RESEARCH ARTICLE

SABRAO Journal
of Breeding and Genetics
47 (4) 467-474, 2015

# ESTIMATION OF HETEROSIS FOR YIELD AND YIELD RELATED TRAITS IN RICE (*Oryza sativa* L.)

**P.K. BHATI*, S.K. SINGH, R. SINGH, A. SHARMA and S.Y. DHURAI**

Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi- 221005, India
*Corresponding author's email: bhatipradeep5@gmail.com
Co-authors' email addresses: shravanranchi@yahoo.co.in, rsingh6361@gmail.com, amita85.22@gmail.com, samir.dhurai@gmail.com

## SUMMARY

Hybrid rice technology is one of the most important and practically feasible technologies to enhance the rice productivity. This study was conducted to assess the hybrids for *per se* performance and heterosis with respect to yield and yield related traits to identify best hybrid combinations for commercial utilization. Result indicated that the magnitude of heterosis for grain yield over better parent was significantly superior to 21 hybrids with highest value of 93.3% in Pusa 6A x Akshaya Dhan. Eighteen hybrids showed significant positive heterosis over standard variety (BPT 5204) with the highest value of 66.9% in Pusa 6A x Akshaya Dhan cross for grain yield plant$^{-1}$. Out of 32 hybrids, 12 showed significant positive heterosis over standard hybrid (Arize-6444) with highest value of 34.8% in Pusa 6A x Akshaya Dhan for grain yield plant$^{-1}$. Top two higher yield heterotic crosses over the standard variety (BPT 5204) were Pusa 6A x Akshaya Dhan (66.9%) and IR79156A x MTU-7029 (60.1%). These 2 hybrids also exhibited significant positive yield heterosis over standard hybrid (Arize 6444) 34.8% and 29.2% respectively. Both the hybrids also exhibited significant positive standard heterosis for almost all the desirable yield attributing traits and significant negative standard heterosis for days to 50% flowering and days to maturity. The top heterotic crosses *viz.*, Pusa 6A x Akshaya Dhan, IR79156A x MTU-7029, Pusa 6A x MTU-7029, Pusa 6A x IET 22202 and IR79156A x Danteswari and others which expressed more than 20% standard heterosis for grain yield along with other desirable yield components need to be tested on larger scale for many assumption.

**Key words:** Heterosis; O*ryza sativa* L., rice hybrid, WA-CMS, standard heterosis

**Key findings:** Highly significant differences were recorded among 32 rice hybrids for a wide range of traits: tillers plant$^{-1}$, effective tillers plant$^{-1}$, panicle length (cm), spikelets panicle$^{-1}$, grains panicle$^{-1}$, chlorophyll content, grain weight panicle$^{-1}$ (g) and 1000- grain weight (g) grain yield per plant. Two hybrids Pusa 6A x Akshaya Dhan and IR79156A x MTU-7029 recorded highest standard heterosis over standard variety and standard hybrid (SV/66.9%, SH/34.8% and SV/ 60.1%, SH/29.2% respectively).

Manuscript received: May 6, 2015; Decision on manuscript: August 14, 2015; Manuscript accepted: September 28, 2015.


Communicating Editor: Bertrand Collard

## INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major staple food crops for about 65% of the world's population (Kumar *et al.,* 2014). The productivity of rice has now stagnated. The present world rice area, production and productivity are 161.6 Mha, 480.7 Mt and 2.9 t/ha, respectively (USDA, Rice Outlook, 2015). In India, rice is grown in 44.0 Mha with the production of 106.0 Mt and productivity of 2.4 t/ha. It contributes 25% to agricultural GDP (USDA, Rice Outlook, 2015). Hybrid rice technology is one of the most practically feasible tools to break yield barriers. In China, the first hybrid rice variety for commercial cultivation was released by Yuan Long Ping in 1976. Hybrid rice development programme in India has been initiated in 1989 and released 65 hybrid rice varieties until 2014 (Singh *et al.*, 2015). Hybrid rice offers an opportunity to boost the yield potential of rice with yield advantage of 15-20% over conventional high-yielding varieties (Dar *et al.,* 2014). Therefore, this study was undertaken to assess the hybrids for *per se* performance and heterosis with respect to yield and yield related traits to identify best hybrid combinations for commercial utilization.

## MATERIALS AND METHODS

This investigation was carried out at the Agricultural Research Farm, Banaras Hindu University, Varanasi, (India) during the kharif 2013 cropping seasons. Experimental material consisting of 32 $F_1$ hybrids obtained by line x tester mating along with their 16 pollen parents, 2 maintainer lines of IR79156A and Pusa6A and 2 checks (BPT 5204 as a standard variety and Arize 6444 as a standard hybrid) were grown in single row of 3.0 m with 3 replications in RBD with spacing of 20 x 15 $cm^2$. Recommended agronomic practices were followed to raise a good crop Observations were recorded on 5 randomly selected plants for estimation of magnitude of heterosis with respect to fifteen quantitative traits *viz.*, days to flowering, days to maturity, tillers $plant^{-1}$, effective tillers $plant^{-1}$, panicle length (cm), spikelets $panicle^{-1}$, grains $panicle^{-1}$, sterile spikelets $panicle^{-1}$, pollen fertility (%), spikelet fertility (%), chlorophyll content, grain weight $panicle^{-1}$ (g), 1000- grain weight (g) and grain yield $plant^{-1}$ (g). The character means of each replication was subjected for analysis of variance (Panse and Sukhatme, 1967) and estimation of heterosis over better parent, standard variety and standard hybrid (Fonseca and Patterson, 1968). Computer software Windostat version 9.2 has been used for analysis of data.

## RESULTS

All crosses shows marked variations in the expression of heterobeltiosis and standard heterosis for yield and yield components (Table 1). Heterobeltiosis for grain yield (Table 2) ranged from -38.4 (Pusa 6A x IET 20524) to 93.3% (Pusa 6A x Akshaya Dhan), standard heterosis over standard variety (BPT 5204) from -34.8 (Pusa 6A x IET 21519) to 66.9% (Pusa 6A x Akshaya Dhan), and from -47.41(Pusa 6A x IET 21519) to 34.8% (Pusa 6A x Akshaya Dhan) over Standard hybrid (Arize 6444). The higher heterotic effects among yield components were observed for tillers $plant^{-1}$, effective tillers $plant^{-1}$, panicle length (cm), spikelets $panicle^{-1}$, grains $panicle^{-1}$, chlorophyll content, grain weight $panicle^{-1}$ (g) and 1000- grain weight (g). Top two higher yielding crosses on the basis of significant standard heterosis over standard variety and tandard hybrid were Pusa 6A x Akshaya Dhan (SV/66.9%, SH/34.8%) and IR79156A x MTU-7029 (SV/ 60.1%, SH/29.2%). These 2 crosses also showed significant negative standard heterosis (SV and SH both) for days to flowering and days to maturity.

## DISCUSSION

Exploitation of heterosis for yield increase in rice through hybrid varieties becomes a practical option. This seems to be more effective, as commercial rice hybrid have been reported to exhibit 38% more yield compared to best commercial variety (Singh *et al.*, 2013). The higher heterotic effects among yield components were observed for tillers $plant^{-1}$, effective tillers $plant^{-1}$, panicle length (cm), spikelets $panicle^{-1}$, grains $panicle^{-1}$, chlorophyll content, grain weight $panicle^{-1}$ (g) and 1000- grain weight (g). Top two higher yielding crosses on the basis of significant standard heterosis over SV and SH were Pusa 6A x Akshaya Dhan (SV/ 66.9%, SH/34.8%) and IR79156A x MTU-7029 (SV/ 60.1%, SH/29.2%). These 2 crosses also showed significant negative standard heterosis (SV and SH both) for days to flowering and days to maturity.

**Table 1.** ANOVA for L x T analysis for different characters in rice.

| Source of Variation | df | Days to Flowe-ring | Days to Maturity | Plant Height(cm) | Tillers Plant$^{-1}$ | Effective Tillers Plant$^{-1}$ | Panicle Length (cm) | Spikelets Panicle$^{-1}$ | Grains Pani-cle$^{-1}$ | Sterile Spikelets Panicle$^{-1}$ | Pollen Ferti-lity (%) | Spikelet Ferti-lity (%) | Chlorophyll content | Grain Weight Panicle$^{-1}$ (g) | 1000 Grain Weight | Grain Yield$^{-1}$ Plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replicates | 2 | 1.0 | 1.6 | 1.9 | 0.3 | 2.0 | 1.8 | 88.0 | 24.5 | 49.6 | 3.0 | 1.4 | 4.0 | 0.1 | 4.1* | 2.4 |
| Treatments | 49 | 234.1** | 318.6** | 602.6** | 21.8** | 19.5** | 41.6** | 6872.9** | 5316.2** | 309.3** | 41.4** | 41.1** | 19.8** | 2.3** | 41.2** | 150.7** |
| Parents | 17 | 285.4** | 496.8** | 675.2** | 9.1** | 8.7** | 18.5** | 7441.3** | 5929.8** | 134.5** | 13.0** | 14.7** | 17.2** | 1.0** | 33.1** | 28.9** |
| Parents (Line) | 1 | 13.5 | 54.0* | 69.0** | 1.0 | 0.9 | 8.6** | 240.6** | 140.1 | 2.6 | 4.7 | 1.6 | 11.7* | 1.9** | 4.3 | 0.3 |
| Parents (Testers) | 15 | 257.7** | 508.6** | 707.8** | 8.6** | 7.8** | 20.4** | 7856.3** | 6420.2** | 114.6** | 9.2** | 11.8** | 18.6** | 1.0** | 37.2** | 31.5** |
| Parents (L vs T) | 1 | 972.0** | 762.6** | 792.7** | 23.4** | 29.5** | 0.0 | 8418.1** | 4363.7** | 564.8** | 78.6** | 71.7** | 0.8 | 0.0 | 1.0 | 18.1** |
| Parents vs Crosses | 1 | 967.7** | 1787.6** | 44.3* | 64.1** | 58.6** | 740.0* | 16439.6** | 2577.8** | 5970.3** | 857.7** | 786.3** | 219.1** | 12.6** | 49.9** | 1298.9** |
| Crosses | 31 | 182.3** | 173.5** | 580.7** | 27.4** | 24.1** | 31.8** | 6252.5** | 5068.0** | 222.5** | 30.1** | 31.5** | 14.8** | 2.7** | 45.4** | 180.4** |
| Error | 98 | 8.1 | 9.6 | 7.6 | 1.2 | 1.0 | 0.9 | 30.5 | 42.3 | 25.5 | 3.2 | 4.9 | 2.2 | 0.0 | 1.3 | 2.6 |
| Total | 149 | 82.3 | 111.1 | 203.2 | 7.9 | 7.1 | 14.3 | 2281.4 | 1776.4 | 119.1 | 15.7 | 16.7 | 8.0 | 0.8 | 14.9 | 51.3 |

* Significant at 5% level ** significant at 1% level

**Table 2.** Estimates of *per se* performance, heterobeltosis and standard heterosis for yield and yield components in 32 hybrids of rice.

| No. | Characters / Crosses | Days to Flowering Mean | BP | BPT 5204 | Arize 6444 | Days to Maturity Mean | BP | BPT 5204 | Arize 6444 | Plant Height(cm) Mean | BP | BPT 5204 | Arize 6444 | Tillers Plant$^{-1}$ Mean | BP | BPT 5204 | Arize 6444 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | IR 79156A x IET 21519 | 84.0 | -17.1** | -24.7** | -14.2** | 112.3 | -13.8** | -26.7** | -12.2** | 93.3 | -15.2** | -0.1 | -6.4** | 9.6 | -15.8* | -19.8** | -29.1** |
| 2. | IR 79156A x IET 22218 | 90.3 | -8.7** | -19.1** | -7.8** | 118.6 | -9.1** | -22.6** | -7.2** | 103.4 | -0.1 | 10.6** | 3.6 | 11.5 | 0.7 | -4.1 | -15.2* |
| 3. | IR 79156A x IET 22228 | 92.0 | -0.7 | -17.6** | -6.1* | 118.3 | -2.7 | -22.8** | -7.5** | 104.7 | -3.3 | 12.0** | 4.9* | 7.0 | -38.9** | -41.8** | -48.6** |
| 4. | IR 79156A x IET 22202 | 100.0 | -7.1** | -10.4** | 2.0 | 127.3 | -7.7** | -16.9** | -0.5 | 120.2 | 4.6* | 28.6** | 20.5** | 8.7 | -23.4** | -27.1** | -35.6** |
| 5. | IR 79156A x IET 20524 | 88.6 | -3.2 | -20.6** | -9.5** | 116.6 | -4.1 | -23.9** | -8.8** | 109.9 | 13.8** | 17.6** | 10.1** | 7.1 | -38.1** | -41.1** | -47.9** |
| 6. | IR 79156A x IET 21542 | 101.6 | -5.2** | -8.9** | 3.7 | 128.6 | -5.3** | -16.0** | 0.5 | 98.0 | -6.2** | 4.9* | -1.6 | 9.0 | -21.1** | -25.0** | -33.7** |
| 7. | IR 79156A x Vardhan | 93.3 | 4.4 | -16.4** | -4.7* | 118.3 | -2.7 | -22.8** | -7.5** | 107.8 | 10.1** | 15.3** | 8.0** | 7.5 | -34.2** | -37.4** | -44.6** |
| 8. | IR 79156A x Akshaya Dhan | 100.0 | 5.6* | -10.4** | 2.0 | 127.0 | 3.8 | -17.1** | -0.7 | 109.8 | -6.8** | 17.4** | 10.0** | 12.1 | 6.1 | 0.9 | -10.7 |
| 9. | IR 79156A x Rajendra Kasturi | 89.6 | -14.6** | -19.7** | -8.5** | 119.0 | -11.4** | -22.3** | -7.0** | 123.1 | 12.9** | 31.7** | 23.4** | 14.5 | 26.7** | 20.6** | 6.4 |
| 10. | IR 79156A x Sarjoo- 52 | 83.6 | -17.1** | -25.0** | -14.6** | 112.3 | -11.3** | -26.7** | -12.2** | 86.4 | -7.8** | -7.4** | -13.3** | 7.1 | -37.8** | -40.8** | -47.7** |
| 11. | IR 79156A x HUR-8-1 | 93.6 | -11.3** | -16.1** | -4.4 | 124.0 | -4.3* | -19.1** | -3.1 | 113.3 | 20.8** | 21.2** | 13.5** | 9.5 | -16.6* | -20.6** | -29.8** |
| 12. | IR 79156A x BPT 5204 | 102.0 | -9.4** | -8.6** | 4.0 | 131.0 | -15.3** | -14.5** | 2.3 | 96.5 | 0.3 | 3.3 | -3.1 | 15.7 | 25.9** | 30.2** | 15.1* |
| 13. | IR 79156A x RPBIO-226 | 105.0 | -5.9** | -5.9** | 7.1** | 129.6 | -13.5** | -15.4** | 1.3 | 93.4 | -0.3 | -0.0 | -6.3** | 15.5 | 33.3** | 28.5** | 13.6* |
| 14. | IR 79156A x Type-3 | 100.0 | 3.0 | -10.4** | 2.0 | 127.0 | 1.6 | -17.1** | -0.7 | 122.6 | -13.9** | 31.1** | 22.1** | 11.4 | -9.7 | -4.9 | -16.0* |
| 15. | IR 79156A x MTU-7029 | 95.6 | -15.5** | -14.3** | -2.3 | 122.6 | -18.2** | -20.0** | -4.1* | 93.1 | -0.7 | -0.3 | -6.6** | 14.6 | 27.6** | 21.4** | 7.4 |
| 16. | IR 79156A x Danteswari | 76.6 | -13.5** | -31.3** | -21.7** | 105.6 | -13.1** | -31.0** | -17.4** | 82.7 | -11.7** | -11.4** | -17.0** | 14.7 | 28.5** | 22.3** | 8.1 |
| 17. | Pusa 6A x IET 21519 | 80.0 | -21.0** | -28.3** | -18.3** | 109.6 | -15.8** | -28.4** | -14.3** | 81.8 | -25.6** | -12.4** | -17.9** | 8.5 | -30.7** | -29.3** | -37.5** |
| 18. | Pusa 6A x IET 22218 | 95.6 | -3.3 | -14.3** | -2.3 | 123.3 | -5.6** | -19.5** | -3.6 | 89.0 | -14.0** | -4.7 | -10.7** | 12.6 | 2.3 | 4.5 | -7.6 |
| 19. | Pusa 6A x IET 22228 | 85.0 | -8.2** | -23.8** | -13.2** | 114.6 | -4.1 | -25.2** | -10.4** | 92.4 | -14.6** | -1.1 | -7.3** | 11.3 | -7.5 | -5.6 | -16.6* |
| 20. | Pusa 6A x IET 22202 | 101.3 | -5.8** | -9.2** | 3.4 | 129.3 | -6.2** | -15.6** | 1.0 | 115.1 | 0.1 | 23.1** | 15.3** | 11.4 | -6.7 | -4.8 | -15.9* |
| 21. | Pusa 6A x IET 20524 | 95.3 | 4.0 | -14.6** | -2.7 | 125.0 | 5.3* | -18.4** | -2.3 | 108.1 | 11.9** | 15.6** | 8.3** | 6.3 | -48.8** | -47.7** | -53.8** |
| 22. | Pusa 6A x IET 21542 | 99.3 | -7.4** | -11.0** | 1.3 | 128.3 | -5.6** | -16.3** | 0.2 | 89.1 | -14.7** | -4.6 | -10.6** | 7.0 | -43.0** | -41.8** | -48.6** |
| 23. | Pusa 6A x Vardhan | 89.7 | 0.3 | -19.7** | -8.5** | 119.3 | 2.2 | -22.1** | -6.7** | 91.4 | -6.5** | -2.1 | -8.3** | 10.9 | -11.5 | -9.6 | -20.1** |
| 24. | Pusa 6A x Akshaya Dhan | 91.6 | -3.1 | -17.9** | -6.4** | 119.6 | -2.1 | -21.9** | -6.5** | 103.5 | -12.1** | 10.7** | 3.7 | 13.5 | 9.8 | 12.0 | -0.9 |
| 25. | Pusa 6A x Rajendra Kasturi | 94.6 | -9.8** | -15.2** | -3.4 | 125.6 | -6.4** | -18.0** | -1.8 | 120.4 | 10.4** | 28.9** | 20.7** | 14.3 | 16.7* | 19.1* | 5.3 |
| 26. | Pusa 6A x Sarjoo- 52 | 91.0 | -9.9** | -18.5** | -7.1** | 118.3 | -6.5** | -22.8** | -7.5** | 94.6 | 1.7 | 1.2 | -5.1* | 10.3 | -16.4* | -14.6 | -24.5** |
| 27. | Pusa 6A x HUR-8-1 | 95.0 | -10.0** | -14.9** | -3.0 | 123.6 | -4.6* | -19.3** | -3.3 | 87.1 | -2.9 | -6.7** | -12.6** | 13.3 | 8.6 | 10.9 | -1.9 |
| 28. | Pusa 6A x BPT 5204 | 104.3 | -7.4** | -6.5** | 6.4** | 132.3 | -14.4** | -13.7** | 3.3 | 84.4 | -12.2** | -9.6** | -15.3** | 15.6 | 25.6** | 29.9** | 14.8* |
| 29. | Pusa 6A x RPBIO-226 | 107.0 | -4.1* | -4.1* | 9.1** | 136.6 | -8.8** | -10.8** | 6.7** | 85.6 | -8.2** | -8.3** | -14.1** | 15.3 | 24.8** | 27.4** | 12.6 |
| 30. | Pusa 6A x Type-3 | 98.3 | 1.3 | -11.9** | 0.3 | 127.3 | 1.8 | -16.9** | -0.5 | 130.5 | -8.4** | 39.6** | 30.8** | 9.5 | -25.1** | -21.1** | -30.2** |
| 31. | Pusa 6A x MTU-7029 | 100.3 | -11.4** | -10.1** | 2.3 | 129.0 | -14.0** | -15.8** | 0.7 | 89.8 | 0.0 | -3.9 | -9.9** | 14.4 | 17.2* | 19.7* | 5.8 |
| 32. | Pusa 6A x Danteswari | 79.0 | -7.7** | -29.2** | -19.3** | 106.3 | -8.0** | -30.6** | -16.9** | 81.2 | -6.5** | -13.0** | -18.5** | 13.6 | 10.6 | 12.9 | -0.1 |
| | Mean | 93.8 | -6.9 | -15.9 | -4.2 | 122.1 | -6.9 | -20.3 | -4.6 | 100.1 | -1.8 | 6.9 | 0.3 | 11.4 | -5.0 | -5.5 | -16.5 |
| | S. E. | | 2.3 | 2.3 | 2.3 | | 2.5 | 2.5 | 2.5 | | 2.2 | 2.2 | 2.2 | | 0.9 | 0.9 | 0.9 |
| | Range | 76.6 to 107 | -21.0 to 5.6 | -31.3 to -4.1 | -21.7 to 9.8 | 105.6 to 136.6 | -18.2 to 5.3 | -31.0 to 10.8 | -17.4 to 6.7 | 81.2 to 130.5 | -25.6 to 20.8 | -13.0 to 39.6 | -18.5 to 30.8 | 6.3 to 15.7 | -48.8 to 33.3 | -47.7 to 30.2 | -53.8 to 15.1 |

Continued…

| No. | Characters / Crosses | Effective Tillers Plant$^{-1}$ Mean | BP | BPT 5204 | Arize 6444 | Panicle length (cm) Mean | BP | BPT 5204 | Arize 6444 | Spikelets panicle$^{-1}$ Mean | BP | BPT 5204 | Arize 6444 | Grains panicle$^{-1}$ Mean | BP | BPT 5204 | Arize 6444 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | IR 79156A x IET 21519 | 8.0 | -16.5 | -24.9** | -30.6** | 24.4 | -7.3* | 4.0 | -18.4** | 208.0 | 8.3** | -23.4** | 0.0 | 180.3 | 5.4 | -25.7** | -4.5 |
| 2. | IR 79156A x IET 22218 | 10.2 | 6.5 | -3.1 | -11.2 | 32.0 | 12.8** | 36.0** | 6.7* | 229.6 | 10.4** | -15.4** | 10.4** | 197.3 | 10.0** | -18.7** | 4.7 |
| 3. | IR 79156A x IET 22228 | 4.8 | -49.3** | -54.3** | -57.8** | 31.2 | 17.7** | 32.9** | 4.2 | 149.0 | -30.3** | -45.1** | -28.3** | 125.3 | -32.3** | -48.4** | -33.4** |
| 4. | IR 79156A x IET 22202 | 6.3 | -34.2** | -40.7** | -45.2** | 32.9 | 12.5** | 40.1** | 9.9** | 214.6 | 11.8** | -20.9** | 3.2 | 178.6 | 6.9* | -26.4** | -5.1 |
| 5. | IR 79156A x IET 20524 | 4.1 | -56.4** | -60.8** | -63.7** | 34.5 | 37.4** | 46.7** | 15.0** | 234.6 | 44.2** | -13.6** | 12.8** | 183.3 | 25.8** | -24.5** | -2.6 |
| 6. | IR 79156A x IET 21542 | 7.0 | -26.3** | -33.7** | -38.7** | 32.4 | 17.6** | 37.9** | 8.1** | 246.6 | 16.7** | -9.2** | 18.5** | 202.0 | 6.6* | -16.8** | 7.2* |
| 7. | IR 79156A x Vardhan | 6.3 | -33.8** | -40.4** | -44.9** | 35.0 | 39.7** | 49.1** | 16.9** | 297.3 | 5.5** | 9.4** | 42.9** | 255.0 | 3.3 | 4.9* | 35.4** |
| 8. | IR 79156A x Akshaya Dhan | 8.7 | -8.3 | -17.4* | -23.7** | 36.0 | 14.5** | 53.0** | 20.0** | 183.3 | 13.8** | -32.2** | -11.6** | 145.3 | -0.2 | -40.1** | -22.8** |
| 9. | IR 79156A x Rajendra Kasturi | 11.6 | 21.3* | 9.2 | 0.9 | 31.3 | 24.9** | 33.3** | 4.6 | 314.0 | 4.3** | 15.5** | 50.9** | 268.6 | 1.2 | 10.5** | 42.6** |
| 10. | IR 79156A x Sarjoo- 52 | 4.3 | -54.6** | -59.2** | -62.3** | 29.6 | 18.1** | 26.1** | -1.0 | 160.0 | -0.6 | -41.1** | -23.0** | 130.0 | -10.7** | -46.5** | -30.9** |
| 11. | IR 79156A x HUR-8-1 | 7.5 | -21.5* | -29.2** | -34.5** | 32.3 | 25.6** | 37.3** | 7.7** | 259.0 | 57.9** | -4.6** | 24.5** | 207.6 | 42.5** | -14.5** | 10.2** |
| 12. | IR 79156A x BPT 5204 | 13.4 | 29.0** | 26.1** | 16.5* | 28.3 | 13.0** | 20.6** | -5.3* | 232.6 | -13.6** | -14.3** | 11.8** | 178.0 | -24.7** | -26.7** | -5.4 |
| 13. | IR 79156A x RPBIO-226 | 13.0 | 27.9** | 22.6** | 13.3 | 27.3 | 8.7** | 16.0** | -8.9** | 218.3 | -19.0** | -19.6** | 4.9 | 174.3 | -24.9** | -28.2** | -7.4* |
| 14. | IR 79156A x Type-3 | 9.4 | -1.5 | -11.3 | -18.0* | 35.9 | 21.9** | 52.8** | 19.8** | 155.3 | -22.4** | -42.8** | -25.3** | 122.0 | -26.0** | -49.7** | -35.2** |
| 15. | IR 79156A x MTU-7029 | 12.4 | 29.9** | 16.9* | 8.0 | 31.3 | 17.6** | 33.2** | 4.5 | 238.0 | 11.9** | -12.3** | 14.4** | 188.6 | 4.0 | -22.3** | 0.1 |
| 16. | IR 79156A x Danteswari | 12.2 | 27.9** | 15.2 | 6.4 | 25.2 | -3.8 | 7.3* | -15.8** | 186.0 | 12.9** | -31.5** | -10.5** | 146.0 | 0.2 | -39.9** | -22.4** |
| 17. | Pusa 6A x IET 21519 | 6.6 | -36.4** | -38.0** | -42.7** | 30.3 | 10.4** | 29.1** | 1.2 | 187.3 | -2.4 | -31.0** | -9.9** | 143.0 | -16.3** | -41.1** | -24.0** |
| 18. | Pusa 6A x IET 22218 | 10.1 | -2.6 | -5.0 | -12.2 | 28.9 | 2.0 | 23.0** | -3.5 | 214.3 | 3.0 | -21.1** | 3.0 | 174.3 | -2.7 | -28.2** | -7.4* |
| 19. | Pusa 6A x IET 22228 | 9.6 | -6.8 | -9.1 | -16.0* | 28.5 | 3.8 | 21.4** | -4.7 | 178.6 | -16.5** | -34.2** | -14.1** | 138.0 | -25.5** | -43.2** | -26.7** |
| 20. | Pusa 6A x IET 22202 | 8.9 | -14.1 | -16.3* | -22.6** | 32.1 | 9.7** | 36.7** | 7.2** | 264.3 | 37.6** | -2.0 | 27.0** | 214.6 | 28.5** | -11.6** | 13.9** |
| 21. | Pusa 6A x IET 20524 | 5.3 | -48.8** | -50.1** | -53.9** | 30.4 | 10.5** | 29.2** | 1.3 | 178.0 | 2.5 | -34.4** | -14.4** | 140.3 | -9.6** | -42.2** | -25.4** |
| 22. | Pusa 6A x IET 21542 | 5.5 | -46.6** | -48.0** | -51.9** | 24.4 | -11.2** | 4.0 | -18.4** | 275.0 | 30.1** | 1.2 | 32.2** | 224.3 | 18.4** | -7.6** | 19.1** |
| 23. | Pusa 6A x Vardhan | 9.4 | -8.6 | -10.8 | -17.6* | 33.3 | 21.3** | 41.8** | 11.2** | 207.3 | -26.3** | -23.6** | -0.3 | 178.3 | -27.7** | -26.6** | -5.3 |
| 24. | Pusa 6A x Akshaya Dhan | 11.1 | 7.1 | 4.4 | -3.5 | 35.7 | 13.5** | 51.8** | 19.0** | 237.0 | 36.4** | -12.7** | 13.9** | 200.6 | 29.1** | -17.4** | 6.5* |
| 25. | Pusa 6A x Rajendra Kasturi | 12.5 | 20.5* | 17.5* | 8.5 | 26.4 | -3.8 | 12.4** | -11.8** | 350.6 | 16.5** | 29.0** | 68.5** | 297.3 | 12.0** | 22.3** | 57.8** |
| 26. | Pusa 6A x Sarjoo- 52 | 8.1 | -22.0** | -23.9** | -29.7** | 32.6 | 18.5** | 38.6** | 8.7** | 195.6 | 12.6** | -27.9** | -5.9** | 163.0 | 4.9 | -32.9** | -13.4** |
| 27. | Pusa 6A x HUR-8-1 | 10.4 | 0.8 | -1.6 | -9.1 | 30.2 | 10.0** | 28.7** | 0.9 | 198.0 | 14.0** | -27.1** | -4.8* | 161.0 | 3.6 | -33.7** | -14.5** |
| 28. | Pusa 6A x BPT 5204 | 12.5 | 20.9* | 18.1* | 9.2 | 27.9 | 1.5 | 18.7** | -6.8* | 255.3 | -5.0** | -6.0** | 22.7** | 203.6 | -13.9** | -16.1** | 8.1** |
| 29. | Pusa 6A x RPBIO-226 | 12.9 | 24.2** | 21.1** | 11.8 | 29.3 | 6.5* | 24.5** | -2.2 | 228.0 | -15.5** | -16.0** | 9.6** | 197.0 | -15.2** | -18.9** | 4.6 |
| 30. | Pusa 6A x Type-3 | 7.3 | -29.5** | -31.3** | -36.5** | 35.9 | 21.8** | 52.6** | 19.7** | 202.3 | 1.0 | -25.5** | -2.7 | 170.0 | 3.0 | -30.0** | -9.7** |
| 31. | Pusa 6A x MTU-7029 | 12.0 | 15.6 | 12.7 | 4.1 | 30.7 | 11.8** | 30.8** | 2.6 | 266.0 | 25.0** | -2.0 | 27.8** | 234.3 | 29.2** | -3.5 | 24.4** |
| 32. | Pusa 6A x Danteswari | 11.6 | 12.4 | 9.6 | 1.3 | 29.9 | 8.9** | 27.4** | -0.0 | 218.0 | 25.5** | -19.7** | 4.8* | 183.3 | 18.0** | -24.5** | -2.6 |
| | Mean | 9.2 | -8.5 | -13.6 | -20.2 | 30.8 | 12.7 | 31.2 | 2.9 | 224.4 | 7.8 | -17.3 | 7.9 | 184.5 | 0.7 | -24.0 | -2.0 |
| | S. E. | | 0.8 | 0.8 | 0.8 | | 0.8 | 0.8 | 0.8 | | 4.5 | 4.5 | 4.5 | | 5.3 | 5.3 | 5.3 |
| | Range | 4.1 to 13.4 | -56.4 to 29.9 | -60.8 to 26.1 | -63.7 to 16.5 | 24.4 to 36 | -11.2 to 39.7 | 4.0 to 53.0 | - 18.4 to 20.0 | 149 to 350. | -30.3 to 57.3 | -45.1 to 29.0 | - 28.3 to 68.5 | 122 to 297.3 | -32.3 to 42.5 | -49.7 to 22.3 | - 35.2 to 57.8 |

Continued…

| No. | Characters | Sterile spikelets panicle$^{-1}$ | | | | Pollen Fertility (%) | | | | Spikelet Fertility (%) | | | | Chlorophyll Content | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crosses | Mean | BP | BPT 5204 | Arize 6444 | Mean | BP | BPT 5204 | Arize 6444 | Mean | BP | BPT 5204 | Arize 6444 | Mean | BP | BPT 5204 | Arize 6444 |
| 1. | IR 79156A x IET 21519 | 27.6 | 31.7 | -3.4 | 40.6 | 88.4 | -5.1** | -4.4** | -4.7** | 86.7 | -4.1* | -3.0 | -4.1* | 42.4 | 5.0 | 16.3** | 5.8 |
| 2. | IR 79156A x IET 22218 | 32.3 | 12.7 | 12.9 | 64.4** | 87.5 | -6.0** | -5.4** | -5.6** | 85.9 | -5.0* | -3.9 | -5.0* | 40.0 | 2.7 | 9.7** | -0.1 |
| 3. | IR 79156A x IET 22228 | 23.6 | -17.4 | -17.4 | 20.3 | 86.6 | -7.0** | -6.4** | -6.6** | 84.1 | -7.0** | -5.9** | -7.0** | 45.2 | 5.9* | 24.1** | 12.8** |
| 4. | IR 79156A x IET 22202 | 36.0 | 44.0** | 25.58 | 83.0** | 85.6 | -8.0** | -7.4** | -7.6** | 83.2 | -8.0** | -6.9** | -8.0** | 44.6 | 5.9* | 22.3** | 11.3** |
| 5. | IR 79156A x IET 20524 | 51.3 | 140.3** | 79.0** | 161.0** | 80.8 | -13.8** | -12.7** | -12.8** | 78.1 | -13.7** | -12.7** | -13.7** | 44.9 | 16.1** | 23.2** | 12.0** |
| 6. | IR 79156A x IET 21542 | 44.6 | 103.0** | 55.8** | 127.1** | 84.0 | -9.8** | -9.2** | -9.4** | 81.8 | -9.5** | -8.4** | -9.5** | 42.5 | -2.4 | 16.5** | 5.9 |
| 7. | IR 79156A x Vardhan | 42.3 | 20.9 | 47.6** | 115.2** | 86.7 | -6.9** | -6.3** | -6.5** | 84.6 | -6.4** | -5.3** | -6.4** | 37.8 | -3.5 | 3.8 | -5.5 |
| 8. | IR 79156A x Akshaya Dhan | 38.0 | 123.5** | 32.5** | 93.2** | 80.5 | -13.5** | -12.9** | -13.1** | 79.3 | -12.3** | -11.3** | -12.3** | 38.2 | -2.1 | 4.7 | -4.7 |
| 9. | IR 79156A x Rajendra Kasturi | 45.3 | 27.1* | 58.1** | 130.5** | 88. | -5.3** | -4.6** | -4.9** | 85.5 | -5.4** | -4.3* | -5.4** | 41.9 | 11.1** | 15.0** | 4.6 |
| 10. | IR 79156A x Sarjoo- 52 | 30.0 | 26.7 | 4.5 | 52.5* | 82.6 | -11.3** | -10.7** | -10.9** | 81.2 | -10.2** | -9.1** | -10.2** | 41.1 | 8.9** | 12.8** | 2.5 |
| 11. | IR 79156A x HUR-8-1 | 51.3 | 97.4** | 79.7** | 161.0** | 82.7 | -11.2** | -10.6** | -10.8** | 80.1 | -11.4** | -10.4** | -11.4** | 38.6 | 2.2 | 5.9** | -3.6 |
| 12. | IR 79156A x BPT 5204 | 54.6 | 67.3** | 90.7** | 177.9** | 78.6 | -15.6** | -15.1** | -15.2** | 76.5 | -15.4** | -14.4** | -15.4** | 40.1 | 6.3 | 10.5** | 0.1 |
| 13. | IR 79156A x RPBIO-226 | 44.0 | 17.8 | 53.4** | 123.7** | 81.3 | -12.7** | -12.1** | -12.3** | 79.8 | -11.7** | -10.7** | -11.7** | 41.3 | 9.4** | 13.3** | 3.0 |
| 14. | IR 79156A x Type-3 | 33.3 | -5.6 | 16.2 | 69.4** | 81.4 | -12.6** | -12.0** | -12.2** | 78.4 | -13.3** | -12.3** | -13.3** | 41.6 | 10.4** | 14.1** | 3.8 |
| 15. | IR 79156A x MTU-7029 | 49.3 | 57.4** | 72.0** | 150.8** | 80.5 | -13.5** | -13.0** | -13.2** | 79.2 | -12.4** | -11.3** | -12.4** | 42.1 | 11.5** | 15.5** | 5.0 |
| 16. | IR 79156A x Danteswari | 40.0 | 48.1** | 39.5** | 103.3** | 81.3 | -12.7** | -12.1** | -12.3** | 78.4 | -13.3** | -12.3** | -13.3** | 40.4 | 7.0* | 10.8** | 0.8 |
| 17. | Pusa 6A x IET 21519 | 44.3 | 111.1** | 54.6** | 125.4** | 78.6 | -14.0** | -15.0** | -15.2** | 76.3 | -14.6** | -14.6** | -15.6** | 43.7 | 7.8* | 20.0** | 9.1** |
| 18. | Pusa 6A x IET 22218 | 40.0 | 39.3** | 39.5** | 103.3** | 82.9 | -9.3** | -10.4** | -10.6** | 81.3 | -9.0** | -9.0** | -10.1** | 40.6 | 0.2 | 11.5** | 1.4 |
| 19. | Pusa 6A x IET 22228 | 40.6 | 41.8** | 41.8** | 106.7** | 78.8 | -13.8** | -14.8** | -15.0** | 77.2 | -13.6** | -13.6** | -14.6** | 43.0 | 0.6 | 17.9** | 7.2* |
| 20. | Pusa 6A x IET 22202 | 49.6 | 98.6** | 73.2** | 152.5** | 82.9 | -9.2** | -10.1** | -10.6** | 81.1 | -9.2** | -9.2** | -10.3** | 45.5 | 8.1** | 24.9** | 13.6** |
| 21. | Pusa 6A x IET 20524 | 37.6 | 76.5** | 31.0* | 91.5** | 80.7 | -11.6** | -12.7** | -12.9** | 78.8 | -11.8** | -11.8** | -12.8** | 42.7 | 5.3 | 17.1** | 6.5* |
| 22. | Pusa 6A x IET 21542 | 52.6 | 139.9** | 83.7** | 167.8** | 83.6 | -8.5** | -9.6** | -9.8** | 81.5 | -8.9** | -8.8** | -9.9** | 42.5 | -2.4 | 16.5** | 5.9 |
| 23. | Pusa 6A x Vardhan | 29.0 | -17.1 | 1.1 | 47.4* | 87.8 | -3.9* | -5.1** | -5.3** | 86.0 | -3.8 | -3.8 | -4.6* | 41.3 | 1.8 | 13.3** | 3.0 |
| 24. | Pusa 6A x Akshaya Dhan | 36.3 | 98.1** | 26.7 | 84.7** | 86.8 | -4.9** | -6.1** | -6.3** | 84.6 | -5.3* | -5.3** | -6.4** | 41.3 | 1.8 | 13.3** | 3.0 |
| 25. | Pusa 6A x Rajendra Kasturi | 53.3 | 49.5** | 86.0** | 171.1** | 86.6 | -5.2** | -6.4** | -6.6** | 84.7 | -5.2* | -5.2* | -6.3** | 42.2 | 4.1 | 15.9** | 5.4 |
| 26. | Pusa 6A x Sarjoo- 52 | 32.6 | 38.0** | 13.9 | 66.1** | 85.0 | -6.9** | -8.1** | -8.3** | 83.3 | -6.8** | -6.8** | -7.9** | 40.2 | -0.7 | 10.4** | 0.4 |
| 27. | Pusa 6A x HUR-8-1 | 37.0 | 42.3** | 29.0* | 88.1** | 83.3 | -8.8** | -9.9** | -10.1** | 81.3 | -9.0** | -9.0** | -10.2** | 40.9 | 0.9 | 12.3** | 2.1 |
| 28. | Pusa 6A x BPT 5204 | 51.6 | 58.1** | 80.2** | 162.7** | 81.9 | -10.4 | -11.5** | -11.7** | 79.7 | -10.8** | -10.8** | -11.8** | 38.9 | -4.0 | 6.7* | -2.9 |
| 29. | Pusa 6A x RPBIO-226 | 31.0 | -16.9 | 8.1 | 57.6** | 87.5 | -4.2* | -5.4** | -5.6** | 86.4 | -3.4 | -3.4 | -4.5** | 37.6 | -7.3* | 3.1 | -6.2* |
| 30. | Pusa 6A x Type-3 | 32.3 | -8.4 | 12.7 | 64.4** | 86.0 | -5.8** | -7.0** | -7.2** | 84.0 | -6.1** | -6.1** | -7.1** | 36.4 | -10.1** | 0.0 | -9.0** |
| 31. | Pusa 6A x MTU-7029 | 31.6 | 1.0 | 10.4 | 61.0** | 89.8 | -1.7 | -2.97 | -3.1* | 88.0 | -1.5 | -1.5 | -2.6 | 41.6 | 2.6 | 14.1** | 3.8 |
| 32. | Pusa 6A x Danteswari | 34.6 | 28.4** | 20.9 | 76.2** | 85.3 | -6.6** | -7.8** | -8.0** | 84.0 | -6.0** | -6.0** | -7.1** | 40.0 | -1.1 | 9.9** | -0.0 |
| | Mean | 39.9 | 68.5 | 39.3 | 103.1 | 83.9 | -9.0 | -9.3 | -9.5 | 81.9 | -8.9 | -8.4 | -9.4 | 41.3 | 3.2 | 13.3 | 3.0 |
| | S. E. | | 4.1 | 4.1 | 4.1 | | 1.4 | 1.4 | 1.4 | | 1.8 | 1.8 | 1.8 | | 1.2 | 1.2 | 1.2 |
| | Range | 23.6 to 54.6 | -5.6 to 140.6 | -3.4 to 90.7 | 20.4 to 177.9 | 78.6 to 89.8 | -15.6 to -1.7 | -15.1 to -2.9 | -15.2 to -3.1 | 76.3 to 88.0 | -15.4 to -1.5 | -14.6 to -1.5 | -15.6 to -2.6 | 36.4 to 45.5 | -10.1 to 16.1 | 0.0 to 24.9 | -9.0 to 13.6 |

Continued…

| No. | Characters / Crosses | Grain Weight Panicle$^{-1}$ (g) Mean | BP | BPT 5204 | Arize 6444 | 1000- Grain Weight (g) Mean | BP | BPT 5204 | Arize 6444 | Grain Yield Plant$^{-1}$ (g) Mean | BP | BPT 5204 | Arize 6444 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | IR 79156A x IET 21519 | 3.1 | 10.4 | -5.5 | -11.1* | 21.3 | 0.5 | 10.0* | -5.8 | 21.4 | -12.9* | -15.6** | -31.8** |
| 2. | IR 79156A x IET 22218 | 4.3 | 67.3** | 29.8** | 22.1** | 27.0 | 27.4** | 39.5** | 19.3** | 27.4 | 20.3** | 7.9 | -12.8** |
| 3. | IR 79156A x IET 22228 | 3.7 | -4.7 | 11.1* | 4.5 | 29.1 | 17.4** | 50.3** | 28.5** | 19.8 | -25.7** | -22.1** | -37.1** |
| 4. | IR 79156A x IET 22202 | 4.5 | 26.3** | 34.5** | 26.5** | 28.0 | 9.8** | 44.8** | 23.8** | 36.6 | 63.3** | 43.9** | 16.2** |
| 5. | IR 79156A x IET 20524 | 4.8 | 41.0** | 43.5** | 35.1** | 21.8 | -15.0** | 12.8** | -3.4 | 20.1 | -25.7** | -20.9** | -36.1** |
| 6. | IR 79156A x IET 21542 | 4.7 | 10.4* | 41.5** | 33.2** | 19.5 | -17.1** | 0.5 | -13.8** | 26.6 | -11.9** | 4.6 | -15.5** |
| 7. | IR 79156A x Vardhan | 4.8 | 39.9** | 44.5** | 36.0** | 21.3 | 0.5 | 10.1* | -5.7 | 34.5 | 60.4** | 35.6** | 9.5* |
| 8. | IR 79156A x Akshaya Dhan | 3.8 | 11.2* | 13.3* | 6.8 | 19.6 | -7.6 | 1.1 | -13.4** | 28.7 | 31.2** | 12.7* | -9.2* |
| 9. | IR 79156A x Rajendra Kasturi | 2.4 | -6.7 | -27.6** | -31.9** | 17.3 | -18.1** | -10.1* | -23.3** | 33.4 | 34.7** | 31.4** | 6.1 |
| 10. | IR 79156A x Sarjoo- 52 | 1.8 | -41.4** | -43.8** | -47.1** | 20.4 | -25.8** | 5.4 | -9.8 | 25.3 | 17.8** | -0.3 | -19.5** |
| 11. | IR 79156A x HUR-8-1 | 4.3 | 59.7** | 30.0** | 22.3** | 24.1 | -6.1 | 24.2** | 6.2 | 20.0 | -7.6 | -21.1** | -36.3** |
| 12. | IR 79156A x BPT 5204 | 3.8 | 33.9** | 14.6** | 7.8 | 21.0 | -1.0 | 8.3 | -7.2 | 35.9 | 43.4** | 41.1** | 14.0** |
| 13. | IR 79156A x RPBIO-226 | 3.3 | 14.7* | -0.7 | -6.5 | 19.2 | -9.2* | -0.6 | -15.0** | 30.1 | 34.9** | 18.2** | -4.5 |
| 14. | IR 79156A x Type-3 | 2.1 | -17.3* | -35.8** | -39.6** | 26.5 | 22.9** | 36.6** | 16.8** | 20.2 | -6.1 | -20.2** | -35.9** |
| 15. | IR 79156A x MTU-7029 | 4.3 | 46.0** | 29.7** | 22.1** | 22.4 | 4.9 | 15.6** | -1.0 | 40.7 | 58.1** | 60.1** | 29.2** |
| 16. | IR 79156A x Danteswari | 3.2 | 26.0** | -2.1 | -7.9 | 22.2 | 0.8 | 14.6** | -1.9 | 38.5 | 52.4** | 51.4** | 22.3** |
| 17. | Pusa 6A x IET 21519 | 2.9 | -22.1** | -13.1** | -18.2** | 26.4 | 15.1** | 36.2** | 16.5** | 16.5 | -32.8** | -34.8** | -47.1** |
| 18. | Pusa 6A x IET 22218 | 2.3 | -37.2** | -30.2** | -34.3** | 20.6 | -10.5* | 6.1 | -9.1 | 21.5 | -5.9 | -15.6** | -31.8** |
| 19. | Pusa 6A x IET 22228 | 4.7 | 21.9** | 42.3** | 33.9** | 24.2 | -2.3 | 25.0** | 7.0 | 23.0 | -13.7** | -9.5 | -26.9** |
| 20. | Pusa 6A x IET 22202 | 5.2 | 40.1** | 56.4** | 47.1** | 24.6 | -3.4 | 27.2** | 8.8* | 38.9 | 53.4** | 52.7** | 23.3** |
| 21. | Pusa 6A x IET 20524 | 2.8 | -23.8** | -14.3** | -19.9** | 19.8 | -22.8** | 2.4 | -12.3** | 16.7 | -38.4** | -34.4** | -47.0** |
| 22. | Pusa 6A x IET 21542 | 5.3 | 25.1** | 60.9** | 51.4** | 25.5 | 8.3* | 31.5** | 12.5** | 34.4 | 13.8** | 35.3** | 9.2* |
| 23. | Pusa 6A x Vardhan | 3.0 | -19.7** | -9.6 | -14.9** | 25.8 | 12.6** | 33.2** | 13.9** | 26.2 | 19.4** | 3.1 | -16.6** |
| 24. | Pusa 6A x Akshaya Dhan | 4.7 | 27.7** | 42.5** | 34.1** | 28.8 | 25.6** | 48.6** | 27.1** | 42.5 | 93.3** | 66.9** | 34.8** |
| 25. | Pusa 6A x Rajendra Kasturi | 3.1 | -15.7** | -5.9 | -11.5* | 15.2 | -33.4** | -21.2** | -32.6** | 31.6 | 27.4** | 24.3** | 0.3 |
| 26. | Pusa 6A x Sarjoo- 52 | 3.1 | -15.0** | -5.1 | -10.7* | 28.8 | 4.7 | 48.8** | 27.3** | 21.4 | -2.4 | -15.7** | -31.9** |
| 27. | Pusa 6A x HUR-8-1 | 3.6 | -3.8 | 7.3 | 1.0 | 20.1 | -21.3** | 4.0 | -11.0** | 33.5 | 52.2** | 31.4** | 6.1 |
| 28. | Pusa 6A x BPT 5204 | 3.4 | -7.2 | 3.5 | -2.3 | 18.3 | -20.1** | -5.5 | -19.1** | 37.5 | 49.9** | 47.5** | 19.1** |
| 29. | Pusa 6A x RPBIO-226 | 2.9 | -21.8** | -12.7* | -17.8** | 15.3 | -32.9** | -20.6** | -32.1** | 34.5 | 54.6** | 35.5** | 9.4* |
| 30. | Pusa 6A x Type-3 | 2.3 | -36.9** | -29.6** | -33.8** | 24.5 | 6.9 | 26.4** | 8.2 | 29.6 | 34.8** | 16.4** | -5.9 |
| 31. | Pusa 6A x MTU-7029 | 4.3 | 17.3** | 31.0** | 23.3** | 26.5 | 15.5** | 36.7** | 16.9** | 40.3 | 56.6** | 58.5** | 28.0** |
| 32. | Pusa 6A x Danteswari | 3.6 | -3.3 | 7.9 | 1.5 | 26.4 | 15.4** | 36.5** | 16.8** | 36.3 | 43.5** | 42.6** | 15.1** |
| | Mean | 3.6 | 7.5 | 9.6 | 3.1 | 22.9 | -1.8 | 18.1 | 1.0 | 29.5 | 23.5 | 15.9 | -6.3 |
| | S. E. | | 0.1 | 0.1 | 0.1 | | 0.9 | 0.9 | 0.9 | | 1.3 | 1.3 | 1.3 |
| | Range | 1.8 to 5.3 | -41.4 to 67.3 | -43.8 to 60.9 | -47.1 to 51.4 | 15.2 to 29.1 | -33.4 to 27.4 | -21.2 to 50.3 | -32.6 to 28.5 | 16.5 to 42.5 | -38.4 to 93.3 | -34.8 to 66.9 | -47.4 to 34.8 |

***** Significant at 5% level    ** significant at 1% level

This study showed that, superior performance for all the characters was not expressed in a single hybrid combination. However, different cross combinations were found to be superior for various characters. These finding are consistent with those of Sharma and Roy (1996), Singh and Haque (1999), Binodh *et al*. (2006), Eradasappa *et al*. (2007), Saravanan *et al*. (2008), Vaithiyalingan and Nadarajan (2010), Adilakshmi and Reddy (2011), Kumar *et al.* (2012 ), Singh *et al.* (2013) and Sharma *et al.* (2013). This study concluded that the top heterotic crosses for yield as well as quality traits, Pusa 6A x Akshaya Dhan (SV= 66.9%, SH=34.8%) and IR79156A x MTU-7029 (SV= 60.1%, SH=29.2%) more about the further testing that is required.

## ACKNOWLEDGEMENT

The financial support for this study was provided by Ministry of Science and Technology, Department of Science and Technology, New Delhi, Government of India as a DST-INSPIRE Fellowship (INSPIRE Code IF-20350) for full-time doctoral (Ph.D.) degree programme at Banaras Hindu University, Varanasi, Uttar Pradesh.

## REFERENCES

Adilakshmi D, Reddy PR (2011). Heterosis and inbreeding depression for grain quality traits in rice (*Oryza sativa* L.). *Res. on Crops*. 12(2): 489-492.

Binodh AK, Kalaiyarasi R, Thiyagarajan K, Manonmani S (2006). Physiochemical cooking quality characteristics of promising varieties and hybrids in rice (*Oryza sativa* L.). *Indian J. Genet*. 66(2): 107-112.

Dar Sajad Hussain, Rather AG, Sangher GS, Ahanger MA, Bhat MA, Noorul-Saleem Ahmad, Syeed Talib M, Kurashi Ahmad Nazir SN (2014). Identification of effective restorers and maintainers for development of rice hybrids in temperate ecology. *Elect. J. of Plant Breed*. 5(4): 756-759.

Eradasappa E, Ganapathy KN, Satish RG, Shanthala J, Nadarajan N (2007). Heterosis studies for yield and yield components using CMS lines in rice (*Oryza sativa* L.). *Crop Res.* (Hisar). 34(1/3): 152-155.

Fonseca S, Patterson FL, (1968). Hybrid vigor in a seven-parent diallel cross in common winter wheat (Triticum aestivum L.). *Crop. Sci.* 8: 85.

Kumar Chetan MR, Devaraju, Prasad SR (2012). Characterization of rice hybrids and their parental lines based on morphological traits. *Oryza*. 49 (4): 302-304.

Kumar S, Dwivedi SK, Singh SS, Jha SK, Lekshmy S, Elanchezhian R, Singh ON, Bhatt BP (2014). Identification of drought tolerant rice genotypes by analysing drought tolerance indices and morpho-physiological traits. *SABRAO J. Breed. Genet.* 46 (2): 217-230.

Panse, V.G. and P.V. Sukhatme, (1967). Statistical Methods for Agricultural Workers, 2nd Ed., Indian Council of Agricultural Research, New Delhi.

Saravanan KT, Sabesan , Kumar ST (2008). Heterosis for yield and yield components in rice (*Oryza sativa* L.). *Adv. in Plant Sci.* 21(1): 119-121.

Sharma RN, Roy A (1996). Studies on heterosis for grain yield and components in rice. *Oryza*. 33: 282-285.

Sharma SK, Singh SK, Nandan R, Amita Sharma, Ravinder Kumar, Kumar V, Singh MK, (2013). Estimation of heterosis and inbreeding depression for yield and yield related traits in rice (*Oryza sativa* L.). *Mol. Plant Breed.* 29(4): 238-246.

Singh SK, Haque MF (1999). Heterosis for yield and yield components in rice (*Oryza sativa* L.). *Indian J. Genet*. 59(2): 337-238.

Singh SK, Vikash Sahu, Amita Sharma, Pradeep Bhati Kumar (2013). Heterosis for yield and yield components in rice (*Oryza sativa* L.). *Bioinfolet.* 10(2B): 752-761.

Singh SK, Bhati PK, Sharma Amita, Sahu Vikas (2015). Super hybrid rice in China and India: current status and future prospects. *Int. J. of Agric. and Biol.* 17 (2): 221-232.

USDA, Rice Outlook, (2014).

Vaithiyalingan M, Nadarajan N (2010). Heterosis for yield and yield contributing characters in inter sub-specific crosses of rice. *Elect. J. of Plant Breed.* 1(3): 305-310.