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Genetics of yield and yield components in scented rice

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ABSTRACT

Parental, F_1, F_2, BC_1 and BC_2 generations of four crosses involving scented and non-scented rice varieties were studied for days to 50% flowering, plant height, panicle number plant^{-1}, panicle length, number of grains panicle^{-1}, 1000 grain weight, grain length, length breadth^{-1} ratio and grain yield plant^{-1}. A simple three parameter model was adequate for the variability in respect of days to 50% flowering, panicle number plant^{-1} and grain length. Among the digenic interaction models both five and six parameter models were fitted for almost all the characters. The dominance effects were more important than the additive effects in most of the crosses. The duplicate type of epistasis was present with the exception of panicle length in cross Muskbudhi x Ratna in which the complementary type of epistasis was evident. Recurrent selection or diallele selective mating seems to be the best method to improve the grain yield and other attributes in scented rice.

Key words: *Generation mean analysis, grain yield, scented rice*

The scented rice has good export value in the international market but they are poor yielders. Hence, it is very much essential to improve the scented rice with higher yield. The grain yield is a highly complex character, generally governed by genes and the interaction between them. To know the pattern of inheritance among different traits in scented rice, diallele mating is frequently used but a few reports are available on generation mean analysis. So the present experiment was undertaken to know the nature and magnitude of gene effects by generation mean analysis which is a simple and successful method in self pollinated crop like rice.

MATERIALS AND METHODS

The experimental material comprised of four crosses between four sceneted (Basmatibahar, Kasturi, Muskbudhi and Kalimochi) and one non scented (Ratna) rice genotypes (Table 1). Six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) were raised in a Randomised Block Design with three replications at Central Rice Research Institute, Cuttack in wet season 2003. Two rows of each parent, one row each of F_1, BC_1 and BC_2 and ten rows each of F_2 per replication were transplanted. Each row was 3.6 m long with row to row and plant to plant spacing of 20 cm. Recommended package of practices were followed during crop growth period. Observations were recorded on ten randomly selected plants from P_1, P_2, F_1, BC_1, BC_2 and 30 plants from F_2 generation of each cross for ten characters. The joint scaling test as proposed by Cavalli (1952) was applied to test the adequacy of additive - dominance model. Components of generation means were worked out by weighted least square estimates as per Mather and Jinks (1982). The three, five and six parameter models were applied for all the characters in each cross to know the adequacy of the model. From the adequacy of the model different genetic parameters were estimated.

RESULTS AND DISCUSSION

The estimates of genetic parameters like mean (m), additive (d), dominanace (h), additive x additive (i), additive x dominance (j), dominance x dominance (l) for different characters in four crosses are presented in table 1. Significant deviation of observed generation mean from the expected mean for most of the characters suggested that the non-allelic interactions were present in these crosses.

The data on Days to 50% Flowering revealed that the additive-dominance model was adequate for Basmatibahar x Ratna cross indicating absence of non allelic interaction. The dominant effect had major role

Table 1. Estimates of gene effects of the best fit model and type of epistasis for different characters in scented rice

Gene effect	Basmatibahar x Kasturi	Basmatibahar x Ratna	Muskbudhi x Ratna	Kalimochi x Ratna	Basmatibahar x Kasturi	Basmatibahar x Ratna	Muskbudhi x Ratna	Kalimochi x Ratna
		Days to 50% flowering				Plant height		
m	114.50** ±7.53	105.480** ±0.58	98.901** ± 3.37	97.320** ± 4.07	141.746** ± 7.16	89.617** ±2.65	177.579**±10.43	150.946** ± 4.57
d	1.833**± 0.52	-0.172 ± 0.55	-3.595** ± 0.84	5.520** ± 0.98	14.750** ± 0.39	12.935** ± 0.46	3.350** ±0.73	28.667** ± 1.05
h	-38.508** ± 16.48	-6.078** ± 1.20	3.550** ± 4.63	6.784* ± 5.29	-60.155** ±15.02	30.570** ± 3.39	-188.287**±22.71	-44.355** ± 10.27
i	-10.668 ± 7.51	-	3.727* ± 3.51	14.546** ± 4.28	-36.796** ±7.15	17.164** ± 2.71	-83.442** ± 10.41	-28477** ± 4.45
j	5.667** ± 2.09	-	22.594** ± 4.59	-33.273** ± 4.44	-	1.758**± 0.33	15.330** ±4.10	-
i	23.001** ± 9.39	-	-	-	29.697** ±8.16	-	125.713** ± 13.11	33.729** ± 6.29
Epistasis	Duplicate				Duplicate		Duplicate	Duplicate
		Panicle number plant^{-1}				Panicle length		
m	11.450** ± 0.35	7.350** ± 0.60	12.965** ± 0.68	10.061** ± 0.08	27.450** ±0.47	12.655** ±0.39	38.155** ±0.54	23.383** ±0.45
d	0.400** ± 0.07	-1.250** ± 0.06	-2.435** ± 0.03	-1.944** ± 0.08	0.490** ±0.17	0.705** ±0.16	-2.715** ±0.10	2.714** ±0.27
h	-4.300** ± 0.93	6.550** ± 1.49	-3.096** ± 1.53	-0.106 ± 0.14	-5.330** ±0.16	24.454** ±1.13	-32.521** ±1.19	6.907** ±0.72
i	-2.400** ± 0.34	3.400** ± 0.60	-3.401 ± 0.68	-	-2.900** ±0.43	11.679** ±0.36	-17.240** ±0.53	2.950** ±0.52
j	0.800** ± 0.30	-1.300** ± 0.04	1.070** ± 0.31	-	-	-	1.630** ±0.28	-0.407** ±0.12
i	2.200** ± 0.63	-4.900** ± 0.93	-2.871 ± 0.87	-	2.780** ±0.79	-11.810** ±0.81	18.663** ±0.68	-
Epistasis	Duplicate	Duplicate	Complementary		Duplicate	Duplicate	Duplicate	
		Number of grains panicle^{-1}				1000-grain weight		
m	77.721** ± 2.55	-14.062* ± 6.45	132.785** ± 5.93	18.315** ± 5.96	13.385** ±0.17	12.055** ±0.54	22.706** ±0.15	17.143** ±0.44
d	23.463** ±1.46	18.235**±1.00	-9.925**±1.07	9.325**±1.26	-2.515** ±0.04	-2.185** ±0.10	-0.255** ±0.10	-0.357** ±0.10
h	4.017** ±3.46	200.950**±15.41	-129.186**±13.26	105.471**±17.03	-5.856** ±0.46	8.435** ±1.25	-7.486** ±0.44	6.450** ±1.04
i	-1.789** ±2.86	95.067**±6.37	-79.940**±5.83	53.779**±5.82	-2.600** ±0.16	3.400** ±0.52	-5.320** ±0.11	0.140** ±0.04
j	27.542**±3.37	10.930**±4.13	-22.010**±3.18	-	4.430** ±0.16	2.970** ±0.33	-0.450** ±022	-
i	-	-106.921**±9.29	86.710**±7.87	-53.087**±11.38	4.970** ±0.29	-4.290** ±0.74	5.311** ±0.31	-5.593** ±0.64
Epistasis		Duplicate	Duplicate	Duplicate	Duplicate	Duplicate	Duplicate	Duplicate
		Grain length					Length / breadth ratio	
m	10.317**± 0.17	9.027**±0.02	9.423**±0.10	10.905**±0.14	5.802** ±0.10	5.110** ±0.02	5.128** ±0.12	5.703** ±0.07
d	-0.693±0.03	-0.125**±0.02	-0.773**±0.02	-0.212*±0.02	-0.225** ±0.01	0.197** ±0.02	-0.698** ±0.02	-0.023** ±0.02
h	-1.630**±0.42	0.301±0.06	-2.050**±0.26	-3.625**±0.31	-0.625* ±0.26	0.355** ±0.04	-2.155** ±0.28	-1.250** ±0.21
i	-0.720**±0.17	-	-1.040**±0.10	-1.760**±0.13	-0.047** ±0.09	0.221** ±0.03	-0.680** ±0.11	-0.580** ±0.07
J	0.387**±0.11	-	0.307**±0.08	-	0.403** ±0.08	-0.140** ±0.07	0.517** ±0.07	-
i	0.913** ±0.26	-	1.407**±0.16	1.870**±0.18	0.523** ±0.17	-	1.757** ±0.16	0.556** ±0.14
Epistasis	Duplicate		Duplicate	Duplicate	Duplicate		Duplicate	Duplicate
		Grain yield plant^{-1}						
m	9.400**±0.57	6.045**±0.47	3.285**±0.83	13.460**±0.80				
d	0.200**±0.08	-0.185**±0.06	-1.885**±0.07	0.290**±0.03				
h	-4.000**±1.37	10.167**±0.96	-10.355**±1.97	-7.280**±1.98				
i	-2.600**±0.56	2.039**±0.46	-6.000**±0.83	-4.000**±0.80				
J	-	2.330**±0.13	-					
i	2800**±0.87	-3.710**±0.54	7.170**±1.18	5.921**±1.25				
Epistasis	Duplicate	Duplicate	Duplicate	Duplicate				

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

in controlling this character. Similar type of gene effects were observed by Dikshit and Mani (1988). In crosses Basmatibahar x Kasturi, Muskbudhi x Ratna and Kalimochi x Ratna, additive (d), dominance (h), additive x additive (i), additive x dominance (j) type of interactions were important. Liang *et al.* (1996) observed non additive gene effects predominated over the additive gene effects for this character. Duplicate type of epistasis was found in cross Basmatibahar x Kasturi supported by the findings of Ray and Panwar (1995) and Liang *et al.* (1996).

Due to failure of additive - dominance model all the crosses exhibited digenic interactions. Genetic control of plant height in Basmatibahar x Kasturi and Kalimochi x Ratna were under additive (d), dominance (h), additive x additive (i), dominance x dominance (l) type of gene effects and the 'h' and 'i' effects were negatively significant. In Basmatibahar x Ratna plant height was controlled by 'd', 'h', 'i' and 'j', effects where as in Muskbudhi x Ratna cross it was controlled by additive dominance and all the three types of non-allelic interactions. The importance of both additive and non-additive types of gene effects were also observed by Dikshit and Mani (1988) and Chakraborty and Hazarika (1995). Duplicate type of epistasis was present in all the crosses except Basmatibahar x Ratna.

Additive type of gene action mainly controlls panicle number plant^{-1} in Kalimochi x Ratna. In rest of the three crosses, additive (d), dominance (h) and all the three types of gene interactions were present. The 'l' was negative in magnitude in cross Basmatibahar x Ratna and Muskbudhi x Ratna. (Singh *et al.*, 1996). Duplicate type of epistasis was present in Basmatibahar x Kasturi and Basmatibahar x Ratna and complementary type of epistasis in Muskbudhi x Ratna. Dikshit and Mani (1988) also observed complementary epistasis for this character.

Digenic interaction was observed in all the four crosses studied. In Basmatibahar x Kasturi and Basmatibahar x Ratna crosses panicle length was controlled by additive (d), dominance (h), additive x additive (i), dominance x dominance (l) effect and 'l' was negative in later cross. The dominant effect predominated over additive effect in Muskbudhi x Ratna. The importance of both additive and non-additive effects have been reported by Ray and Panwar (1995), and Chakravorty and Hazarika (1996). Duplicate type of epistasis was found in all the croses except Kalimochi x Ratna.

The data on number of grains panicle^{-1} showed that five parameter model was adequate for the cross Basmatibahar x Ratna and Kalimochi x Ratna and six parameter model was adequate for the rest of the two crosses. In cross Basmatibahar x Kasturi the additive effect and dominance x dominance (l) effect were positive and significant. For the rest two crosses additive (d), dominance (h) and all the three types of non-allelic interactions controlled the characer. Singh *et al.* (1996) reported similar results for this character. The 'l' was high and negatively significant in cross Basmatibahar x Ratna and Kalimochi x Ratna.

Digenic interaction model was fitted to all the crosses studied for two grain weight character. Additive (d), dominance (h) and all the three types of interactions controlled the chracter except additive x dominance (j) type in Kalimochi x Ratna. (Chakravorty and Hazarika 1996, Kumar and Mani 1998). In all the crosses the dominance effect was predominant over additive effect but negatively significant in cross Basmatibahar x Kasturi and Kalimochi x Ratna. Duplicate type of epistasis was found in all the crosses studied.

The additive-dominance model was adequate for cross Basmatibahar x Ratna and only additive gene effect controls grain length. Whereas only non-additive gene effects like dominance (h) additive x additive (i), dominance x dominance (l) type of gene effects were responsible for the inheritance of this character in Kalimochi x Ratna. In other two crosses 'd', 'h' and all the three types of non-allelic interaction controlled the character. The above findings were supported by Vivekanandan and Giridharan (1995) and Sharma and Talukdar (1998). Duplicate type of epistasis was found in all the crosses except Basmatibahar x Ratna.

Digenic interaction model was fitted to all the crosses studied for length breadth ratio. Additive, dominance and all the types of non-allelic interactionswere present in all the crosses except dominance x dominance (l) type in Basmatibahar x Ratna and additive x additive (i) type in Kalimochi x Ratna. Importance of both additive and non-additive effects were observed by Sharma and Talukdar (1998). Duplicate type of epistasis was found in all the crosses except Basmatibahar x Ratna.

For grain yield plant^{-1} six parameter model was fitted for Basmatibahar x Ratna and five parameter model to the rest of the crosses. All the gene effects 'd', 'h', 'i', 'j', and 'I' were important except 'j' type in three later crosses which fitted to five parameter model. The dominance effect was negative in magnitude in Basmatibahar x Kasturi, Muskbudhi x Ratna and Kalimochi x Ratna and 'I' was negative in Basmatibahar x Ratna. Ghorai and Pande (1982), Dikshit and Mani (1988) and Chakraborty and hazarika (1996) got similar results for this character. In all the crosses non-additive effect was more pronounced than the additive effect. Duplicate type of epistasis was observed for all the crosses.

From the present findings it was contemplated that digenic interaction was found in most of the crosses studied. However, the failure of digenic interaction model for days to 50% flowering and grain length in cross Basmatibahar x Ratna, panicle number in Kalimochi x Ratna does not preclude the absence of higher order interactions. On the other hand, in crosses like Basmatibahar x Ratna and Kalimochi x Ratna for panicle length and number of grains panicle^{-1} the fixable 'd' and 'i' type of gene effects were positive and significant which indicated the presence of sufficient genetic variability among the parental lines and possibility of improvement through selection. In the present study only one cross Muskbudhi x Ratna for panicle number showed complementary type of epistasis which can be utilized in subsequent generation by fixation in this particular cross.

The present findings also indicated the importance of both additive non-additive effects for the improvement of grain yield and its component traits. In general, the predominance of dominance effects over the corresponding additive effects indicated the importance of dominance or complete dominance effects in the inheritance of these traits. Duplicate type of epistasis in majority of the cases further confirmed the prevalence of dominance effects in the inheritance of different characters under study. The presence of significant dominant effect coupled with duplicate type of epistasis restricted the scope for simple selection for grain yield and most of the component traits studied. Non-allelic interactions with duplicate type of epistasis can be utilized effectively in pedigree breeding by delaying selection to a later generation. It is therefore, suggested that the use of biparental mating in the early segreegating generations or recurrent selection which exploit both additive and dominance gene effects for the simultaneous improvement of grain yield and important component traits in scented rice.

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