

ESTIMATION OF HETEROSIS FOR QUANTITATIVE AND QUALITY TRAITS IN QUALITY HYBRIDS RICE (*ORYZA SATIVA* L.)

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Abstract: The heterosis study on quantitative and quality traits in quality hybrids rice from line x tester analysis from 24 F₁ hybrids derived from 3 female and 8 male lines. The observations were recorded on 28 quantitative and quality traits. Analysis of variance revealed that all the treatments exhibited highly significant variation for almost all the traits under study. The highest heterotic effects observed for mid parents, better parent and standard heterosis were 233.33%, 97.50% and 60.14% for grain yield per plant noted for the crosses IR 58025A/R1679-1674-1-234-1. Maximum heterosis over mid parents of 313.25%, 33.67%, 26.98% and 100.15% for productive tillers per plant, panicle length, spikelet fertility percentage and harvest index and maximum heterobeltiosis of 163.64%, 29.18%, 24.54% and 43.35% for productive tillers per plant, panicle length, spikelet fertility percentage and harvest index and maximum standard heterosis of 218.68%, 21.10%, 5.89% and 49.09% for productive tillers per plant, panicle length, spikelet fertility percentage and harvest index was found in IR 58025A/R1679-1674-1-234-1.

Keywords: Heterosis, Trait, Hybrids, Rice

INTRODUCTION

Rice is life and prince among cereals. More than half of the world's population depends on rice for calories and proteins, especially in developing countries. Exploitation of hybrids vigour is one of the possible ways for increasing production and productivity to meet the demand of population for food and raw materials. Hybrids rice breeding holds promise to make a breakthrough in rice production. Hybrid rice technology exploits the phenomenon of heterosis and involves raising a commercial crop from F₁ seeds. This technology enabled china to increase rice production from 140 million tones in 1978 to 188 million tones in 1990 (Virmani, 1990). The exploitation of heterosis is considered an outstanding application of the principles of the science of genetics in agriculture. Heterosis breeding had led to a breakthrough in yield in several crop plants. For the exploitation of heterosis, it is imperative to study the magnitude of heterosis. The expression of heterosis is greatly influenced by the magnitude of genetic differences among parents involved in the crosses. The parents with optimal to intermediate genetic diversity will show maximum heterosis (Moll and Stuber, 1974). Varying levels of heterosis in grain yield and yield components have been reported by several workers in rice.

MATERIAL AND METHOD

The material for the present study comprised 24 F₁ of rice generated involving 3 lines (*viz.*, PUSA 6A, CRMS 32A, IR 58025A) and 8 diverse rice varieties (*viz.*, R1607-673-2-322-1, R1679-1674-1-234-1, R1519-815-1-646-1, R1551-1066-1-449-1, R1630-342-1-47-1, R1665-1620-1-985-1, RNR2354 and

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Improved pusa basmati) as testers through Line x Tester design during *Kharif* 2011-2012. The resultant 24 F₁ were grown in completely randomized block design at the Research Farm, Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG). Each genotype was grown in two replication with spacing 20 x 15 cm, respectively. Recommended agronomic package and practices were followed to raise a good crop. In each entry, five plants were selected randomly from each replication and biometrical observations were recorded for days to 50% flowering, plant height, productive tillers per plant, panicle length, number of filled grains per panicle, number of unfilled grains per panicle, spikelet fertility (%), spikelet sterility (%), grain yield per plant (g), seed index/hundred seed weight (g), biological yield per plant (g), harvest index (%), hulling (%), milling (%), head rice recovery (%), paddy length (mm), paddy breadth (mm), paddy L/B ratio, brown rice length (mm), brown rice breadth (mm), brown rice L/B ratio, kernel length (mm), kernel breadth (mm), kernel L/B ratio, kernel length after cooking (mm), kernel breadth after cooking (mm), cooked rice L/B ratio and elongation ratio.

RESULT AND DISCUSSION

Analysis of variance presented in Table 1 revealed that the differences among genotypes for almost all the traits under study were highly significant. It was suggested that the material has adequate variability and validated further statistical and genetically analysis.

Evaluation of heterosis

Percent heterosis for quantitative and quality traits was computed over mid parents, better parent and standard heterosis. The magnitude of heterosis varied from trait to trait and crosses to cross. For days to 50 % flowering, plant height, number of unfilled grains per panicle, spikelet sterility percentage, paddy breadth, brown rice breadth, kernel breadth and kernel breadth after cooking negative heterosis was desirable but for rest of the traits positive heterosis was desirable.

Days to 50% flowering

The mid parent heterosis ranged from -9.14 (IR 58025A/R1679-1674-1-234-1) to 20.25% (PUSA 6A/R1630-342-1-47-1). Among 24 hybrids, 5 hybrids showed significant negative heterosis and 17 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -8.65 (IR 58025A/R1679-1674-1-234-1) to 23.60% (CRMS 32A/R1665-1620-1-985-1 and IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 1 hybrid showed significant negative heterosis and 22 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from 1.21 (PUSA 6A/R1679-1674-1-234-1) to 20.61% (CRMS 32A/R1665-1620-1-985-1, IR 58025A/R1630-342-1-47-1, IR 58025A/R1665-1620-1-985-1 and IR 58025A/Improved pusa basmati). Among 24 hybrids, none hybrids showed significant negative heterosis and 23 hybrids showed significant positive heterosis for this trait. Similar finding have also been reported by Chaudhry *et al.* (2007), Gawas *et al.* (2007), Wang *et al.* (2010) and Kumar *et al.* (2012).

Plant height (cm)

The mid parent heterosis ranged from -29.96 (PUSA 6A/R1607-673-2-322-1) to 23.38% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 13 hybrids showed significant negative heterosis and 6 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -23.83 (PUSA 6A/R1607-673-2-322-1) to 24.17% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 7 hybrids showed significant negative heterosis and 12 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -36.32 (PUSA 6A/R1607-673-2-322-1) to 3.81% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 23 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. Similar results have also been reported by Gawas *et al.* (2007), Saidaiiah *et al.* (2010) and Kumar *et al.* (2012).

Productive tillers per plant

The mid parent heterosis ranged from -66.35 (PUSA 6A/R1607-673-2-322-1) to 313.25% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and

5 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -72.66 (PUSA 6A/R1607-673-2-322-1) to 163.64% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -61.54 (PUSA 6A/R1607-673-2-322-1) to 218.68% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 9 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Soni *et al.* (2005) and Kumar *et al.* (2012).

Panicle length (cm)

The mid parent heterosis ranged from -24.93 (PUSA 6A/R1607-673-2-322-1) to 33.67% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 7 hybrids showed significant negative heterosis and 9 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -25.05 (PUSA 6A/R1607-673-2-322-1) to 29.18% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -26.16 (PUSA 6A/R1607-673-2-322-1) to 21.10% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 10 hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. Similar findings reported by Soni *et al.* (2005), Pandya and Tripathi (2006), and Singh *et al.* (2007).

Number of filled grains per panicle

The mid parent heterosis ranged from -97.85 (PUSA 6A/R1607-673-2-322-1) to 64.38% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 17 hybrids showed significant negative heterosis and 5 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -97.94 (PUSA 6A/R1607-673-2-322-1) to 52.56% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 18 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -95.67 (PUSA 6A/R1607-673-2-322-1) to 201.58% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 10 hybrids showed significant negative heterosis and 12 hybrids showed significant positive heterosis for this trait. Similar findings reported by Singh *et al.* (2007).

Number of unfilled grains per panicle

The mid parent heterosis ranged from -63.81 (IR 58025A/R1679-1674-1-234-1) to 296.97% (IR 58025A/R1519-815-1-646-1). Among 24 hybrids, 3 hybrids showed significant negative heterosis and 16 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -57.55 (IR 58025A/R1679-1674-1-234-1) to 446.44% (CRMS

32A/RNR2354). Among 24 hybrids, 1 hybrid showed significant negative heterosis and 17 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from 52.01 (R1551-1066-1-449-1) to 1645.42% (CRMS 32A/RNR2354). Among 24 hybrids, none hybrids showed significant negative heterosis and 21 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Soni *et al.* (2005).

Spikelet fertility (%)

The mid parent heterosis ranged from -96.18 (PUSA 6A/R1607-673-2-322-1) to 26.98% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 16 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -96.34 (PUSA 6A/R1607-673-2-322-1) to 24.54% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 17 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -96.83 (PUSA 6A/R1607-673-2-322-1) to 5.89% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 19 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait. Similar results have been reported by Singh (2005), Soni *et al.* (2005), Shanthi *et al.* (2006) and Kumar *et al.* (2012).

Spikelet sterility (%)

The mid parent heterosis ranged from -71.72 (IR 58025A/R1679-1674-1-234-1) to 394.13% (CRMS 32A/RNR2354). Among 24 hybrids, 4 hybrids showed significant negative heterosis and 16 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -70.17 (IR 58025A/R1679-1674-1-234-1) to 561.07% (CRMS 32A/RNR2354). Among 24 hybrids, 4 hybrids showed significant negative heterosis and 17 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -39.89 (IR 58025A/R1679-1674-1-234-1) to 656.14% (PUSA 6A/R1607-673-2-322-1). Among 24 hybrids, none hybrids showed significant negative heterosis and 19 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Veni *et al.* (2005) and Pandya and Tripathi (2006).

Grain yield per plant (g)

The mid parent heterosis ranged from -98.59 (PUSA 6A/R1607-673-2-322-1) to 233.33% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -98.74 (PUSA 6A/R1607-673-2-322-1) to 97.50% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 16 hybrids showed significant negative heterosis and

4 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -99.01 (PUSA 6A/R1607-673-2-322-1) to 60.14% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 19 hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Issac (2007), Li *et al.* (2008), Vaithiyaligan and Nandarajan (2010), Mirarab *et al.* (2011), Tiwari *et al.* (2011) and Kumar *et al.* (2012).

Seed index/hundred seed weight (g)

The mid parent heterosis ranged from -6.76 (PUSA 6A/R1607-673-2-322-1) to 36.07% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 1 hybrid showed significant negative heterosis and 19 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -16.14 (PUSA 6A/R1607-673-2-322-1) to 28.61% (PUSA 6A/R1665-1620-1-985-1). Among 24 hybrids, 5 hybrids showed significant negative heterosis and 13 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -27.73 (IR 58025A/R1679-1674-1-234-1) to 23.64% (PUSA 6A/R1665-1620-1-985-1). Among 24 hybrids, 8 hybrids showed significant negative heterosis and 6 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Wang *et al.* (2010).

Biological yield per plant (g)

The mid parent heterosis ranged from -84.02 (PUSA 6A/R1607-673-2-322-1) to 126.62% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 8 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -85.88 (PUSA 6A/R1607-673-2-322-1) to 64.21% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 6 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -86.32 (PUSA 6A/R1607-673-2-322-1) to 31.34% (IR 58025A/R1519-815-1-646-1). Among 24 hybrids, 14 hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Hossain *et al.* (2004), Verma *et al.* (2004), Singh *et al.* (2006) and Kumar *et al.* (2012).

Harvest index (%)

The mid parent heterosis ranged from -91.22 (PUSA 6A/R1607-673-2-322-1) to 100.15% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 17 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -91.40 (PUSA 6A/R1607-673-2-322-1) to 43.35% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 17 hybrids showed significant negative heterosis and

2 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -92.56 (PUSA 6A/R1607-673-2-322-1) to 49.09% (IR 58025A/R1679-1674-1-234-1). Among 24 hybrids, 18 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Tiwari *et al.* (2011) and Kumar *et al.* (2012).

Hulling (%)

The mid parent heterosis ranged from -12.60 (CRMS 32A/R1665-1620-1-985-1) to 4.67% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 11 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -13.84 (CRMS 32A/R1665-1620-1-985-1) to 1.80% (PUSA 6A/R1551-1066-1-449-1). Among 24 hybrids, 15 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -11.78 (CRMS 32A/R1665-1620-1-985-1) to 3.86% (PUSA 6A/R1551-1066-1-449-1). Among 24 hybrids, 7 hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Pandya and Tripathi (2006).

Milling (%)

The mid parent heterosis ranged from -14.97 (IR 58025A/R1551-1066-1-449-1) to 9.23% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 7 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -15.65 (PUSA 6A/Improved pusa basmati) to 1.37% (CRMS 32A/Improved pusa basmati). Among 24 hybrids, 9 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -14.77 (PUSA 6A/Improved pusa basmati) to 5.41% (CRMS 32A/Improved pusa basmati). Among 24 hybrids, 4 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Pandya and Tripathi (2006).

Head rice recovery (%)

The mid parent heterosis ranged from -50.01 (PUSA 6A/Improved pusa basmati) to 16.53% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 10 hybrids showed significant negative heterosis and 5 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -51.55 (PUSA 6A/Improved pusa basmati) to 10.45% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -52.21 (PUSA 6A/Improved pusa basmati) to 7.56% (PUSA 6A/R1607-673-2-322-1 and IR 58025A/R1607-673-

2-322-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Singh and Lal, (2005), and Singh (2005).

Paddy length (mm)

The mid parent heterosis ranged from -6.48 (IR 58025A/RNR2354) to 25.63% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 3 hybrids showed significant negative heterosis and 12 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -23.35 (PUSA 6A/R1679-1674-1-234-1) to 11.05% (CRMS 32A/RNR2354). Among 24 hybrids, 11 hybrids showed significant negative heterosis and 5 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -20.63 (CRMS 32A/R1679-1674-1-234-1) to 15.87% (PUSA 6A/R1519-815-1-646-1). Among 24 hybrids, 6 hybrids showed significant negative heterosis and 13 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Bisne and Motiramani (2005).

Paddy breadth (mm)

The mid parent heterosis ranged from -19.61 (PUSA 6A/R1607-673-2-322-1) to 14.94% (PUSA 6A/RNR2354). Among 24 hybrids, 4 hybrids showed significant negative heterosis and 10 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -6.82 (PUSA 6A/R1607-673-2-322-1) to 22.73% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, 1 hybrids showed significant negative heterosis and 12 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -10.87 (PUSA 6A/R1607-673-2-322-1) to 17.39% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, 3 hybrids showed significant negative heterosis and 5 hybrids showed significant positive heterosis for this trait.

Paddy L/B ratio

The mid parent heterosis ranged from -17.57 (IR 58025A/RNR2354) to 36.01% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 8 hybrids showed significant negative heterosis and 8 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -29.61 (PUSA 6A/R1679-1674-1-234-1) to 8.29% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 15 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -23.36 (PUSA 6A/R1679-1674-1-234-1) to 15.82% (PUSA 6A/R1519-815-1-646-1). Among 24 hybrids, 8 hybrids showed significant negative heterosis and 6 hybrids showed significant positive heterosis for this trait.

Brown rice length (mm)

The mid parent heterosis ranged from -8.30 (PUSA 6A/R1679-1674-1-234-1) to 19.49% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 9 hybrids showed significant negative heterosis and 10 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -26.57 (PUSA 6A/R1679-1674-1-234-1) to 5.22% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 13 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -30.92 (PUSA 6A/R1679-1674-1-234-1) to -1.97% (PUSA 6A/R1519-815-1-646-1 and CRMS 32A/R1665-1620-1-985-1). Among 24 hybrids, none hybrids showed significant negative heterosis and 24 hybrids showed significant positive heterosis for this trait.

Brown rice breadth (mm)

The mid parent heterosis ranged from -9.52 (PUSA 6A/R1551-1066-1-449-1) to 16.22% (PUSA 6A/RNR2354). Among 24 hybrids, 6 hybrids showed significant negative heterosis and 12 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from 0.00 (CRMS 32A/R1665-1620-1-985-1 and IR 58025A/R1630-342-1-47-1) to 23.68% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, none hybrids showed significant negative heterosis and 20 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -5.13 (IR 58025A/R1519-815-1-646-1) to 20.51% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, 1 hybrid showed significant negative heterosis and 10 hybrids showed significant positive heterosis for this trait.

Brown rice L/B ratio

The mid parent heterosis ranged from -19.73 (IR 58025A/RNR2354) to 28.03% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 13 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -33.88 (PUSA 6A/R1679-1674-1-234-1) to 2.55% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 20 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -35.38 (CRMS 32A/R1679-1674-1-234-1) to 0.51% (PUSA 6A/R1519-815-1-646-1 and CRMS 32A/R1665-1620-1-985-1). Among 24 hybrids, 18 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait.

Kernel length (mm)

The mid parent heterosis ranged from -11.97 (CRMS 32A/RNR2354) to 22.33% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 9 hybrids showed

significant negative heterosis and 13 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -23.26 (PUSA 6A/R1679-1674-1-234-1) to 10.94% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 14 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -28.68 (CRMS 32A/R1679-1674-1-234-1) to 4.41% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 19 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. Similar results have been reported by Veni *et al.* (2005) and Singh (2005).

Kernel breadth (mm)

The mid parent heterosis ranged from -13.25 (IR 58025A/R1551-1066-1-449-1) to 17.95% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, 4 hybrids showed significant negative heterosis and 9 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -5.26 (IR 58025A/R1551-1066-1-449-1) to 17.95% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, 1 hybrid showed significant negative heterosis and 14 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -7.69 (IR 58025A/R1551-1066-1-449-1) to 17.95% (CRMS 32A/R1607-673-2-322-1). Among 24 hybrids, 3 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait.

Kernel L/B ratio

The mid parent heterosis ranged from -20.29 (CRMS 32A/RNR2354) to 38.34% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 11 hybrids showed significant negative heterosis and 7 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -29.08 (PUSA 6A/R1679-1674-1-234-1) to 14.57% (IR 58025A/R1551-1066-1-449-1). Among 24 hybrids, 16 hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -29.80 (CRMS 32A/RNR2354 and IR 58025A/RNR2354) to 10.03% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 15 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait.

Kernel length after cooking (mm)

The mid parent heterosis ranged from -22.44 (IR 58025A/R1519-815-1-646-1) to 28.43% (PUSA 6A/R1551-1066-1-449-1). Among 24 hybrids, 11 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -32.08 (PUSA 6A/Improved pusa basmati) to 20.00% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids,

16 hybrids showed significant negative heterosis and 2 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -40.85 (CRMS 32A/R1679-1674-1-234-1) to 2.13% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 23 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait. Similar results have been reported by Veni *et al.* (2005).

Kernel breadth after cooking (mm)

The mid parent heterosis ranged from -6.87 (CRMS 32A/R1519-815-1-646-1) to 11.11% (CRMS 32A/R1665-1620-1-985-1). Among 24 hybrids, none hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -6.15 (CRMS 32A/R1519-815-1-646-1) to 17.24% (PUSA 6A/RNR2354). Among 24 hybrids, none hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -10.45 (IR 58025A/R1519-815-1-646-1) to 4.48% (PUSA 6A/R1630-342-1-47-1, PUSA 6A/R1665-1620-1-985-1, CRMS 32A/R1607-673-2-322-1 and CRMS 32A/R1665-1620-1-985-1). Among 24 hybrids, none hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait.

Cooked rice L/B ratio

The mid parent heterosis ranged from -19.74 (PUSA 6A/Improved pusa basmati) to 29.48% (PUSA

6A/R1551-1066-1-449-1). Among 24 hybrids, 12 hybrids showed significant negative heterosis and 3 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -35.29 (IR 58025A/R1679-1674-1-234-1) to 19.51% (PUSA 6A/R1551-1066-1-449-1). Among 24 hybrids, 16 hybrids showed significant negative heterosis and 2 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -38.75 (IR 58025A/R1679-1674-1-234-1) to 8.83% (IR 58025A/R1665-1620-1-985-1). Among 24 hybrids, 23 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait.

Elongation ratio

The mid parent heterosis ranged from -27.45 (IR 58025A/R1630-342-1-47-1) to 16.82% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 13 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The heterobeltiosis ranged from -31.40 (IR 58025A/R1519-815-1-646-1) to 8.75% (PUSA 6A/R1679-1674-1-234-1). Among 24 hybrids, 16 hybrids showed significant negative heterosis and 1 hybrids showed significant positive heterosis for this trait. The standard heterosis ranged from -35.26 (CRMS 32A/R1519-815-1-646-1) to 4.05% (CRMS 32A/RNR2354 and IR 58025A/RNR2354). Among 24 hybrids, 19 hybrids showed significant negative heterosis and none hybrids showed significant positive heterosis for this trait.

Table 1. Mid parent heterosis, Heterobeltiosis and Standard heterosis for different characters

| Parents | Kernel breadth after cooking (mm) | | | Cooked rice L/B ratio | | | Elongation ratio | | |
|------------------------------|-----------------------------------|--------|-------|-----------------------|----------|----------|------------------|----------|----------|
| | MP | BP | SH | MP | BP | SH | MP | BP | SH |
| PUSA 6A/ | | | | | | | | | |
| R1607-673-2-322-1 | -0.74 | 0.00 | 0.00 | 8.89 | 0.00 | -17.09** | 14.38** | 0.00 | -1.16 |
| R1679-1674-1-234-1 | -0.76 | 3.17 | -2.99 | 15.09* | 1.03 | -29.91** | 16.82** | 8.75** | -6.36* |
| R1519-815-1-646-1 | 0.00 | 1.52 | 0.00 | -10.99 | -21.68** | -28.49** | -6.45* | -13.58** | -24.28** |
| R1551-1066-1-449-1 | -0.75 | 1.54 | -1.49 | 29.48** | 19.51* | -17.09** | 4.33 | -3.02 | 16.76** |
| R1630-342-1-47-1 | 5.26 | 7.69 | 4.48 | -13.29* | -19.86** | -34.47** | -12.85** | -25.35** | -22.54** |
| R1665-1620-1-985-1 | 8.53 | 14.75* | 4.48 | -13.75* | -24.06** | -30.77** | -9.64** | 16.78** | 27.17** |
| RNR2354 | 7.94 | 17.24* | 1.49 | -11.19 | -21.75** | -28.77** | 2.56 | -9.06** | 13.29** |
| Improved pusa basmati | -0.76 | 3.17 | -2.99 | -19.74** | -34.29** | -28.49** | 14.81** | 25.15** | 27.17** |
| CRMS 32A/ | | | | | | | | | |
| R1607-673-2-322-1 | 6.06 | 7.69 | 4.48 | -3.83* | -7.22 | -23.08** | -4.61 | -12.28** | -13.29** |
| R1679-1674-1-234-1 | 0.00 | 1.59 | -4.48 | -4.29* | -19.59** | -38.18** | -1.71 | -3.37 | -17.34** |
| R1519-815-1-646-1 | -6.87 | -6.15 | -8.96 | - | - | - | - | - | - |

| | | | | | | | | | |
|------------------------------|--------|--------|--------|---------|---------|---------|---------|---------|---------|
| | | | | 16.07** | 22.62** | 29.34** | 24.28** | 26.16** | 35.26** |
| R1551-1066-1-449-1 | 0.00 | 0.00 | -2.99 | -1.36 | -13.12 | - | - | - | - |
| | | | | | | 33.05** | 12.14** | 13.76** | 25.43** |
| R1630-342-1-47-1 | -3.08 | -3.08 | -5.97 | 3.68 | 0.70 | - | - | - | - |
| | | | | | | 17.66** | 13.31** | 22.01** | 19.08** |
| R1665-1620-1-985-1 | 11.11* | 14.75* | 4.48 | -10.92 | - | - | -4.23 | -6.91* | - |
| | | | | | | 17.81** | 25.07** | - | 18.50** |
| RNR2354 | 5.69 | 12.07 | -2.99 | -2.71 | -10.17 | - | - | - | - |
| | | | | | | 18.23** | 16.18** | 8.46** | 4.05 |
| Improved pusa basmati | -4.69 | -3.17 | -8.96 | -8.97 | - | - | - | - | - |
| | | | | | | 22.25** | 15.38** | 11.04** | 17.75** |
| IR 58025A/ | | | | | | | | | |
| R1607-673-2-322-1 | 5.51 | 11.67 | 0.00 | -6.73 | -12.61* | - | -0.29 | -0.58 | -1.16 |
| | | | | | | 17.09** | - | - | - |
| R1679-1674-1-234-1 | 7.32 | 10.00 | -1.49 | -16.63* | - | - | - | - | - |
| | | | | | | 35.29** | 38.75** | 11.39** | 17.44** |
| R1519-815-1-646-1 | -4.76 | 0.00 | -10.45 | - | - | - | - | - | - |
| | | | | | | 18.90** | 20.42** | 24.50** | 26.93** |
| R1551-1066-1-449-1 | 5.60 | 10.00 | -1.49 | -13.73* | - | - | - | - | - |
| | | | | | | 30.18** | 33.62** | 24.30** | 29.36** |
| R1630-342-1-47-1 | 7.20 | 11.67 | 0.00 | - | - | - | - | - | - |
| | | | | | | 21.77** | 27.18** | 31.05** | 27.45** |
| R1665-1620-1-985-1 | 4.13 | 5.00 | -5.97 | 17.00** | 14.71* | 8.83 | 4.32 | -1.74 | -2.31 |
| | | | | | | - | - | - | - |
| RNR2354 | 10.17 | 12.07 | -2.99 | -12.03* | -13.81* | - | - | - | - |
| | | | | | | 18.23** | 6.37** | 4.36 | 4.05 |
| Improved pusa basmati | 2.44 | 5.00 | -5.97 | - | - | - | - | - | - |
| | | | | | | 16.92** | 22.25** | 15.38** | -7.04** |
| | | | | | | | | | -7.85** |
| | | | | | | | | | -8.09** |

*= Significant P > 0.05, **= Significant P > 0.01, MP= Mid Parent Heterosis, BP= Better Parent Heterosis, SH= Standard Heterosis

Table 2. ANOVA for different quantitative and quality characters

| Source of Variation | df | Mean sum of square | | | | | | | | | | | | | | |
|---------------------|----|--------------------|---------|--------|--------|---------|--------|--------|---------|---------|--------|--------|--------|---------|------|------|
| | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | | |
| Replication | 1 | 0.027 | 0.011 | 0.090 | 0.0031 | 0.0051 | 0.022 | 0.0012 | 0.00054 | 0.00030 | 0.36* | 0.0012 | 0.044 | 0.015* | | |
| Treatment | 34 | 2.97** | 0.064** | 0.94** | 1.37** | 0.044** | 0.63** | 1.18** | 0.028** | 0.51** | 3.43** | 0.045 | 0.39** | 0.073** | | |
| Error | 34 | 0.030 | 0.0053 | 0.029 | 0.0047 | 0.0013 | 0.0044 | 0.0068 | 0.0023 | 0.0068 | 0.060 | 0.031 | 0.034 | 0.0018 | | |
| Error | 34 | 0.68 | 3.67 | 1.73 | 0.93 | 70.52 | 152.08 | 7.77 | 7.77 | 3.50 | 0.0051 | 39.41 | 3.16 | 0.80 | 1.22 | 3.50 |

*= Significant P > 0.05, **= Significant P > 0.01

1. Days to 50% flowering
2. Plant height (cm)
3. Productive tillers per plant
4. Panicle length (cm)
5. Number of filled grains per panicle
6. Number of unfilled grains per panicle
7. Spikelet fertility (%)
8. Spikelet sterility (%)
9. Grain yield per plant (g)
10. Seed index/hundred seed weight (g)
11. Biological yield per plant (g)
12. Harvest index (%)
13. Hulling (%)
14. Milling (%)

15. Head rice recovery (%)
16. Paddy length (mm)
17. Paddy breadth (mm)
18. Paddy L/B ratio
19. Brown rice length (mm)
20. Brown rice breadth (mm)
21. Brown rice L/B ratio
22. Kernel length (mm)
23. Kernel breadth (mm)
24. Kernel L/B ratio
25. Kernel length after cooking (mm)
26. Kernel breadth after cooking (mm)
27. Cooked rice L/B ratio
28. Elongation ratio

Table 3. Mid parent heterosis, Heterobeltiosis and Standard heterosis for different characters

| Parents | Days to 50% flowering | | | Plant height (cm) | | | Productive tillers per plant | | | Panicle length (cm) | | | Number of filled grains per panicle | | |
|------------------------------|-----------------------|---------|---------|-------------------|---------|---------|------------------------------|---------|---------|---------------------|---------|---------|-------------------------------------|---------|---------|
| | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH |
| PUSA 6A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | -3.43** | 6.29** | 2.42* | - | - | - | - | - | - | - | - | - | - | - | - |
| R1679-1674-1-234-1 | -3.47** | 5.03** | 1.21 | 29.96** | 23.83** | 36.32** | 66.35** | 72.66** | 61.54** | 24.93** | 25.05** | 26.16** | 97.85** | 97.94** | 95.67** |
| R1519-815-1-646-1 | -3.47** | 5.03** | 1.21 | 23.38** | 24.17** | 3.81* | 86.68** | 28.75 | 13.19 | 26.26** | 19.16** | 17.40** | 50.65** | 43.46** | 201.58* |
| R1519-815-1-646-1 | 5.14** | 15.72** | 11.52** | 5.35** | 14.71** | -4.10* | - | - | -10.99 | 7.75* | 0.99 | 13.78** | - | - | -12.13 |
| R1551-1066-1-449-1 | 29.26** | 45.64** | - | 29.26** | 45.64** | -10.99 | - | - | 7.75* | 0.99 | 13.78** | 58.07** | 58.21** | - | - |
| R1551-1066-1-449-1 | 4.24** | 8.18** | 4.24** | 7.23** | 13.91** | -4.77* | 43.23** | 38.75* | 21.98 | 12.02** | 6.05 | 4.48 | 3.81 | 2.99 | 119.96* |
| R1630-342-1-47-1 | 20.25** | 21.38** | 16.97** | - | - | - | -5.62 | -14.29 | -7.69 | -9.34* | - | - | - | - | 5.81 |
| R1630-342-1-47-1 | 14.02** | 13.35** | 28.67** | 14.02** | 13.35** | 28.67** | -5.62 | -14.29 | -7.69 | -9.34* | - | - | 48.14** | 49.67** | - |
| R1665-1620-1-985-1 | 13.75** | 14.47** | 10.30** | -7.98** | -7.19** | - | - | - | - | -9.73* | - | - | - | - | - |
| R1665-1620-1-985-1 | 13.75** | 14.47** | 10.30** | -7.98** | -7.19** | 23.72** | 50.25** | 58.12** | 46.15** | -9.73* | 12.69** | 13.99** | 95.29** | 96.45** | 92.53** |
| RNR2354 | 5.54** | 13.84** | 9.70** | -4.76* | 1.02 | - | -26.04* | - | -21.98 | -4.76 | -7.48 | -3.33 | - | - | 102.75* |
| RNR2354 | 5.54** | 13.84** | 9.70** | -4.76* | 1.02 | 15.55** | -26.04* | 36.61** | -21.98 | -4.76 | -7.48 | -3.33 | 16.88** | 26.98** | - |
| Improved pusa basmati | -2.03* | 6.29** | 2.42* | -4.88** | 3.10 | - | 48.51** | 22.95* | 64.84** | -0.17 | -7.45* | 6.75 | 3.22 | - | 76.99** |
| Improved pusa basmati | -2.03* | 6.29** | 2.42* | -4.88** | 3.10 | 13.80** | 48.51** | 22.95* | 64.84** | -0.17 | -7.45* | 6.75 | 3.22 | 15.81** | - |
| CRMS 32A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 0.00 | 2.19* | 13.33** | -3.80* | 7.84** | - | - | - | -29.67* | -5.87 | -8.34* | -10.00* | - | - | 48.35** |
| R1607-673-2-322-1 | 0.00 | 2.19* | 13.33** | -3.80* | 7.84** | 14.69** | 39.91** | 50.00** | -29.67* | -5.87 | -8.34* | -10.00* | 17.41** | 23.01** | - |
| R1679-1674-1-234-1 | 1.08 | 2.19* | 13.33** | 2.87 | 6.48** | - | 129.30* | 55.59** | 45.39** | 10.73** | 7.40 | -0.04 | 12.88** | 5.88 | 101.34* |
| R1679-1674-1-234-1 | 1.08 | 2.19* | 13.33** | 2.87 | 6.48** | 15.77** | 129.30* | 55.59** | 45.39** | 10.73** | 7.40 | -0.04 | 12.88** | 5.88 | - |
| R1519-815-1-646-1 | 2.14** | 4.37** | 15.76** | 1.13 | 13.50** | - | - | - | -15.39 | -0.20 | -8.89* | 2.63 | - | - | - |
| R1519-815-1-646-1 | 2.14** | 4.37** | 15.76** | 1.13 | 13.50** | 10.21** | 34.19** | 48.32** | -15.39 | -0.20 | -8.89* | 2.63 | 86.45** | 87.82** | 74.56** |
| R1551-1066-1-449-1 | 11.86** | 15.79** | 20.00** | - | -5.63* | - | - | - | -15.39 | -0.20 | -8.89* | 2.63 | - | - | - |
| R1551-1066-1-449-1 | 11.86** | 15.79** | 20.00** | 13.76** | -5.63* | 25.35** | 41.69** | 45.12** | 48.79** | -1.70 | -4.35 | 11.02** | 36.16** | 43.18** | 21.36* |
| R1630-342-1-47-1 | 7.25** | 14.20** | 12.12** | 2.87 | 4.96* | - | -7.10 | -13.27 | -6.59 | 16.96** | 10.34* | 2.67 | -10.66* | - | 62.81** |
| R1630-342-1-47-1 | 7.25** | 14.20** | 12.12** | 2.87 | 4.96* | 16.97** | -7.10 | -13.27 | -6.59 | 16.96** | 10.34* | 2.67 | -10.66* | 17.72** | - |
| R1665-1620-1-985-1 | 15.70** | 23.60** | 20.61** | 7.18** | 9.27** | - | -6.93 | -19.66 | 3.30 | 12.27** | 11.67** | 3.91 | - | - | - |
| R1665-1620-1-985-1 | 15.70** | 23.60** | 20.61** | 7.18** | 9.27** | 13.56** | -6.93 | -19.66 | 3.30 | 12.27** | 11.67** | 3.91 | 90.73** | 92.40** | 87.33** |
| RNR2354 | 1.91* | 2.19* | 13.33** | -8.03** | 0.47 | - | -2.28 | -14.06 | 5.71 | - | - | - | - | - | - |
| RNR2354 | 1.91* | 2.19* | 13.33** | -8.03** | 0.47 | 20.51** | -2.28 | -14.06 | 5.71 | 11.29** | 16.14** | 12.38** | 94.64** | 95.71** | 88.09** |
| Improved pusa basmati | -1.90* | -1.09 | 9.70** | -9.35** | 1.27 | - | - | - | - | -5.53 | - | -1.56* | - | - | 28.14** |
| Improved pusa basmati | -1.90* | -1.09 | 9.70** | -9.35** | 1.27 | 19.88** | 54.59** | 61.48** | 48.35** | -5.53 | 14.66** | -1.56* | 14.38** | 23.08** | - |
| IR 58025A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 4.79** | 6.49** | 19.39** | - | -6.79** | - | - | - | - | - | - | - | - | - | - |
| R1607-673-2-322-1 | 4.79** | 6.49** | 19.39** | 17.72** | -6.79** | 27.65** | 57.98** | 60.94** | 45.06** | 18.77** | 20.61** | 22.05** | 68.09** | 70.56** | 43.28** |
| R1679-1674-1-234-1 | -9.14** | -8.65** | 2.42* | 9.52** | 14.49** | - | 313.25* | 163.64* | 218.68* | 33.67** | 29.18** | 21.10** | 64.38** | 52.56** | 190.11* |

| | | | | | | | | | | | | | | | |
|------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|--------|---------|---------|---------|
| | | | | | | 11.14** | * | * | * | | | | | | * |
| R1519-815-1-646-1 | 2.66** | 4.32** | 16.97** | 3.09 | 16.93** | -9.24** | 9.65 | -4.70 | 56.04** | -0.72 | -9.05* | 2.47 | - | - | - |
| R1551-1066-1-449-1 | 1.69* | 5.85** | 9.70** | -1.48 | 8.93** | - | 13.51 | -4.55 | 15.39 | 9.53* | 6.19 | -0.45 | 26.26** | 11.25* | 137.61* |
| R1630-342-1-47-1 | 14.70** | 22.84** | 20.61** | 16.02** | 19.54** | -7.22** | -14.42 | -19.09 | -2.20 | 8.24* | 1.76 | -4.61 | 26.89** | 15.65** | 128.84* |
| R1665-1620-1-985-1 | 15.03** | 23.60** | 20.61** | - | - | - | - | - | -36.26* | -0.77 | -1.67 | -7.82 | - | - | - |
| RNR2354 | 6.78** | 7.07** | 19.39** | - | - | - | - | - | - | - | - | - | - | - | - |
| Improved pusa basmati | 7.28** | 7.57** | 20.61** | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | 18.83** | -8.35** | 28.87** | 47.54** | 50.12** | -33.08* | 13.57** | 21.67** | -9.63* | 66.67** | 69.75** | 50.75** |

*= Significant P > 0.05, **= Significant P > 0.01, MP= Mid Parent Heterosis, BP= Better Parent Heterosis, SH= Standard Heterosis

Table 4. Mid parent heterosis, Heterobeltiosis and Standard heterosis for different characters

| Parents | Number of unfilled grains per panicle | | | Spikelet fertility (%) | | | Spikelet sterility (%) | | | Grain yield per plant (g) | | | Seed index/hundred seed weight (g) | | |
|------------------------------|---------------------------------------|---------|----------|------------------------|---------|---------|------------------------|---------|---------|---------------------------|---------|---------|------------------------------------|---------|---------|
| | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH |
| PUSA 6A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 86.54** | 111.78* | 874.36** | - | - | - | 251.09* | 297.93* | 656.14* | - | - | - | -6.76* | - | -9.09** |
| R1679-1674-1-234-1 | -23.81 | -18.63 | 274.36** | 15.29** | 11.99** | -2.89 | - | - | 19.60 | 213.75* | 93.66** | 23.87** | 11.30** | - | - |
| R1519-815-1-646-1 | 137.06* | 160.31* | 901.25** | - | - | - | 173.98* | 193.70* | 387.87* | - | - | - | 19.45** | 13.65** | -1.82 |
| R1551-1066-1-449-1 | -15.30 | 4.06 | 228.57* | 4.03 | -0.12 | -5.89 | -15.00 | 0.56 | 39.89 | -0.66 | -6.25 | - | 24.19** | 15.22** | 0.00 |
| R1630-342-1-47-1 | 113.86* | 189.40* | 680.22** | - | - | - | 153.08* | 210.98* | 305.44* | - | - | - | 32.42** | 26.51** | 9.55** |
| R1665-1620-1-985-1 | 167.03* | 210.78* | 976.92** | - | - | - | 236.88* | 291.41* | 643.70* | - | - | - | 35.32** | 28.61** | 23.64** |
| RNR2354 | 129.14* | 179.59* | 793.04** | - | - | - | 102.55* | 172.41* | 206.30* | - | - | -20.72* | 18.95** | 12.86** | -2.27 |
| Improved pusa basmati | -15.63 | 6.02 | 222.34* | 4.92 | 5.54 | -9.54** | -14.88 | -13.36 | 64.62** | 71.62** | 61.49** | 17.12* | 15.73** | 6.64* | 9.55** |
| CRMS 32A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | -21.53 | 2.74 | 271.06** | 0.82 | -3.66 | - | -2.15 | 11.43 | 109.95* | -7.64 | -18.54 | - | 9.49** | -0.84 | 7.73** |
| R1679-1674-1-234-1 | - | -38.13 | 123.44 | 17.18** | 13.68** | -1.16 | - | - | 7.78 | 151.03* | 56.25** | -4.28 | 15.53** | - | - |
| R1519-815-1-646-1 | 232.61* | 243.41* | 1140.29* | - | - | - | 285.00* | 310.86* | 582.43* | - | - | - | 14.91** | 8.53** | -4.55 |

| | | | | | | | | | | | | | | | |
|------------------------------|--------------|--------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------|---------|--------------|
| | * | * | * | 84.15** | 84.44** | 85.95** | * | * | * | 84.08** | 87.97** | 85.59** | | | |
| R1551-1066-1-449-1 | 108.87* * | 123.90* * | 606.96** | - 31.92** | - 34.55** | - 38.33** | 119.66* * | 158.62* * | 259.72* * | - 45.95** | - 50.00** | - 63.96** | 19.78** | 10.34** | -3.18 |
| R1630-342-1-47-1 | 53.66* * | 79.76* * | 384.62** | - 12.23** | - 16.17** | - 19.92** | 47.43** * | 80.26** * | 134.99* * | -20.25 * | - 30.00** | - 43.24** | 0.27 | -4.91 | - 16.36** |
| R1665-1620-1-985-1 | 270.19* * | 278.01* * | 1209.89* * | - 91.42** | - 91.88** | - 92.94** | 231.77* * | 287.33* * | 629.78* * | - 86.30** | - 87.18** | - 90.99** | 5.43 | 0.95 | -2.73 |
| RNR2354 | 412.92* * | 446.44* * | 1645.42* * | - 94.53** | - 94.84** | - 94.94** | 394.13* * | 561.07* * | 643.31* * | - 88.56** | - 91.69** | - 88.74** | 21.26** | 14.21** | 0.45 |
| Improved pusa basmati | 149.17* * | 172.59* * | 728.72** | - 32.00** | - 32.49** | - 41.30** | 97.21** * | 101.59* * | 279.86* * | - 74.75** | - 76.71** | - 83.11** | 12.04** | 3.98 | 6.82* |
| IR 58025A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 109.34* * | 162.26* * | 918.32** | - 61.75** | - 63.05** | - 68.58** | 155.43* * | 180.30* * | 464.70* * | - 88.83** | - 88.89** | - 90.99** | 8.76** | -5.03 | 2.73 |
| R1679-1674-1-234-1 | - 63.81** | -57.55* * | 64.84 | 26.98** | 24.54** | 5.89 | - 71.72** | - 70.17** | -39.89 * | 233.33* * | 97.50** | 60.14** | 11.62** | -10.96* | - 27.73** |
| R1519-815-1-646-1 | 296.97* * | 298.86* * | 1434.07* * | - 83.98** | - 84.44** | - 85.97** | 271.33* * | 310.88* * | 582.43* * | - 79.37** | - 82.71** | - 79.28** | 16.86** | 14.89** | -6.82* |
| R1551-1066-1-449-1 | -56.82* * | -51.86 | 52.01 | 16.98** | 11.26** | 4.85 | - 60.57** | - 51.72** | -32.81 * | 2.94 | -2.78 | -21.17* | 24.93** | 19.66** | -3.18 |
| R1630-342-1-47-1 | 40.31 | 71.20* * | 361.54** | -2.06 | -7.44* | - 11.59** | 7.60 | 36.95* | 78.54** | 11.11 | 11.11 | -9.91 | -0.71 | -1.97 | - 20.45** |
| R1665-1620-1-985-1 | 192.32* * | 209.94* * | 973.99** | - 95.88** | - 96.06** | - 96.65** | 233.29* * | 274.68* * | 654.90* * | 88.10** | - 88.89** | - 90.99** | 36.07** | 25.30** | 20.45** |
| RNR2354 | 92.03** | 112.73* * | 579.49** | - 88.37** | - 89.15** | - 89.35** | 349.42* * | 527.35* * | 605.37* * | 91.68** | - 93.36** | - 90.99** | 16.91** | 14.61** | -7.27* |
| Improved pusa basmati | 68.25** | 91.57** | 482.42** | - 51.07** | - 51.27** | - 58.23** | 148.36* * | 151.33* * | 394.56* * | 88.27** | - 88.89** | - 90.99** | 4.46 | -6.64* | -4.09 |

*= Significant P > 0.05, **= Significant P > 0.01, MP= Mid Parent Heterosis, BP= Better Parent Heterosis, SH= Standard Heterosis

Table 5. Mid parent heterosis, Heterobeltiosis and Standard heterosis for different characters

| Parents | Biological yield per plant (g) | | | Harvest index (%) | | | Hulling percentage (%) | | | Milling percentage (%) | | | Head rice recovery (%) | | |
|---------------------------|--------------------------------|--------------|--------------|-------------------|--------------|--------------|------------------------|---------|--------|------------------------|-------|--------|------------------------|---------|---------|
| | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH |
| PUSA 6A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | - 84.02** | - 85.88** | - 86.32** | - 91.22** | - 91.40** | - 92.56** | -0.02 | -0.04 | 1.98 | 1.97 | 0.00 | 5.11** | 7.50** | 0.00 | 7.56** |
| R1679-1674-1-234-1 | 126.62* * | 64.21** | 22.14** | 54.51** | 17.44* | 1.56 | 4.67** | -3.75** | -1.81 | 9.23** | -0.28 | 0.75 | 16.53** | 10.45** | 2.24 |
| R1519-815-1-646-1 | -4.63 | - 21.12** | -10.32 | - 54.27** | - 58.43** | - 56.06** | -0.88 | -1.04 | 0.96 | -0.69 | -0.85 | 0.50 | -3.14 | -6.52** | -6.98** |
| R1551-1066-1-449-1 | -16.57* | - 24.66** | - 30.47** | 17.81* | 12.48 | -2.72 | 2.68* | 1.80 | 3.86** | 1.50 | 1.12 | 2.95 | -4.53* | -8.86** | -7.21** |

| | | | | | | | | | | | | | | | |
|------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| R1630-342-1-47-1 | -12.48 | -15.09 | - | - | - | - | -2.86** | -3.55** | -1.60 | -4.75** | -5.67** | -2.82 | -9.61** | - | - |
| R1665-1620-1-985-1 | -0.87 | -5.02 | - | - | - | - | -4.79** | -5.97** | -4.07** | -1.07 | -2.05 | -1.04 | -3.94 | -4.10 | - |
| RNR2354 | 14.45 | 2.37 | -3.48 | - | - | - | -0.32 | -1.70 | 0.29 | 1.20 | 0.79 | 1.84 | 4.80* | -0.31 | 2.24 |
| Improved pusa basmati | 64.27** | 57.01** | 28.11** | 4.84 | 3.69 | -8.35 | -3.12** | -4.56** | -2.63* | - | - | - | - | - | - |
| CRMS 32A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | -8.61 | -21.69* | - | 0.18 | -3.22 | -13.93* | 1.51 | 1.30 | 3.73** | 0.37 | -0.16 | 4.92** | -2.65 | -4.56* | 2.66 |
| R1679-1674-1-234-1 | 102.75* | 50.36** | 3.98 | 37.01** | 3.14 | -8.27 | 3.34** | -5.13** | -2.85* | 5.65** | -4.79** | -0.99 | 8.71** | -2.04 | 1.22 |
| R1519-815-1-646-1 | - | - | - | - | - | - | -3.31** | -3.64** | -1.33 | -3.39* | -4.61** | -0.81 | - | - | - |
| R1551-1066-1-449-1 | 42.86** | 54.05** | 47.76** | 71.84** | 74.07** | 72.61** | -4.96** | -5.95** | -3.69** | -8.84** | -9.80** | -6.21** | 13.93** | 15.52** | 12.71** |
| R1630-342-1-47-1 | -4.47 | -16.44* | - | - | - | - | -4.96** | -5.95** | -3.69** | -8.84** | -9.80** | -6.21** | 21.65** | 22.23** | 19.65** |
| R1665-1620-1-985-1 | 23.49* | 15.72 | -8.46 | - | - | - | 1.02 | 0.11 | 2.52* | 0.05 | -0.42 | 3.56* | -9.01** | -9.95** | -4.97* |
| RNR2354 | -22.10* | -22.66 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Improved pusa basmati | 46.52** | 82.41** | 83.61** | 83.09** | 12.60** | 13.84** | 11.78** | 11.67** | 13.78** | 10.34** | 14.41** | 18.74** | 16.03** | | |
| IR 58025A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | -11.72 | - | - | - | - | - | -0.23 | -1.79 | 0.57 | 0.90 | -0.93 | 3.02 | 2.50 | 2.12 | 5.52* |
| R1679-1674-1-234-1 | 23.48** | 27.86** | 85.94** | 88.63** | 83.64** | -0.52 | -2.17 | 0.18 | 3.80** | 1.37 | 5.41** | -6.35** | -8.48** | -5.43* | |
| R1519-815-1-646-1 | -24.09* | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| R1551-1066-1-449-1 | 32.06** | 38.38** | 40.30** | 83.79** | 85.44** | 84.83** | -0.88 | -1.74 | 1.98 | 0.85 | 0.00 | 5.11** | 3.14 | 0.00 | 7.56** |
| R1630-342-1-47-1 | 91.66** | 36.44** | 7.59 | 100.15* | 43.35** | 49.09** | 2.68* | -6.31** | -2.76* | 9.00** | -1.50 | 1.79 | 12.32** | 2.26 | 3.28 |
| R1665-1620-1-985-1 | 36.43** | 15.54* | 31.34** | - | - | - | -2.39* | -3.37** | 0.29 | 1.16 | 0.20 | 3.54* | -2.12 | -2.84 | -1.87 |
| RNR2354 | 84.93** | 85.05** | 84.18** | - | - | - | - | - | - | - | - | - | - | - | - |
| Improved pusa basmati | 30.81** | 21.29* | 11.94 | 22.75** | 32.16** | 29.46** | -5.38** | -6.98** | -3.46** | - | - | - | - | - | - |
| CRMS 32A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 11.50 | 11.32 | -11.94 | -0.69 | -1.45 | 2.50 | -2.86** | -4.36** | -0.74 | -0.13 | -0.29 | 3.04** | -1.71 | -3.82 | 1.50 |
| R1679-1674-1-234-1 | -18.61 | -24.13* | - | - | - | - | -2.60* | -4.62** | -1.01 | -2.04 | -4.08* | -0.88 | 1.75 | -2.34 | -1.38 |
| R1519-815-1-646-1 | - | - | - | - | - | - | -0.91 | -3.10** | 0.57 | 1.22 | -0.31 | 3.02 | 3.68 | 2.89 | 5.52* |
| R1551-1066-1-449-1 | 28.88** | 34.70** | 38.43** | 88.18** | 89.82** | 85.34** | -0.91 | -3.10** | 0.57 | 1.22 | -0.31 | 3.02 | 3.68 | 2.89 | 5.52* |
| R1630-342-1-47-1 | -20.93* | -22.26* | - | - | - | - | -3.39** | -5.62** | -2.05 | -3.55* | -5.52** | -2.36 | - | - | - |
| R1665-1620-1-985-1 | 36.57** | 85.12** | 86.24** | 85.70** | -3.39** | -5.62** | -2.05 | -3.55* | -5.52** | -2.36 | 19.00** | 19.95** | 19.15** | | |

*= Significant P > 0.05, **= Significant P > 0.01, MP= Mid Parent Heterosis, BP= Better Parent Heterosis, SH= Standard Heterosis

Table 6. Mid parent heterosis, Heterobeltiosis and Standard heterosis for different characters

| Parents | Paddy length (mm) | | | Paddy breadth (mm) | | | Paddy L/B ratio | | | Brown rice length (mm) | | | Brown rice breadth (mm) | | |
|------------------------------|-------------------|------------------|--------------|--------------------|---------|--------------|-----------------|--------------|--------------|------------------------|--------------|--------------|-------------------------|---------|---------|
| | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH |
| PUSA 6A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 5.26* * | -3.55* | 0.53 | - 19.61** | -6.82* | - 10.87** | 26.90** | 3.58 | 12.90** | -4.83** | - 10.49** | - 15.79** | 1.20 | 16.67** | 7.69** |
| R1679-1674-1-234-1 | - 5.33* * | - 23.35* * | - 20.11** | 6.67* | 9.09** | 4.35 | - 11.64** | - 29.61** | - 23.36** | -8.30** | - 26.57** | - 30.92** | 8.11** | 11.11** | 2.56 |
| R1519-815-1-646-1 | 4.53* * | -1.35 | 15.87** | 4.55 | 4.55 | 0.00 | -0.16 | -5.93 | 15.82** | 0.68 | -2.61** | -1.97* | 5.56** | 5.56** | -2.56 |
| R1551-1066-1-449-1 | 24.77** | 3.55* | 7.94** | -8.33** | 0.00 | -4.35 | 32.90** | 3.58 | 12.90** | 17.55** | 0.70 | -5.26** | -9.52** | 5.56** | -2.56 |
| R1630-342-1-47-1 | 15.94** | 1.52 | 5.82** | -5.26 | 2.27 | -2.17 | 20.60** | -0.56 | 8.27 | 12.06** | 0.70 | -5.26** | -3.80* | 5.56** | -2.56 |
| R1665-1620-1-985-1 | 0.25 | -0.50 | 5.29** | 9.30** | 11.90** | 2.17 | -8.18* | - 10.92** | 3.16 | 0.35 | -0.68 | -4.61** | 10.81** | 13.89** | 5.13** |
| RNR2354 | -2.76 | - 10.66* * | -6.88** | 14.94** | 16.28** | 8.70** | - 15.28** | - 21.34** | - 14.36** | -4.91** | - 11.89** | - 17.11** | 16.22** | 19.44** | 10.26** |
| Improved pusa basmati | 0.00 | -4.19* | 8.99** | 8.05** | 9.30** | 2.17 | -7.55* | - 12.40** | 6.57 | -3.95** | -9.32** | -3.95** | 2.70 | 5.56** | -2.56 |
| CRMS 32A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 4.35* | -0.55 | -4.76* | 5.88* | 22.73** | 17.39** | -4.10 | - 19.08** | - 18.98** | 2.29* | -1.47 | - 11.84** | 10.59** | 23.68** | 20.51** |
| R1679-1674-1-234-1 | -0.99 | - 17.13* * | - 20.63** | -2.22 | 0.00 | -4.35 | 1.62 | - 16.40** | - 16.30** | -4.50** | - 22.06** | - 30.26** | 10.53** | 10.53** | 7.69** |
| R1519-815-1-646-1 | -0.74 | -9.91** | 5.82** | -2.27 | -2.27 | -6.52* | 1.47 | -8.00* | 13.38** | -2.42** | -7.84** | -7.24** | 2.70 | 5.56** | -2.56 |
| R1551-1066-1-449-1 | 22.83** | 5.52** | 1.06 | -4.17 | 4.55 | 0.00 | 25.62** | 0.97 | 0.97 | 13.45** | -0.74 | - 11.18** | -6.98** | 5.26** | 2.56 |
| R1630-342-1-47-1 | 21.58** | 10.50* * | 5.82** | -5.26 | 2.27 | -2.17 | 26.78** | 8.14 | 8.27 | 13.60** | 4.41** | -6.58** | -1.23 | 5.26** | 2.56 |
| R1665-1620-1-985-1 | 4.46* * | -0.50 | 5.29** | 13.95** | 16.67** | 6.52* | -8.39* | - 14.60** | -0.97 | 5.67** | 2.05* | -1.97* | 0.00 | 0.00 | -2.56 |
| RNR2354 | 16.18** | 11.05* * | 6.35** | 5.75 | 6.98* | 0.00 | 9.94* | 6.20 | 6.33 | 7.75** | 2.21* | -8.55** | 7.89** | 7.89** | 5.13** |
| Improved pusa basmati | 1.52 | -6.51** | 6.35** | 10.34** | 11.63** | 4.35 | -8.06* | - 16.20** | 1.95 | -3.03** | - 10.56** | -5.26** | 5.26** | 5.26** | 2.56 |
| IR 58025A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 4.52* | -2.63 | -2.12 | -2.91 | 11.11** | 8.70** | 4.96 | - 12.32** | -9.98* | -1.54 | -4.48** | - 15.79** | -3.53* | 7.89** | 5.13** |

| | | | | | | | | | | | | | | | |
|------------------------------|-----------------|------------------|--------------|--------------|---------|--------|--------------|--------------|--------------|--------------|--------------|--------------|---------|---------|---------|
| R1679-1674-1-234-1 | 1.28 | - 16.84* * | - 16.40** | 3.30 | 4.44 | 2.17 | -2.11 | - 20.26** | - 18.00** | -0.91 | - 18.66** | - 28.29** | 7.89** | 7.89** | 5.13** |
| R1519-815-1-646-1 | 2.43 | -4.95** | 11.64** | 1.12 | 2.27 | -2.17 | 1.08 | -7.31* | 14.11** | 0.35 | -5.88** | -5.26** | 0.00 | 2.78 | -5.13** |
| R1551-1066-1-449-1 | 25.63** | 5.79** | 6.35** | -9.28** | -2.22 | -4.35 | 36.01** | 8.29* | 11.19* | 19.49** | 5.22** | -7.24** | -9.30** | 2.63 | 0.00 |
| R1630-342-1-47-1 | 13.02** | 0.53 | 1.06 | - 10.42** | -4.44 | -6.52* | 24.77** | 5.33 | 8.03 | 9.68** | 1.49 | - 10.53** | -6.17** | 0.00 | -2.56 |
| R1665-1620-1-985-1 | 1.03 | -1.50 | 4.23* | 8.05** | 11.90** | 2.17 | -6.57 | - 11.87** | 1.95 | 4.29** | 0.00 | -3.95** | 5.26** | 5.26** | 2.56 |
| RNR2354 | - 6.48* * | - 12.63* * | - 12.17** | 13.64** | 16.28** | 8.70** | - 17.57** | - 21.33** | - 19.22** | -7.03** | - 11.19** | - 21.71** | 15.79** | 15.79** | 12.82** |
| Improved pusa basmati | - 6.17* * | - 11.63* * | 0.53 | 9.09** | 11.63** | 4.35 | - 13.99** | - 20.70** | -3.41 | - 13.22** | - 20.50** | - 15.79** | 10.53** | 10.53** | 7.69** |

*= Significant P > 0.05, **= Significant P > 0.01, MP= Mid Parent Heterosis, BP= Better Parent Heterosis, SH= Standard Heterosis

Table 7. Mid parent heterosis, Heterobeltiosis and Standard heterosis for different characters

| Parents | Brown rice L/B ratio | | | Kernel length (mm) | | | Kernel breadth (mm) | | | Kernel L/B ratio | | | Kernel length after cooking (mm) | | |
|------------------------------|----------------------|--------------|--------------|--------------------|--------------|--------------|---------------------|---------|---------|------------------|--------------|--------------|----------------------------------|--------------|--------------|
| | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH | MP | BP | SH |
| PUSA 6A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | -8.34** | - 23.17** | - 21.79** | -6.17** | - 11.63** | - 16.18** | 2.63 | 5.41* | 0.00 | -8.81** | - 16.19** | - 16.33** | 8.33** | 0.00 | - 17.02** |
| R1679-1674-1-234-1 | - 15.73** | - 33.88** | - 32.82** | -4.35** | - 23.26** | - 27.21** | 3.90 | 8.11** | 2.56 | -9.01** | - 29.08** | - 29.23** | 13.88** | -3.03 | - 31.91** |
| R1519-815-1-646-1 | -4.62** | -7.76** | 0.51 | -3.73** | -7.19** | -5.15** | 6.85** | 8.33** | 0.00 | -9.93** | -5.16** | -5.16* | 10.40** | 20.00** | 28.51** |
| R1551-1066-1-449-1 | 24.36** | -4.53** | -2.82 | 21.46** | 3.10* | -2.21 | -4.88** | 5.41* | 0.00 | 24.29** | -2.15 | -2.29 | 28.43** | 16.36** | - 18.30** |
| R1630-342-1-47-1 | 14.42** | -4.53** | -2.82 | 3.45** | -6.98** | - 11.76** | -1.27 | 5.41* | 0.00 | 3.62 | - 11.75** | - 11.75** | -8.00** | - 12.97** | - 31.49** |
| R1665-1620-1-985-1 | -9.35** | - 10.83** | -9.23** | 4.28** | 3.88** | -1.47 | 1.33 | 2.70 | -2.56 | 2.92 | 1.15 | 1.15 | -5.56* | - 12.82** | - 27.66** |
| RNR2354 | - 18.38** | - 26.20** | - 24.87** | -6.22** | - 12.40** | - 16.91** | 13.51** | 13.51** | 7.69** | 17.48** | 22.92** | 22.92** | -2.86 | -8.11** | - 27.66** |
| Improved pusa basmati | -6.46** | -9.43** | -1.54 | -4.80** | -9.15** | -5.15** | 2.70 | 2.70 | -2.56 | -7.37** | - 11.59** | -2.87 | - 19.51** | - 32.08** | - 30.64** |
| CRMS 32A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | -9.02** | - 20.39** | - 26.92** | 6.78** | 3.28* | -7.35** | 17.95** | 17.95** | 17.95** | -9.50** | - 12.46** | - 21.49** | 2.16 | -3.08 | - 19.57** |

| | | | | | | | | | | | | | | | |
|------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------|---------|--------------|--------------|--------------|--------------|--------------|--------------|
| R1679-1674-1-234-1 | - 13.70** | - 29.61** | - 35.38** | -3.00* | - 20.49** | - 28.68** | 6.33** | 7.69** | 7.69** | -9.06** | - 26.20** | - 33.81** | -4.47 | - 20.57** | - 40.85** |
| R1519-815-1-646-1 | -5.24** | - 12.71** | -4.87** | 3.45** | -2.88* | -0.74 | -1.33 | 2.78 | -5.13* | 4.43* | -5.44* | 4.58 | - 21.56** | - 28.10** | - 35.74** |
| R1551-1066-1-449-1 | 18.32** | -5.73** | - 13.33** | 12.26** | -2.46 | - 12.50** | -4.76* | 2.56 | 2.56 | 15.87** | -4.95 | - 14.90** | -0.97 | - 12.57** | - 34.89** |
| R1630-342-1-47-1 | 13.87** | -0.84 | -8.97** | 15.56** | 6.56** | -4.41** | -1.23 | 2.56 | 2.56 | 16.38** | 3.83 | -6.88** | 1.11 | -1.62 | - 22.55** |
| R1665-1620-1-985-1 | 5.66** | 2.08 | 0.51 | 4.00** | 1.56 | -4.41** | 11.69** | 13.16** | 10.26** | -6.92** | - 10.24** | - 13.18** | -0.54 | -5.64* | - 21.70** |
| RNR2354 | 0.00 | -5.17** | - 13.08** | - 11.97** | - 15.57** | - 24.26** | 10.53** | 13.51** | 7.69** | - 20.29** | - 21.57** | - 29.80** | 2.78 | 0.00 | - 21.28** |
| Improved pusa basmati | -7.93** | - 15.09** | -7.69** | -1.52 | -8.45** | -4.41** | 0.00 | 2.70 | -2.56 | -1.87 | - 10.94** | -2.01 | - 12.77** | - 24.58** | - 22.98** |
| IR 58025A/ | | | | | | | | | | | | | | | |
| R1607-673-2-322-1 | 0.56 | - 11.47** | - 20.00** | -0.87 | -1.72 | - 16.18** | 1.30 | 2.63 | 0.00 | -2.17 | -4.26 | - 16.33** | -1.27 | -2.50 | - 17.02** |
| R1679-1674-1-234-1 | -8.12** | - 24.65** | - 31.79** | 3.09* | - 13.79** | - 26.47** | 2.56 | 5.26* | 2.56 | -0.10 | - 18.17** | - 28.37** | - 10.13** | - 29.00** | - 39.57** |
| R1519-815-1-646-1 | 0.13 | -8.35** | -0.26 | 5.88** | -2.88* | -0.74 | 5.41* | 8.33** | 0.00 | 0.22 | - 10.23** | -0.57 | - 22.44** | - 24.29** | - 32.34** |
| R1551-1066-1-449-1 | 28.03** | 2.55 | -7.18** | 22.33** | 8.62** | -7.35** | - 13.25** | -5.26* | -7.69** | 38.34** | 14.57** | 0.29 | -8.38** | - 23.50** | - 34.89** |
| R1630-342-1-47-1 | 15.76** | 1.42 | -8.21** | 15.98** | 9.48** | -6.62** | -5.00* | 0.00 | -2.56 | 21.42** | 9.49** | -4.30 | - 15.84** | - 19.00** | - 31.06** |
| R1665-1620-1-985-1 | -0.95 | -4.95** | -6.41** | 16.39** | 10.94** | 4.41** | -2.63 | -2.63 | -5.13* | 19.53** | 13.95** | 10.03** | 21.52** | 20.00** | 2.13 |
| RNR2354 | - 19.73** | - 23.37** | - 30.77** | -9.65** | - 11.21** | - 24.26** | 12.00** | 13.51** | 7.69** | - 19.31** | - 19.64** | - 29.80** | -3.90 | -7.50** | - 21.28** |
| Improved pusa basmati | - 21.49** | - 28.07** | - 21.79** | -8.53** | - 16.90** | - 13.24** | 9.33** | 10.81** | 5.13* | - 16.46** | - 25.00** | - 17.48** | - 15.00** | - 22.08** | - 20.43** |

*= Significant P > 0.05, **= Significant P > 0.01, MP= Mid Parent Heterosis, BP= Better Parent Heterosis, SH= Standard Heterosis

REFERENCES

- Bisne, R. and Motiramani, N.K.** (2005). Identification of maintainers and restorers using WA source cytoplasmic male sterile lines in rice. *IRRN*, **30**(1): 14-15.
- Chaudhary, A., Sharma, P., Singh Harpal., Pradhan, S.K. and Pandey, M.P.** (2007). Study on heterosis for yield and physiological characters in rice hybrids. *Oryza*, **44**(1): 7-13.
- Gawas, Y.K., Bhawe, S.G., Bendale, V.W., Sawant, S.S. and Jadhav, B.B.** (2007). Nature and magnitude of heterosis for growth yield and yield components in hybrid rice. *J. Maharashtra. Agric. Univ.*, **32**(1): 52-56.
- Hossain, M.S., Zaman, F.V., Singh, A.K. and Prasad, H.** (2004). Studies on the level of heterosis in hybrids developed from *Indica/Japonica* derived lines. Proc. International Symposium on rice. Extended summaries 04-06. Oct., 2004. 133.
- Issac, S.** (2007). Heterosis for economic traits in early, mid early and very early rice cultivars for the cauvery delta zone. *Indian J. Agril. Res.*, **41**(4): 249-255.
- Kumar, A., Singh, S. and Singh, S.P.** (2012). Heterosis for Yield and yield components in basmati rice. *Asian Journal of Agricultural Research*, **6**: 21-29.
- Li, Y.J., Fang, S.H., Lu, Y.G., Li, J.Q., Chen, X.H. and Liu, X.D.** (2008). Heterosis analysis on main agronomic traits in autotetraploid rice. *Journal of South China Agricultural University*, **29**(3): 117-119.
- Mirarab, M., Ahmadikhah, A. and Pahlavani, M.H.** (2011). Study on combining ability, heterosis and genetic parameters of yield traits in rice. *African J. Biotechnology*, **10**(59): 12512-12519.
- Pandya, R. and Tripathi, R.S.** (2006). Heterosis breeding in hybrid rice. *Oryza*, **43**(2): 87-93.
- Saidaiyah, P., Sudheer Kumar, S. and Ramesha, M.S.** (2010). Combining ability studies for development of new hybrids in rice over environments. *Journal of Agriculture Science*, **2**(2): 226-233.
- Shanthi, P. Shanmugasundaram and S. Jebaraj** (2006). Heterosis in three line Rice (*Oryza sativa* L.) Hybrids. *Indian J. Agric. Res.*, **40**(3): 208-211.
- Singh, N.K., Kumar, A. and Kumar, R.** (2007). Combining ability for yield and yield components in rice. *Oryza*, **44**: 156-159.
- Singh, R.K. and Lal, J.P.** (2005). Exploitation of heterosis in aromatic rices for different physico-chemical traits. *Indian J. Genet.*, **65**: 47-48.
- Singh, R.K.** (2005). Heterosis breeding in aromatic rice (*Oryza sativa* L.) for yield and quality characters. *Indian J. Genet.*, **65**(3): 176-179.
- Singh, V., Verma, O.P., Dwivedi, J.L. and Singh, R.K.** (2006). Heterosis studies in rice hybrids using CMS-System. *Oryza*, 154 - 156.
- Soni, D.K., Kumer, A., Nag S. and Sahu, L.** (2005). Study of heterosis by utilizing cytoplasmic-genetic male sterility system in rice (*Oryza sativa* L.). *Plant-Archives*, **5**(2): 617-621.
- Tiwari, D.K., Pandey, P., Giri, S.P. and Dwivedi.** (2011). Heterosis Studies for Yield and its Component in Rice Hybrids using CMS system. *Asian Journal of Plant Sciences*, **10**(1): 29-42.
- Vaithiyalingan, M. and Nadarajan, N.** (2010). Heterosis for yield and yield contributing characters in inter sub-specific crosses of rice. *Electronic Journal of Plant Breeding*, **1**(3): 305-310.
- Veni, B.K., Rani, N.S. and Prasad, A.S.R.** (2005). Heterosis for yield components and Key quality traits in basmati rice. *Oryza*, **42**: 97-102.
- Verma, R.S., Yadav, R.D.S., Singh, R.S., Giri, S.P. and Dwivedi, J.L.** (2004). Studies on heterosis and inbreeding depression in rice (*Oryza sativa* L.). *Oryza*, **41**: 131-132.
- Wang, H.F., Wang, N.Y., Li, Y., Liang, K.J., Qiu, X.L., Zhou, W.Y.,** (2010). Genetic effects and heterosis analysis on yield-related traits of CMS-FA hybrid rice. *Scientia Agricultura Sinica*, **43**(2): 230-239.

