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# Studies on Heterosis for Grain Yield, Yield Components and Quality Characters in Rice (*Oryza Sativa* L.)

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**ABSTRACT**

The manifestation of hybrid vigour in 50 rice hybrids for grain yield, yield components and quality parameters were investigated during *Rabi* 2017-18. The results revealed hybrids to be high yielding, relatively early, dwarf with greater panicle length, more number of grains panicle$^{-1}$ and high head rice recovery percentage compared to the parents and checks. Existence of significant levels of relative heterosis, heterobeltiosis and commercial heterosis for all the traits, except milling percentage in the material studied was also noticed from the significant mean squares recorded for parents vs. hybrids components of variation in the ANOVA. Further, the expression of heterosis was maximum over mid-parent for grain yield plant$^{-1}$ and number grains panicle$^{-1}$ (>90%). Grain yield plant$^{-1}$ and number of grains panicle$^{-1}$ had also recorded high levels of heterosis over better parent (>70%). Standard heterosis more than 50 per cent was also recorded for grain yield plant$^{-1}$ and number of grains panicle$^{-1}$. Among the hybrids studied, APMS 8A x MTU 2247-55-2, APMS 8A x MTU 2331-216-1-1 and APMS 8A x MTU 2337-216-1-1 recorded significant and positive standard heterosis more than 50 per cent over both the checks studied for grain yield plant$^{-1}$ and hence, are identified as potential hybrids for commercial exploitation. The hybrid, APMS 6A x NLR 5815-10-1-1-1 was also identified as high yielding and quality hybrid in the present study.

**Key words:** *Rice, heterosis, grain yield, yield components, quality parameters.*

Rice is a staple food for more than half of the world population and is referred as "Global Grain". 'Rice is Life' was the theme of International year of rice during 2004 denoting its overwhelming importance as an item of food and commerce. However, to meet the food demand of the growing population and to achieve food security in the country, the present production levels of rice need to be increased by 2 million tonnes every year which has been reported to be possible through heterosis breeding (Spielman *et al.*, 2013).

Rice hybrids were first commercialized in China during late 1970s. In India, first rice hybrids (APHR 1, APHR 2) were released in 1994. Gradually, hybrid rice technology has gained importance in India with a total cultivated area of about 2.5 million hectares (Singh *et al.*, 2016). However, widespread use of hybrids is restricted mainly due to lack of quality hybrids with good yield potential. Therefore, identification of parents with high yield and good quality traits is essential for successful hybrid breeding programme. The present study was undertaken in this context and is aimed at estimating the heterotic effects for grain yield, yield components and quality traits for identification of high heterotic crosses for grain yield and quality.

## MATERIAL AND METHODS

The experimental material comprised of two CMS lines namely, APMS 6A and APMS 8A; 25 testers namely, BPT 5204, RP6112-MS-128-5-2-3-1-4-5, MTU 2244-128-18, MTU 2201-34-3-1, MTU 2049-5-2-1, MTU 2247-55-2, BPT 2659, JMP 16, MTU 1061, RM 168-28-1-1-1, MTU 2336-70-46-25-44, MTU 2347-158-3-1-1, MTU 2336-62-25-39-16, MTU 2284-103-1-7, HR L4, NLR 5815-10-1-1-1, UTR 51, NLR 3445, BPT 2782, MTU 2284-103-1-9, MTU 2345-98-3, MTU 2067-9-1-1-2, RM 138-80-3-1-1-1, MTU 2337-216-1-1 and MTU 2331-216-1-1 obtained from the germplasm collections maintained at Regional Agricultural Research Station, Maruteru, West Godavari district and their fifty hybrids derived from the 2 x 25 Line x Tester mating of these lines and testers. The hybrids and parents were evaluated along with the hybrid check, Arize 6444 Gold and varietal check, MTU 1153 in a Randomized Block Design with two replications for grain yield; yield component characters, namely, days to 50% flowering, plant height, ear bearing tillers plant$^{-1}$, panicle length, number of grains panicle$^{-1}$, spikelet fertility percentage and 1000-Seed weight; and quality characters, namely, L/B ratio, hulling, milling and head rice recovery percentage at the Regional Agricultural Research Station, Maruteru.

The sowings were under taken in nursery during the second fortnight of November and transplanting of the seedlings were affected 25 days after sowing, depending on the growth of seedlings. The normal, healthy and vigorous seedlings of each genotype were transplanted in a six-row plot of 4.5 m length, with a spacing of 20 x 15 cm and the crop was raised following recommended package of practices.

Data was recorded on five randomly selected plants in each replication for the characters, namely, plant height, ear bearing tillers plant$^{-1}$, panicle length, number of grains panicle$^{-1}$, spikelet fertility percentage and grain yield plant$^{-1}$ for all the genotypes. However, days to 50 per cent flowering was recorded on plot basis, while observations on 1000-Seed weight, L/B ratio, hulling percentage, milling percentage and head rice recovery percentage were obtained from a random grain sample drawn from each genotype in each replication. Heterosis over mid-parent, better parent, commercial varietal check, MTU 1153 and the hybrid check, Arize 6444 Gold were obtained for each hybrid and for each character, as per the procedures outlined by Liang *et al.* (1971) and their significance was tested using t-test suggested by Snedecor and Cochran (1967).

**RESULTS AND DISCUSSION**

Analysis of variance (Table 1) revealed significant mean squares for the genotypes, parents and hybrids components of variation for all the characters studied except for hulling percentage for parents and plant height for hybrids, indicating the existence of sufficient variation in the material under investigation. Further, parents vs. hybrids component of variation was also significant for all the traits except milling percentage, indicating the existence of significant levels of relative heterosis, heterobeltiosis and standard heterosis for grain yield, yield components and quality parameters in the material studied.

A critical analysis of results on *per se* performance of the genotypes for yield, yield components and quality characters (Table 2.) revealed the hybrids were high yielding with early duration, dwarf, stature greater panicle length, higher number of grains panicle$^{-1}$ and high head rice recovery percentage compared to the parents and checks. Greater range was also noticed for the hybrids, compared to the parents with regard to grain yield and the yield component characters studied, namely, days to 50% flowering, number of grains panicle$^{-1}$ and spikelet fertility percentage; quality traits namely, L/B ratio and hulling percentage. However, relatively lower mean values were noticed in the hybrids with regards to ear bearing tillers plant$^{-1}$, spikelet fertility percentage and 1000-seed weight compared to the parents.

The best genotype identified for parents and hybrids based on their *per se* performance is presented in Table 2 for different traits studied. A perusal of these results revealed APMS 8A to be the best parent for grain yield plant$^{-1}$, number of grains panicle$^{-1}$, 1000-Seed weight and hulling percentage; APMS 6A for days to 50% flowering (early) and L/B ratio; UTR 51 for plant height (dwarf); HR L4 for panicle length; MTU 1061 for ear bearing tillers plant$^{-1}$; NLR 3445 for spikelet fertility percentage; MTU 2284-103-1-7 for milling percentage and MTU 2244-128-18 for head rice recovery percentage. Among the hybrids, APMS 8A x MTU 2247-55-2 hybrids was superior to both checks and all other hybrids studied with regards to grain yield plant$^{-1}$ and hulling percentage, while APMS 6A x NLR 5815-10-1-1-1 was observed to be the best hybrid for days to 50% flowering; APMS 8A x MTU 2049-5-2-1 for plant height; APMS 6A x MTU 1061 for ear bearing tillers plant$^{-1}$; APMS 8A x MTU 2337-216-1-1 for panicle length and spikelet fertility percentage; APMS 8A x MTU 2244-128-18 for number of grains panicle$^{-1}$; APMS 6A x BPT 2659 for 1000-Seed weight and milling percentage; APMS 8A x RP6112-MS-128-5-2-3-1-4-5 for L/B ratio and APMS 8A x BPT 2782 for head rice recovery percentage.

The range of relative heterosis, heterobeltiosis and standard heterosis recorded for different traits studied are presented in Table 3. A perusal of these results revealed high levels of relative heterosis (136.57%, heterobeltiosis 104.26 and standard heterosis 116.51 over MTU 1153 and 63.61% over arize 6444 for grain yield plant$^{-1}$ followed by number of grains panicle$^{-1}$. Similar high levels of relative heterosis, heterobeltiosis and standard heterosis for grain yield plant$^{-1}$ (Borah *et al.* 2017) and number of grains panicle$^{-1}$ (Devi *et al.* 2014) were reported earlier. A perusal of the results also revealed several heterotic hybrids with significant and desirable heterosis for grain yield plant$^{-1}$ and other yield attributes. Further, Virmani (1996) reported that 20 to 30 per cent standard heterosis is sufficient to offset the extra cost of hybrid seed. In the present investigation, the hybrids, APMS 8A x MTU 2247-55-2, APMS 8A x MTU 2331-216-1-1 and APMS 8A x MTU 2337-216-1-1 recorded significant and positive standard heterosis more than 50 per cent over both the checks studied for grain yield plant$^{-1}$ and hence, are identified as potential hybrids for commercial exploitation.

The expression of heterosis in terms of number of hybrids with significant and desirable heterosis (Table 3) was most evident for number of grains panicle$^{--1}$, followed by days to 50 per cent flowering and grain yield plant$^{--1}$. Thirty hybrids recorded significant and positive heterosis over mid-parent, better parent and standard checks for number of grains panicle$^{-1}$. Of these, APMS 8A x MTU 2244-128-18 recorded more than 40 per cent significant and desirable heterosis over mid-parent, better parent and standard checks. Further, 10 hybrids recorded desirable and significant heterosis over mid-parent, better parent and the standard checks for days to 50% flowering. Of these, APMS 6A x MTU 2336-70-46-25-44 and APMS 6A x MTU 2284-103-1-7 recorded heterosis more than 10 per cent in the desired direction over mid-parent, better parent and

**Table 1. Analysis of variance (mean squares) for grain yield, yield components and quality traits in rice (*Oryza sativa* L.)**

| Source of variation | d.f | Days to 50% flowering | Plant height | Ear bearing tillers | Panicle length | Number of grains panicle$^{-1}$ | Spikelet fertility (%) | 1000-Seed weight | Grain yield plant$^{-1}$ | L/B Ratio | Hulling (%) | Milling (%) | HRR (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replications | 1 | 71.11 | 377.01 | 0.59 | 0.26 | 371.12 | 2.23 | 0.05 | 0.43 | 0.09 | 0.83 | 1.34 | 3.36 |
| Genotypes | 77 | 134.58** | 104.65** | 7.78** | 11.89** | 3053.20** | 300.98** | 128.79** | 9.23** | 0.43** | 21.18** | 29.75** | 88.65** |
| Parents | 26 | 60.34** | 156.36** | 11.32** | 12.40** | 5338.96** | 145.49** | 9.16** | 35.69** | 0.09* | 9.94 | 57.15** | 127.97** |
| Hybrids | 49 | 104.77** | 38.38 | 4.50** | 6.44** | 5557.09** | 761.54** | 36.27** | 182.85** | 0.61** | 469.44** | 361.72** | 334.54** |
| Parents vs Hybrids | 1 | 3704.27** | 2025.44** | 88.28** | 281.52** | 2360.38** | 1699.92** | 38.72** | 1932.52** | 0.31* | 225.29** | 0.82 | 1087.90** |
| Error | 78 | 5.76 | 41.62 | 1.26 | 2.35 | 240.65 | 13.57 | 3.87 | 2.57 | 0.05 | 11.74 | 12.02 | 11.75 |

*,**Significant at 5 and 1 per cent levels, respectively

**Table 2. *Per se* performance of parents, hybrids and checks for grain yield, yield components and quality characters in rice**

| Character | Mean | | | Range | | Best genotype | |
|---|---|---|---|---|---|---|---|
| | Parents | Hybrids | Check | Parents | Hybrids | Parents | Hybrids |
| Grain yield plant$^{-1}$ | 16.7 | 24.8 | 23.64 | 10.21-26.96 | 11.10-44.06 | APMS 8A | APMS 8A x MTU 2247-55-2 |
| Days to 50% flowering | 108 | 98 | 102 | 94.50-118.00 | 86.00-112.00 | APMS 6A | APMS 6A x NLR 5815-10-1-1-1 |
| Plant height (cm) | 112.99 | 105.38 | 112.14 | 95.67-133.33 | 96.50-118.17 | UTR 51 | APMS 8A x MTU 2049-5-2-1 |
| Ear bearing tillers plant$^{-1}$ | 11.15 | 9.56 | 9.3 | 6.16-15.16 | 6.50-12.66 | MTU 1061 | APMS 6A x MTU 1061 |
| Panicle length (cm) | 24.86 | 27.69 | 26.82 | 20.08-29.75 | 24.10-31.28 | HR L4 | APMS 8A x MTU 2337-216-1-1 |
| Number of grains panicle$^{-1}$ | 189.61 | 320.67 | 249.7 | 107.50-293.00 | 180.35-420.20 | APMS 8A | APMS 8A x MTU 2244-128-18 |
| Spikelet fertility percentage | 81.09 | 75.94 | 87.44 | 66.63-96.21 | 44.26-92.30 | NLR 3445 | APMS 8A x MTU 2337-216-1-1 |
| 1000-Seed weight (g) | 19.5 | 19.26 | 22.38 | 13.95-22.78 | 15.30-23.17 | APMS 8A | APMS 6A x BPT 2659 |
| L/B Ratio | 2.64 | 2.65 | 2.81 | 2.12-3.00 | 2.34-3.27 | APMS 6A | APMS 8A x RP6112-MS-128-5-2-3-1-4-5 |
| Hulling (%) | 76.12 | 76.64 | 77.69 | 70.01-79.46 | 71.49-81.21 | APMS 8A | APMS 8A x MTU 2247-55-2 |
| Milling (%) | 64.24 | 66.76 | 66.17 | 46.01-70.71 | 61.29-70.88 | MTU 2284-103-1-7 | APMS 6A x BPT 2659 |
| HRR (%) | 54.61 | 62.68 | 60.52 | 36.69-66.18 | 51.40-67.62 | MTU 2244-128-18 | APMS 8A x BPT 2782 |

**Table 3. Relative heterosis, heterobeltiosis and standard heterosis for grain yield, yield components and quality characters in rice**

| Character | Relative heterosis | | Heterobeltiosis | | Standard heterosis over | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | MTU 1153 | | Arize 6444 Gold | |
| | Range | No. of desirable heterotic hybrids | Range | No. of desirable heterotic hybrids | Range | No. of desirable heterotic hybrids | Range | No. of desirable heterotic hybrids |
| Grain yield plant$^{-1}$ | -44.33** to 136.57** | 25 | -56.32** to 104.26** | 19 | -45.45** to 116.51** | 22 | -58.78** to 63.61** | 11 |
| Days to 50% flowering | -17.02** to 8.03** | 29 | -21.24** to 1.48 | 40 | -10.88** to 16.06** | 10 | -18.87** to 5.66** | 31 |
| Plant height | -18.03** to 8.95 | 2 | -25.29** to 3.02 | 10 | -18.05** to 0.36 | 21 | -9.43 to 10.91 | -- |
| Ear bearing tillers plant$^{-1}$ | -47.79** to 35.20** | 2 | -54.11** to 31.44** | 1 | -24.99 to 46.16** | 8 | -34.57** to 27.48* | 4 |
| Panicle length | -10.14* to 25.54** | 24 | -12.39* to 19.10** | 10 | -5.23 to 23.02** | 14 | -14.58** to 10.88 | -- |
| Number of grains panicle$^{-1}$ | -1.18 to 96.98** | 49 | -21.02** to 79.09** | 40 | -20.20** to 85.93** | 44 | -34.03** to 53.69** | 31 |
| Spikelet fertility percentage | -43.81** to 20.19** | 10 | -44.56** to 8.61* | 12 | -51.34** to 1.48 | -- | -43.87** to 9.97* | 5 |
| 1000-Seed weight | -32.11** to 10.44 | -- | -40.06** to 6.63 | -- | -31.85** to 3.21 | -- | -31.39** to 3.90 | -- |
| L/B Ratio | -17.38* to 19.56** | 2 | -18.09* to 19.34* | 1 | -11.89 to 23.40** | 1 | -21.38** to 10.10 | -- |
| Hulling (%) | -8.53* to 8.66** | 1 | -9.93* to 2.20 | -- | -7.13 to 5.49 | -- | -8.81* to 3.59 | -- |
| Milling (%) | -9.11* to 20.88** | 4 | -10.43* to 6.69 | -- | -6.21 to 8.46 | -- | -8.50 to 5.82 | -- |
| HRR (%) | -15.47** to 32.65** | 19 | -16.73** to 11.54* | 1 | -16.46** to 9.90 | -- | -13.61* to 13.65* | 6 |

*,**Significant at 5 and 1 per cent levels, respectively

the standard checks. For grain yield plant$^{-1}$, nine hybrids recorded significant and positive heterosis over mid-parent, better parent and standard checks. Of these APMS 8A x MTU 2247-55-2 recorded more than 50 per cent significant and desirable heterosis over mid-parent, better parent and the standard checks. The results are in broad conformity with the reports of Borah *et al.* (2017).

For plant height, only one hybrid APMS 8A x MTU 2049-5-2-1 recorded more than 18 per cent significant and desirable heterosis over mid-parent, better parent and the standard varietal check. Similarly lack of hybrids with significant and negative heterosis over standard hybrid check for plant height were reported earlier by Dar *et al.* (2015). Further, only one hybrid APMS 6A x BPT 5204 recorded more than 30 per cent significant and desirable heterosis over mid-parent, better parent and the standard varietal check for ear bearing tillers plant$^{-1}$, while two hybrids, APMS 6A x JMP 16 and APMS 6A x MTU 2331-216-1-1 recorded more than 15 per cent significant and desirable heterosis over mid-parent, better parent and the standard varietal check for panicle length. These findings are in broad agreement with the results reported by Haque *et al.* (2014). However, only one hybrid APMS 8A x MTU 2337-216-1-1 recorded more than eight per cent significant and desirable heterosis over mid-parent, better parent and the standard hybrid check for spikelet fertility percentage. Results of similar trend were reported earlier by Borah *et al.* (2017).

In the present study, none of the hybrids had exhibited significant and positive heterosis over mid-parent, better parent and standard checks for 1000-Seed weight. Further, only one hybrid APMS 8A x RP 6112-MS-138-5-2-3-1-4-5 had recorded more than 15 per cent significant and desirable heterosis over mid-parent, better parent and the standard varietal check for L/B ratio. For hulling percentage, only one hybrid exhibited significant and positive heterosis over mid-parent. However, for milling percentage, four hybrids exhibited significant and positive heterosis over mid-parent. A perusal of these results for hulling and milling percentage studied in the present investigation revealed that none of the hybrids studied had significant and desirable heterobeltiosis and standard heterosis. Viraktamath (1987) also observed that there was no significant superiority of rice hybrids over better parent and standard parent regarding hulling and milling recovery. In contrast, the feasibility of developing heterotic rice hybrids for yield and head rice recovery were reported by Kumar (2004). In the present study also, significant and desirable relative heterosis, heterobeltiosis and standard heterosis over the hybrid check were recorded for APMS 6A x NLR 5815-10-1-1-1 for head rice recovery. The hybrid had also recorded significant and desirable relative heterosis (58.89%), heterobeltiosis (25.19%) and standard heterosis over the varietal check, MTU 1153 (21.38%) for grain yield plant$^{-1}$ and hence, is identified as a potential high yielding hybrid with good head rice recovery and scope for commercial exploitation.

## CONCLUSION

Thus the findings from the present investigation on heterosis revealed that the hybrids, APMS 8A x MTU 2247-55-2, APMS 8A x MTU 2331-216-1-1 and APMS 8A x MTU 2337-216-1-1 had recorded significant and positive standard heterosis more than 50 per cent over both the checks studied for grain yield plant$^{-1}$ and hence, are identified as potential hybrids for commercial exploitation. The present study also revealed that the hybrid APMS 6A x NLR 5815-10-1-1-1 has potential high yielding with good head rice recovery and scope for commercial exploitation.

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