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# HETEROSIS FOR YIELD, YIELD COMPONENTS AND QUALITY TRAITS IN RICE HYBRIDS (*ORYZA SATIVA* L.)

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## Abstract

Twenty hybrids developed from crossing four CMS lines and five testers were evaluated for the extent of heterosis over standard parent for yield, yield components and quality traits in rice during *kharif*, 2013. Four crosses out of twenty crosses exhibited highly significant standard heterosis for grain yield per plant. Heterosis for grain yield was manifested due to the significant and positive heterosis for its components *viz.*, Ear bearing tillers, number of fertile grains per panicle, test weight, Harvest index, Hulling%, Milling%, Kernel length, L/B ratio, kernel length after cooking and Elongation ratio. The top four heterotic combinations identified for grain yield per plant were APMS 9A × RM 83-19-3, CMS 12A × RM 83-19-3, APMS 10A × RM 89-12-3, APMS 10A × RM 80-55-2 which exhibited more than 20% standard heterosis.

***Key words :*** CMS lines, heterosis, quality traits, rice, yield components.

## Introduction

Rice is a staple food crop in India providing 43% of calories requirement for more than 70% of Indian population. In India, rice is cultivated in an area of 43.77 m. ha. with a production of 95.32 mt. Still there is need for the increase in productivity to meet the needs of the growing population. Hybrid rice giving a yield advantage of about 20-30% over high yielding varieties is a better choice for increasing productivity and quality also play a major role for fetching higher remunerative price. A higher yield over high yielding check varieties and wider adaptability has been instrumental in rapid spread of hybrid rice in India. Heterosis refers to the increase (or) decrease in $F_1$ value over the mean parental value. From the view point of plant breeding, increased yield of $F_1$ over the better (or) best commercial variety is more relevant (Virmani *et al*., 1981). Commercial exploitation of heterosis has been made possible by the use of cytoplasmic genetic male sterility and fertility restoration system. Identification of locally adapted restorers, which show consistently high degree of restoration of CMS lines would be great value in commercial hybrid programme. Hence, the present study was carried out to study the performance of the experimental hybrid crosses in order to estimate the magnitude of standard heterosis. Hence, the crosses with high heterotic potential could be exploited for further evaluation and commercial cultivation.

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## Materials and Methods

Four CMS lines *viz*., APMS 6A, APMS 9A, CMS 12A and APMS 10A were crossed with five testers RM 89-12-3, RM 83-19-3, RM 80-55-2, RM 80-55-3 and RM 1-21-1 in a line × Tester fashion to synthesize 20 hybrids (table 1). The hybrids along with parents and checks (varietal check RGL 2537 and hybrid check MTUHR 2089) were grown in a randomized block design (RBD) with three replications at Regional Agricultural Research Station, Anakapalle during *kharif* 2013. Recommended package of practice were followed to raise the crop. Each plot consisted of three rows of 5 m length, single seedling was planted per hill with a spacing of 20 cm × 15 cm. Observations were recorded on ten randomly selected plants for plant height, days to 50% flowering, ear bearing tillers plant$^{-1}$, panicle length, number of fertile grains panicle$^{-1}$, number of unfilled grains panicle$^{-1}$, test weight, harvest index and grain yield plant$^{-1}$. Quality characters

**Table 1 :** Experimental material.

| S. no. | Hybrid | Line | Tester |
|---|---|---|---|
| 1. | TCN12591 | APMS 6A (A1) | RM 89-12-3(R1) |
| 2. | TCN12575 | APMS 6A (A1) | RM 83-19-3(R2) |
| 3. | TCN12580 | APMS 6A (A1) | RM 80-55-2(R3) |
| 4. | TCN12581 | APMS 6A (A1) | RM 80-55-3(R4) |
| 5. | TCN12553 | APMS 6A (A1) | RM 1-21-1(R5) |
| 6. | TCN12667 | APMS 9A (A2) | RM 89-12-3(R1) |
| 7. | TCN12662 | APMS 9A(A2) | RM 83-19-3(R2) |
| 8. | TCN12649 | APMS 9A(A2) | RM 80-55-2(R3) |
| 9. | TCN 12650 | APMS 9A(A2) | RM 80-55-3(R4) |
| 10. | TCN 12635 | APMS 9A(A2) | RM 1-21-1(R5) |
| 11. | TCN 12536 | CMS 12 A(A3) | RM 89-12-3(R1) |
| 12. | TCN 12528 | CMS 12 A(A3) | RM 83-19-3(R2) |
| 13. | TCN 12761 | CMS 12 A(A3) | RM 80-55-2(R3) |
| 14. | TCN 12762 | CMS 12 A(A3) | RM 80-55-3(R4) |
| 15. | TCN 12746 | CMS 12 A(A3) | RM 1-21-1(R5) |
| 16. | TCN 12692 | APMS 10A(A4) | RM 89-12-3(R1) |
| 17. | TCN 12693 | APMS 10 A(A4) | RM 83-19-3(R2) |
| 18. | TCN 12680 | APMS 10 A(A4) | RM 80-55-2(R3) |
| 19. | TCN 12681 | APMS 10 A(A4) | RM 80-55-3(R4) |
| 20. | TCN 12673 | APMS 10 A(A4) | RM 1-21-1(R5) |
| | Varietal Check | RGL 2537 | CRT145*CRT1014 |
| | Hybrid Check | MTUHR 2089 | APMS 9A / MTU II-156-13-11-2 |

*viz.*, Hulling per cent, Milling per cent, Head rice recovery, L/B ratio, Water uptake, Kernel length after cooking, elongation ratio, Alkali spreading value and Amylose content were recorded for all hybrids. Estimation of heterosis over standard parent was computed as suggested by Liang *et al*. (1971).

## Results and Discussion

The analysis of variance of Line × Tester revealed that the variance due to genotypes were highly significant for yield, yield components and quality character except for hulling per cent and elongation ratio indicating considerable variation in the material under study (tables 2a & 2b).

The estimates of standard heterosis for yield, yield components and quality character were given in tables 3a and 3b, respectively. In the present investigation, considerable heterosis existed both in positive and

**Table 2a :** Line × Tester ANOVA for yield and yield components in rice hybrids.

| Source of variation | d.f | Plant height (cm) | Days to 50% flowering | Ear bearing tillers | Panicle length (cm) | Fertile grains/panicle | Unfilled grains /panicle | Test weight (g) | Harvest index | Grain yield/ plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Replicates | 2 | 35.389 | 13.117* | 1.358 | 2.389* | 44.927 | 0.301 | 0.323 | 14.307* | 82.853 |
| Crosses | 19 | 48.336 * | 63.996** | 29.048** | 5.882** | 3522.07** | 72.368** | 9.322** | 27.253** | 1269.468** |
| Line Effect | 3 | 72.483 | 37.839 | 116.299** | 4.391 | 264.639 | 66.616 | 18.294 | 31.540 | 2813.100* |
| Tester Effect | 4 | 38.694 | 50.208 | 19.077 | 5.474 | 2224.815 | 33.169 | 9.489 | 23.945 | 1528.886 |
| Line * Tester Eff. | 12 | 45.514 * | 75.131** | 10.559* | 6.390** | 4768.861** | 86.873** | 7.023** | 27.284** | 797.087** |
| Error | 38 | 20.659 | 3.696 | 4.578 | 0.577 | 202.066 | 1.552 | 0.256 | 1.891 | 40.164 |
| Total | 59 | 30.071 | 23.434 | 12.349 | 2.347 | 1265.896 | 24.315 | 3.178 | 10.479 | 437.489 |

**Table 2b :** Line × Tester ANOVA for quality traits in rice hybrids.

| Source of variation | d.f. | Hulling % | Milling % | Head rice recovery | Kernal length (mm) | Kernal breadth (mm) | L/B ratio | Water uptake | Amylose content | Alkali spreading value | Kernal length after cooking | Elongation Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replicates | 2 | 8.253** | 23.546* | 0.424 | 0.047* | 0.001 | 0.034* | 646.667* | 0.324 | 1.017 | 0.060* | 31088.860 |
| Crosses | 19 | 10.903 | 22.955** | 18.067** | 0.271** | 0.087 ** | 0.398** | 3384.737** | 1.761** | 3.701 ** | 0.226** | 31094.820 |
| Line Effect | 3 | 11.026 | 45.180 | 3.993 | 0.376 | 0.133 | 0.489 | 5767.778 | 1.105 | 4.594 | 0.287 | 31068.480 |
| Tester Effect | 4 | 8.021 | 15.774 | 5.477 | 0.285 | 0.077 | 0.464 | 3166.042 | 4.919** | 3.642 | 0.182 | 31133.670 |
| Line * Tester Eff. | 12 | 11.834** | 19.792** | 25.783** | 0.240** | 0.079 ** | 0.354** | 2861.875** | 0.873* | 3.497 ** | 0.225** | 31088.460 |
| Error | 38 | 2.916 | 5.899 | 3.242 | 0.008 | 0.002 | 0.008 | 91.842 | 0.387 | 0.596 | 0.009 | 31084.190 |
| Total | 59 | 5.669 | 11.990 | 7.921 | 0.094 | 0.029 | 0.135 | 1171.073 | 0.827 | 1.610 | 0.080 | 31087.770 |

*significant at 5% level, **significant at 1% level.

**Table 3a :** Standard heterosis for yield, yield components in rice hybrids.

| Hybrids | Plant height (cm) | Days to 50% flowering | Ear bearing tillers | Panicle length (cm) | Fertile grains/ panicle | Unfilled grains /panicle | Test weight (g) | Harvest index | Grain yield /plant (g) |
|---|---|---|---|---|---|---|---|---|---|
| A1R1 | -4.01 | -9.90** | 34.60** | -25.35** | -33.56** | 67.98** | 6.91** | -5.87* | -43.37** |
| A1R2 | -1.69 | -8.95** | 76.78** | -21.99** | -39.54** | 109.45** | 7.87** | 10.27** | -9.64 |
| A1R3 | 3.94 | -3.51* | 37.44** | -19.13** | -9.71* | -38.06** | -11.80** | 3.93 | 32.01* |
| A1R4 | -3.10 | -11.82** | 50.24** | -17.70** | -32.57** | 30.18** | 14.36** | -3.56 | -34.77* |
| A1R5 | -9.98** | -8.63** | 41.23** | -11.43** | -22.73** | 9.71 | 0.99 | 0.92 | -1.72 |
| A2R1 | -1.97 | -10.86** | 15.64 | -22.35** | -28.71** | 25.46** | 11.30** | 0.65 | -11.36 |
| A2R2 | 2.81 | -2.24 | 9.95 | -13.32** | -22.73** | 36.48*8 | -0.53 | -2.37 | 59.90** |
| A2R3 | -2.74 | -6.07** | -18.96 | -18.70** | -14.83** | 43.83** | 7.67** | -6.42* | 47.85** |
| A2R4 | -6.18* | -3.51* | 7.58 | -16.34** | -25.12** | 2.36 | 5.57* | 11.67** | -25.6 |
| A2R5 | -6.32** | -4.15** | 9.00 | -13.38** | -27.13** | -1.84 | 5.38* | -10.24** | -38.21** |
| A3R1 | -5.34* | -11.18** | 35.55** | -11.43** | -40.02** | 30.71** | 20.66** | 3.95 | 38.90** |
| A3R2 | -7.31** | -6.39** | 12.80 | -9.54** | -7.81 | -12.34 | 16.46** | -4.29 | 75.39** |
| A3R3 | -8.15** | -1.92 | -13.74 | -20.15** | -5.34 | -37.53** | 3.67 | -7.81** | 75.22** |
| A3R4 | -2.11 | -9.90** | 12.80 | -27.80** | -38.76** | 24.93** | 16.27** | 3.80 | 32.70** |
| A3R5 | -8.92** | -3.51* | -6.16 | -17.52** | -31.69** | 11.81 | 32.49** | -5.02 | 51.64* |
| A4R1 | -10.61** | 2.56 | 22.27 | -5.88* | 10.47* | -70.08** | 27.15** | 13.95** | 117.04** |
| A4R2 | -5.62* | -14.06** | 24.64 | -14.19** | -37.69** | 10.24 | 0.23 | -0.30 | -31.33** |
| A4R3 | -4.57 | -0.96 | 26.54* | -15.93** | -41.23** | 30.18** | 14.55** | 6.08* | 151.46* |
| A4R4 | -13.14** | -2.24 | 21.33 | -19.82** | -33.24** | 0.79 | 3.67 | 5.23 | 39.41** |
| A4R5 | -2.95 | -9.90** | 28.91* | -14.65** | -28.16** | 29.66** | 9.39** | 0.74 | 22.55** |

*significant at 5% level, **significant at 1% level.

**Table 3b :** Standard heterosis for quality traits in rice hybrids.

| Hybrids | Hulling % | Milling % | Head rice recovery | Kernel length (mm) | Kernel breadth (mm) | L/B ratio | Water uptake | Amylose content | Alkali preading value | Kernel length after cooking | Elongation ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A1R1 | -3.42 | -7.97* | -3.58 | 10.96** | 9.10** | 1.80 | 25.86** | -4.85* | -6.25 | 13.15 | 5.86** |
| A1R2 | 4.71* | 8.55** | -1.33 | -3.79* | 6.70** | -9.76** | -15.52** | -8.85** | -6.25 | 0.59 | 6.61** |
| A1R3 | 5.33** | 2.48 | -5.43* | -2.83 | 8.23** | -10.02** | -12.93** | -6.85** | 12.50 | 1.91 | 9.14** |
| A1R4 | 2.20 | 1.35 | -10.85** | 1.96 | 6.46** | -4.17 | 4.31** | -2.84 | 6.25 | 5.87 | 8.56** |
| A1R5 | 1.77 | 2.13 | -3.68 | -3.10* | 13.02** | -14.25** | -13.79** | 1.80 | -31.25* | 2.74** | 15.43** |
| A2R1 | 0.90 | -0.40 | -5.62* | -1.39 | -7.81** | 7.08* | -10.34* | -2.16 | -18.75 | 4.30** | 16.05** |
| A2R2 | -0.46 | -2.07 | -10.45** | -3.19* | 1.11 | -4.30 | -16.38** | -6.01** | -18.75 | 2.05* | 11.81** |
| A2R3 | 0.36 | -1.68 | -9.24** | -4.03** | 7.40** | -10.63** | -16.38** | -1.56 | -18.75 | 1.47** | 12.95** |
| A2R4 | -0.78 | -1.15 | -3.11 | -3.81* | 8.33** | -11.16** | -15.52** | -2.48 | -43.75** | 0.64 | 6.47** |
| A2R5 | 2.88 | -1.24 | -4.78 | 3.56* | -3.72 | 7.65** | 2.59 | 2.50 | 12.50 | 5.82** | -1.08 |
| A3R1 | 1.53 | 0.74 | -1.46 | 2.74 | -4.13* | 7.28** | 4.31 | -3.21 | -31.25* | 4.69** | -2.51 |
| A3R2 | 1.97 | 1.50 | -1.63 | 1.83 | 3.19 | -1.19 | 1.72 | -1.22 | -18.75 | 8.26** | 24.58** |
| A3R3 | 2.53 | -3.23 | -9.32** | 3.43* | 0.59 | 2.91 | 5.17 | -3.21 | -18.75 | 5.33** | -2.08 |
| A3R4 | 1.29 | 0.95 | -6.00* | 4.89** | -12.19** | 19.68** | 9.48 | -6.37** | -50.00** | 7.59** | 3.74* |
| A3R5 | -5.39** | -4.58 | -4.72 | 10.36** | 4.41* | 5.74* | 45.69** | 1.96 | -18.75 | 12.71** | 13.97** |
| A4R1 | 3.88* | 3.82 | -8.03** | 3.02* | 19.58** | -13.77** | 1.72 | -4.97* | -12.50 | 4.65** | -3.85* |
| A4R2 | 2.94 | 3.88 | -14.82** | -5.23** | 7.22** | -11.56** | -21.55** | -5.42* | 12.50 | 0.93 | 15.72** |
| A4R3 | 3.00 | 9.41 | 3.98 | 4.79** | 14.17** | -8.13** | 9.48 | -1.22 | -25.00* | 6.60** | -1.38 |
| A4R4 | 2.11 | 3.35** | -4.11 | 10.76** | -15.52** | 31.32** | 25.86** | -5.32* | -50.00** | 13.35** | 7.97** |
| A4R5 | 1.53 | 0.59 | -3.52 | -1.88 | 10.35** | -10.96** | -10.34* | -1.08 | -56.25** | 3.91** | 16.22** |

*significant at 5% level, **significant at 1% level.

**Table 4a :** The best heterotic hybrids identified for yield and yield components based on overall performance.

| Character | Hybrids | *Per se* performance | SCA effect | Standard heterosis |
|---|---|---|---|---|
| Plant height | $A_4R_4$ | 82.40 | -4.30 ** | -13.14** |
| | $A_4R_1$ | 84.80 | -2.51 | -10.61** |
| | $A_1R_5$ | 85.40 | -4.62** | -9.98** |
| Days to 50% flowering | $A_4R_2$ | 89.66 | -7.92** | -14.06** |
| | $A_3R_1$ | 92.66 | -3.77** | -11.82** |
| | $A_1R_4$ | 92.00 | -2.87* | -11.18** |
| Ear bearing tillers plant$^{-1}$ | $A_1R_2$ | 24.86 | 2.69* | 76.78** |
| | $A_1R_4$ | 21.13 | 0.09 | 50.24** |
| | $A_1R_5$ | 19.86 | -0.51 | 41.23** |
| No. of fertile grains panicle$^{-1}$ | $A_4R_1$ | 274.80 | 84.31** | 10.47** |
| No. of unfilled grains per panicle | $A_4R_1$ | 3.80 | -8.71** | -70.08** |
| | $A_1R_3$ | 7.86 | -7.41** | -38.06** |
| | $A_3R_3$ | 7.93 | -3.23** | -37.53** |
| Test weight | $A_3R_5$ | 23.13 | 2.12** | 32.49** |
| | $A_3R_1$ | 21.06 | -0.72* | 20.66** |
| | $A_3R_2$ | 20.33 | 0.38 | 16.46** |
| Harvest index | $A_4R_1$ | 51.66 | 2.90** | 13.95** |
| | $A_2R_4$ | 50.63 | 4.30** | 11.67** |
| | $A_1R_2$ | 50.00 | 4.11** | 10.27** |
| Grain yield plant$^{-1}$ | $A_4R_3$ | 97.40 | 16.42** | 151.46** |
| | $A_4R_1$ | 84.06 | 22.97** | 117.04** |
| | $A_2R_2$ | 61.93 | 22.16** | 59.90** |

**significant at 1% level, *significant at 5% level.

negative directions for all the traits. The hybrid A4R2 showed significant negative, but desirable heterosis for days to 50% flowering as also reported by Yolanda and Vijendradas (1996). High number of ear bearing tillers plant$^{-1}$ was observed in $A_1R_2$, however presence of high heterosis for this trait could not result in higher yield, especially in hybrids where spikelet sterility was greatly affected due to varying levels of fertility restoration. Therefore due consideration is required for both panicles plant$^{-1}$ and spikelet fertility simultaneously (Virmani *et al*., 1981).

Fourteen hybrids exhibited significant positive heterosis for test weight (Yolanda and Vijendradas, 1996). Most of the hybrids exhibited positive and significant heterosis for kernel length after cooking and elongation ratio.

The best heterotic hybrids selected for grain yield, yield components and quality traits presented in the tables 4a & 4b. Based on *per se* performance, significant *sca* effects and heterosis for yield in the crosses APMS 6A × RM 83-19-3, CMS 12A × RM 83-19-3, APMS 10A × RM 89-12-3 and APMS 10A × RM 80-55-2 recorded high *per se* performance, significant *sca* effects and standard heterosis over the best check MTUHR 2089 for grain yield plant$^{-1}$ were identified as promising heterotic hybrids.

A perusal of the results on hybrid vigour over standard check for the different traits studied revealed maximum expression of heterosis for grain yield per plant followed by ear bearing tillers. Hybrid vigour to an extent of 151.46 per cent over standard check in the hybrid $A_4R_3$ followed by extent of 117.04 per cent in the hybrid $A_4R_1$. Similar results were reported by Singh *et al*. (2007), Tiwari *et al*. (2011) and Venkata Subbaiah *et al*. (2013).

All the high yielding hybrids also manifested significant and useful heterosis over standard check for traits like plant height, test weight, harvest index, kernel length after cooking and elongation ratio (table 4). The present study confirmed that high heterotic combinations were realized in the cross combinations APMS 6A × RM 83-19-3, CMS 12A × RM 83-19-3, APMS 10A × RM 89-12-3 and APMS 10A × RM 80-55-2. Parental *gca*

**Table 4b :** The best heterotic hybrids identified for quality traits based on overall performance.

| Character | Hybrids | *Per se* performance | SCA effect | Standard heterosis |
|---|---|---|---|---|
| Hulling % | $A_1R_3$ | 79.42 | 1.40 | 5.33** |
| | $A_1R_2$ | 78.95 | 1.31 | 4.71* |
| Milling % | $A_1R_2$ | 74.27 | 3.49* | 8.55** |
| Kernel length | $A_1R_1$ | 6.49 | 0.46** | 10.96** |
| | $A_4R_4$ | 6.47 | 0.38** | 10.76** |
| | $A_3R_5$ | 6.45 | 0.29 ** | 10.36** |
| Kernel breadth | $A_4R_4$ | 1.62 | -0.30** | -15.52** |
| | $A_3R_4$ | 1.68 | -0.07* | -12.19** |
| | $A_2R_1$ | 1.77 | -0.18** | -7.81** |
| L/b ratio | $A_4R_4$ | 3.99 | 0.72** | 31.32** |
| | $A_3R_4$ | 3.64 | 0.08 | 19.68** |
| | $A_2R_5$ | 3.27 | 0.35** | 7.65** |
| Water uptake | $A_4R_2$ | 151.66 | -18.33** | -21.55** |
| | $A_2R_3$ | 161.66 | -2.58 | -16.38** |
| | $A_2R_4$ | 163.33 | -19.67** | -15.52** |
| Amylose content | $A_1R_2$ | 22.75 | -0.56 | -8.85** |
| | $A_1R_3$ | 23.25 | -0.60 | -6.85** |
| | $A_3R_4$ | 23.37 | -0.69 | -6.37** |
| Alkali spreading value | $A_4R_5$ | 2.33 | -1.37** | -56.25** |
| | $A_4R_4$ | 2.66 | -0.45 | -50.00** |
| | $A_2R_4$ | 3.00 | -0.58 | -43.75** |
| Kernel length after cooking | $A_4R_4$ | 7.72 | 0.40** | 13.35** |
| | $A_3R_5$ | 7.68 | 0.27** | 12.71** |
| | $A_3R_2$ | 7.38 | 0.20** | 8.26** |
| Elongation ratio | $A_3R_2$ | 1.44 | 0.12** | 24.58** |
| | $A_4R_5$ | 1.34 | 0.07** | 16.22** |
| | $A_2R_1$ | 1.34 | 0.13** | 16.05** |

**significant at 1% level, *significant at 5% level.

status for grain yield, yield components and quality traits indicating the importance of both additive and non-additive gene effects in realization of heterosis for grain yield. The heterosis potential realized in these four hybrids could be further evaluated across the locations and environments for testing their feasibility of commercialization in due course.

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