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Genetic analysis of grain yield and milling quality characters of two line rice hybrids

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SUMMARY

The experiment was laid out at Agricultural College and Research Institute, Madurai, Tamil Nadu. India and the materials for this study consisted of three TGMS lines *viz*., TS 29, TS 6 and GD 98013 and 11 testers *viz.*, ADT 39, ADT 41, Pusa Basmathi 1, Basmathi 370, Improved White ponni, AD 98028, GEB 24, ADT 43, ADT 45, Taroari Basmathi and Jeeraga samba. Crossing was done according to clipping and churning method in L X T fashion. Based on the nature of combining ability inferred from line x tester analysis, three cross combinations *viz*, TS 29 / ADT 41, TS 29 / Pusa Basmathi 1 and TS 29 / Basmathi 370 were selected for generation mean analysis study. The scaling tests indicated the presence of epitasis for all the characters and therefore, six parameters model was followed to estimate the various gene action. The scales A and C were negatively significant in all the crossed *viz.*, TS 29 / ADT 41, TS 29 / Pusa Basmathi 1 and TS 29 / Basmathi 370 for grains per panicle and hundred grains weight. The scale B was negatively non significant for grains per panicle and hundred grains weight in all the three crosses. The crosses TS 29 / ADT 41, TS 29 / Pusa Basmathi 1 and TS 29 / Basmathi 370 showed positively significant A and C scales for grain yield. The mean effect m was significantly positive and greater than all other effects in all the three crosses *viz.*, TS 29 / ADT 41, TS 29 / Pusa Basmathi 1 and TS 29 / Basmathi 370 for productive tillers, hundred grain weights, grain yield, hulling per cent, milling per cent and head rice recovery. A significant additive x dominance (j) effect was recorded in TS 29 / Pusa Basmathi 1 and TS 29 / Basmathi 370 crosses for grain yield and hulling per cent. A significant additive x dominance (j) was observed in TS 29 / ADT 41 cross (panicle length and milling per cent). The (h) and (l) effects took opposite signs in all the three crosses indicating the involvement of duplicate dominant epistatic kinds of interaction for productive tillers, hundred grains weight, grain yield, hulling per cent, milling per cent and head rice recovery. In general , both additive and non-additive gene effects appear to all eight characters studied. Therefore, improvement of these traits appears to be set with difficulties as simple selection techniques will not be able to fix superior lines in the early segregating generations. Postponement of selection of superior lines to later generations in pedigree breeding will be effective.

Key words : Combining ability, Pedigree breeding, Epistasis, Additive effect, Dominance, Rice

Rice has always been one of the most important food crops in the world. It is estimated that 40 per cent of the world's population take rice as their major source of food. The advent of higher yielding semi dwarf varieties has been instrumental in acheiving consistent progress in rice production in the past three decades and attaining self sufficiency. This has enabled the country to become the world's second largest producer of rice after China with a dramatic increase in rice production. China was the first country where yield barrier in semi-dwarf rice broken by successful development of hybrid rice, which yielded about 20 per cent more than the conventional varieties (Virmani *et al*.,1992). Though the three line system involving cytoplasmic male sterility-fertility restoration system to a large extent is quite effective for the development of commercial rice hybrids, this system cumbersome and tedious as it involves three lines (A, B and R) and has negative effects of cytoplasm.

A new vista in hybrid rice breeding has been opened by successful development of two line hybrids using Thermo Sensitive Genetic Male Sterile lines. It further enhances the hopes of exploiting the additional heterotic potential, which can outyield the intervarietal hybrids by 20 – 30 per cent (Virmani, 1994). Immense efforts of rice breeders made during the last ten years have enabled the country to become the second largest in the world to develop and commercialize hybrid and its technology.

Though 16 rice hybrids have been released all over India for cultivation, their spread is not commensurate with expectations. Along with other reasons, lack of consumer acceptance also added the cause for slow spread. Since rice hybrids have entered the country recently, there is a need to look in to the quality aspects so that hybrid rice can be developed coupled with improved quality characteristics. Research work on quality rice hybrids are scanty. Even though many studies have indicated the nature of gene action conditioning the quality traits are limited. But most of the quality traits are

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quantitatively inherited and need continuous efforts to combine. Hence, an attempt was made in the present study to unravel the genetic architecture of grain quality traits by involving basmati rice varieties.

MATERIALS AND METHODS

The experiment was laid out at Agricultural College and Research Institute , Madurai, Tamil Nadu, India and the materials for this study consisted of three TGMS lines *viz*., TS 6, TS 29 and GD 98013 and 11 testers *viz*., ADT 39, ADT 41, Pusa Basmati 1,Basmati 370, Improved White Ponni, AD 98028, GEB 24, ADT 43, ADT 45, Taroari Basmati and Jeeragasamba. Each of the lines and testers in three rows of 3 m length were raised during *Kharif* 2002. Three staggered sowings were taken up to have synchronisation of flowering. Crossing was done according to clipping and churning method in Line x Tester fashion.. Three panicles of male parent were used to dust one female panicle. After 20-25 days the crossed seeds were harvested. The seeds of the testers were also collected separately.

The 33 hybrids obtained by crossing three lines and 11 testers were raised in a randomized block design with two replications during *Rabi* 2004-2005.Each hybrid was accomodated in a single row of 3m length. A spacing of 20cm between rows and 15cm between plants in row was adopted. The parents were also raised in similar design in an adjacent plot with two replications as suggested by Arunachalam (1974). Observations were recorded individually on ten plants in each replication for each hybrid and parent for combining ability analysis.

Based on the nature of combining ability inferred from line x tester analysis, three cross combinations *viz*., TS 29 /ADT41 , TS 29 / Pusa Basmati 1 and TS29/ Basmati 370 were selected for generation mean analysis study. The female parent *viz*., TS 29 and the three testers *viz*., ADT 41, Pusa Basmati 1 and Basmati 370 and their corresponding F_1s were raised during summer 2006 in a crossing block with four rows of female parent and three testers and two rows of F_1s of 3m length. The parents

Plate : 1 (A) Crossing block (B) Emasculation technique
(C) Evaluation of F_4 hybrids (D) Evaluation of segregating generations

were used as females and pollen from F_1s was dusted to obtain the two back crosses B_1(back cross to P_1) B_2 (back cross to P_2 after emasculation).Fresh crosses were effected simultaneously to obtain all cross combinations (F_1s). Parental lines and F_1 were raised separately to obtain the generations P_1, P_2 and F_2. Thus, the six generations *viz*., P_1, P_2, F_1, F_2, B_1 and B_2 for all the three crosses were constituted. During *Rabi* 2006-07, the six generations of three selected crosses were raised in a row of 3 meter length spaced 20cm apart. Observations were recorded randomly on 20 plants each in P_1,P_2 and F_1 and 200 plants in F_2 and 80 plants in B_1 and B_2 (Plate 1).

RESULTS AND DISCUSSION

The scaling tests (Table 1) indicated the presence of epistasis for all the characters and therefore, six parameters model (Hayman, 1958) was followed to estimate the various gene action. All the three crosses showed negatively significant except B scale in TS29/ ADT 41 for productive tillers trait. A positive value was obtained for A scale in TS29/ADT41 cross only regarding panicle length attribute. The scales A and C were negatively significant in all the crosses *viz*., TS29/ADT41, TS29/Pusa Basmati 1 and TS29/ basmati 370 for grains per panicle and hundred grain weight. The scale B were negatively non significant for grains per panicle and hundred grain weight in all the three crosses. The crosses *viz*., TS29/ADT 41, TS29/Pusa Basmati 1 and TS29/ Basmati 370 showed positively significant A and C scales for grain yield. The scales A and C were positively significant for hulling per cent in the cross TS29/Pusa Basmati 1 only. Regarding milling per cent character all the three scales were negative in all the three crosses (TS 29/ADT41, TS 29/Pusa Basmati 1 and TS29/ Basmati 370). A significant positive C was noticed in TS29/ADT 41 only for head recovery.

The mean effect m was significantly positive and greater than all other effects in all the three crosses *viz*., TS29/ADT 41, TS29/ Pusa Basmati 1 and TS29/ Basmati 370 for productive tillers, hundred grain weight, grain yield, hulling per cent, milling per cent and head rice recovery. The mean effect m was positive and significant in all the crosses for all the characters except hundred grain weight (positive and non significant) in TS 29/Pusa Basmati 1. The additive effect (d) was positive and significant in TS29/Pusa Basmati 1 and TS29/Basmati370 for productive tillers and head rice recovery. A negative additive (d) effect was observed for panicle length, grains per panicle, hundred grains weight, grain yield, hulling per cent and milling per cent in the following crosses of TS29/ ADT41, TS29/Pusa Basmati 1 and TS29/Basmati 370.

A positive significant dominance effect (h) was observed for hundred grains weight (TS29/ADT41, TS29/ Pusa Basmati 1 and TS29/Basmati 370), panicle length (TS29/ADT 41), grains per panicle and grain yield (TS29/ Basmati 370). A positive and significant additive x additive(i) effect was observed only in TS29/ADT41 cross for panicle length. The cross TS29/Pusa Basmati 1 showed negative additive x additive (i) effect for all the characters except hundred grains weight (positive and non significant). A significant additive x dominance effect (j) was recorded in TS 29/Pusa Basmati 1 and TS29/ Basmati 370 crosses for grains per panicle, hundred grains weight, grain yield and hulling per cent. A significant positive additive x dominance effect (j) was observed in TS29/ADT41 cross (panicle length and milling per cent). In all the three crosses a positive dominance x dominance effect(l) was noticed for productive tillers, hulling per cent and head rice recovery, of which significant positive

Table 1 : Scaling tests for grain yield and milling characters

Cross	PT	PL	GPP	HGW	GYD	HP	MP	HRR
TS29/ADT41								
A	-2.89 ±0.84*	2.67±1.39	22.30±14.75*	2.13±0.09*	20.78±3.07*	-7.94±3.14*	-5.75±3.24	-9.66±2.69*
B	-2.00±1.14	-1.26±1.17	16.20±25.95	-0.43±0.23	3.30±2.57	-19.66±1.81*	-18.07±2.67*	-9.48±2.34*
C	-4.62±1.27*	-6.19±2.15*	79.13±18.29*	2.08±0.13*	31.34±4.75*	-12.41±3.15*	-29.35±5.55*	20.92±2.33*
TS29/Pusa Basmati 1								
A	-3.20± 0.85*	-3.91±1.54*	99.10±6.32*	1.60±0.25*	19.18±2.83*	3.46±1.68*	-7.95±2.99*	-3.90±1.24*
B	-2.60±1.05*	-5.74±1.22*	-5.19±12.00	-0.33±0.28	-8.13±4.82	-3.79±1.62*	-10.04±1.83*	0.66±1.07
C	-4.32±1.75*	-7.63±1.74*	180.34±18.22*	0.97±0.29*	11.77±3.20*	3.38±1.22*	-12.20±2.53*	-2.24±1.89
TS29/Basmati 370								
A	-1.89±0.67*	-0.28±2.09	124.30±18.98*	2.42±0.21*	24.87±7.80*	1.76±1.74	-3.90±2.33	-5.54±3.68
B	-1.39±0.83	-1.40±1.96	-3.60±19.60	-0.35±0.22	-5.44±6.55	-5.68±2.06*	-2.78±2.55	1.36±3.99
C	-3.73±1.85*	-2.28±0.85*	119.14±31.88*	2.07±0.41*	29.07±6.12*	-4.19±2.13*	-5.31±2.17*	-7.24±2.81*

Table 2 : Estimates of gene effects for grain yield and milling quality characters

	Cross	m	d	h	i	j	L
	TS29/ADT41	14.93±2.13*	0.35±0.18	-4.61±5.24	-0.28±2.13	-0.44±0.65	5.18±3.20
PT	TS29/PB1	15.76±2.05*	0.80±0.15*	-7.12±4.98	-1.56±2.05	-0.30±0.64	7.36±3.05
	TS29/B 370	14.00±1.93*	0.55±0.16*	-0.57±4.38	0.44±1.92	-0.25±0.48	2.86±2.59
	TS29/ADT41	15.36±2.61*	-0.83±0.35*	16.08±6.44*	7.59±2.59*	1.98±0.89*	-8.99±3.93*
PL	TS29/PB1	24.46±2.11*	-0.35±0.44	-10.31±5.71	-2.01±2.06	0.92±0.94	11.67±3.74*
	TS29/B 370	23.49±2.51*	-1.21±0.58*	-2.33±6.98	0.55±2.45	0.56±1.19	1.13±5.05
	TS29/ADT41	297.68±24.22*	-57.04±1.46*	20.67±15.09	7.40±34.19	3.04±14.82	2.14±16.74
GPP	TS29/PB1	137.29±63.26*	-50.84±1.57*	-15.12±17.26	-86.44±83.34	52.15±9.88*	-7.46±90.11
	TS29/B 370	62.69±19.55*	-64.24±4.35*	181.06±53.71*	1.55±19.20	63.95±8.88*	-122.25±4.42*
	TS29/ADT41	1.51±0.26*	-1.13±0.02*	2.20±0.74*	-0.38±0.26	1.28±0.12*	-1.32±0.49*
HGW	TS29/PB1	0.84±0.40	-1.14±0.04*	3.21±1.11*	0.29±0.40	0.96±0.18*	-1.56±0.74*
	TS29/B 370	1.35±0.22*	-1.36±0.02*	3.30±0.55*	0.01±0.22	1.39±0.08*	-2.07±0.51*
	TS29/ADT41	26.06±6.16*	-12.28±0.16*	2.25±15.20	-13.77±6.16*	12.08±1.99*	-3.79±9.26
GYD	TS29/PB1	12.63±5.61*	-11.89±0.39*	23.65±15.37*	-0.73±5.40	13.65±2.46*	-10.31±10.24
	TS29/B 370	23.21±10.97*	-13.55±0.72*	13.88±31.55	-9.65±10.94	15.15±5.04*	-9.77±20.62
	TS29/ADT41	85.91±4.67*	-2.11±0.17*	-54.43±12.30*	-15.20±4.67*	5.86±1.79*	42.81±7.80*
HP	TS29/PB1	74.70±2.63*	-2.46±0.10*	-4.32±7.41	-3.72±2.62	3.62±1.17*	4.04±4.82
	TS29/B 370	70.85±3.17*	-2.57±0.15*	-0.48±8.58	0.26±3.17	3.72±1.30*	3.65±5.58
	TS29/ADT41	59.53±6.84*	-0.88±0.37*	-9.34±16.50	5.52±6.83	6.16±2.09*	18.30±9.91
MP	TS29/PB1	70.61±4.24*	-0.69±0.23*	-26.65±11.49*	-5.79±4.23	1.04±1.75	23.78±7.37*
	TS29/B 370	65.14±3.82*	-0.43±0.16*	-8.11±10.72	-1.38±3.82	-0.55±1.68	8.08±7.05
	TS29/ADT41	45.58±4.07*	-0.41±0.42	-88.53±11.27	1.78±4.06	-0.09±1.78	17.37±7.29*
HRR	TS29/PB1	48.62±2.46*	0.75±0.19*	-5.81±6.09	-2.32±2.45	-1.62±0.82*	6.88±3.71
	TS29/B 370	39.03±6.07*	4.93±0.20*	4.58±17.15	3.06±6.07	-3.45±2.71	1.12±11.17

dominance x dominance (l) effect was observed in TS29/ Pusa Basmati1 (panicle length and milling per cent). All the three crosses showed negative and significant dominance x dominance (l) effect for hundred grains weight (Table 2 and Fig.1 - 8).

The (h) and (l) effects took opposite signs in all the three crosses indicating the involvement of duplicate dominant epistatic kind of interactions for productive tillers, hundred grains weight, grain yield, hulling per cent, milling per cent, head rice recovery traits. Several workers have studied the nature of gene action for productive tillers. Sidhu *et al*. (2001) and Hasib *et al*. (2002) observed greater additive genetic variance for productive tillers. Lang and Bu (1993) and Ram *et al*. (1998) observed

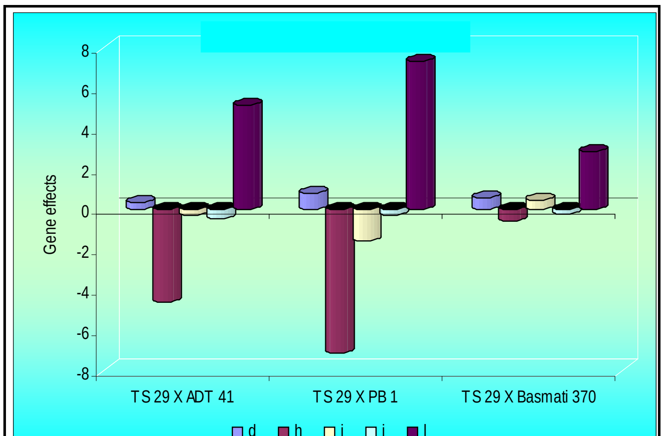

Fig. 1 : Gene effects : Productive tillers

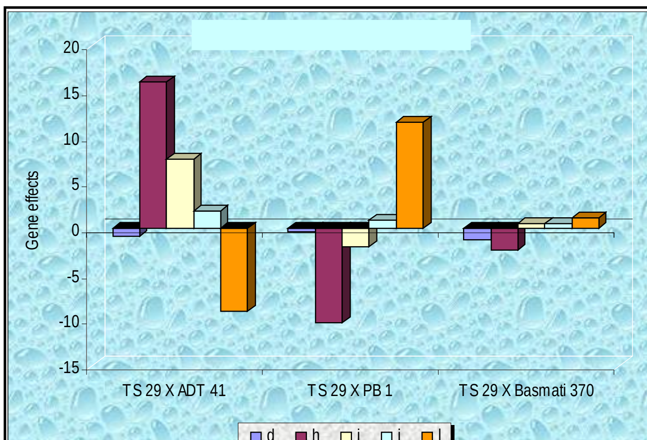

Fig. 2 : Gene effects : Productive length

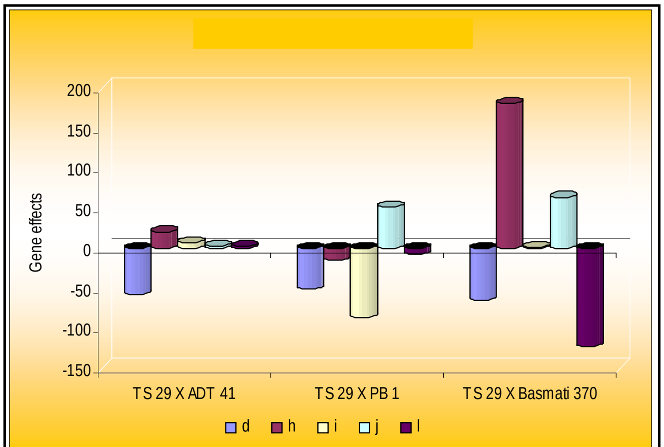

Fig. 3 : Gene effects : Grains per panicle

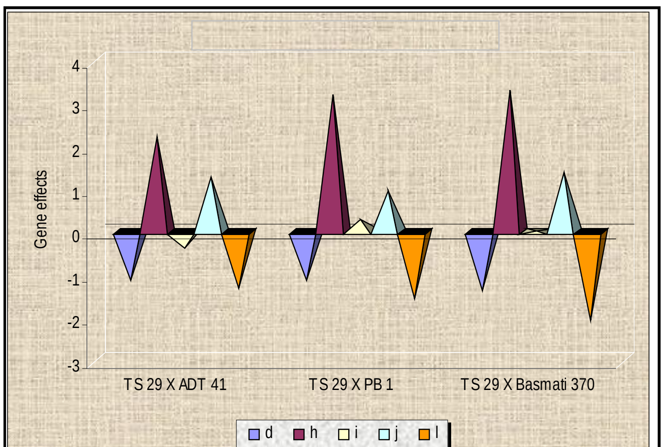

Fig. 4 : Gene effects : Hundred grains weight

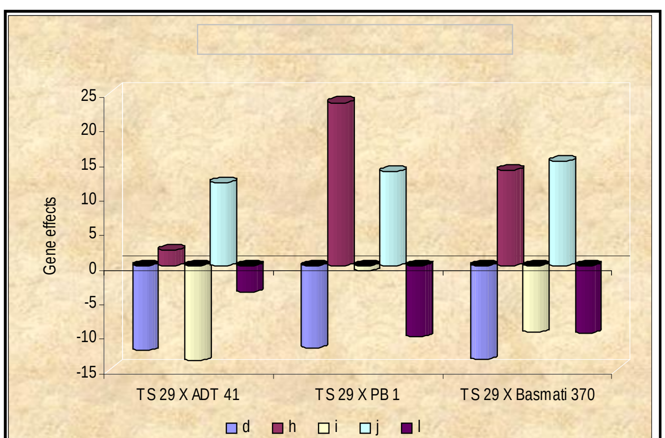

Fig. 5 : Gene effects : Grains yield

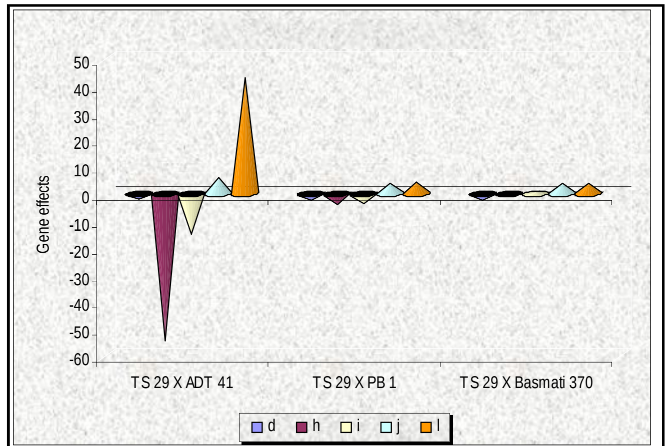

Fig. 6 : Gene effects : Hulling per cent

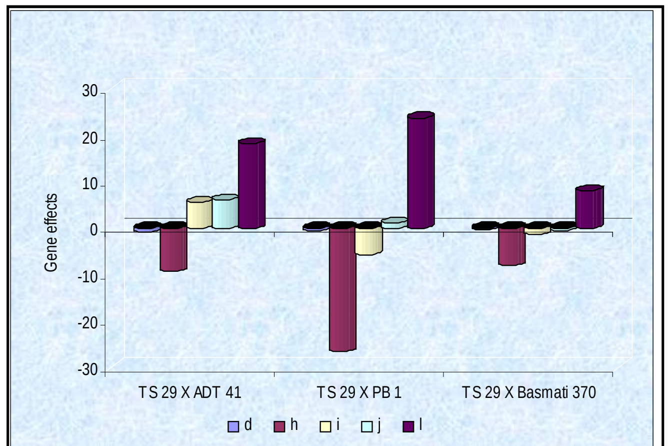

Fig. 7 : Gene effects : Milling per cent

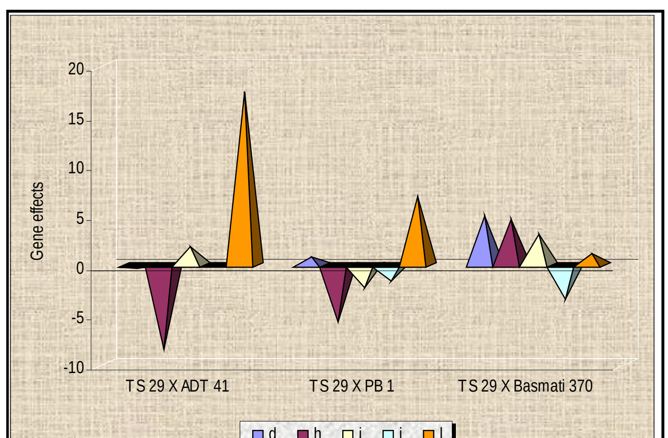

Fig. 8 : Gene effects : Head rice recovery

additive as well as non additive gene action for this trait. Dominance type of gene action was reported by Ramalingam *et al*. (1993), Rogbell and Subbaraman (1997) and Annadurai and Nadarajan (2001) for hundred grains weight. Bobby and Nadarajan (1994), Geetha *et al*. (1994), Munhot *et al*. (2000) and Annadurai and Nadarajan (2001) reported non additive genetic variance for grain yield attribute. The (h) and (l) effect revealed unlike signs in all the crosses indicating the presence of duplicate dominant interaction for hulling per cent.

Threfore, additive, dominance and epistatic interaction of all the three and duplicate type appeared to govern hulling per cent trait. Tomar (1987), Vivekanandan and Giridharan(1995), Paramasivam *et al*. (1996) and Liao *et al*. (2000) also obtained additive gene effcets for this trait.

In milling per cent trait the (h) and (l) effects had opposite signs in all the crosses indicating the presence of dominant interaction effect. The manifestation of additive gene action for this trait was reported by Tomar (1987), Vivekanandan and Giridharan (1995) and Liao *et al*. (2000). The (h) and (l) effects took opposite signs for head rice recovery attribute indicating duplicate dominant epistatic kind of interaction. The presence of additive genetic variance was earlier reported by many workers *viz*., Arumugachamy *et al*. (1993). In general, both additive and non-additive gene effects appear to all eight characters studied. Therefore, improvement of these traits appears to beset with difficulties as simple selection techniques will not be able to fix superior lines in the early segregating generations. Postponement of selection of superior lines to later generations in pedigree breeding will be effective. However, one or two cycles of recurrent selection followed by pedigree breeding will be effective and useful to utilize both additive and non additive gene effects.

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