STUDIES ON GENE ACTION AND COMBINING ABILITY ANALYSIS IN BASMATI RICE

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Manuscript received: November 2, 2005; Reviewed: July 17, 2006; Accepted for publication: August 13, 2006

ABSTRACT

Thirty-six hybrids generated from crossing three lines with twelve testers were studied along with parents for combining ability and gene action in basmati rice. The general combining ability (GCA) and specific combining ability (SCA) were significant for all the characters, indicating the importance of both additive and non-additive genetic components. But it is found that there was predominance of non-additive genetic components for expression of different traits in the present set of materials. Amongst the male parental lines, Taraori Basmati, Pusa 2503-693-1, Pusa 1235-95-73-1 and Pusa 2512-97-83-98-4 were best general combiners for grain yield along with other traits. The female cms line IR 68281A was best general combiner for grain yield along with other traits. The most promising specific combiners for grain yield and other traits were IR 68281A x UPRI 93-63-2, Pusa 3A x Taraori Basmati, Pusa 3A x UPR 2268-4-1, IR 58025A x Pusa 2511-97-107, IR 68281A x UPR 1840-31-1-1 and IR 58025A x RP 3135-17-12-88. Hence, the present study was carried out to obtain information on combining ability and gene action involved in expressing the different characters in basmati rice.

KEY WORDS: Combining ability, gene action and basmati rice

INTRODUCTION

The nature and magnitude of gene action involved in expression of quantitative traits is important for successful development of crop varieties. Also, the correct choice of parents for hybridization is crucial for development of cultivars. Combining ability analysis provides such information so as to frame the breeding programme effectively. This analysis helps in identification of parents with high general combining (GCA) and parental combinations with high specific combining (SCA). The estimation of additive and non-additive gene action through this technique may be useful in determining the possibility of commercial exploitation of heterosis and isolation of pure line among the progenies of the good hybrids. Numerous reports like Ramalingam et al. (6), Ganesan et al. (4), Ganesan and Ragaswamy (3), Bansal et al. (1) and Thirumeni (8) are available in rice for combining ability and gene action on various characters including yield. But very less information is available on this aspect in basmati rice. Hence, the present study was carried out to obtain information on combining ability and gene action involved in expressing the different characters in basmati rice.

MATERIALS AND METHODS

The experimental materials comprised of thirty-six basmati rice hybrids derived from the crossing of three cms lines with twelve basmati type male parents in line x tester fashion. The parents used as lines were Pusa3A, IR58025A and IR68281A. Pusa 2504-1-3-1, Pusa 2504-1-3-1, RP 3392-32-8-3-3, Pusa 1235-95-73-1, Pusa 2503-693-1, UPRI 93-63-2, UPR 1840-31-1-1, UPR 2268-4-1, NDR 6111, Pusa2512-97-83-98-4, Pusa 2511-97-107 and Taraori Basmati were used as testers. The hybridization work was carried out in wet season 2001. In 2002 wet season, the F_1 hybrids along with parents and two popular check varieties were grown in randomized complete block design with three replications. Thirty days old single seedling per hill was planted at a spacing of 20 X 15 cm with three-meter length row having three rows in each entry. The experiment was conducted with normal package of practices and need based plant protection measures. Observations were recorded on ten competitive plants of the middle row of each plot for twelve morphological and quality parameters. The combining ability analysis was performed following the method of Kempthorne (5).

RESULTS

The analysis of variance revealed significant differences among the lines, testers and lines x testers (Table 1). This indicated that the treatments had wide genetic diversity among themselves. Significant variances due to lines x testers interaction for all the characters suggested the presence of significant variances for SCA among hybrids. These results emphasized the importance of combining ability studies and indicated good prospects for selection of suitable parents and crosses for the development of appropriate varieties and hybrids. Estimates of highly significant GCA and SCA variances for all the characters indicated the importance of both additive and non-additive gene in the expression of the characters. The ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ was less than unity for all the characters also indicated pre- ponderence of non- additive genetic variance .It suggested greater importance of non-additive gene action in their expression and indicated very good prospect for the exploitation of non- additive genetic variation for grain and its component characters through hybrid breeding.

Estimate of GCA showed that the male parents Taraori Basmati, Pusa 2503-693-1, Pusa 1235-95-73-1 and Pusa2512-97-83-98-4 were found to be good general combiner for grain yield/plant (Table 2). High GCA effect of Taraori Basmati was associated with its high GCA effect for spikelet fertility percent. The good combining ability of line Pusa 2503-693-1 was due to high spikelet percent, high harvest index, earliness, panicle length and kernel length. Among the female parents, IR68281A was the best general combiner for grain yield/plant along with high GCA for number of spikelets / panicle, number of panicles/plant, spikelet fertility per cent, dry matter content per plant and harvest index. It was followed by Pusa3A with good GCA for grain yield/plant, harvest index, panicle length, spikelets / panicle and grain breadth.

The high general combiners for component characters were Taraori Basmati, Pusa 2503-693-1 and Pusa 1235-95-73-1 for grain yield/plant; UPRI 93-63-2 and UPR 1840-31-1-1 for short plant height; Pusa 2504-1-3-1, Pusa2512-97-83-98-4 and Pusa 1235-95-73-1 for earliness; Pusa2512-97-83-98-4, Pusa 2504-1-3-1, Taraori Basmati and UPR 2268-4-1 for spikelet fertility percent; UPR 1840-31-1-1, RP 3392-32-8-3-3 and UPRI 93-63-2 for number of panicles/plant; Pusa 2504-1-3-1, Pusa 2511-97-107 and UPR 2268-4-1 for panicle length; NDR 6111 and UPR 2268-4-1 for spikelets/panicle; Pusa 2511-97-107, Pusa 1235-95-73-1 and Pusa 2504-1-3-1 for kernel length; Pusa 1235-95-73-1, Pusa 2503-693-1 and Pusa2512-97-83-98-4 for harvest index.

The estimates of specific combining ability of 36 crosses for 12 characters are presented in Table3.It is observed that a total of 14 crosses exhibited positive and significant

Table 1: Analysis of variance for combining ability for different characters in basmati rice

Sources of Variation	PH	DF	SF	PN	PL	SN	SW	GY	GL	DM	GB	HI
Replication	9.5	1.65	5.3	13.1	0.8	23.4	5.8	61.5	000000.19	91.2	0.04	7.2
Treatment	463.6**	137.1**	2425.2**	73.4**	10.6*	5824.3**	22.1**	601.5**	0.7**	384.7**	0.04**	512.3**
Parents	337.4**	185.3**	30.3**	7.6**	8.4**	4373.9**	10.4**	75.5**	0.8**	38.6**	0.03**	77.9**
Crosses	286.2**	107.0**	2025.9**	64.5**	9.5**	4162.3**	17.4**	718.8**	0.7**	327.7**	0.04**	526.6**
Parent vs. Crosses	4116.6**	4.7**	7875.7**	2051.6**	119.4**	110966.8**	5.5**	717.2**	6.8**	8924.8**	0.001**	2471.0**
Females	3570.9**	1954.3**	3153.2**	793.9**	70.1**	4202.5**	145.6**	2548.1**	3.9**	2314.7**	0.03**	2313.8**
Males	512.4**	61.8**	3407.7**	55.5**	5.7**	5218.2**	17.3**	674.9**	0.8**	412.4**	0.05**	762.2**
Females x Males	253.0**	67.7**	1228.6**	49.3**	7.2**	3253.8**	18.1**	512.8**	0.5**	237.2**	0.03**	412.6**
Error	56.6	0.4	13.4	4.4	0.5	290.4	8.5	9.2	0.3	18.3	0.02	7.6
σ^2_{gca}	50.15	34.13	53.02	11.4	1.78	46.96	2.7	39.4	0.04	33.88	0.4	37.16
σ^2_{sca}	95.46	37.81	689.43	31.96	3.93	1561.13	9.87	282.8	0.27	146.08	0.1	196.00
$\sigma^2_{gca}/\sigma^2_{sca}$	0.48	0.90	0.08	0.39	0.27	0.03	0.33	0.13	0.18	0.23	0.00	0.16

PH-Plant height (cm), DF-Days to 50% flowering, SF-Spikelet fertility%, PN-Panicle number/plant, PL-Panicle length,
SN-Spikelets / Panicle, SW-1000-seed weight, GY-grain yield/plant, GL-Grain length, GB-Grain breadth, DM-Dry matter/plant, HI-Harvest index%

SCA for grain yield/plant The promising combinations for grain yield along with other traits were IR68281A x UPRI 93-63-2,Pusa3A x Taraori Basmati, Pusa3A x UPR 2268-4-1,IR58025A xPusa2511-97-107, IR68281A x UPR1840-31-1-1 and IR58025A x RP3135-17-12-88.It is observed that majority of the crosses with high SCA for grain yield were involved with high/low or average/low combining parents. But very few crosses showing low/low general combiners showed high SCA.

The cross combinations showing high negative SCA for days to panicle emergence (earliness) were IR58025A xRP3135-17-12-88 and IR68281A x NDR 6111. For plant height, negative estimates of SCA are desirable and the good specific combiners were IR68281A x Taraori Basmati and Pusa3A x RP 3135-17-12-88.The cross combinations viz., Pusa 3A x Pusa2511-97-107 and IR58025A x Pusa2512-97-83-98-4 were good specific combiners for panicle length. The best specific combiners for number of grains/panicle were IR58025A x Pusa2512-97-83-98-4 and IR58025A x RP3135-17-12-88.The cross combinations viz., IR58025A x RP3135-17-12-88, IR58025A x Pusa2511-97-107 and IR68281A x UPRI 93-63-2 showed higher SCA for spikelet fertility. For number of panicles/plant, the cross of Pusa3A x RP3135-17-12-88, IR68281A x Pusa2503-693-1 and IR68281A x UPR1840-31-1-1 exhibited high specific combining ability for the trait. Cross IR68281A x UPRI 93-63-2 and IR58025A x RP3135-17-12-88 showed high SCA for harvest index. Good specific combiners for long kernel were IR68281A x Pusa2512-97-83-98-4 and IR68281A x Taraori Basmati while IR68281A x UPRI 93-63-2 and IR68281A x Pusa2504-1-3-1 for low kernel breadth.

DISCUSSION

The significant differences among the lines, testers and lines x testers indicated that the treatments had wide genetic diversity among themselves. Also, Significant variances due to line x testers interaction for all the characters suggested the presence of SCA variances among hybrids. Presence of highly significant GCA and SCA variances for all the characters indicated the importance of both additive and non-additive gene in the expression of the characters. The ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ was less than unity for all the characters also indicated pre- ponderence of non- additive genetic variance .It suggested greater importance of non-additive gene action in their expression and indicated very good prospect for the exploitation of non- additive genetic variation for grain and its component characters through hybrid breeding. Importance of non-additive gene for expression of different traits have also been reported by Ganesan, et

Table 2: Estimates of general combining ability of parents

Name of the genotypes	PH	DF	SF	PN	PL	SN	SW	GY	GL	DM	GB	HI	Combiner for yield
LINES													
Pusa 2504-1-3-1	-0.91	-4.71**	24.76**	-4.36**	1.11**	-4.74	1.94*	1.48	0.48**	-8.11**	0.10**	.72**	A
RP 3135-17-12-88	8.87**	-2.16**	-9.81**	-0.51	-1.08	-32.51**	-1.03	-11.19**	-0.59**	1.33	0.04**	-10.28**	L
RP 3392-32-8-3-3	-7.69**	-0.16	-11.99**	4.93**	-0.94**	-3.18	-0.42	3.48**	-0.42**	15.89**	0.10**	-2.03**	G
Pusa 1235-95-73-1	-4.46	-3.60**	16.68**	-2.74**	-0.45**	8.04	1.4	13.15**	0.49**	-7.67**	0.13**	16.84**	G
Pusa 2503-693-1	4.76*	-1.16**	16.76**	0.93	0.52**	-10.74	-0.97	14.81**	0.25**	-2.89*	0.01	14.83**	G
UPRI 93-63-2	-14.02**	-0.49**	-20.68**	4.60**	-0.59**	-11.96*	1.76*	1.15	-0.14**	11.89**	0.00	-11.71	A
UPR 1840-31-1-1	-12.46**	0.95**	-11.56**	5.49**	-1.65**	-29.07**	-1.05	-3.41**	0.09	-1.56	-0.09**	-5.57**	L
UPR 2268-4-1	0.86	-2.94*	23.47**	2.26**	0.60**	22.37**	-2.31**	5.48**	-0.13**	0.67	-0.05**	5.19**	G
NDR 6111	-1.57	4.73**	-37.42**	-2.29**	-1.04**	72.63**	-1.92*	-9.08**	0.32**	6.56**	0.05**	-9.26**	L
Pusa2512-97-83-98-4	-1.02	-4.38**	25.34**	-1.85**	-0.34**	-13.63*	6.41**	9.37**	0.30**	-3.78**	0.04**	12.19**	G
Pusa 2511-97-107	-0.80	-1.60**	-7.72**	-1.18	0.68**	-15.63**	1.03	-2.08*	0.65**	-1.11	0.06**	1.24	L
Taraori Basmati	15.98**	4.17**	23.87**	-2.85	-0.15	-4.5	-0.81	17.48**	-0.05	1.33	-0.04*	12.22**	G
SE (sgi) male	2.41	0.18	1.07	0.70	0.23	5.46	0.78	0.83	0.05	1.24	0.02	0.72	
SE (sgi-sgj)	3.30	0.25	1.51	0.99	0.32	7.45	1.1	1.19	0.07	1.76	0.02	1.02	
TESTERS													
Pusa 3A	5.22**	3.95**	-4.32**	-0.42	1.21**	5.70**	1.58**	-2.91**	0.25**	4.74**	0.03*	-5.72**	L
IR 58025A	-7.43**	-6.14**	-3.87**	-2.89**	-0.98**	-8.86**	0.07	-4.43**	-0.21**	-5.81**	0.00	0.12	L
IR 68281A	2.28**	2.25**	8.15**	3.32**	-0.04	3.43*	-1.62**	7.11**	-0.16**	1.31**	-0.09**	5.62**	G
SE (sgi) female	0.71	0.07	0.34	0.26	0.09	1.9	0.35	0.32	0.06	0.42	0.00	0.26	
SE (sgi-sgj)	0.98	0.12	0.51	0.36	0.14	2.35	0.38	0.39	0.08	0.52	0.04	0.40	

PH-Plant height, DF-Days to 50%flowering, SF-Spikelet fertility %, PN-Panicle number/plant, PL-Panicle length, SN-Spikelets / Panicle, SW-1000-seed weight, GY-grain yield/plant, GL-Grain length, GB-Grain breadth, DM-Dry matter/plant, HI-Harvest index%, L-low, A-Average and G-good

Table 3: Estimates of specific combining ability of crosses for various characters

F_1 hybrids	PH	DF	SF	PN	PL	SN	SW	GY	GL	DM	GB	HI	GCA of parents
Pusa3AxPusa 2504-1-3-1	-7.83	0.68*	8.81**	3.84**	-0.48	8.25	-3.16*	4.80**	-0.32**	8.98**	-0.05	-0.72	L/A
Pusa3AxRP3135-17-12-88	-14.95**	-0.21	-17.86**	6.40**	0.48	41.37**	-0.53	-1.54	-0.82**	14.87**	0	-4.45**	L/L
Pusa3AxRP3392-32-8-3-3	0.28	-3.88**	-13.71**	-1.38	0.44	-5.97	1.89	-1.2	0.01	13.64**	-0.05	-2.70*	L/G
Pusa 3A x Pusa 1235-95-73-1	-3.28	-1.77**	15.49**	-1.71	-0.18	-23.86*	2.47	-2.2	0.20*	-12.13**	0.01	7.79**	L/G
Pusa 3A x Pusa 2503-693-1	5.17	0.12	15.44**	-4.71**	-0.16	-7.08	-1.45	1.13	0.11	-6.91**	0	5.74**	L/G
Pusa 3A x UPRI 93-63-2	-6.72	0.45	-19.42**	-6.71**	-0.05	-2.19	-3.55*	-22.54**	-0.23**	-12.02**	-0.05	-12.22**	L/A
Pusa 3A x UPR 1840-31-1-1	3.72	2.01**	-2.87	-11.27**	-0.95*	0.59	-1.41	1.35	0.21*	-14.24**	0.04	16.24**	L/L
Pusa3A x UPR 2268-4-1	5.39	1.90**	4.43*	1.96	1.70**	-11.52	0.98	16.80**	0.22**	0.87	-0.01	12.68**	L/G
Pusa 3A x NDR 6111	3.17	-0.77*	9.99**	-0.49	-2.16**	-57.75**	-0.87	-1.65	0.41**	-1.69	-0.11**	-0.47	L/L
Pusa 3AxPusa2512-97-83-98-4	-2.39	-0.99**	-1.27	0.4	-1.29**	-25.52**	11.53**	2.91*	0.19*	-7.69**	0	7.05**	L/G
Pusa3A xPusa 2511-97-107	-3.61	5.23**	-29.01**	1.07	2.09**	16.14	1.91	-2.31	0.08	9.98**	-0.02	-5.54**	L/L
Pusa3Ax Taraori Basmati	25.61**	5.45**	-1.43	3.07*	1.19**	-12.19	-1.75	26.80**	-0.02	15.87**	0.08**	8.45**	L/G
IR 58025A x Pusa 2504-1-3-1	4.1	-2.40**	-5.96**	-2.70*	0.34	23.13*	0.54	10.57**	0.37**	1.03	-0.13**	7.94**	L/A
IR 58025A x RP 3135-17-12-88	1.99	-9.29**	49.81**	-1.48	0.26	45.24**	-2.76*	12.90**	0.50**	-9.08**	-0.14**	18.80**	L/L
IR 58025A x RP 3392-32-8-3-3	2.88	6.71**	-5.18**	3.08*	0.46	14.57	-0.14	2.90*	0.30**	2.03	0.07*	-2.14	L/G
IR 58025A x Pusa1235-95-73-1	3.65	0.16	0.95	-3.25**	0.77*	-11.31	-0.9	5.23**	-0.04	4.59*	0.04	0.95	L/G
IR 58025A x Pusa 2503-693-1	-1.9	-2.29**	6.08**	-2.25	-0.01	-11.54	0.78	-8.77**	0.07	-10.19**	-0.01	1.79	L/G
IR 58025A x UPRI 93-63-2	-3.79	-0.96**	-17.16**	3.41**	-1.70**	-9.65	-1.99	-16.43**	0.06	5.37*	-0.20**	-11.80**	L/A
IR 58025A x UPR 1840-31-1-1	-14.01**	-3.73**	-28.94**	5.86**	0.34	14.13	0.26	-17.54**	0.1	-2.19	0.06*	-24.24**	L/L
IR 58025A x UPR 2268-4-1	-0.35	-4.84**	-4.87*	-5.59**	-0.05	18.69*	0.45	-11.43**	0.08	-9.08**	-0.12**	-4.93**	L/G
IR 58025A x NDR 6111	-0.57	6.16**	1.69	0.97	1.59**	22.46*	1.16	8.46**	-0.16	-2.63	0.11**	7.85**	L/L
IR58025AxPusa2512-97-83-98-4	6.88	-1.40**	15.03**	-3.48**	1.96**	54.35**	-2.58	3.01*	0.58**	-3.3	-0.04	4.74**	L/G
IR 58025A x Pusa 2511-97-107	4.32	-4.51**	41.05**	-3.81**	1.50**	21.35*	2.51	16.46**	0	-5.97**	0.10**	17.08**	L/L
IR 58025A x Taraori Basmati	-7.46	-2.96**	19.40**	3.52**	0.57	18.69*	-0.22	0.57	-0.63**	-2.41	-0.06*	2.74*	L/G

PH-Plant height, DF-Days to 50%flowering, SF-Spikelet fertility%, PN-Panicle number/plant, PL-Panicle length, SN-Spikelets / Panicle, SW-1000-seed weight, GY-grain yield/plant, GL-Grain length, GB-Grain breadth, DM-Dry matter/plant, HI-Harvest index%, L-low, A-Average and G-good al. (4), Ramalingam et al. (6), Ganesan and Rangaswamy (3), Bansal et al. (1) and Thirumeni (8).

Among the male parents Taraori Basmati, Pusa 2503-693-1, Pusa 1235-95-73-1 and Pusa2512-97-83-98-4 were found to be good general combiner for grain yield/plant. These parents can be used in the hybridization programme to harness more heterosis. IR68281A was only good general combiner single plant yield among the female lines. All varieties were not good general combiners for the component traits. Varieties like UPRI 93-63-2 and UPR 1840-31-1-1were good combiner for short plant height. Taraori Basmati, Pusa 2503-693-1 and Pusa 1235-95-73-1 for grain yield/plant like wise Pusa 2504-1-3-1, Pusa2512-97-83-98-4 and Pusa 1235-95-73-1 for earliness. Therefore, It suggested the importance of multiple crosses or recurrent selection allowing random mating facilitated by cms system.

IR68281A x UPRI 93-63-2,Pusa3A x Taraori Basmati, Pusa3A x UPR 2268-4-1,IR58025A xPusa2511-97-107, IR68281A x UPR1840-31-1-1 and IR58025A x RP3135-17-12-88 were good cross combinations with high SCA for grain yield. Majority of these crosses were involved with high/low or average/low combinations indicating additive x dominance type of gene interactions for expression of traits. But very few crosses showing low/low general combiners showed high SCA, suggesting the epistatic gene action may be due to genetic diversity in the form of heterozygous loci. Thus, in majority of the crosses, high SCA for grain yield were attributed to dominance and epitasis gene action. Similar results have also been reported by Shrivastava and Seshu (7), Dwivedi et al. (2).

CONCLUSION

From the study it is revealed that the importance of non-additive gene action in their expression and indicated very good prospect for the exploitation of non- additive genetic variation for grain and its component characters through hybrid breeding. Amongst the parental lines, Taraori Basmati, Pusa 2503-693-1, Pusa 1235-95-73-1, Pusa2512-97-83-98-4 and IR68281A were best general combiners for grain yield along with other traits. The most promising specific combiners for grain yield and other traits were IR68281A x UPRI 93-63-2,Pusa3A x Taraori Basmati, Pusa3A x UPR 2268-4-1,IR58025A x Pusa2511-97-107, IR68281A x UPR1840-31-1-1 and IR58025A x RP3135-17-12-88.Also, it is revealed that the good x good general combiners exhibiting high SCA can be utilized for improvement through single plant selection in segregating generations. But in crosses having high SCA due to good x poor general combiners have to be improved through population improvement. The crosses showing high SCA involving poor x poor general combiners may be exploited for heterosis breeding programme.

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