The Bioscan 8(4): 1417-1420, 2013 (Supplement on Genetics & Plant Breeding)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

# COMBINING ABILITY ANALYSIS FOR YIELD AND RELATED TRAITS IN RICE (*ORYZA SATIVA* L.)

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**KEYWORDS**
Rice
CMS lines
Combining ability

**Received on :**
12.04.2013

**Accepted on :**
28.08.2013

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**ABSTRACT**
Combining ability study on grain yield and component traits from a line x tester analysis of 20 lines, 2 CMS & 1 TGMS testers and 60 crosses, indicated non additive gene effects were predominant for all the traits viz. Days to 50% flowering, plant height, panicle length, panicle number per plant, tiller per plant, panicle weight, 1000 grain weight, spikelet number per panicle, grain number per panicle, % spikelet fertility and harvest index. Amongst parents PUSA 6A ($T_3$) in testers and UPR 3456-4-2-2 ($L_{14}$) in lines are good combiners for grain yield and other yield related component traits based on their GCA effects. Top hybrids expressing highest SCA effects for grain yield were obtained with general combiners involved into different parental combinations of UPR 3403-4-1-1 x UPRI 95-167 ($L_1$ x $T_1$), UPRI 2008-62 x UPRI 95-17A ($L_{20}$ x $T_2$) and UPR 3428-4-1-1 x UPRI 95-17A($L_{11}$ x $T_2$). Two lines viz. UPR 3456-4-2-2 ($L_{14}$) and UPR 3434-1-1-2 ($L_{12}$) were identified as good general combiners based on their mean performance and GCA effects for yield and its various traits. These crosses may be exploited for commercial cultivation besides the possibility of isolating transgressive segregants from their segregating generations.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the most premier crop in the term of its contribution to the value of food production in the developing countries. The basic objective of breeding is to increase the yield per unit area to meet the demand of increasing populations. The breeding methodology involves three approaches. (a) Three line method or CMS system which has been found to be most effective genetic tool for developing hybrids, (b) Two line method or PGMS and TGMS system and (c) One line system or apomictic system which enable the farmers to use their own seeds for successive crops without experiencing genetic segregation (Khan *et al*., 2012). Hybrid rice includes three line and two line hybrid rice that is developed via cytoplasmic male sterility and photo/thermo sensitive male sterility respectively given by Yuan and Peng (2005). The first approach is called three-line system involving CMS line, a maintainer line and restorer line. The second approach is called two-line system involving environmentally sensitive male sterility (Sheeba *et al*., 2009). In 1974, Chinese scientist successfully transferred the male sterility gene from wild rice to create the CMS line and hybrid combination (FAO org., 2004). The present study is based on the estimation of combining ability of CMS, TGMS testers, 20 lines and 60 crosses in rice were planted for evaluation in a Randomized Block Design (RBD) with two replications, combining ability helps in the evaluation of inbreds in term of their genetic value, in the selection of suitable parents for hybridization which may be utilized for the commercial cultivation (Lyngdoh *et al*., 2013).

## MATERIALS AND METHODS

The experiment was conducted in randomized block design with 60 $F_1$ crosses generated by crossing Two CMS testers (UPRI 95-17A and PUSA 6A), one TGMS tester (UPRI 95-167) with twenty lines in line x tester mating design in two replications at Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during *kharif* 2010. Observations were recorded on five randomly selected plants for twelve characters viz., Days to 50% flowering, plant height (cm),

| S.No. | Code | Genotypes |
|---|---|---|
| 1 | $T_1$ | UPRI 95-167 |
| 2 | $T_2$ | UPRI 95-17A |
| 3 | $T_3$ | Pusa 6A |
| 4 | $L_1$ | UPR 3403-4-1-1 |
| 5 | $L_2$ | UPR 3403-11-1-2 |
| 6 | $L_3$ | UPR 3403-3-1-2 |
| 7 | $L_4$ | UPR 3406-7-2-1 |
| 8 | $L_5$ | UPR 3406-7-2-2 |
| 9 | $L_6$ | UPR 3406-8-1-1 |
| 10 | $L_7$ | UPR 3411-1-1-1 |
| 11 | $L_8$ | UPR 3413-8-2-1 |
| 12 | $L_9$ | UPR 3413-8-3-1 |
| 13 | $L_{10}$ | UPR 3425-11-1-1 |
| 14 | $L_{11}$ | UPR 3428-4-1-1 |
| 15 | $L_{12}$ | UPR 3434-1-1-2 |
| 16 | $L_{13}$ | UPR 3443-1-3-1 |
| 17 | $L_{14}$ | UPR 3456-4-2-2 |
| 18 | $L_{15}$ | UPR 3480-1-1-1 |
| 19 | $L_{16}$ | UPR 3480-9-1-1 |
| 20 | $L_{17}$ | UPR 3430-9-2-1 |
| 21 | $L_{18}$ | UPR 3469-13-1-1 |
| 22 | $L_{19}$ | UPRI 2008-39 |
| 23 | $L_{20}$ | UPRI 2008-62 |

**Table 1: Analysis of variance for combining ability**

| Source of variation | d.f. | Days to 50% flowering | Plant height | Panicle Length | Panicle number per plant | Tiller per plant | Panicle weight | 1000 grain weight | Spikelet number per panicle | Grain number per panicle | % spikelet fertility | Harvest Index | Grain yield per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lines | 19 | 60.18** | 280.38** | 10.25** | 11.06** | 11.73** | 1.26** | 38.42** | 1818.95** | 1298.67** | 75.76** | 42.83** | 21.93** |
| Tester | 2 | 0.166ns | 87.76** | 13.82** | 2.67ns | 1.50ns | 1.87** | 34.93** | 3375.5** | 524.66** | 205.07** | 112.68** | 23.88** |
| Line × Tester | 38 | 55.40** | 173.13** | 3.83** | 15.18** | 15.42** | 1.09** | 10.09** | 2227.38** | 2832.53** | 808.28** | 234.99** | 123.97** |
| Error | 82 | 2.84 | 2.37 | 1.32 | 0.86 | 0.93 | 0.031 | 0.60 | 5.46 | 12.09 | 5.12 | 11.19 | 0.89 |
| Components of variance | | | | | | | | | | | | | |
| $\sigma^2$ gca | | -3.53 | -0.63 | 0.15 | -1.80 | -1.80 | -0.05 | -2.35 | -40.24 | -132.02 | -14.91 | -3.76 | -0.42 |
| $\sigma^2$ sca | | 29.78 | 104.52 | 2.65 | 8.32 | 8.42 | 0.63 | 12.34 | 1122.11 | 1185.39 | 263.19 | 72.07 | 41.52 |
| $\sigma^2$ gca/$\sigma^2$ sca | | 0.12 | -0.006 | 0.056 | -0.25 | -0.22 | -0.08 | -0.19 | -0.04 | -0.11 | -0.06 | 0.52 | -0.01 |
| $\sigma^2$A | | -0.68 | -5.64 | -0.12 | -1.06 | -1.16 | 0.01 | -1.01 | -55.63 | 132.92 | 58.39 | 21.25 | 5.83 |
| $\sigma^2$D | | 29.78 | 104.52 | 2.65 | 8.32 | 8.42 | 0.63 | 12.34 | 1122.11 | 1185.39 | 263.19 | 72.07 | 41.52 |

**Table 2: Estimates of general combining ability effect of parents**

| Parents (Lines) | Days to 50% flowering | Plant height | Panicle Length | Panicle number per plant | Tillers per plant | Panicle weight | 1000 grain weight | Spikelet number per panicle | Grain number per panicle | % spikelet fertility | Harvest Index | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 0.93 | 2.39** | 0.35 | -0.22 | -1.00** | 0.52** | -0.96** | 16.77** | 27.18** | 9.15** | 5.05** | 5.81** |
| $L_2$ | -0.40 | 4.23** | 1.46** | -0.88** | -1.00** | 0.65** | 0.15 | 32.44** | 30.84** | 4.81** | 4.56** | 3.58** |
| $L_3$ | 0.10 | -4.65** | -0.15 | -0.88** | -1.00** | -0.59** | 0.80** | -37.39** | -19.49** | 10.38** | 1.23ns | -3.75** |
| $L_4$ | -2.07** | -2.90** | 0.78* | 0.12 | 0.00 | 0.30** | -0.38* | -8.89** | 3.68** | 11.09** | -3.26* | -1.50** |
| $L_5$ | -2.40** | -2.94** | -0.77* | -1.38** | -2.17** | -0.36** | -2.41** | 14.11** | -0.99ns | -11.68** | -5.16** | -1.71** |
| $L_6$ | -3.73** | 0.35 | -2.01** | 1.12** | 1.50** | -0.30** | -0.37* | -3.39** | -17.82** | -10.27** | -2.92* | -2.08** |
| $L_7$ | 0.77 | 4.60** | 1.51** | 0.95** | 0.50 | 0.11** | -1.91** | -25.56** | -6.16** | 13.12** | 7.77** | -0.09 |
| $L_8$ | 2.10** | 5.43** | -0.35 | -0.22 | 0.67* | 0.36** | 0.79** | 0.77 | 0.68ns | -5.10** | 0.94 | 1.67** |
| $L_9$ | -1.90** | 4.60** | 1.63** | -0.22 | -0.67* | -0.41** | -0.23 | -18.89** | -13.99** | -0.08ns | 0.41 | -0.42 |
| $L_{10}$ | 2.60** | 3.89** | 0.80** | -1.05** | -1.33** | -0.03 | 1.78** | 16.44** | 10.59** | -0.76ns | -0.55 | -4.79** |
| $L_{11}$ | 0.93 | 5.64** | 1.88** | 1.78** | 1.33** | 0.12** | 0.07 | 2.27** | 6.34** | 3.68** | 1.70 | -2.85** |
| $L_{12}$ | -5.90** | 2.39** | -0.58 | -1.55** | -1.33** | 0.51** | 0.66** | 22.94** | 18.51** | 1.24ns | 1.32ns | 1.43** |
| $L_{13}$ | -3.40** | -14.27** | -0.43 | -0.05ns | 0.83* | -0.05* | 0.29ns | -11.56** | -11.91** | -2.78** | 1.57ns | -1.37** |
| $L_{14}$ | 1.77** | -3.07** | -0.17 | -1.05** | 0.00ns | 0.45** | -0.91** | 17.11** | 29.18** | 11.07** | 6.55** | 4.04** |
| $L_{15}$ | 2.10** | -2.02** | -1.36** | -1.05** | -0.33 | -0.84** | 0.36* | 7.77** | -1.16ns | -2.92** | -10.47** | -6.75** |
| $L_{16}$ | -1.23* | 6.39** | 0.45 | 0.28 | 0.00 | 0.13** | 2.18** | -16.73** | -6.49** | 4.92** | 1.65 | -0.52 |
| $L_{17}$ | 0.27 | 0.39 | -0.40 | 1.28** | 1.17** | -0.34** | -0.77** | -23.23** | -23.99** | -8.66** | -4.92** | -2.53** |
| $L_{18}$ | 3.10** | -14.19** | -0.65* | 2.12** | 1.67** | -0.12** | 3.05** | 1.77** | -0.66ns | -3.60** | -4.91** | 2.72** |
| $L_{19}$ | 2.27** | 1.48** | -0.80** | 0.78* | 0.50 | -0.20** | -1.62** | -1.23 | -9.99** | -5.53** | 5.44** | 8.57** |
| $L_{20}$ | 4.10** | 2.27** | -1.21** | 0.12 | 0.67* | 0.09** | -0.57** | 14.44** | -14.16** | -18.09** | -6.02** | 0.55 |
| SE lines | 0.50 | 0.37 | 0.30 | 0.32 | 0.33 | 0.02 | 0.16 | 0.63 | 1.27 | 0.82 | 1.30 | 0.31 |
| $T_1$ | -1.49** | 1.38** | -0.28** | 0.29** | 0.12 | 0.01 | -0.68** | -2.68** | 1.07* | 2.28** | -0.86* | -0.95** |
| $T_2$ | 0.63** | -1.51** | 0.19 | -0.33** | -0.25* | -0.21** | 0.55** | -3.65** | -12.98** | -7.86** | -3.60** | -1.72** |
| $T_3$ | 0.86** | 0.14 | 0.10 | 0.04 | 0.12 | 0.20** | 0.14** | 6.32** | 11.92** | 5.59** | 4.45** | 2.67** |
| SE testers | 0.16 | 0.12 | 0.10 | 0.10 | 0.11 | 0.01 | 0.05 | 0.21 | 0.18 | 0.22 | 0.42 | 0.10 |

*, ** significant at 5 and 1 per cent probability level, respectively.

**Table 3: Best parents and specific crosses for various Characters**

| Character | Parent | | Specific cross | | gca of parent in specific cross |
|---|---|---|---|---|---|
| | Per se performance | General combiner | Per se performance | Specific cross | |
| Days to 50 per cent flowering | $L_{19}$ | $L_{12}$ | $L_2 \times T_2$ | $L_{16} \times T_2$ | A/P |
| | $L_{15}$ | $L_6$ | $L_2 \times T_3$ | $L_{13} \times T_3$ | P/P |
| | $L_{20}$ | $L_{13}$ | $L_{11} \times T_2$ | $L_{17} \times T_3$ | P/P |
| Plant height | $T_3$ | $L_{13}$ | $L_{20} \times T_1$ | $L_{11} \times T_3$ | P/P |
| | $T_2$ | $L_{18}$ | $L_{20} \times T_3$ | $L_{20} \times T_3$ | P/P |
| | $T_1$ | $L_3$ | $L_{18} \times T_3$ | $L_{13} \times T_3$ | G/P |
| Panicle length | $L_{19}$ | $L_{11}$ | $L_{11} \times T_1$ | $L_7 \times T_1$ | G/P |
| | $L_{20}$ | $L_9$ | $L_{17} \times T_1$ | $L_2 \times T_3$ | G/P |
| | $L_{12}$ | $L_7$ | $L_8 \times T_1$ | $L_{15} \times T_1$ | P/P |
| Panicle number per plant | $L_{11}$ | $L_{18}$ | $L_4 \times T_2$ | $L_{16} \times T_1$ | P/G |
| | $L_{13}$ | $L_{11}$ | $L_{13} \times T_2$ | $L_4 \times T_2$ | P/P |
| | $L_{15}$ | $L_{17}$ | $L_{16} \times T_1$ | $L_{13} \times T_2$ | P/P |
| Tillers per plant | $L_{13}$ | $L_{18}$ | $L_4 \times T_2$ | $L_4 \times T_2$ | P/P |
| | $L_{11}$ | $L_6$ | $L_{16} \times T_1$ | $L_{12} \times T_1$ | P/G |
| | $L_{15}$ | $L_{11}$ | $L_{13} \times T_2$ | $L_{13} \times T_1$ | A/G |
| Panicle weight | $L_{14}$ | $L_2$ | $L_1 \times T_1$ | $L_{17} \times T_1$ | P/P |
| | $L_{12}$ | $L_1$ | $L_1 \times T_2$ | $L_{11} \times T_3$ | G/G |
| | $L_{10}$ | $L_{12}$ | $L_{16} \times T_3$ | $L_{19} \times T_1$ | P/P |
| 1000 grain weight | $L_{16}$ | $L_{18}$ | $L_{20} \times T_1$ | $L_{17} \times T_1$ | P/P |
| | $L_{14}$ | $L_{16}$ | $L_8 \times T_2$ | $L_{11} \times T_3$ | P/G |
| | $L_{17}$ | $L_{10}$ | $L_6 \times T_2$ | $L_{19} \times T_1$ | P/P |
| Spikelet number per panicle | $L_7$ | $L_2$ | $L_1 \times T_2$ | $L_3 \times T_1$ | P/P |
| | $L_{14}$ | $L_{12}$ | $L_1 \times T_1$ | $L_1 \times T_2$ | G/P |
| | $T_2$ | $L_{14}$ | $L_{14} \times T_3$ | $L_{12} \times T_3$ | G/G |
| Grain number per plant | $L_{14}$ | $L_2$ | $L_1 \times T_1$ | $L_{12} \times T_3$ | G/G |
| | $L_7$ | $L_{14}$ | $L_1 \times T_2$ | $L_3 \times T_1$ | P/G |
| | $L_{17}$ | $L_1$ | $L_{18} \times T_3$ | $L_1 \times T_1$ | G/G |
| % spikelet fertility | $L_{12}$ | $L_7$ | $L_2 \times T_1$ | $L_7 \times T_2$ | G/P |
| | $L_{13}$ | $L_4$ | $L_1 \times T_1$ | $L_2 \times T_2$ | G/G |
| | $L_{10}$ | $L_{14}$ | $L_{18} \times T_3$ | $L_{12} \times T_2$ | P/G |
| Harvest Index | $L_{14}$ | $L_7$ | $L_{14} \times T_2$ | $L_{12} \times T_2$ | P/P |
| | $L_{10}$ | $L_{14}$ | $L_{20} \times T_1$ | $L_6 \times T_2$ | P/P |
| | $L_{16}$ | $L_{19}$ | $L_9 \times T_2$ | $L_9 \times T_2$ | P/P |
| Grain yield per plant | $L_{14}$ | $L_{19}$ | $L_{20} \times T_2$ | $L_1 \times T_1$ | G/G |
| | $L_{10}$ | $L_1$ | $L_1 \times T_1$ | $L_{20} \times T_2$ | P/P |
| | $L_{11}$ | $L_{14}$ | $L_{20} \times T_3$ | $L_{11} \times T_2$ | P/G |

number of tillers per plant, number of panicles per, plant, panicle length (cm), panicle weight (g), number of grains per panicle, number of spikelets per panicle, fertility percentage, 1000-grain weight (g), harvest index and grain yield per plant (g).

The mean data on various characters were subjected to combining ability analysis through line x tester method developed by Kempthorne (1957) and detailed by Singh and Chaudhary (1985).

**Genotypes used for experimental material**

## RESULTS AND DISCUSSION

Significance for all the characters indicated wide genetic differences among them.

The significance of variance due to L x T for all the characters provided a direct test indicating that dominance or no-additive variance was important for all studied characters. The SCA variances were higher than GCA variances for all the traits suggesting the significant role of non-additive gene action for grain yield and its components was also reported by other workers, Rita and Motiramani (2005); Singh *et al*. (2005) and Venkatesan *et al*. (2007). (Table 1).

UPR 3403-11-1-2 ($L_2$), UPR 3428-4-1-1 ($L_{11}$), UPR 3456-4-2-2 ($L_{14}$) were best general combiners among lines as evident from significant GCA effects for seven characters and UPR 3403-4-1-1 ($L_1$), UPR 3434-1-1-2 ($L_{12}$) and UPR 3469-13-1-1 ($L_{18}$) for six characters. Among testers PUSA 6A ($T_3$) was found to be the best general combiner for seven characters viz. Panicle weight, 1000 grain weight, spikelet number per panicle, grain number per panicle, % spikelet fertility, harvest index and grain yield per plant. Results indicated that UPR 3480-9-1-1 ($L_{19}$), UPR 3403-4-1-1 ($L_1$), UPR3456-4-2-2 ($L_{14}$) among lines and PUSA 6A ($T_3$) among testers are best combiners for grain yield (Table 2). Highly significant values for both combining capabilities and greater GCA value received Sabouri *et al.* (2013).

Parents showing maximum *per se* performance were also the best general combiner for the characters *viz*. UPR 3428-4-1-1 ($L_{11}$) for panicle number per plant and tillers per plant, UPR 3456-4-2-2 ($L_{14}$) for spikelet number per panicle, grain number per plant, harvest index and grain yield per plant. Relationship between per se performance and SCA effects of crosses was also revealed. The specific cross UPRI 2008-62 x Pusa 6A ($L_{20}$ x $T_3$) for plant height, UPR 3406-7-2-1 x UPRI 95-17A ($L_4$ x $T_2$) panicle number per plant and tillers per plant, UPR 3443-1-3-1 x UPRI 95-17A ($L_{13}$ x $T_2$) and UPR 3480-9-1-1 x UPRI 95-167 ($L_{16}$ x $T_1$) for panicle number per plant, UPR 3403-4-1-1 x UPRI 95-17A ($L_1$ x $T_2$) for spikelet number per plant, UPR 3413-8-3-1 x UPRI 95-17A ($L_9$ x $T_2$) for harvest index, UPRI 2008-62 x UPRI 95-17A ($L_{20}$ x $T_2$) for grain yield per plant and UPR 3403-4-1-1 x UPRI 95-167 ($L_1 \times T_1$) for grain number per plant and grain yield per plant were the best specific crosses along with their best per se performance and are therefore, suggested for exploitation to isolate high yielding pure lines and/or for straight use in hybrid breeding programme presented in table 3. A comparison of the magnitude of variance components due to GCA and SCA combined the nature of gene action in controlling the expression of the traits was also reported by Bhadru *et al*. (2013).

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