# HETEROSIS AND COMBINING ABILITY ANALYSIS IN BASMATI RICE HYBRIDS

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**ABSTRACT**

Two CMS lines, IR69616A and IR70369A were crossed with 60001 (a fine grain aromatic advance line) and Basmati 385 (a commercial Basmati variety). Fine grain aromatic line, 60001 and Basmati 385 were used as testers. Two lines x two tester mating design along with four genotypes and their F1's were studied to estimate heterosis and combining ability effects in yield and yield influencing traits i.e., plant height, number of productive tillers per plant, number of spike-lets per panicle, number of filled grains per panicle, sterility %age and grain yield. Significant differences were observed in lines, testers and line x testers. Both the CMS lines reduced the plant height of their respective $F_1$ hybrids. The highest positive heterosis over better parents was observed for grain yield (41.83 %), number of productive tillers per plant (11.04 %) and number of filled grains per panicle (7.39 %) in the cross of IR69616A x Basmati 385. GCA effects were found higher for filled grains and number of spike-lets per panicle. Except plant height, mean performance of the parents was positively and strongly correlated with GCA effects. Within the CMS lines, IR 69616A found to be a good general combiner for most of the traits. Where as within the testers, Basmati 385 was observed to be a good general combiner for most of the traits.

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

## INTRODUCTION

Breeding strategies for developing hybrids with high yield potential and better grain quality require the expected level of heterosis and combining ability. In breeding for high yield crop plants, the breeders often face with the problem of selecting parents and crosses. Combining ability analysis is one of the effective approaches available for estimating the combining ability effects that help in selecting desirable parents and crosses for the exploitation of heterosis. Presence of heterosis and specific combining ability (SCA) effects for yield and yield related traits in rice hybrids are reported by Young and Virmani (1990), Faiz *et al*. (2000) and Sarker *et al*.2002. Sethi *et al*. (1989) observed 159.4 % heterosis for grain yield in wheat. To exploit maximum heterosis using male sterility system in hybrid breeding programme, we must know the combining ability of different male sterile and restorer lines. The study was under taken to determine the nature and magnitude of gene action for yield and yield components to explore the best combination of male sterile and restorer lines for the exploitation of maximum heterosis or hybrid vigour in $F_1$ hybrids.

## MATERIALS AND METHODS

Four rice genotypes (two cytoplasmic male sterile lines and two testers) were crossed in a line x tester mating design (Table-3). All the parents along with their four crosses were transplanted during last week of the July 2003 at Rice Research Institute, Kala Shah Kaku, Lahore, Punjab. The experiment was laid out in randomized complete block design with three replications. Recommended inputs were applied at the recommended time. Forty-three days old seedlings were transplanted with single seedling per hill in a single row plot of 2.0 m length. Data on plant height, number of productive tillers per plant, number of spike-lets per panicle, number of filled grains per panicle, sterility percentage and grain yield were recorded. Heterosis was estimated from mean values according to the 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 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 displayed highly significant differences among the genotypes for all characters that depicted vide range of variability for the genotypes (Table 1). The mean sum of squares due to parent versus crosses differed significantly for all characters. Manickan and Das (1995) observed similar findings in sorghum for plant height, number of tillers per plant, days to heading, spike let sterility percentage and grain yield per hill. The significance of the means of sum of squares due to line x testers for number of productive tillers per plant and number of grains per panicle indicated the importance of both additive and non additive variance. Several researchers have reported the predominance of dominant gene action for a majority of the yield traits (Peng and Virmani 1999, Ramalingan *et al.* 1993 and Satyanarayana *et al* .2000), while Vijay Kumar *et al.* (1994) reported the predominance of additive gene action.

**Table-1. Analysis of variance for combining ability for agronomic traits**

| Source of variation | df | Prod. Till. plant$^{-1}$ | Plant height (cm) | No. of spike lets panicle$^{-1}$ | No. of filled grains panicle$^{-1}$ | Yield plant$^{-1}$ | Spikelet Sterility (%) |
|---|---|---|---|---|---|---|---|
| Replication | 2 | 1.777 | 20.96 | 31.07 | 4.57 | 4.51 | 4.31 |
| Treatments | 7 | 12.98** | 1252.18** | 2770.99** | 2413.827** | 175.78** | 3603.46** |
| Parents | 3 | 10.87** | 2491.53** | 4705.74** | 3521.72** | 230.38** | 6315.84** |
| Parents vs crosses | 1 | 7.37* | 1124.69** | 1312.76** | 392.04** | 44.71* | 129.97 ** |
| Crosses | 3 | 16.96** | 55.333** | 1322.31** | 1979.86** | 164.87** | 2048.93** |
| Line | 1 | 15.18 | 120.33 | 2106.75 | 468.75 | 87.95 | 977.41 |
| Tester | 1 | 33.00 | 40.33 | 1850.63 | 3996.75 | 381.09 | 4637.42** |
| Line x tester | 1 | 7.33* | 5.33 | 101.674 | 1474.08** | 25.57 | 532.00** |
| Error | 14 | 1.168 | 7.15 | 54.97 | 36.71 | 6.52 | 7.56 |

*** =** Significant (P ,0.05), ** = Significant (P < 0.01)

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

| Source | No. of prod. tillers plant$^{-1}$ | Plant height (cm) | No. of spike-lets panicle$^{-1}$ | Filled grains panicle$^{-1}$ | Yield plant$^{-1}$ (g) | Sterility %age |
|---|---|---|---|---|---|---|
| Due to line | 29.84 | 72.48 | 53.11 | 7.89 | 17.78 | 15.90 |
| Due to tester | 64.83 | 24.29 | 46.63 | 67.29 | 77.04 | 75.44 |
| Due to line x tester | 4.80 | 3.21 | 2.56 | 24.81 | 5.17 | 8.65 |

The contribution of lines, testers and interactions to total variances are presented in Table 2. The contribution of testers to the total sum of squares due to crosses was higher than that of interactions of line x testers for all the characters studied. The smaller contribution of interactions of line x testers than the testers indicated higher estimates of variances due to general combining ability. Rissi *et al.* (1991) also reported higher estimates of GCA variances due to testers in rice.

**Heterosis:** Percent heterosis for yield and yield related traits was computed over better parents. The magnitude of heterosis varied from trait to trait and cross to cross. For plant height and spikelet sterility negative heterosis was desirable but for rest of the traits positive heterosis was desirable. Highly significant and maximum positive heterosis over better parents (41.83%) was observed in a cross of IR69616A x Basmati 385 for grain yield correlated with highly significant and desirable heterosis (11.04%) for productive tillers per plant and number of filled grains per panicle (7.39%). Where as the cross of IR69616 x 60001 displayed highly significant and negative heterosis for all the traits studied except productive tillers plant$^{-1}$. These results are in corroborance with the findings of Watanesk (1993), Rao *et al.* (1996) and Sarker *et al.* (2002) who reported high heterosis for grain yield and yield related traits in rice. Highly significant and positive heterosis (21.45%) for number of spikelets panicle$^{-1}$ and productive tillers plant$^{-1}$ (4.37) was observed in the cross of IR70369A x 60001.

**Table-3 Heterobeltiosis (%) for different characteristics in Basmati rice hybrids**

| Cross | Prod. tillers plant$^{-1}$ | Plant height | No. of spike-lets panicle$^{-1}$ | Filled grains panicle$^{-1}$ | Yield plant$^{-1}$ (grams) | Sterility %age |
|---|---|---|---|---|---|---|
| IR69616A/60001 | 0.00 | -13.48** | -28.78** | -38.66** | -34.29** | -36.02** |
| IR69616A/BAS.385 | 11.04** | 0.35 | -40.38** | 7.39** | 41.83** | -64.33** |
| IR70369A/60001 | -37.50** | -2.27 | 36.98** | -80.47** | -87.95** | 3.24** |
| IR70369A/BAS.385 | 4.37** | -2.65 | 21.45** | -2.24 | -7.31** | -57.03** |

** = Significant (P < 0.01)

**General Combining Ability:** Negative GCA effects were desirable for plant height and spikelet sterility percentage while in other traits positive GCA effects were desirable. None of the CMS lines or testers (pollinators) was observed to be good general combiner for all the traits studied (Table 4). The female parent, IR69616A was found to be good combiner due to its highly significant and positive GCA effects for productive tillers plant$^{-1}$, number of filled grains panicle$^{-1}$ and grain yield plant$^{-1}$. Similar findings have been reported by Sarker *et al*. (2002) in rice and Singh *et al*. (1996 a) in wheat. Chowdhry *et al*. (1996) and Sharma *et al*. (1992) have reported good general combiner female parents with high GCA effects in wheat.

Among the testers, 60001 showed highly significant and positive GCA effects for number of spikelets panicle$^{-1}$ and spikelet sterility indicating that the tester line, 60001 is a poor general combiner. While Basmati 385 was observed to be the best general combiner due to its highly significant and positive GCA effects for productive tillers plant$^{-1}$, number of filled grains panicle$^{-1}$ and grain yield plant$^{-1}$. Rogbell *et al*. (1998) and Singh *et al*. (1996 b) observe similar good general combiner for yield in rice.

**Specific Combining Ability:** For plant height and spikelet sterility negative SCA effects were desirable where as in other traits positive SCA effects were desirable. None of the cross combinations was observed to be a good cross combination for all the traits studied (Table 5). The cross of IR69616A x Basmati 385 exhibited the highest and significant SCA effects for yield, number of productive tillers plant$^{-1}$, number of filled grains panicle$^{-1}$ and highly significant and negative SCA effect for spikelet sterility. Above cross combination was found to be a good specific combination with high heterotic effects for grain yield along with most of the yield contributing traits. Rogbell *et al*. (1998), Chen *et al*. (1995) and Young & Virmani (1990) observed similar findings for good specific cross combinations in rice.

**Table -4 General Combining Ability effects of parents for different characters in rice.**

| Lines | Prod. tillers plant$^{-1}$ | Plant height (cm) | No. spike lets panicle$^{-1}$ | No. of filled grains panicle$^{-1}$ | Grain yield plant$^{-1}$ (g) | Sterility (%) |
|---|---|---|---|---|---|---|
| IR 69616A | 1.125** | -3.167** | -12.417** | 6.250** | 2.707** | -9.025** |
| IR70369A | -1.125** | 3.167** | 12.417** | -6.250** | -2.707** | 9.025** |
| Testers | | | | | | |
| 60001 | -1.658** | -1.833** | 13.250** | -18.250** | -5.635** | 19.658** |
| Bas 385 | 1.658** | 1.833** | -13.250** | 18.250** | 5.635** | -19.658** |
| **SE** | *0.441* | *1.092* | *3.026* | *2.473* | *1.1224* | *1.042* |

** = Significant ($P < 0.01$)

**Table -5 Specific Combining Ability effects for different characters in Basmati rice hybrids.**

| Crosses | Prod. tillers plant$^{-1}$ | Plant height (cm) | No. spike- lets panicle$^{-1}$ | No. filled grains panicle$^{-1}$ | Grain yield plant$^{-1}$ (g) | Sterility (%) |
|---|---|---|---|---|---|---|
| IR69616A / 60001 | -0.47 | 0.67 | -0.92 | 11.08** | 1.46 | -6.66 ** |
| IR69616A / Bas 385 | 2.73** | -7.00** | -23.92** | 1.41 | 3.95** | -11.39** |
| IR70369A / 60001 | -1.78** | 5.67** | 25.75** | -23.58** | -6.87** | 24.71** |
| IR70369A / Bas 385 | -0.48 | 0.67 | -0.92 | 11.08** | 1.46 | -6.65** |
| SE | 0.623 | 1.543 | 4.280 | 3.498 | 1.473 | 1.587 |

** = Significant ($P < 0.01$)

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