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Studies on inheritance of yield and yield components in rice

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ABSTRACT

Inheritance of seven yield and yield contributing characters was studied in three crosses viz., BPT 5204/ MTU 1081, MTU 1010/ JGL 13595 and NLR 34449/ MTU 1075. The results of scaling tests indicated the significance of epistatic interactions for all the characters in the three crosses studied. Days to 50% flowering showed significantly negative additive and additive x additive gene effects in all the crosses which can be utilized for development of early duration lines through direct selection. All the crosses exhibited significant additive and dominance effects for plant height. The dominance effects played a major role in the inheritance of the number of tillers plant^{-1}. The genetic components dominance and dominance x dominance were opposite in direction for 1000 grain weight in all crosses. For grain yield per plant, complementary epistasis was observed in MTU 1010 / JGL 13595 and NLR 34449 / MTU 1075 while duplicate epistasis was found in BPT 5204 / MTU 1081.

Key words: *rice, grain yield, inheritance, generation mean analysis, epistasis, gene action*

The inheritance of the metric traits are preliminary for planning and executing a breeding strategy leading to their genetic improvement. Generation mean analysis is a powerful statistical procedure for detection of epistasis using several basic generations from a cross between two inbred lines. In the present study, six parameter model as suggested by Hayman (1958) was applied to three crosses. Each cross is analyzed as a separate unit and the estimates were obtained. The analysis of the model gives information about six parameters *viz.,* mean (m), additive gene effects (d), dominance effects (h) and three types of non additive gene interactions like additive x additive (i), additive x dominance (j) and dominance x dominance (l). This information helps in deciding a suitable procedure for improvement of various traits. Gene action in rice has been determined mostly by using diallel method which furnishes information only on additive and dominant gene effects. Hence to study the epistatic gene effects the present study was undertaken.

MATERIALS AND METHODS

With an aim to understand non allelic components three crosses *viz.,* BPT 5204 / MTU 1081, MTU 1010 / JGL 13595 and NLR 34449 / MTU 1075 were effected during dry season 2008-09 at Maruteru. During wet season 2009-10, backcrosses (Both BC1 and BC2) were effected. Six populations (P_1,P_2,B_1,B_2,F_1 and F_2) of the three crosses were evaluated during dry season 2009-10 in a randomized block design with three replications at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station, Maruteru. Data was collected on yield components like days to 50% flowering, plant height, number of tillers plant^{-1}, number of panicles plant^{-1}, panicle length, 1000 grain weight including grain yield plant^{-1} in ten randomly selected plants in each parent 1, parent 2, F_1, and 20 plants each in BC_1, BC_2 and 50 plants in F_2in each replication The means and variances of means for six basic generations in three crosses were computed using individual plant data. The variation among the plants with in each replication was used for calculating the sampling variances (variances of mean).The generation mean analysis was carried out following the methodology of Hayman (1958). The adequacy of simple additive-dominance model was verified by scaling tests of Mather (1949).

RESULTS AND DISCUSSION

In the present investigation, all the three scaling tests were highly significant for majority of the characters under study, indicating inadequacy of additive dominance model to explain the inheritance of the characters studied.

Among six generations BC_2 of BPT 5204/ MTU 1081 flowered earliest, while F_2 of NLR 34449/ MTU 1075 flowered late. (Table1). All the F_1 populations recorded higher mean plant heights than their parental values and same was the case with F_2 progenies also. The backcross populations produced by all the three crosses under study recorded mean plant heights which tended to follow their corresponding recurrent parent. For number of tillers and panicles per plant, all the F_1 crosses averaged higher values than their parents, while the F_2 population had a mean less than the lower parent. The mean values for panicle length in F_1 generation were higher than their respective higher parent in all the three crosses studied. All the F_1 population recorded 1000 grain weights intermediate to their parent's values while F_2 progenies produced higher means than the parents and F_1s. The mean yield per plant for all the F_1s was higher than the higher parent. Among the F_2 progenies BPT 5204 / MTU1081 recorded mean value intermediate to the parents while the remaining two crosses averaged lower values than the parental means.

All the three crosses exhibited significant additive [d] and additive x additive [i] gene effects in negative direction for days to 50% flowering, which can be utilized for further improvement through direct selection (Table 2). The dominance [h] and dominance x dominance [l] effects were significant in opposite direction for all the crosses indicating duplicate type of epistasis playing a major role for this trait. Similar results were also obtained by Roy and Panwar (1993), Roy (1999), Murugan and Ganesan (2006) and Nayak*et. al.* (2007).

All the crosses exhibited significant additive and additive x additive effects for plant height at maturity which indicated scope of direct selection for improvement of this trait (Table 2). All the crosses also exhibited duplicate type of epistasis, as the signs of dominant [h] and dominance x dominance [l] gene effects which were in opposite direction. Preponderance of duplicate epistasis suggests that inheritance of this trait might pose problems in its genetic improvement, but one can expect some progress in selection programmes due to presence of substantial amount of non allelic interaction (Mather and Jinks, 1982). Verma *et.al.* (2006) reported complementary epistasis for this trait in the cross Jhona 349 / IET 12944 and duplicate epistasis in Narendra 80 / Lalmati.

The dominance effects were significant and positive which played a greater role in the inheritance of this trait which was contradictory to the observation of Mishra and Singh (1998), who reported the importance of additive gene effects. Among the interaction effects [i] and [j] characters were highly significant in BPT 5204 / MTU 1081 while the remaining crosses were highly significant for dominance x dominance [l] gene effects (Table 2). The dominance [h] and dominance x dominance [l] effects were operating in same direction indicating complementary epistasis for which only biparental mating in early segregating generations followed by selection in advanced generations would be more effective rather than direct selection in early segregating generations. Epistatic interactions were also reported by Dhirendra Singh and Katoch (1997)

All the scaling tests were significant in three crosses for number of panicles plant^{-1}. In case of BPT 5204 / MTU 1081, all the gene effects except dominance x dominance [l] component were positive and significant, whereas, in MTU 1010 / JGL 13595 all the gene effect were significant, and positive suggesting either composite or population improvement programme should be taken up for the development of superior lines with several desirable genes (Table 2). Dhirendra Singh *et. al.* (1996) also reported epistatic interactions for this trait. Kumar and Mani (1995) highlighted the importance of additive gene effects in governing the trait. In case of NLR 34449 / MTU 1075 dominance [h] and dominance x dominance [l] were predominant in same direction. Hence selection has to be postponed to later generations by reducing heterozygosity.

Both additive [d] and dominance [h] components were significant for panicle length in all the crosses studied except in MTU 1010 / JGL 13595 in which dominant component was not significant. Epistatic interactions, for all the three types of interactions were non significant in BPT 5204 / MTU

Table 1. Estimates of generation means and standard errors of three crosses for grain yield and yield components

Cross/ Generation	P_1	P_2	F_1	F_2	BC_1	BC_2
Days to 50% flowering						
C_1	117.00±1.65	77.76±1.29	81.43±1.75	61.52±2.16	73.14±1.44	65.98±2.12
C_2	89.60+1.03	95.27+ 1.37	85.00+ 1.79	97.17+ 1.40	84.60+ 1.32	93.10+ 1.03
C_3	95.00±0.60	117.07±1.21	119.60±1.90	124.08±1.36	95.83±1.64	104.93±1.54
Plant height at maturity (cm)						
C_1	92.45±1.03	93.00±0.79	101.33±1.43	103.25±0.90	94.87±0.35	92.7±0.47
C_2	96.86 + 2.36	92.10 + 2.75	102.19+2.17	100.30 + 0.82	94.60+0.60	92.82+0.53
C_3	97.09±2.37	106.89±1.75	121.45±2.20	111.38±2.14	98.17±0.82	105.62±1.07
Number of tillers plant^{-1}						
C_1	14.59±0.45	13.61±0.68	18.29±0.84	12.65±0.35	15.84±0.35	12.86±0.25
C_2	17.67±0.76	11.77±0.80	19.53±1.37	13.90±0.41	15.92±0.33	12.14±0.25
C_3	13.28±0.49	18.09±1.03	21.36±1.24	10.65±0.44	9.31±0.45	12.47±0.45
Number of panicles plant^{-1}						
C_1	11.82±0.51	12.84±0.63	17.27±0.88	9.53±0.34	13.24±0.34	11.07±0.24
C_2	16.34±0.95	10.00±0.45	18.90±1.39	9.35±0.21	13.48±0.25	7.24±0.66
C_3	11.09±0.45	15.53±1.05	17.58±1.28	9.617±0.44	10.77±0.50	11.74±0.28
Panicle length (cm)						
C_1	22.15±0.77	24.31±0.93	26.23±0.64	22.14±0.61	22.21±0.52	25.13±1.28
C_2	24.00±0.63	23.17±0.78	25.14±0.61	23.64±0.16	24.31±0.12	22.66±0.19
C_3	23.05±0.47	25.67±0.48	27.67±0.71	24.54±0.20	20.81±0.47	24.85±0.19
1000 grain weight (g)						
C_1	13.07±0.63	17.67±1.00	15.52±0.73	18.63±0.75	12.13±0.57	19.61±0.96
C_2	22.86±0.66	13.17±0.46	18.21±0.72	24.64±1.04	19.36±0.75	14.26±0.13
C_3	14.01±0.45	19.28±0.79	16.93±0.61	22.64±0.79	15.42±0.15	17.04±0.16
Grain yield plant^{-1} (g)						
C_1	16.53±0.93	20.56±1.18	29.79±1.07	18.90±0.88	11.03±0.87	19.79±1.18
C_2	22.81±1.400	18.26±1.24	36.43±1.77	13.95±0.91	15.52±1.35	14.78±1.36
C_3	18.873±1.15	24.66±1.27	36.37±1.58	17.44±0.89	1.94±1.21	15.98±1.57

C_1 = BPT 5204/ MTU 1081, C_2 = MTU 1010/ JGL 13595, C_3 = NLR 34449/ MTU 1075

1081 and additive x additive [i] component was non significant in MTU 1010 / JGL 13595 while all interactions were significant in NLR 34449 / MTU 1075. The cross NLR 34449 / MTU 1075 exhibited significant additive and additive x additive gene effects in negative side which could be utilized for further improvement through direct selection (Table 2). Verma et.al. (2006) reported the importance of both additive and dominance effects. Epistatic interactions were also reported by Dhirendra Singh *et. al.* (1996).

Significance of ABC scaling tests in all crosses except A in NLR 34449 / MTU 1075 showed all types of non allelic interactions were presented for 1000 grain weight. All the crosses exhibited significant additive and dominant effects suggesting that pedigree method can be followed for isolating good recombinants (Table 3). Significance of additive component for this trait was also reported by Kumar and Mani (1995) and Thirugnana Kumar *et. al.* (2007). Among epistatic interactions additive x additive type was significant and negative for all crosses while dominance x dominance component was significant and positive for MTU 1010 / JGL 13595 and NLR 34449 / MTU 1075. The genetic components dominant and dominance x dominance took opposite sign for this trait which indicated the presence of duplicate dominant epistasis (Kumar and Mani , 1995 and Thirugnana Kumar *et. al.* 2007). The cross MTU

Table 2. Genetic components of generation mean for yield components

Cross combination	A	B	C	m	d	h	i	j	l
Days to 50% flowering									
BPT 5204/ MTU 1081	0.032 ** ± 0.179	-2.33** ± 0.622	0.833** ± 0.907	109.08** ± 2.053	25.467** ± 2.901	-24.067* ± 10.239	-29.667** ± 10.057	12.667** ± 3.032	51.00** ± 14.729
MTU 1010/ JGL 13595	-5.4* ±2.63	5.933* ±2.937	33.8** ±6.862	97.167** ±1.4	-8.5** ±1.669	-40.7** ±6.815	-33.267** ±6.52	-5.667** ±1.877	32.733** ±9.574
NLR 34449/ MTU 1075	-22.933** ±3.856	-26.8** ±3.83	45.067** ±6.788	124.083** ±1.364	-9.1** ±2.261	-81.233** ±7.368	-94.8** ±7.086	1.933* ±2.361	144.533** ±11.309
Plant height at maturity									
BPT 5204/ MTU 1081	-4.447* ±1.902	-8.93** ±1.894	24.487**± 4.802	103.25** ±0.907	2.167** ±0.593	-29.457** ±4.13	-37.867** ±3.819	2.243** ±0.882	51.247** ±5.356
MTU 1010/ JGL 13595	-9.848** ±3.421	-8.649** ±3.661	7.864NS± 6.533	100.3** ±0.818	1.78* ±0.8	-18.652** ±4.611	-26.36** ±3.643	-0.6NS ±1.98	44.856** ±7.274
NLR 34449/ MTU 1075	-22.209** ±3.637	-17.102** ±3.546	-1.355NS ±10.08	111.383** ±2.143	-7.451** ±1.354	-18.493* ±8.372	-37.955** ±8.988	-2.553NS ±2.003	77.266** ±11.445
Number of tillers plant^{-1}									
BPT 5204/ MTU 1081	-1.193** ±0.442	-6.18** ±1.197	-14.18** ±2.349	12.65** ±0.352	2.983** ±0.435	10.99** ±1.904	6.807** ±1.656	2.493** ±0.597	0.567NS ±0.194
MTU 1010/ JGL 13595	-5.36** ±1.695	-7.02** ±1.66	-12.9** ±3.372	13.9** ±0.409	3.78** ±0.409	5.337* ±2.35	0.52NS ±1.83	0.83NS ±0.689	11.86** ±3.748
NLR 34449/ MTU 1075	-16.023** ±1.623	-14.507** ±1.86	-31.495** ±3.267	10.65** ±0.443	-3.164** ±0.645	6.638* ±2.586	0.965NS ±2.191	-0.758NS ±0.863	29.565** ±4.164
Number of panicles plant^{-1}									
BPT 5204/ MTU 1081	-2.607* ±1.236	97.967** ±1.195	-21.06** ±2.389	9.533** ±0.344	2.17** ±0.422	15.423** ±1.887	10.487** ±1.614	2.68** ±0.588	0.087NS ±2.925
MTU 1010/ JGL 13595	-8.28** ±1.759	-14.416** ±1.975	-26.743** ±3.087	9.35** ±0.207	6.237** ±8.771	9.775* ±2.218	4.047* ±1.646	3.068** ±0.885	18.649** ±4.197
NLR 34449/ MTU 1075	-7.121** ±1.697	-9.627** ±1.754	-23.306** ±3.317	9.617** ±0.442	-0.967NS ±0.583	10.832** ±2.539	6.559** ±2.116	1.253NS ±0.817	10.189* ±4.054
Panicle length (cm)									
BPT 5204/ MTU 1081	-3.967** ±1.461	-0.273 NS ±2.806	-10.345** ±3.042	22.145** ±0.619	-2.923* ±1.388	9.109* ±3.823	6.105NS ±3.719	-1.847NS ±1.515	-1.866NS ±6.331
MTU 1010/ JGL 13595	-0.53NS ±0.912	-2.989** ±1.06	-2.909NS ±1.705	23.636** ±0.158	1.647** ±0.223	0.943NS ±1.108	-0.61NS ±0.775	1.229* ±0.55	4.129* ±1.925
NLR 34449/ MTU 1075	-9.107** ±1.029	-3.653** ±0.951	-5.885** ±1.782	24.545** ±0.201	-4.04** ±0.516	-3.564* ±1.53	-6.876** ±1.308	-2.727** ±0.617	19.637** ±2.726
Test weight (g)									
BPT 5204/ MTU 1081	-4.335** ±1.504	6.026** ±2.291	12.753** ±3.55	18.634** ±0.752	-7.479** ±1.122	-10.914** ±3.869	-11.056** ±3.753	-5.181** ±1.269	9.371NS ±1.638
MTU 1010/ JGL 13595	-2.355* ±1.166	-2.86** ±0.894	26.12** ±4.483	24.64** ±1.042	5.101** ±0.758	-31.145** ±4.511	-31.335** ±4.435	0.252NS ±0.859	36.551** ±5.412
NLR 34449/ MTU 1075	-0.096NS ±0.822	-2.133** ±0.952	23.415** ±3.515	22.639** ±0.791	-1.616** ±0.223	-25.362** ±3.285	-25.645** ±3.194	1.019* ±0.51	27.874** ±3.627
Grain yield plant^{-1} (g)									
BPT 5204/ MTU 1081	-24.245** ±2.246	-10.76** ±2.852	-21.053** ±4.417	18.902** ±0.889	-8.759** ±1.467	-2.708** ±4.792	-13.951** ±4.609	-6.742** ±1.649	48.956** ±.344
MTU 1010/ JGL 13595	-28.2** ±3.524	-25.12** ±3.483	-58.135** ±5.435	13.948** ±0.916	0.737NS ±1.919	20.705** ±5.673	4.815NS ±9.406	-1.54NS ±2.136	48.505** ±9.406
NLR 34449/ MTU 1075	-31.373** ±3.116	-29.073** ±3.744	-46.504** ±5.072	17.444** ±0.892	-4.043* ±1.985	0.664NS ±5.635	-13.943** ±5.339	-1.15NS ±2.163	74.389** ±9.422

* Significant at 5% level ** Significant at 1% level

1010 / JGL 13595 clearly underlines the scope of recovering the plants showing transgressive effect due to the presence of significant additive x additive component besides duplicate epistasis. The predominant role of dominance and epistasis was also observed by Verma *et.al.* (2006)

The present study revealed the presence of non allelic interactions as all the scaling tests were found significant for grain yield per plant. The additive and dominant gene components were significant in BPT 5204 / MTU 1081; whereas additive gene effect was non significant in MTU 1010 / JGL 13595 and dominant component was non significantin NLR 34449 / MTU 1075. In BPT 5204 / MTU 1081, all the epistatic interactions were found significant. In case of MTU 1010 / JGL 13595, only dominant and dominance x dominance components were involved which indicates selection in early generation is ineffective. Complementary epistasis was observed in case of MTU 1010 / JGL 13595 and NLR 34449 / MTU 1075(Table2). Presence of both duplicate and complementary epistasis indicates that improvement of yield mainly depends upon the cross selected for improvement, for which only bi parental mating in early generations followed by selection in advance generation would be more effective than direct selection in early segregating generations. Predominance of non additive gene action was also earlier reported by Kumar and Mani (1995), Dhirendra Singh and Katoch (1997) and Verma *et.al.* (2006). In all crosses dominance x dominance component was predominant and positive which was in conformity with the findings of Mishra and Singh (1998).

The results indicated for majority of the yield and quality traits, additive, dominant and epistatic interactions were found significant indicating their complex nature of inheritance. Generally for the characters governed by non additive gene actions and epistasis, recurrent selection methods can be recommended. But these methods have certain limitations in self pollinated crops like rice, due to difficulty in crossing and seed sterility. Repeated back crossing is more rewarding to pool up the desired genes into single line. Hence biparental mating in early generation followed by selection besides, repeated back crossing will give fruitful results.

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