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Combining ability studies for yield and yield components in Basmati rice

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ABSTRACT

Five genetically diverse varieties viz., Sanwaal Basmati, Super Basmati, Pusa 2517-2-51-1, P1121-92-8-1-1-3-3 and PAU 2935-16-3-5-2 were crossed with three well adapted varieties, Ranbir Basmati, Pusa Basmati 1 and Basmati 370 in a line x tester design. The preponderance of dominant gene action was observed for plant height, effective tillers plant^{-1}, panicle length, number of grain panicle^{-1}, spikelet sterility, 1000-grain weight and grain yield plant^{-1}. Pusa 2517-2-51-1, Sanwaal Basmati, Super Basmati, Ranbir Basmati and Basmati 370 were found to be good general combiners which can be taken up to generate desirable segregates for further selection. High sca effects were observed in the crosses, Super Basmati / Ranbir Basmati, Pusa 2517-2-51-1 / Pusa Basmati 1, P1121-92-8-1-1-3-3 / Ranbir Basmati and PAU 29-35-16-3-5-2 / Basmati 370. The crosses Pusa 2517-2-51-1 / Pusa Basmati 1, P1121-91-8-1-1-3-3 / Ranbir Basmati and PAU 2935-16-3-5-2 / Basmati 370 found to be the best for grain yield and its components which can be used for exploitation of heterosis for yield.

Key words: Combining ability, gca, sca, grain yield, Basmati rice

The combining ability studies of the parents and their crosses provide information for the selection of high order parents for effective breeding. Success of any plant breeding programme depends on the choice of right type of genotypes as parents in the hybridization programme. Combining ability analysis provides information on two components of variance viz., additive and dominance variance. Its role is important to decide parents, crosses and adoption of appropriate breeding procedures to be followed to select desirable segregants. Although, there is an urgent need to initiate a systematic hybridization programme in Basmati rice, the progress in the direction is very slow due to lack of information of the combining ability of the promising indigenous varieties of north-west India. Therefore, the present investigation was undertaken to select right type of Basmati varieties as parents in the hybridization programme and the appropriate breeding procedures to be followed involving indigenous and exotic promising Basmati varieties.

MATERIALS AND METHODS

Eight indigenous and exotic promising Basmati varieties were selected on the basis of their diversity for various quantitative characters. Five genetically diverse varieties (Sanwaal Basmati, Super Basmati, Pusa 2517-2-51-1, P1121-92-8-1-1-3-3 and PAU 2935-16-3-5-2) were crossed as female parents with three well adapted varieties (Ranbir Basmati, Pusa Basmati 1 and Basmati 370) as pollinator in a line x tester design (Kempthorne, 1957). Thus, the experimental material comprised of 23 entries including 15 crosses and their eight parents. The F_1s and their parents were grown in the field at the Research Farm of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Science and Technology, Jammu of Jammu and Kashmir during wet season 2005 in a complete randomized block design with three replications. Each plot consisted of single row of 5m length with spacing of 20cm between rows and 15 cm between plants. Single seeding hill^{-1} was

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planted to raise the Basmati rice crop. All the recommended cultural practices were followed to obtain normal growth of the crop.

Observations were recorded on 10 plants selected randomly from each row for 11 characters viz., plant height, days to 50 percent flowering, seedling vigour, effective tillers plant^{-1}, panicle exsertion, panicle length, days to maturity, number of grains panicle^{-1}, spikelet sterility, 1000-grain weight and grain yield plant^{-1}. Data were recorded for days to 50 percent flowering and days to maturity on plot basis in the field. The mean values of all these 11 characters were used for combining ability analysis as suggested by Kempthorne (1957). The observations were recorded for these traits using standard evaluation system of IRRI (1988).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the entries in respect of all the characters (Table 1). The parents involved in the study also differed significantly indicating considerable diversity among them. Significant differences were observed for parents versus crosses for all the characters, except days to 50 percent flowering and 1000-grain weight which may be due to expression of heterosis for these characters. Significant differences for plant height, days to 50 per cent flowering, seedling vigour and days to maturity (testers); for plant height, days to 50 percent flowering, seedling vigour and days to maturity (lines), and for all the characters due to crosses, except 1000-grain weight showed wide range of diversity for these characters. Mean sum of squares due to line x tester interactions were significant for all the characters, except 1000-grain weight.

The partitioning of combining ability variance into fixable and non-fixable variances indicated both additive and non-additive gene action playing a significant role in controlling the expression of all the characters. The preponderance of dominance (non-additive) gene action for plant height, effective tillers plant^{-1}, panicle length, number of grain panicle^{-1}, spikelet sterility, 1000-grain weight and grain yield plant^{-1} with the exception for days to 50 per cent flowering (Table 1) for which additive gene action played a major role. The gene actions of the present study are in conformity with Vijay Kumar *et al.* (1994),

Table 1. Analysis of variance for line x tester in Basmati rice

Source	df	Plant height	Days to 50% flowering	Seedling vigour	Panicle exsertion	Effective tillers plant^{-1}	Panicle length	No. of grains panicle^{-1}	Spikelet sterility	1000-grains weight	Grain yield plant^{-1}	Days of maturity
Replication	2	2.0**	2.2**	0.3	0.001	0.08	1.5*	165.5**	3.3**	2.3	0.2	3.7
Treatments	22	859.1**	33.0**	3.4**	1.9**	2.67**	5.0**	2981.0**	2.0**	1.5	3.7**	368.1**
Parents	7	460.1**	35.8**	4.2**	1.4**	1.4**	3.4**	66.2*	2.3**	1.3	5.0**	390.2**
Parents vs Crosses	1	310.1**	0.001	10.6**	2.8**	36.5**	13.9**	51081.1**	0.5**	0.8	29.9**	600.7**
Crosses	14	497.8**	34.0**	2.9**	3.0**	1.3**	5.1**	1002.7**	2.0**	1.6	1.1**	271.3**
Lines (Female)	4	375.9	41.8**	5.0**	3.1	0.4	8.2	801.5	0.1	1.5	0.5	303.4**
Testers (Male)	2	209.6	150.8**	11.4**	3.7	1.8	4.1	1205.2	0.9	4.1	0.09	988.5**
L x T	8	630.8**	0.9**	1.2**	2.9**	1.6**	3.8**	1052.2**	3.3**	1.1	1.8**	60.4**
Error	44	0.3	0.3	0.29	0.001	0.31	0.41	27.6	0.1	0.2	0.4	3.9
s^2 gca		5.3	10.6	0.11	0.001	0.03	0.01	42.1	0.01	0.2	0.007	6.1
s^2 sca		52.7	0.6	0.27	-	1.5	3.46	579.8	2.9	1.7	2.0	18.4
s^2 gca / s^2 sca		0.1	15.6	0.40	-	0.02	0.005	0.07	0.004	0.1	0.003	0.33

* and ** significant at P=0.05 and 0.01 levels, respectively

Satyanarayana *et al.* (2000) and Janardhanam *et al.* (2000) for effective tillers plant^{-1}, number of grains panicle^{-1}, 1000-grain weight and grain yield plant^{-1}; Sarawgi *et al.* (1991) for tillers plant^{-1}; Chakraborty *et al.* (1994) for plant height; Roy and Panwar (1995) for panicle length and Anand Kumar *et al.* (2006) for number of tillers plant^{-1}, panicle length and grain yield plant^{-1}.

All the parents with significant negativ general combining ability (gca) estimates for days to 50 percent flowering, plant height and days to maturity and with significant positive gca effects for the remaining characters are considered as good general combiners. The parents with significant positive gca effects for days to 50 percent flowering, plant height and days to maturity are considered as poor general combiners. The parents with non-significant gca estimates for all the characters were considered as average general combines. The results (Table 2) indicated that Pusa 2517-2-51-1 was the best combiner for grain yield plant^{-1}, followed by Sanwaal Basmati, Super Basmati, Ranbir Bansmati and Basmati 370. These genotypes were also good combiners for plant height and grains pancle^{-1} with exception of Basmati-370. Pusa 2517-2-51-1 and Sanwaal Basmati were good combiners for days to 50 percent flowering and days to maturity. Pusa 2517-2-51-1 alone was good combiner for effective tillers plant^{-1} and panicle length. Likewise Basmati 370 was also a good combiner for panicle length and 1000-grain weight. It may be suggested that in a multiple crossing programme involving Pusa 2517-2-51-1, Sanwaal Basmati, Super Basmati, Ranbir Basmati and Basmati 370 as parents may to taken up to generate desirable segregates for selection.

Out of fifteen crosses, four were identified as the specific good combinations for grain yield plant^{-1} (Table 3). These were Super Basmati / Ranbir Basmati followed by Pusa 2517-2-51-1 / Pusa Basmati 1, P1121-92-8-1-3-3 / Ranbir Basmati and PAU 2935-15-3-5-2 / Basmati 370. The cross, Super Basmati / Ranbir Basmati, the best specific combination for grain yield plant^{-1}, was also good with high sca effects for effective tillers plant^{-1}, panicle length, reduced spikelet sterility, grains panicle^{-1}, and days to maturity. The cross, Pusa 2517-2-51-1/Pusa Basmati 1 showed significantly positive sca effect for grain yield plant^{-1} might be due to good specific combination for grains pancile^{-1}, 1000-

Table 2. General combining ability (gca) effects of parents in Basmati rice

Parents	Plant height (cm)	Days to 50% flowering (No.)	Seedling vigour (%)	Panicle exsertion (%)	Effective tillers plant^{-1} (No.)	Panicle length (cm)	Grains panicle^{-1} (No.)	Spikelet sterility (%)	1000-grains weight (g)	Grain yield plant^{-1} (g)	Days of maturity (No.)
Lines											
Pusa 2517-2-51-1	-2.53**	-2.22**	-0.70**	0.20**	0.37**	1.65**	10.64**	-0.23	-0.06	1.52**	-7.80**
P1121-92-8-1-3-3	-8.40**	1.00**	-0.80**	0.40**	0.004	-0.41**	1.27	0.08	-0.46**	0.01	-2.60**
PAU 2935-16-3-5-2	-4.76**	-1.77**	0.20	-0.70**	-0.12	-0.13	-12.04**	-0.06	0.64**	0.41	-2.00**
Super Basmati	-7.63**	1.33**	1.60**	1.20**	-0.05	-0.79**	7.00**	0.09	-0.23	0.54*	1.20**
Sanwaal Basmati	2.99**	-2.77**	0.40**	0.10**	-0.19	-0.31	6.90**	0.12	0.11	0.55**	-0.50**
SE±	0.22	0.14	0.20	-0.001	0.17	0.19	1.66	0.12	0.13	0.25	0.40
Testers											
Ranbir Basmati	-2.31**	3.26**	0.60**	-0.30**	-0.17	0.12	6.48**	-0.11	0.01	0.52*	2.00**
Pusa Basmati 1	-2.00 **	0.20	-0.001	0.20 **	-0.22	-0.58 **	10.23**	-0.17	-0.53 **	-0.13	-5.10**
Basmati 370	4.31**	3.06**	0.50**	0.40**	-0.40	0.45**	-3.74**	0.28**	0.52**	0.51*	3.20**
SE±	0.17	0.11	0.10	0.001	0.13	0.15	1.28	0.09	0.10	0.20	0.30
SE (g_i-g_j) lines	0.32	0.21	0.30	0.0001	0.24	0.27	2.35	0.17	0.19	0.36	0.60
SE (g_i-g_j) testers	0.24	0.16	0.10	0.0001	0.18	0.21	1.82	0.13	0.14	0.28	0.50

*and** significant at P=0.05 and 0.01 levels, respectively

Table 3. Specific combining ability (sca) effects of the crosses in Basmati rice

Parents	Plant height (cm)	Days to 50% flowering (No.)	Seedling vigour (%)	Panicle exsertion (%)	Effective tillers plant^{-1} (No.)	Panicle length (cm)	Grains panicle^{-1} (No.)	Spikelet sterility (%)	1000-grains weight (g)	Grain yield plant^{-1} (g)	Days of maturity (No.)
Pusa 2517-2-51.1 / Ranbir Basmati	-4.63**	-0.28	0.03	-0.28**	0.04	-0.36	0.77	-0.18	0.42	-0.57	3.94**
P1121-92-8-1-1-3-3 / Ranbir Basmati	-1.22**	0.60*	-0.60	1.00**	-0.22	-0.12	2.98*	-1.43**	0.72**	0.98*	1.61‘
PAU 2935-16-3-5-2 / Ranbir Basmati	-0.06	-0.28	0.20	-1.24**	0.44	-1.23**	1.27	0.22	-0.64**	-0.32	-1.80**
Super Basmati / Ranbir Basmati	5.43**	0.26	0.61	-0.30**	0.93**	1.25**	16.38**	-0.87**	-0.03	1.05*	-3.45**
Sanwaal Basmati / Ranbir Basmati	0.48	-0.28	0.81*	0.10**	0.67*	0.47	17.32**	-0.14	0.14	-0.60	1.85**
Pusa 2517-2-51-1 / Pusa Basmati 1	-7.84**	-0.08	1.20**	1.22**	-0.37	-0.42	23.60**	-0.68**	-0.83**	0.99*	-6.05**
P1121-92-8-1-1-3-3 / Pusa Basmati 1	-14.03**	-0.86**	0.88*	-0.87**	0.12	-0.52	14.29**	-0.20	-0.36	-0.18	1.18
PAU 2935-16-3-5-2 / Pusa Basmati 1	17.45**	0.24	-0.40	0.12**	-0.77*	0.53	-2.90	0.84**	0.90**	-0.55	3.48**
Super Basmati / Pusa Basmati 1	9.72**	0.46	0.71*	-0.42**	0.55*	-0.70	24.02**	-0.37	-0.08	-0.35	4.12**
Sanwaal Basmati / Pusa Basmati 1	-5.30**	0.24	0.58	1.06**	0.46	1.11**	-11.79**	0.42	0.38	0.64	-1.74**
Pusa 2517-2-51-1 / Basmati 370	12.47**	0.37	1.31**	1.41**	0.32	0.78*	22.83**	0.87**	0.41	-0.29	0.66‘
P1121-92-8-1-1-3-3 / Basmati 370	15.25**	0.26	-0.07	3.01**	0.09	0.64	-11.30**	-1.23**	0.24	-0.39	0.51
PAU 2935-16-3-5-2 / Basmati 370	-17.39**	0.04	0.32	0.23**	0.32	0.70*	11.63*	-0.62**	-0.25	0.97*	-1.15
Super Basmati / Basmati 370	-15.15**	-0.73**	-0.75	0.18**	0.38	-0.54	-7.63*	1.25**	0.12	-0.61	5.24**
Sanwal Basmati / Basmati 370	4.82**	0.04	-0.61	-0.10**	-1.13**	-1.58**	-5.52	-0.27	-0.53*	0.38	-0.72
SE±	0.39	0.25	0.30	0.0001	0.29	0.34	2.88	0.21	0.23	0.33	0.87
SE (S_{ij}-S_{kij})	0.55	0.36	0.44	0.0002	0.42	0.48	4.07	0.31	0.32	0.61	1.21

*and** significant at P=0.05 and 0.01 levels, respectively grain weight, plant height and days to maturity. The cross P1121-92-8-1-1-3-3/ Ranbir Basmati, the third best specific combination for grain yield plant^{-1}, was also a good specific combination for grains panicle^{-1}, panicle length, reduced spikelet sterility and plant height. Thus, all these crosses were found to be outstanding with respect to grain and its contributing traits.

The best specific combining ability (sca) hybrid, Super Basmati / Ranbir Basmati involved high x high combining parents indicating additive x additive type of interaction. Meenakshi and Amirthadevanathinam (1999) and Kalitha (2000) also observed positive alleles in crosses involving high x high combiners which can be fixed in subsequent generations if not repulsion phase linkage are involved. The crosses viz., Pusa 2517-2-51-1/ Pusa Basmati 1, P1121-91-8-1-1-3-3 / Ranbir Basmati and PAU 2935-16-3-5-2/ Basmati 370 involved low x high dominance interactions. Peng and Virmani (1990) also reported the possibility of interaction between positive alleles for good combiner and negative alleles for poor combiner which suggested for the exploitation of heterosis in F_1 generation as their high yield potential would be unfixable in succeeding generations.

From this study, it is suggested that both additive and non-additive gene actions were important in controlling various characters. The best combiners were Pusa 2517-2-51-1, Sanwaal Basmati, Super Basmati, Ranbir Basmati and Basmati 370 and could be utilized in future breeding programmes. The crosses viz., Pusa 2517-2-51-1/ Pusa Basmati 1, P1121-91-8-1-1-3-3 / Ranbir Basmati and PAU 2935-16-3-5-2 / Basmati 370 could be used for exploitation of heterosis for yield in F_1 generation.

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