simple scaling tests in all the cases.

In case of days to 50% flowering in NTP additive (d) gene effect was significant in cross I and III while dominant (h) gene effect was significant in cross II and III among the epistatic interactions additive x additive (i) and dominance x dominance (1) interaction effects were significant in all the three crosses. In the delayed transplanting, significant estimates off all the fine gene effect, namely (d), (h), (i), (j) and (1) alongwith presence of duplicate epistasis were observed in all the three crosses. Chakraborty *et al* (1994) noticed importance of additive gene effects for this traits. The significant estimates of all the five genes effects along with duplicate type of epistatis was observed for plant height for all the three crosses in both the transplanting condition except non significant value of (d) recorded for cross I and cross II in delayed transplanting. This indicated importance of additive, dominance as well as epistatic gene effects in inheritance of plant height. Importance of additive as well as non additive gene effects in inheritance of plant height were reported with predominance of additive gene effects by Manueal and Palanisamy (1984).

For harvest index (d), (h), (i), j and (1) type of gene effects were significant in cross II and III, while (h), (i) and (1) estimates were significant for cross I in NTP. Duplicate epistatis was present in all the crosses indicating importance of additive as well as non additive gene effects in inheritance of harvest index in cross II and III. Whereas in DTP condition, additive gene effects were significant for harvest index in all the three crosses while dominant gene effects were found significant in cross I and III. Duplicate epistatis was found in cross I only. Similar results were also reported by Sharma (1986).

Additive (d) and dominance (h) gene effects and additive x additive (1), additive x dominance (i) and dominance x dominance (1) gene interaction effects were significant in all the crosses for grain yield plant^{-1}. Duplicate type of epistasis was also present in all the crosses in NTP condition indicating role of additive dominance as well as epistatic gene effects in expression of grain yield. Whereas in delayed transplanting condition (h), (i), (j) and (1) estimates were significant for grain yield plant^{-1} in cross I while (d), (j) and (1) parameters were significant in cross II. Duplicate epistatis was recorded in cross 1.

Additive gene effects alongwith (i) and (1) interaction were significant in cross II for tillers plant^{-1} while (j) type of epistatic interaction in cross I and additive gene effect in cross III was observed in NTP condition, whereas dominance (h) gene effect and (i) and (1) type of non allelic interaction were significant for tillers plant^{-1} in all the three crosses of DTP. Duplicate epistatis was recorded for cross I and III. Significance of dominance (h), gene effect and additive x additive (i) and dominance x dominance (1) interaction in these crosses indicated, preponderance of non additive gene action for tiller plant^{-1} in DTP condition. Singh and Srivastava (1982) observed that tillers plant^{-1} was conditioned by additive gene action.

Table 1. Simple scaling tests and gene effects for different characters under NTP condition

Characters	Gene effects						Simple scaling tests				Type of epistasis
	M	(d)	(h)	(i)	(j)	(I)	A	B	C	D	
Cross-I											
Days to 50% flowering	102.76 ±0.88	25.20** ±0.32	-3.43 ±3.64	-14.79** ±0.51	14.90** ±3.60	39.79** ±3.90	2.40** ±0.63	-27.40** ±0.91	-10.20** ±3.69	7.40** ±1.80	
Plant height (cm)	124.97 ±0.58	-35.15** ±1.94	-54.07** ±4.59	-23.90** ±4.54	-15.11** ±1.96	124.93** ±8.23	-40.62** ±1.38	-10.40** ±3.76	22.88** ±2.68	36.95** ±2.27	Duplicate
Tillers/plant	7.86 ± 0.67	0.73 ± 0.50	4.83 ± 2.95	1.20 ± 2.90	1.43** ±0.51	5.00 ± 3.56	-1.66 ±0.98	-4.53 ±0.81	-7.40* ±2.93	-6.60 ±1.45	
Grains/panicle	157.51 ±1.43	8.13** ±2.92	-188.10** ±8.23	-199.40** ±8.20	0.36 ± 2.94	422.40** ±13.10	-111.13** ±5.84	-111.86** ±1.02	-23.60** ±5.88	99.70** ±4.10	Duplicate
Harvest-index(%)	28.66 ±0.60	1.64 ± 0.89	-11.57** ±3.08	-13.10** ±3.02	1.19 ± 0.90	21.19** ±4.48	-2.85 ±1.73	-5.24** ±0.97	5.00 ± 2.72	6.55** ±1.51	Duplicate
Grain yield/plant	12.14 ±0.21	-0.85** ±0.15	-11.74** ±0.98	-17.04** ±0.91	0.48** ±0.16	33.65** ±1.27	-7.82* ±0.45	-8.79** ±0.38	0.42 ± 1.10	8.52** ±0.45	Duplicate
Cross-II											
Days to 50% flowering	107.61 ±0.69	-0.72 ±2.28	-77.27** ±5.36	-90.97** ±5.35	-1.68± 2.30	139.01** ±9.57	-25.70** ±4.43	-22.33** ±1.26	42.93** ±2.83	45.48** ±2.97	Duplicate
Plant height (cm)	107.60 ±1.21	19.30** ±0.43	79.62** ±4.96	52.88** ±4.94	43.03** ±0.46	-34.34 ±5.22	33.76** ±0.60	-52.30** ±0.82	-71.42** ±4.91	-26.44** ±2.47	Duplicate
Tillers/plant	8.56 ± 0.24	-3..86** ±0.53	2.53 ± 1.45	0.93 ± 1.44	-2.29** ±0.55	6.66** ±2.39	-6.10** ±0.85	-1.50* ±0.74	-8.53** ±1.05	-4.46 ±0.72	
Grains/panicle	117.88 ±0.94	-2.40 ±1.23	51.08** ±7.97	50.60* ±4.50	-3.31** ±1.25	-6.50 ±14.55	-25.36** ±6.62	-18.73** ±7.00	-94.70** ±13.70	-25.30** ±2.25	
Harvest-index(%)	26.37 ±0.37	-8.69** ±0.82	7.10** ±2.27	6.35** ±2.22	-8.24** ±0.87	-767* ±3.75	-7.58** ±1.32	8.90** ±1.27	9.04** ±1.76	-3.18** ±1.11	Duplicate
Grain yield/plant	11.37 ±0.33	-4.26** ±0.36	-3.07* ±1.52	-6.81** ±1.51	-3.02** ±0.38	15.82** ±2.00	-7.53** ±0.29	-1.48* ±0.73	-2.20 ±1.36	3.40** ±0.75	Duplicate
Cross-III											
Days to 50% flowering	105.50 ±0.30	14.26** ±0.63	-40.03** ±1.82	-55.59** ±1.76	9.16** ±0.73	92.19** ±2.97	-9.13** ±1.12	-27.46 ±1.01	19.00** ±1.51	27.80** ±0.88	Duplicate
Plant height (cm)	120.73 ±0.49	-8.73** ±0.47	-28.90** ±2.25	-35.98** ±2.20	2.22** ±0.53	72.29** ±2.91	-15.93** ±1.02	-20.38** ±0.64	-0.62 ±2.20	17.99** ±1.10	Duplicate
Tillers/plant	7.66 ± 0.11	1.64** ±0.57	0.76 ± 0.62	0.76 ± 0.56	1.24 ± 0.74	0.40 ± 0.96	-1.17** ±0.30	-3.66** ±0.41	-5.60** ±0.72	-0.38 ±0.28	
Grains/panicle	143.90 ±1.21	-3.00** ±0.47	-33.46** ±5.01	-44.26** ±4.94	-1.53* ±0.70	106.80** ±5.45	-32.80** ±0.97	-29.73** ±1..35	-18.26** ±5.12	22.13** ±2.47	Duplicate
Harvest-index(%)	29.17 ±0.05	6.64** ±0.80	-8.15** ±1.69	-9.33** ±1.63	5.83** ±0.91	8.19* ±3.36	6.40** ±1.55	-5.26** ±0.96	10.47** ±0.90	4.66** ±0.81	Duplicate
Grain yield/plant	14.13 ±0.07	2.78** ±0.33	-8.67** ±0.74	-12.49** ±0.73	1.44** ±0.35	23.50** ±1.40	-4.06** ±0.56	-6.94** ±0.44	1.48** ±0.38	6.24** ±0.36	Duplicate

*and** indicating significant at 5% and 1% probability level, respectively.

Table 2. Simple scaling tests and gene effects for different characters under delayed transplanting.

Characters	Gene effects						Simple scaling tests				Type of epistasis
	M	(d)	(h)	(i)	(j)	(l)	A	B	C	D	
Cross-I											
Days to 50% flowering	122.20 ±0.88	9.10** ±0.68	-16.20** ±3.83	-22.20** ±3.80	-1.89* ±0.73	31.60** ±0.99	-6.60** ±0.99	-2.80* ±1.22	12.80** ±3.69	11.10** ±1.90	Duplicate
Plant height (cm)	104.85 ±0.26	3.16 ± 2.31	-66.37** ±4.76	-80.62** ±4.74	11.36** ±2.32	109.30** ±9.34	-2.97 ±3.56	-25.70** ±3.02	51.95** ±1.31	40.31** ±2.37	Duplicate
Tillers plant^{-1}	7.00 ± 0.22	-0.03 ±0.47	6.59** ±1.32	6.99** ±1.31	0.63 ± 0.48	-7.59** ±2.13	0.93 ± 0.72	-0.33 ±0.66	-6.40** ±0.97	-3.50** ±0.65	Duplicate
Grains panicle^{-1}	109.50 ±0.25	13.73** ±0.68	4.91** ±1.74	5.46** ±1.71	6.98** ±0.75	4.96 ± 3.00	1.76* ±0.80	-12.20** ±1.29	15.90** ±1.23	-2.73** ±0.85	
Harvest-index(%)	37.73 ±0.79	-8.67** ±0.71	-21.20** ±3.51	-23.69** ±3.47	-7.79** ±0.85	34.55** ±4.40	-13.22** ±1.48	2.36* ±0.92	12.83** ±3.34	11.84** ±1.73	Duplicate
Grain yield plant^{-1}	11.16 ±0.37	0.25 ± 0.17	-6.71** ±1.56	-10.10** ±1.55	0.45* ±0.22	17.65** ±1.69	-3.32** ±0.32	-4.22** ±0.32	2.55 ± 1.54	5.05** ±0.77	Duplicate
Cross-II											
Days to 50% flowering	118.21 ±0.18	4.59** ±1.02	-36.60** ±0.21	-49.00 ±2.17	2.59* ±1.03	80.60** ±4.20	-13.20** ±0.67	-18.40 ±1.98	17.40** ±0.93	24.50** ±1.08	Duplicate
Plant height (cm)	96.60 ±1.23	-0.19 ±0.69	-33.46** ±5.14	-50.63** ±5.13	2.82** ±0.73	98.76** ±5.70	-21.24** ±0.87	-26.89** ±1.21	2.50 ± 4.99	25.31** ±2.56	Duplicate
Tillers plant^{-1}	6.08 ± 0.64	-0.56 ±0.31	8.41** ±2.67	7.89** ±2.67	-0.38 ±0.32	-5.16* ±2.89	-1.73** ±0.60	-0.96** ±0.29	-10.56** ±2.61	-3.93** ±1.33	
Grains panicle^{-1}	112.25 ±0.33	9.20** ±1.87	-81.06** ±4.14	-79.13** ±3.98	5.20* ±2.16	153.13** ±7.95	-31.80** ±4.07	-42.20** ±1.54	5.13 ± 2.65	39.56** ±1.99	Duplicate
Harvest-Index(%)	45.48 ±0.61	7.68* ±3.53	-11.46 ±7.53	-18.32* ±7.48	1.55 ± 3.58	19.24 ±14.46	1.09 ± 4.17	-2.01 ±5.90	17.40** ±3.01	9.16* ±3.74	
Grain yield plant-1	10.75 ±0.20	3.99** ±0.53	-0.07 ±1.43	-1.86 ±1.33	1.77** ±0.55	5.79* ±2.50	-0.18 ±0.98	-3.74** ±0.88	-2.06 ±1.33	0.93 ± 0.66	
Cross-III											
Days to 50% flowering	124.50 ±0.77	11.30** ±2.49	-46.08** ±5.89	-64.33 ±5.88	6.35* ±2.50	104.56** ±10.48	-13.76** ±4.98	-26.46** ±0.58	24.10** ±3.17	32.16** ±2.94	Duplicate
Plant height (cm)	102.81 ±1.45	6.76** ±1.09	-25.55** ±6.24	-48.53 ±6.21	11.29** ±1.13	100.41** ±7.36	-14.64** ±1.97	37.23** ±1.29	-3.34 ±5.91	24.26** ±3.10	Duplicate
Tillers plant^{-1}	7.23 ± 0.08	-1.23** ±0.16	-3.10** ±0.49	-4.86** ±0.48	-0.36* ±0.17	10.20** ±0.78	-3.03** ±0.27	-2.30** ±0.26	-0.46 ±0.41	2.43** ±0.24	Duplicate
Grains panicle-1	103.90 ±0.36	-5.93** ±0.86	-9.76** ±2.31	-13.86** ±2.25	-5.69 ±0.89	43.66** ±3.89	-20.60** ±1.61	-9.20 ±1.01	-15.93** ±1.77	6.93** ±1.12	Duplicate
Harvest-Index(%)	29.59 ±0.92	-6.17* ±0.97	9.01* ±4.24	7.82 ± 4.19	-4.83** ±1.16	2.74 ± 5.56	-10.11** ±1.73	-0.45 ±1.59	-18.40** ±3.95	-3.91 ±2.09	
Grain yield plant-1	8.73 ± 0.35	0.43 ± 0.28	-2.44 ±1.51	-4.02** ±1.51	0.01 ± 0.29	11.72** ±1.81	-3.84** ±0.58	-3.86** ±0.16	-3.67** ±1.41	2.01** ±0.75	

*and** indicating significant at 5% and 1% probability level, respectively.

The additive (d) and dominance (h) gene effects and additive x additive (i) and dominance x dominance (1) epistatic interaction effects were significant for cross I and III for grains panicle^{-1} in NTP. Presence of duplicate epistatis was also recorded in cross I and cross III. These observations clearly underline the predominance of dominance and epistatic gene effects in inheritance of grains panicle^{-1} under NTP whereas in DTP, all the five estimates of gene effects (d, h, I, j, I) were significant for grains panicle^{-1} in the three crosses except non-significant (I) type of non-allelic interactions in cross I. Similar observations were also reported by Perraju and Sharma (1999).

The estimates of gene effects obtained for five traits in three crosses under normal and delayed transplanting condition, showed in general, importance of additive as well as non additive gene effects in their inheritance. The significance of additive gene effects for most of the five traits in three crosses indicated that substantial improvement in yield and its components can still be achieved by following conventional breeding procedures leading to development of pure line varieties for normal and delayed transplanting in rainfed low land rice.

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