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LINE X TESTER ANALYSIS IN BASMATI RICE

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Abstract

2 line x 3 tester mating design along with 5 rice genotypes and 6 F_1s were used of line, tester was higher than that of interaction of line x tester for all the characters. The predictability ratio indicated the predominance of non-additive gene action in the inheritance of all these characters. The highest significant heterosis (61.9) was observed in the cross Super Basmati/DM-107-4 for yield/plant. The female Super Basmati, male DM-25 and DM-107-4 were observed to be good general combiners for most of the characters studied. The crosses between Basmati-370/DM-25 and Super Basmati/DM-107-4 were observed good specific combiners for yield/plant. However, the cross combination Basmati-370/EL.-30-2-1 was identified as the promising specific combiner for further improvement in rice.

Introduction

Rice occupies an important position in the economy of Pakistan. The total area under rice is about 2.25 million hectares producing about 4.47 million tones but the major growing area (1.51 million hectares) lies in the Punjab province (Anon., 2002-03). It accounts for 5.4% of value added in agriculture and 1.3% of G.D.P. (Anon., 2003-04).

The fine grain Basmati varieties of rice are considered high quality rice and fetch a high price in the national and international trade. However, yield per unit area of Basmati rice is very low due to tall plant habit and late maturity. So, broadening the genetic base of rice is an essential requirement for rice improvement programme. The shortest possible method is induced mutation (Rashid *et al.*, 2003). Semidwarfism and earliness are the frequently induced mutations of the released rice mutant cultivars world over (Awan, 1999). Most are directly utilized mutants, but an increasing numbers of cultivars are resulting from crossing with induced mutants (Wang, 1991).

Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability. In breeding high yielding varieties of crop plant, the breeders often face with the problem of selecting parents and crosses. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis. Line x tester analysis provides information about general combining ability (gca) and specific combining ability (sca) effects of parents and is helpful in estimating various types of gene actions. Manivannan & Ganesan (2001) applied line x tester analysis in sesame. Presence of heterosis and SCA effects for yield and its related traits in rice are reported by Roy & Mandal (2001). Sarker *et al.*, (2002) observed 100.7% heterosis for grain yield per hill in rice. Zhang *et al.*, (2002) studied the heterosis and combining ability of hybrid rice. Ahmed *et al.*, (2003) used line x tester techinique in Summer squash to calculate the combining ability. Singh & Kumar (2004) also identified suitable parents through line x tester analysis in rice.

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In the present study 2 lines x 3 tester mating design along with 5 rice genotypes and 6 F_1s were used to determine the heterosis, combining ability as well as the gene action on yield and yield components.

Materials and Methods

Five rice genotypes (two commercial varieties viz., Basmati-370 and Super Basmati and three mutants viz., DM-25, DM-107-4 and E.L.-30-2-1were crossed in a line x tester mating design (Table 3). The crosses among lines and testers were attempted during the year 2002 and all the parents and their 6 hybrids were grown at institute farm during 2003. The experiment was laid out in completely randomized block design with 3 replications. Nitrogen and phosphorous fertilizers were applied @ 137 and 67 kg/ha. Thirty-six days old seedlings were transplanted with single seedling per hill. Data on plant height (cm), productive tillers/plant, panicle length (cm), fertility %, 1000-grain weight (gm) and yield/plant (gm) were recorded from 10 randomly selected plants. Data recorded for plant traits were analyzed according to Analysis of variance (ANOVA) technique as outlined by Steel & Torrie (1980). Heterosis was estimated from mean values according to Fehr (1987) and t-test was performed. Combining ability analysis was done using line x tester method (Kempthorne, 1957).

Results and Discussion

The recorded data on different agronomic parameters were subjected to analysis of variance to confirm the differences among rice genotypes. Mean squares from analysis of variance of six indicated traits of rice are presented in Table 1. The table depicted highly significant differences among rice genotypes for all the characters studied. Sum of squares of rice genotypes for these traits were further portioned into parents, cross and parents vs crosses, which revealed highly significant differences among themselves. Singh & Kumar (2004), reported similar results. The sum of squares calculated for rice crosses were further portioned into lines, testers and line x tester components. Highly significant ($P \leq 0.01$) differences were displayed among line x tester interaction for all the characters. However, non-significant differences existed among lines and testers for these traits. These results are in confirmation with the findings of Sarker *et al.*, (2002). The ratio of SCA and GCA variances was very high and more than one for all the characters studied that revealed the preponderance of non-additive gene action over the additive gene action. These results agreed with the results of Bobby & Nadarajan (1993), Singh *et al*., (1996) and Ganesen & Rangaswamy (1997) for grain yield in rice.

The proportional contribution of lines, testers and their interaction for six indicated traits is presented in Table 2. It is evident from the table that lines played important role towards plant height (41.18%), fertility % (38.46%) and 1000-grain weight (44.14%) indicating predominant maternal influence for these traits. Testers were more important for productive tillers/plant (54.62%), panicle length (66.67%) and yield/plant (60.30%). It revealed preponderance influence for these traits. The contribution of maternal and paternal interaction (line x tester) was low for all the characters. These results are similar to those obtained by Sarker *et al*., (2002) and Zhang *et al*., (2002).

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

Source	df	Plant height (cm)	Productive tillers/plant	Panicle length (cm)	Fertility %	1000-grain weight (gm)	Yield/plant (gm)
Replication	2	12.12	4.03	1.45	1.30	0.18	5.07
Genotypes	10	719.00**	30.42**	8.79**	173.49**	26.73**	304.49**
Parents	4	1206.43**	14.40**	7.23**	339.10**	49.28**	497.90**
P vs C	1	1271.60**	44.97**	20.95**	147.40**	5.87**	355.56**
Crosses	5	218.53**	40.32**	7.60**	46.22**	12.86**	139.55**
Lines	1	450.00	24.50	0.22	88.89	28.38	10.67
Testers	2	145.17	55.06	12.67	28.22	14.00	210.37
L x T	2	176.17**	33.50**	6.22**	42.89**	3.95**	133.18**
Error	20	23.75	1.26	0.49	3.54	0.26	1.47
σ^2gca		50.80	10.75	1.91	13.12	1.23	43.90
σ^2 sca		3.36	0.54	0.11	0.26	0.71	0.51
σ^2 gca/σ^2 sca		15.11	19.90	17.36	50.46	1.73	86.07

*Significant at 5% level of significance and **Highly significant at 1% level of significance.
σ^2gca = Variance of general combining ability and σ^2 sca = Variance of specific combining ability

Table 2. Proportional contribution of lines, testers and their interactions to total variance in rice.

Source	Plant height (cm)	Productive tillers/plant	Panicle length (cm)	Fertility %	1000-grain weight (gm)	Yield/plant (gm)
Due to lines	41.18	12.15	0.58	38.46	44.14	1.53
Due to testers	26.57	54.62	66.67	24.42	43.56	60.30
Due to line x testers	32.25	33.23	32.75	37.12	12.29	38.17

Table 3. Heterosis of hybrids for different characters in rice.

Hybrids	Plant height (cm)	Productive tillers/ plant	Panicle length (cm)	Fertility %	1000-grain weight (gm)	Yield/ plant (gm)
Basmati-370 x DM-25	4.9 *	14.0 **	-4.7 **	1.6	5.1 **	5.6 **
Super Basmati x DM-25	14.3 **	34.8 **	6.2 **	2.9 *	27.7 **	14.2 **
Basmati-370 x DM-107-4	8.2 **	13.5 **	8.2 **	1.0	-2.7	-1.4
Super Basmati x DM-107-4	9.6 **	-12.6 **	7.0 **	-2.8 *	9.1 **	61.9 **
Basmati-370 x E.L.30-2-1	-1.7	1.8	3.8 **	15.4 **	-7.0 **	7.6 **
Super Basmati x E.L.30-2-1	15.7**	14.2 **	6.8 **	3.8 *	-1.2	10.7 **

*Significant at 5% level of significance and **Highly significant at 1% level of significance.

Table 4. GCA effects and mean performance (in parenthesis) of parents for different characters in rice.

Parents	Plant height (cm)		Productive tillers/plant		Panicle length (cm)		Fertility %		1000-grain weight (gm)		Yield/ plant (gm)	
Basmati-370	5.00**	(158.7)	-1.17 **	(18.0)	0.11	(34.7)	2.22 **	(94)	-1.26 **	(22.3)	-0.77	(46.0)
Super Basmati	-5.00**	(117.7)	1.17 **	(21.3)	-0.11	(31.7)	-2.22 **	(93)	1.26 **	(21.5)	0.77	(35.3)
S. E. (gi)	1.62		0.37		0.23		0.63		0.17		0.40	
S.E (gi-gj)	2.30		0.53		0.33		0.89		0.24		0.57	
DM-25	3.17	120.3)	3.39 **	(18.3)	-1.67**	(31.0)	2.22 **	(89)	0.68 **	(20.5)	4.14 **	(33.0)
DM-107-4	-5.67**	(105.0)	-2.44 **	(16.0)	0.67 *	(31.3)	-0.11	(90)	-1.75 **	(21.2)	2.64 **	(20.3)
E.L.30-2-1	2.50	(126.0)	-0.94 *	(16.0)	1.00 **	(33.3)	-2.11 *	(68)	1.07 **	(30.3)	-6.78**	(13.3)
S.E (gi)	1.99		0.46		0.29		0.77		0.21		0.50	
S.E (gi-gj)	2.81		0.65		0.40		1.09		0.29		0.70	

*Significant at 5% level of significance and **Highly significant at 1% level of significance.

Heterosis: Percent heterosis was calculated for six yield and yield components (Table 3). The degree of heterosis varied from cross to cross and from character to character. Alam *et al*., (2004) in upland rice observed the varying degree of heterosis for yield and its related traits. For plant height negative heterosis was desirable but for rest of the characters positive heterosis was desirable. Positive heterosis ranges from 1.8-34.8%; 3.8-8.2%; 1.0-15.4%; 5.1-27.7% and 5.6-61.9% for productive tillers/plant, panicle length, fertility %, 1000-grain weight and yield/plant. Watanesk (1993) and Rao *et al*., (1996), Li *et al*., (1997b), Perera *et al*., (2001) and Nuruzzaman *et al*., (2002) found high heterosis for grain yield and its components in rice. However, out of six crosses, significant and desirable heterosis was observed in 4 crosses for productive tillers/plant, 5 for panicle length, 3 for fertility %, 3 for 1000-grain weight, 5 for yield/plant. No cross was found to be desirable heterotic for plant height. Ultimate aim of breeding is to gain the heterotics yield associated with other heterotic characters. Yield is a complex character; so 6 crosses may be considered for further study of combining ability.

General combining ability effects: Variation in general combining ability (GCA) effects was estimated among lines and testers for 6 plant traits to identify the best parent for subsequent hybrid development programme. The results of the general combining ability effects of lines and testers are presented in Table 4. For plant height negative GCA effects, while in case of other characters positive GCA effects are desirable. Minimum plant height is needed to protect the crop from lodging. Therefore, Super Basmati is a potential female parent and has highly significant GCA effect in the desirable direction (negative direction) for plant height. These findings are in accordance with Sarker *et al*., (2002). Female line Super Basmati indicated highly significant GCA effects for productive tillers/plant and 1000-grain weight. However the female line Basmati-370 also showed positive and highly significant GCA effect for fertility %. Our research findings are in conformity with Singh & Kumar (2004).

Among testers DM-107-4 is the potential male parent having negative and highly significant GCA effects for plant height thus confirming the findings of Won & Yoshida (2000), Roy & Mandal (2001). Among testers, positive GCA effects are important for productive tillers/plant. Therefore the tester DM-25 having the positive and highly significant GCA effect is the potential parent wherein the selection will be effective for their efficient use in subsequent hybrids development with more number of productive tillers/plant. These results are in line with Roy & Mandal (2001), Sarker *et al*., (2002).

Male parent DM-107-4 and E.L.-30-2-1 showed significant and highly significant GCA effects for panicle length respectively. However DM-25 indicated positive and highly significant GCA effect for fertility %. Highly significant and positive GCA effects for 1000-grain weight were given by DM-25 and E.L.-30-2-1. Yield/plant, being the ultimate objective, is very important to rice breeders. Testers DM-25 and DM-107-4 with positive and highly significant GCA effects can play a vital role in increased yield/plant. These results are in conformity with the findings of Singh *et al*., (1996) and Rogbell *et al*., (1998).

Specific combining ability effects: The estimates of specific combining ability effects of 6 Basmati rice hybrids are presented in Table 4. Minimum plant height is desirable trait of rice crop. The cross Basmati-370/E.L.-30-2-1 is the best showing negative and significant combining ability effect of -5.50 for plant height. The results confirm the findings of Rogbell *et al*., (1998), Roy & Mandal, (2001) and Sarker *et al*., (2002).

Table 5. SCA effects for hybrids (Crosses) for different characters in rice.

Hybrids	Plant height (cm)	Productive tillers/ plant	Panicle length (cm)	Fertility %	1000-grain weight (gm)	Yield/ plant (gm)
Basmati-370 x DM-25	0.17	-1.83**	-1.11*	-2.56*	-0.89**	2.10**
Super Basmati x DM-25	-0.17	1.83**	1.11*	2.56*	0.89**	-2.10**
Basmati-370 x DM-107-4	5.33	2.67**	0.89*	-0.22	0.21	-5.40**
Super Basmati x DM-107-4	-5.33	-2.67**	-0.89*	0.22	-0.21	5.40**
Basmati-370 x E.L.30-2-1	-5.50*	-0.83	0.22	2.78*	0.69*	3.29**
Super Basmati x E.L.30-2-1	5.50*	0.83	-0.22	-2.78*	-0.69*	-3.29**
S.E (sca effects)	2.80	0.65	0.40	1.09	0.29	0.70
S.E (Sij-Skl)	3.98	0.92	0.57	1.54	0.41	0.99

*Significant at 5% level of significance and **Highly significant at 1% level of significance.

More productive tillers/plant and increased panicle length is also a desirable trait of rice hybrids with increased yield/plant. The cross combinations namely Super Basmati/DM-25 and Basmati-370/DM-107-4 possess highly significant and positive SCA effects for productive tillers/plant and displayed significantly positive SCA effects for panicle length. These studies are in conformity with the reports of Chen *et al*., (1995).

The positive and significant SCA effect for fertility % was recorded in two cross combinations i.e., Super Basmati/DM-25 and Basmati-370/E.L.-30-2-1, whereas, Basmati-370/E.L.-30-2-1 exhibited positive and significant SCA effects for 1000-grain weight while Super Basmati/DM-25 have highly significant positive SCA effect for 1000-grain weight. These results are in line with the findings of Roy & Mandal (2001) and Singh & Kumar (2004). Yield/plant is an ultimate objective of rice breeding and hybrid development programmes. The cross combinations Basmati-370/DM-25, Super Basmati-/DM-107-4 and Basmati-370/E.L.-30-2-1 revealed positive and highly significant SCA effects for yield/plant. This is in agreement with the results obtained by Ganesen & Rangaswamy (1997), Roy & Mandal (2001), Sarker *et al*., (2002) and Singh & Kumar (2004).

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