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Heterosis and Genetic Analysis in Rice Hybrids

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Abstract: Two line x 13 tester mating design along with 15 rice genotypes and their 26 F_1s were used to study the heterosis as well as combining ability of yield and 7 yield contributing characters. Highly significant genotypic differences were observed. The SCA variances were found highly significant while GCA variances were insignificant for all the characters. The highest heterosis (100.70%) was observed in cross IR62829A x IR44675R followed by other 17 crosses for yield and most of its related traits. The contribution of testers was observed to be higher than that of the interactions of line x tester except panicle weight that revealed the higher estimates of GCA variance I. e., additive gene action among the testers used. Except panicle weight, mean performance of parents for all the traits were strongly and positively correlated with GCA effects. Within CMS parents, IR62829A was found to be good general combiner for most of the traits. Among male parents, BR827R, IR44675R, IR55838R, IR21567R and IR50404R were observed to be good general combiners for most of the characters studied. The cross combinations IR62829A x IR44675R, IR58025A x IR46R, IR58025A x BR736R, IR58025A x IR50404R, IR58025A x IR32809R, IR58025A x AjayaR, IR58025A x IR55838R and IR62829A x IR21567R were observed to be good specific cross combinations for grain yield and most of other 7 yield related traits due to highly significant SCA and heterotic effects. In several cases, cross between high x high general combiner did not produce good specific cross. Rather good specific crosses were obtained from high x high, high x low, low x high and low x low general combiner indicating predominance of non-additive gene action.

Key words: Heterosis, combining ability, line x tester, rice hybrids

Introduction

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. Presence of heterosis and SCA effects for yield and its related traits are reported by Young and Virmani (1990) in 24 hybrids in rice. Sethi *et al.* (1989) observed 159.4 % heterosis for grain yield in wheat. To exploit maximum heterosis using cytoplasmic male sterile technique in the hybrid programme, we must know the combining ability of different male sterile and restorer lines. The study was undertaken to determine the nature and magnitude of gene action on yield and its components or other agronomic characters. To explore suitable combination of male sterile and restorer lines for the exploitation of maximum heterosis or hybrid vigour in F_1.

Materials and Methods

Fifteen HYV modern rice genotypes (two cytoplasmic male sterile lines and thirteen restorer lines) (Table 4) were crossed in a line x tester mating design (Table 3). All the parents and their twenty-six hybrids were grown at Bangabandhu Sheikh Mujibur Rahman Agricultural University farm, Gazipur, Bangladesh, during December 2000 to June 2001. The experiment was laid out in completely randomized block design with two replications. Urea, TSP, MP, Gypsum and Zinc sulphate were applied @ 270-130-120-70-10 kg/ha respectively, recommended for field dose by Julfiquar (1999). Soil belongs to madhupur tract with pH of 6.45-6.55. Forty days old seedlings were transplanted with single seedling per pot. Each of the pot constitutes an experimental unit. Data on plant height (cm), number of tillers per hill, leaf blade length (cm), days to heading, panicle weight (g), spikelet sterility percentage, grain yield per hill (g) and harvest index were recorded from 10 sample tillers of each hill. Analysis of variance (ANOVA) was done on sample mean basis for all the traits. 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). The variances for general combining ability (GCA) and specific combining ability (SCA) were tested against their respective error variances derived from ANOVA reduced to mean level. Significance test for GCA and SCA effects were performed using t-test.

Results and Discussion

The analysis of variances showed highly significant differences among the genotypes for all yield and yield related characters that revealed wide range of variability for the genotypes (Table 1). Manickan and Das (1995) reported similar results in sorghum for plant height. Highly significant differences due to lines for plant height (cm), number of tillers per hill, days to heading, spikelet sterility percentage and grain yield per hill were observed. Testers showed high differences due to highly significant values for plant height, days to heading, spikelet sterility percentage, harvest index and grain yield per hill. Highly significant differences due to interactions of line x tester for all the characters were observed that revealed wide range of variability among lines, testers and interactions of line x tester for these traits.

Insignificant general combining ability analysis of the variances was found for all the traits. But highly significant differences due to specific combining ability were observed for all the characters studied indicating non-additive type of gene action for this concerned character. Ali *et al.* (1993) in rice and Pillai *et al.* (1995) in sorghum found similar findings for specific

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

Source of variation	df	Plant height (cm)	Number of tillers per hill	Leaf blade length (cm)	Days to heading	Panicle weight (g)	Spikelet sterility Percent	Grain yield per hill (g)	Harvest index
Replication	1	2.39	2.74	4.83	5.38	0.05	54.17	13.89	0.002
Genotype	40	104.17**	52.10**	25.80**	160.04**	0.43**	255.39**	432.80**	0.02**
Line	1	517.23**	325.0**	5.82	117.00**	0.03	418.67*	322.27*	0.002
Tester	12	73.81*	35.65	21.73	89.32**	0.32	327.75*	941.12**	0.03**
Line x tester	12	27.98**	27.13**	12.85**	14.38**	0.44**	149.69**	222.60**	0.005**
Error	40	5.29	4.29	2.12	1.15	0.04	35.78	16.37	0.0002
σ^2gca	14	1.08	0.42	0.10	1.04	0.002	2.50	2.85	0.11
σ^2sca	25	11.35**	11.42**	5.36**	6.61**	0.2**	56.96**	103.12**	5.36**
σ^2sca/σ^2gca	-	10.51	27.19	52.04	6.36	104.73	22.78	36.18	51.54

Significant at 5% level of significance and ** Significant at 1% level of significance

σ^2gca = variance of general combining ability and σ^2sca = variance of specific combining ability

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

Source	Plant height (cm)	Number of tillers per hill	Leaf blade length (cm)	Days to heading	Panicle weight (g)	Spikelet sterility percent	Grain yield per hill	Harvest index
Due to line	29.75	30.14	1.38	8.60	0.29	6.81	11.34	0.48
Due to tester	50.94	39.67	61.98	78.73	41.90	63.97	56.50	83.55
Due to line x tester	19.31	30.19	36.64	12.67	57.81	29.22	32.16	15.97

Table 3: Heterobeltiosis of hybrids (crosses) for different characters in rice

Hybrids	Plant height (cm)	Number of tillers per hill	Leaf blade length (cm)	Days to heading	Panicle weight (g)	Spikelet sterility percent	Grain yield per hill (g)	Harvest index
IR62829A x IR21567R	-3.03	-6.25	-5.00	-3.36**	2.90	-24.21**	66.75**	1.92
IR62829A x IR46R	3.92	-27.50**	-24.85**	-8.96**	26.79**	-39.83**	14.17	20.83**
IR62829A x IR50404R	-3.09	-17.50**	-3.59	-6.02**	-19.16*	35.03**	0.63	14.58**
IR62829A x IR44675R	-5.56*	3.75	-5.98	-16.11**	4.51	-37.06**	100.70**	20.83**
IR62829A x BR827R	-8.81**	-14.81**	-19.09**	-9.62**	43.30**	-33.59**	16.62*	12.50**
IR62829A x IR29723R	-6.56*	-18.75**	-4.71	-12.87**	32.14**	-24.84**	42.10**	-6.25*
IR62829A x BR736R	-14.66**	-22.50**	-16.55**	-11.72**	-12.78	-14.60**	-13.29	6.25*
IR62829A x AjayaR	0.66	-22.50**	-11.41*	-6.07**	20.98*	-30.02**	14.45	6.25*
IR62829A x IR32809R	-12.10**	-32.50**	5.38	-12.12**	3.64	-16.75**	82.75**	-18.75**
IR62829A x IR34686R	-14.67**	-33.75**	-27.31**	-16.30**	37.05**	-57.62**	42.94**	-8.33**
IR62829A x IR54742R	-14.29**	1.25	-16.01**	-12.54**	47.32**	6.82	0.89	-2.08
IR62829A x IR55838R	-10.61**	-18.75**	-16.02**	-8.48**	12.60	-21.15**	39.05**	6.25*
IR62829A x IR62030R	-3.09	-15.00**	-6.20	-6.39**	-4.80	-4.30	34.34**	18.00**
IR58025A x IR21567R	0.00	-16.13*	-12.05*	-4.05**	-13.09	-24.00**	28.66**	13.46**
IR58025A x IR46R	5.42	0.00	-13.60**	-7.53**	21.46*	-36.68**	61.89**	36.59**
IR58025A x IR50404R	6.63*	-8.06	-7.59	-10.70**	25.78**	-30.78**	58.96**	22.22**
IR58025A x IR44675R	-10.00**	-9.68	-26.31**	-16.77**	-4.51	-54.32**	31.46**	31.11**
IR58025A x BR827R	-3.11	-23.46**	-2.88	-7.22**	56.41**	-23.77**	2.05	38.46**
IR58025A x IR29723R	-4.92	-11.29	-8.85*	-10.56**	16.67*	-24.98**	14.91*	15.38**
IR58025A x BR736R	-8.38**	-19.36**	-8.56*	-6.23**	19.17*	-30.90**	74.17**	36.36**
IR58025A x AjayaR	10.84**	-11.11	-13.78**	-6.57**	37.61**	-34.43**	30.72**	37.50**
IR58025A x IR32809R	-2.41	-14.52*	-1.69	-9.09**	-39.27**	66.11**	-48.49**	-53.49**
IR58025A x IR34686R	-10.87**	-27.42**	-20.36**	-12.54**	35.39**	-31.05**	6.27	23.08**
IR58025A x IR54742R	-11.43**	-14.52*	-13.40**	-7.40**	14.69	-23.88**	17.69*	7.69*
IR58025A x IR55838R	2.79	-4.84	-10.08*	-7.42**	31.71**	-35.91**	70.91**	23.08**
IR58025A x IR62030R	1.20	-19.35**	13.19**	-2.21**	5.90	-35.18**	23.47*	0.00
SE	2.3	2.07	1.46	1.07	0.20	1.58	4.05	0.014

* Significant at 5% level of significance ** Significant at 1% level of significance

combining ability. 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 and Nadarajan (1993) in rice, Bhuiyan *et al.* (1997) in barley and Chavan and Nerkar (1994) in pearl millet. Salam *et al.* (1996) for harvest index and grain yield, Ganesen and Ramalingam (1997) and Singh *et al.* (1996a) for grain yield in rice, Singh *et al.* (1996b) in spring wheat, Yilmaz and Konak (2000) in barley for panicle weight, observed the same preponderance of non-additive gene action. In this situation the most appropriate and efficient breeding approach would be to map up the additive gene simultaneously maintaining the degree of heterozygosity for exploring the non-additive components.

The contribution of lines, testers and interactions to total variances are presented in Table 2. The contribution of testers to the total sum square due to crosses was higher than that of interactions of line x tester for all the characters except panicle weight. The smaller contribution of interactions of the line x tester than testers, indicating higher estimates of variances due to general combining ability. Rissi *et al.* (1991) observed higher estimates of GCA variances due to testers in rice. Contribution of interactions of line x tester was higher than that of lines or testers for panicle weight indicating higher estimates of GCA variances for interaction.

Heterobeltiosis: Percent heterosis over better parents was calculated for grain yield per hill and 7 yield related traits (Table 3). The degree of heterosis varied from cross to cross and from character to character. Pathak and Sanghi (1992) in sorghum and Patel *et al.* (1990) in upland rice

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

Parents	Plant height	Number of tillers per hill	Leaf blade length	Days to heading	Panicle weight	Spikelet sterility Percent	Grain yield per hill	Harvest index
Lines								
IR62829A	−3.15** (72.50)	2.50**(40.00)	−0.34(30.65)	−1.50**(133.00)	0.02(2.24)	−2.84*(32.06)	4.26**(41.69)	0.006(0.48)
IR58025A	3.15**(83.00)	−2.5**(31.00)	0.34(29.60)	1.50**(135.50)	−0.02(1.95)	2.84*(42.75)	−4.26**(36.05)	−0.006(0.39)
SE (g_i)	0.45	0.41	0.29	0.21	0.04	1.17	0.80	0.003
SE (g_i−g_k)	0.64	0.57	0.40	0.30	0.06	1.66	1.12	0.004
Testers								
IR21567R	−2.42(82.50)	1.14(23.00)	−1.74*(31.95)	−0.87(134.00)	−0.19**(2.75)	−2.12(28.40)	4.95*(38.38)	−0.059**(0.52)
IR46R	−0.42(76.50)	0.89(34.00)	−3.34**(34.20)	−2.62**(139.50)	−0.04(2.19)	−7.33*(25.99)	−1.57(31.89)	0.07**(0.41)
IR50404R	−0.42(81.00)	0.14(28.50)	−2.19**(30.30)	−7.62**(131.00)	0.17**(2.87)	5.98(11.55)	4.89*(55.15)	0.049**(0.45)
IR44675R	−0.92(90.00)	4.14**(28.00)	−2.92**(33.45)	−3.62**(152.00)	−0.13**(2.66)	−10.66**(26.46)	10.98**(35.36)	0.079**(0.45)
BR827R	6.83**(96.50)	2.14(40.50)	1.44(36.40)	2.64**(145.50)	0.34**(1.95)	−3.57(30.98)	14.94**(34.18)	0.032**(0.38)
IR29723R	2.33(91.50)	−0.62(22.00)	1.71*(35.05)	3.14**(151.50)	0.34**(2.52)	−1.99(33.21)	−0.72(25.97)	−0.058**(0.38)
BR736R	0.58(95.50)	−2.62*(29.50)	−0.32(35.05)	−6.37**(136.50)	−0.05(2.66)	−2.05(24.92)	−3.78(53.79)	0.047**(0.44)
AjayaR	0.08(75.50)	0.89(36.00)	−1.47(33.75)	0.39*(140.00)	−0.06(2.18)	−4.78(33.48)	0.60(44.99)	0.022**(0.40)
IR32809R	−8.92**(78.50)	−3.87**(29.00)	2.14*(32.50)	2.14**(148.50)	−0.76**(2.47)	26.28**(45.56)	−24.23**(30.91)	−0.21**(0.43)
IR34686R	−3.67**(92.00)	−6.12**(28.00)	0.87(41.75)	5.89**(159.50)	0.06(1.47)	1.14(56.87)	−11.08**(13.57)	−0.048**(0.26)
IR54742R	7.58**(105.00)	4.64**(35.00)	4.99**(42.15)	9.39**(155.50)	0.06(2.11)	4.54(35.17)	−3.54(32.50)	−0.06**(0.33)
IR55838R	2.08(89.50)	0.39(29.50)	0.51(36.20)	−0.37(141.50)	0.21**(2.46)	−4.12(28.20)	5.75*(36.64)	−0.12**(0.36)
IR62030R	−2.67**(81.00)	−1.12(20.50)	0.36(29.95)	−2.15**(129.50)	−0.07(2.71)	−1.32(8.46)	2.81(39.24)	0.039**(0.50)
SE (g_j)	1.15	1.04	0.73	0.54	0.11	2.99	2.02	0.008
SE (g_j−g_l)	1.63	1.47	1.03	0.76	0.15	4.23	2.86	0.01
r (GCA, Mean)	0.64**	0.38	0.53*	0.70**	−0.20	0.33	0.33	0.37

* Significant at 5% level of significance and ** Significant at 1% level of significance

SE (g_i) = Standard error (gca effects for line), SE (g_i−g_k) = Standard error (Between gca effects of two lines)

SE (g_j) = Standard error (gca effects for tester), SE (g_j−g_l) = Standard error (Between gca effects of two testers)

Table 5: SCA effects of hybrids (crosses) for different characters in rice

Hybrids	Plant height (cm)	Number of tillers per hill	Leaf blade length (cm)	Days to heading	Panicle weight (g)	Spikelet sterility percent	Grain yield per hill	Harvest index
IR62829A x IR21567R	1.65	3.25*	1.46	1.25	0.19	−1.26	5.87*	−0.03**
IR62829A x IR46R	−0.85	−5.00**	−1.59	0.50	0.07	−1.05	−9.63**	0.004
IR62829A x IR50404R	−1.85	−0.25	1.11	3.50**	−0.67	9.74*	−8.19**	−0.003
IR62829A x IR44675R	5.15**	4.25**	3.74**	2.00*	0.10	3.16	13.88**	−0.008
IR62829A x BR827R	0.40	−0.75	−2.62	−0.25	0.06	−2.82	2.45	−0.006
IR62829A x IR29723R	2.40	0.00	1.06	−0.25	0.17	−0.72	1.45	−0.006
IR62829A x BR736R	0.15	0.50	−1.07	−2.25**	−0.45**	1.76	−8.38**	−0.006
IR62829A x AjayaR	−4.85**	−3.00	0.74	2.00*	−0.17	0.54	−7.92*	−0.026*
IR62829A x IR32809R	−2.85	−2.25	1.49	−0.75	0.51**	−16.04**	7.49*	0.087**
IR62829A x IR34686R	1.40	−0.50	−1.12	−1.50	0.19	−4.72	0.90	−0.026*
IR62829A x IR54742R	1.65	2.75	−0.22	−2.50**	0.41*	5.35	4.32	0.019
IR62829A x IR55838R	−2.85	−1.00	−0.74	0.75	−0.26	1.73	−6.58*	0.012
IR62829A x IR62030R	0.40	2.00	−2.24	−2.50**	−0.17	4.32	4.65	0.037**
IR58025A x IR21567R	−1.65	−3.25*	−1.46	−1.25	−0.19	1.26	−5.87*	0.03**
IR58025A x IR46R	0.85	5.00**	1.59	−0.50	−0.07	1.05	9.63**	−0.004
IR58025A x IR50404R	1.85	0.25	−1.11	−3.50**	0.67	−9.74*	8.19**	0.003
IR58025A x IR44675R	−5.15**	−4.25**	−3.74**	−2.00*	−0.10	−3.16	−13.88**	0.008
IR58025A x BR827R	−0.40	0.75	2.62	0.25	−0.06	2.82	−2.45	0.006
IR58025A x IR29723R	−2.40	−0.00	−1.06	0.25	−0.17	0.72	−1.45	0.006
IR58025A x BR736R	−0.15	−0.50	1.07	2.25**	0.45**	−1.76	8.38**	0.006
IR58025A x AjayaR	4.85**	3.00	−0.74	−2.00*	0.17	−0.54	7.92*	0.026*
IR58025A x IR32809R	2.85	2.25	−1.49	0.75	−0.51**	16.04**	−7.49*	−0.087**
IR58025A x IR34686R	−1.40	0.50	1.12	1.50	−0.19	4.72	−0.90	0.026*
IR58025A x IR54742R	−1.65	−2.75	0.22	2.50**	−0.41*	−5.35	−4.32	−0.019
IR58025A x IR55838R	2.85	1.00	0.74	−0.75	0.26	−1.73	6.58*	−0.012
IR58025A x IR62030R	−0.40	−2.00	2.24	2.50**	0.17	−4.32	−4.65	−0.037**
SE (s_{ij})	1.63	1.47	1.03	0.76	0.15	4.23	2.86	0.01
SE (s_{ij}− s_{kl})	2.30	2.07	1.46	1.07	0.21	5.98	4.05	0.02

* Significant at 5% level of significance and ** Significant at 1% level of significance

SE (s_{ij}) = Standard error (sca effects for crosses) SE (s_{ij}- s_{kl}) = Standard error (Between sca effects of two crosses)

observed the varying degree of heterosis for yield and its related traits. For plant height, days to heading and spikelet sterility percentage negative heterosis were desirable but for rest of the characters positive heterosis were desirable. Positive heterosis ranges from 0.00-3.75%; 5.35-13.35%; 2.90-56.41%; 0.63-100.70% and 0.00-38.48% for number of tillers per hill, leaf blade length, panicle weight, grain yield per hill and harvest index, respectively. Negative heterosis ranges from −2.41 to −14.67%; -2.21 to −16.77% and −4.30 to −57.62% for plant height, days to heading and spikelet sterility percentage. Watanesk (1993) and Rao *et al.* (1996) found high heterosis for grain yield and its components in rice. Significantly the highest heterosis (100.70%) for grain yield was observed in cross, IR62829A x IR44675R associated with the significant and desirable heterosis for plant height, days to heading, spikelet sterility percentage and harvest index. Desirable and significant heterosis for grain yield per hill was found in 18 crosses associated with higher heterosis for most of the yield related traits.

However, out of 26 crosses, significant and desirable heterosis was observed in 12 crosses for plant height, 1 for leaf blade length, all the crosses for days to heading, 14 for panicle weight, 22 for spikelet sterility percentage and 19 for harvest index. No crosses were found to be desirable heterotic for number of tillers per hill. Ultimate aim of breeding is to gain the heterotics yield associated with other heterotic characters. Yield is the complex character of all other yield contributing characters. So, 18 crosses may be considered for further study of combining ability.

General combining ability: For plant height, days to heading and spikelet sterility percentage negative GCA effects were desirable, while in case of other characters positive GCA effects were desirable. Strong positive and desirable correlation between mean performance and the GCA effects were found for all the traits studied except panicle weight. Das and Islam (1994) also observed similar results. There was negative and very weak correlation for panicle weight due to mean performance and GCA effects indicating almost the absence of any relation between them (Table 4). None of the CMS lines or pollinators was found to be good general combiner for all the characters studied. Female parents, IR62829A was observed as a good general combiner due to its highly significant and positive GCA effects for grain yield per hill and desirable GCA effects for other 7 yield related characters except leaf blade length (Table 4). Singh *et al.* (1996a) reported the CMS line IR62829A as a good general combiner. Chowdhry *et al.* (1996) and Sharma *et al.* (1992) in wheat and Sethi *et al.* (1989) in barley, reported good general combiner female parents with high GCA effects. Rawat and Tyagi (1997) and Kandaswami and Ramalingam (1995) in pearl millet for reducing the growth duration and Watanesk (1993) in rice observed good CMS parents for yield and its contributing traits.

The pollinator, BR827R was the best general combiner due to highly significant GCA effects for grain yield per hill and most of the yield contributing traits. IR44675R showed highly significant GCA effects for grain yield with all other desirable GCA effects, except leaf blade length and panicle weight. It was considered to be a good general combiner pollinator followed by IR55838R, IR21567R and IR50404R (Table 4). Rogbell *et al.* (1998) and Singh *et al.* (1996b) observed similar good general combiner male parents for yield in rice.

Desirable GCA effects were observed in 4 parents (IR62829A, IR34686R, IR32809R and IR62030R) for reduced plant height, 3 parents (IR62829A, IR44675R and IR54742R) for number of tillers per hill, 3 parents (IR29723R, IR32809R and IR54742R) for leaf blade length and 6 parents (IR62829A, IR46R, IR50404R, IR44675R, BR736R, and IR62030R) for reduced growth duration. Similarly desirable GCA effects were also found in 4 parents (IR50404R, BR827R, IR29723R and IR55838R) for panicle weight, 3 parents (IR62829A, IR46R and IR44675R) for spikelet sterility percentage, 6 parents (IR62829A, IR21567R, IR50404R, IR44675R, BR827R and IR55838R) for grain yield per hill and 7 parents (IR46R, IR50404R, IR44675R, BR827R, BR736R, AjayaR and IR62030R) for harvest index. Above parents were considered to be good general combiners for these characters, respectively (Table 4).

Specific combining ability: For plant height, days to heading and spikelet sterility percentage, negative SCA effects were desirable while in case of other characters positive SCA effects were desirable. None of the cross combinations were found to be good specific cross combinations for all the characters studied (Table 5).

The cross combination IR62829A x IR44675R was the best specific cross combination for the highest and significant SCA effects for yield with desirable characters for number of tillers per hill, leaf blade length and panicle weight. The cross IR58025A x IR46R showed significant or insignificant desirable SCA effects for yield and 4 yield related traits. The cross IR58025A x BR736R for most of the characters except number of tillers per hill and days to heading, crosses IR58025A x IR50404R and IR58025A x AjayaR for all characters except plant height and leaf blade length, the cross IR62829A x IR32809R for all characters except number of tillers per hill, the cross IR58025A x IR55838R for all the traits except plant height and harvest index and the cross IR62829A x IR21567R for all the traits except plant height, days to heading and harvest index showed significant desirable SCA effects. Above cross combinations were found to be good specific combinations with high heterotic effects for grain yield along with most of the yield contributing characters (Table 5). Singh *et al.* (1996b) also found good specific cross combinations with CMS line IR62829A. Rogbell *et al.* (1998), Chen *et al.* (1995) and Young and Virmani (1990) found similar good specific cross combinations in rice.

Good specific cross combination hybrids for grain yield per hill, IR58025A x IR46R, IR58025A x AjayaR and IR58025A x BR736R were evolved from low x low general combiner parents revealed over dominance and epistatic type of gene action (Table 5). These results agree with the results of Salam *et al.* (1996) and Gile *et al.* (1997) in rice.

Generally, in most of the good specific cross combinations at least one low general combiner parents were involved for all the characters along with grain yield per hill. It also indicated both additive and non-additive types of gene action. Several crosses high x high general combiners were involved for production of good specific cross combinations in many characters in which additive type of gene action was found (Table 5).

Generally, high x high, low x low, low x high and high x low general combiner parents produced good specific cross combinations. In these crosses additive x additive, dominance x dominance, dominance x additive and additive x dominance type of gene action was found. In many cases, high x high general produced inferior cross combinations indicating epistatic type of gene action for these traits.

Eight good specific cross combinations (IR62829A x IR44675R, IR58025A x IR46R, IR58025A x BR736R, IR58025A x IR50404R, IR58025A x AjayaR, IR62829A x IR32809R, IR58025A x IR55838R and IR62829A x IR21567R) might be released as hybrid variety for

commercial utilization after further study. Heterosis breeding might be suggested for the improvement of characters. The information on the nature of gene action with respective variety and characters might be used depending on the breeding objectives.

References

Ali, S. S., S. Jahangeer, H. Jafri and M. A. Butt, 1993. Diallel analysis for combining ability in rice. Pak. J. Sci. Ind. Res., 11: 476-478.

Bobby, T. P. M. and N. Nadarajan, 1993. Genetic analysis of yield components in rice involving CMS lines. Int. Rice Res. Not., 18: 8-9.

Bhuiyan, M. S. A., M. N. Uddin, M. A. Ammiruzzaman, M. A. Yousuf and N. N. Hoque, 1997. Estimation of combining ability in barley. Bangla. J. Pl. Breed., 10: 35-39.

Chavan, A. A. and Y. S. Nerkar, 1994. Heterosis and combining ability studies for grain yield and its components in pearl millet. J. Maharasthra Agril. Univ., 19: 58-61.

Chen, S., H. Lu, J. Yang, S. H. Chen, H. R. Lu and J. B. Yang, 1995. Study on the utilization of intersubspecific heterosis in rice by two line method analysis of cytoplasmic effects. J. Fujian Agril. Univ. 24: 133-137.

Das, U. R. and M. H. Islam, 1994. Combining ability and genetic studies for grain yield and its components in maize. Bangla. J. Pl. Breed., 7: 41-47.

Chowdhry, M. A., M. T. Mahmood, N. Mahmood and I. Khaliq, 1996. Genetic analysis of some drought and yield related characters in Pakistani spring wheat varieties. Wheat Information Service, 82: 11-18.

Fehr, W. R., 1987. Heterosis In: Principles of cultivar development: Theory and Techniques (Vol. 1). Macmillan Publishing Company. New York, pp: 115

Ganesen, K. N. and M. Rangaswamy, 1997. Heterosis in rice hybrids bred with wild abortive source of CMS lines. Crop Res. Hisar., 13: 603-607.

Gile, B. D., P. W. Khorgade, R. B. Ghorade and B. A. Sakhare, 1997. Combining ability of some newly developed male sterile and restorer lines in sorghum. J. Soils and Crops, 7: 80-82.

Julfiquar, A. W., 1999. Unnata podhatite Adhunik Dhaner Chash. A lecture sheet of 'Rice Production, Communication and Office Management' training. BRRI.

Kandaswami, G. and R. S. Ramalingam, 1995. Combining ability of two new male sterile lines of diverse sources in pearl millet for yield and its components. Madras Agril. J., 82: 422-424.

Kempthorne, O., 1957. The theoretical values of correlations between relatives in random mating populations Genetics, 40: 153-167.

Manickan, S. and L. D. V. Das, 1995. Combining ability analysis for forage characters in sorghum. Ann. Agril. Res., 16: 49-52.

Patel, P. I., R. S. Patel and M. S. Desani, 1990. Heterosis and combining ability of grain sorghum at different location in gujarat. Indian J. Agril. Sci., 60: 382- 386.

Pathak, H. C. and A. K. Sanghi, 1992. Genetic analysis of leaf and physiological traits in forage sorghum across environments. Gujarat Agril. Univ. Res. J., 17: 49-55.

Pillai, M. A., P. Rangaswamy, N. Nadarajan, C. Vanniarajan and J. Ramlingam, 1995. Combining ability analysis for panicle characters in sorghum. Indian J. Agril. Sci., 29: 98-102.

Rao, A. M., S. Ramesh, R. S. Kulkarni, D. L. Savithramma and K. Madhusudhan, 1996. Heterosis and combining ability in rice. Crop Improvement, 23: 53-56.

Rawat, R. S. and D. V. S. Tyagi, 1997. Combining ability of ergot resistant mutamts of the restorer K560-230 in pearl millet. Indian J. Gen. and Pl. Breed, 57: 101-107.

Rissi, R. D., A. R. Hallauer and R. R. De, 1991. Evaluation of four testers for evaluating maize lines in a hybrid development program. Revista Brasllelia de Genetica, 14: 467-481.

Rogbell, J. E., N. Subbaraman and C. Karthikeyan, 1998. Heterosis in rice under saline conditions. Crop Res. Hisar., 15: 68-72.

Salam, M. A., M. A. Hossain and S. Khatun, 1996. Combining ability for grain yield and its components in rice. Ann. Bangla. Agric., 6: 21-26.

Sethi, S. K., S. Dalvir and S. Singh, 1989. Combining ability studies for yield and its components in hulled x hullless crosses of barley. Haryana Agril. Univ. J. Res., 19: 230-234.

Sharma, S. C., S. Iqbal and I. Singh, 1992. Combining ability analysis for some quantitative traits in bread wheat. Haryana Agril. Univ. J. Res., 22: 267-270.

Singh, K. P., R. Yadav and R. K. Behl, 1996a. Combining ability effects for some traits in wheat. Crop Improvement, 17: 45-48.

Singh, P. K., R. Thakur, V. K. Chaudhary and N. B. Singh, 1996b. Combining ability for grain yield and its components in relation to rice breeding. Crop Res. Hisar., 11: 62-66.

Watanesk, O., 1993. Heterosis and combining ability evaluation of cytoplasmic male sterile (A) lines and restorer (R) lines. Int. Rice Res. Not., 10: 5-6.

Yilmaz, R. and C. Konak, 2000. Combining abilities of some barley genotypes under saline conditions. Turkish J. Agric. Forest., 24: 405-411.

Young, J. and S. S. Virmani, 1990. Heterosis of rice over environments. Euphytica., 51: 87-98.