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**RESEARCH ARTICLE**

# Study of heritability gene action and combining ability using CMS line in hybrid rice (*Oryza sativa* L.)

■ **SUJEET KUMAR AND ALOK KUMAR SINGH**

## SUMMARY

Low heritability ( $h^2_{ns}$ ) estimate was observed with grain yield plant$^{-1}$ and test weight indicating preponderance of non-additive gene action to govern these traits. Combining ability revealed higher specific combining ability variance than their respective general combining ability variances indicating the predominance of non-additive gene effects indicated relevance of heterosis breeding for improving the yield and yield contributing attributes. Among the testers high gca was recorded in Sarjoo 52 and Narendra Usar 3 for harvest index, grain yield plant$^{-1,}$ days to 50% flowering (earliness), plant height (dwarf stature), panicle bearing tillers plant$^{-1}$ and biological yield. Among the female parental lines, IR 58025 was observed as a good general combiner only for seedling height, panicle length, spikelets panicle$^{-1}$, test weight, biological yield palnt$^{-1}$. Cross between IR 688897A X Sarjoo 52 , IR 58025 A X 21-2-5-B-1-1, IR 58025 A X Narendra Usar 3 and IR 58025 A X IR 71829-3R-73-1-2-B shown favorable *per se* performances and higher significant positive sca effects in related to grain yield plant$^{-1}$. These combinations proved to be good hybrids based on CMS system in rice.

**Key Words :** Heterosis, Combining ability, Line x tester, Rice hybrids

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Rice (*Oryza sativa* L., 2n = 2x = 24) is second most widely grown cereal crop and the staple food for more than half of world's population, providing two thirds of calorie intake for more than three billion people in Asia and one-third of calorie intake of nearly 1.5 billion people in Africa and Latin America. The average growth rate of rice yield was 3.68 per cent per year in the early 1980's but has decreased to 0.74 per cent per year in the late 1990's. China and India together produced 364.73 mt from an area of 74.60 mha. However, the average productivity of China (6.72 t/ha) is much higher than that of India (3.61 t/ha). In India rice provides 43 per cent of calorie requirement for more than 70 per cent of population. India contributed 77.49 per cent (816.11 Lt) of total rice production during 2012. The largest production of 146.06 Lt came from West Bengal followed by 140.22 Lt from UP and 128.95 Lt

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To full-fill the demand of increasing population, developing new high yielding hybrids and improved lines/ varieties along with stable performance in different agro climatic is a big challenge. Genetic improvement depends on the availability high magnitude of genetic variability in germplasm. The most common, easy and effective means for enveloping/identifying new hybrids or line is by utilizing cytoplasmic genetic male sterility (CMS) technique in the hybrid breeding programme is fruitful. The development and use of hybrid rice varieties on commercial scale utilizing CMS - fertility restoration system has now proved to be one of the plausible milestones in the history of rice improvement. The hybrid rice technology now in operation, aims at yield augmentation through higher exploitable heterosis levels. With the moto of increasing interest in exploitation of heterosis in rice, there is an urgent need to make available various CMS lines and good restoration capability lines for combining ability tests. nicking ability in self-pollinated crops and at the same time elucidate the nature and magnitude of gene actions involved, provides to the breeder about insight of nature and relative magnitude of fixable and non-fixable genetic variances *i.e*. due to dominance or epistatic components. Hence, this study provides useful information for the selection of donor parents for effective breeding programme. Such informations are required to design efficient breeding programmes for rapid dynamic and strategic crop improvement for quantitative along with qualitative nature of traits.

## MATERIAL AND METHODS

### Plant materials :

The experimental material for this investigation comprised of 3 CMS lines *viz*., IR 68897 A, IR 58025 A and Pusa 6 A possessing "wild abortive" (WA) cytoplasm as lines (females), 20 diverse rice varieties/genotypes as testers (males) and 60 crosses obtained through crossing in a "line × tester" mating design (Kempthorne, 1957). These diverse elite strains were selected from the collection of genetic stock available in Rice Section of the Department of Genetics and Plant Breeding, N.D. University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad. The resulting set of 60 $F_1$'s along with their 23 parents were evaluated in Randomized Complete Block Design with three replications during *Kharif*, 2011. All the recommended cultural practices were followed to raise a good crop. The experimental data collected on thirteen characters *i.e*. seedling height, number of leaves seedling$^{-1}$, days to 50 per cent flowering, flag leaf area, plant height, panicle bearing tillers plant$^{-1}$, panicle length, spikelets panicle$^{-1}$, spikelet fertility, grain yield plant$^{-1}$, test weight, biological yield plant$^{-1}$ and harvest index .

### Statistical analysis :

Data were recorded on five randomly selected plants from parents and $F_1$'s plant samples. The combining ability analysis was carried out following line × tester mating design outlined by Kempthorne (1957) and further elaborated by Arunachalam (1974). Heritability in narrow sense ($h^2_{ns}$) was calculated as suggested by Kempthorne (1957).

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

### Analysis of variance :

The analysis of variance (Table 1) revealed that the variation among CMS lines (females) for all characters and testers (males) except number of leaves seedling$^{-1}$, spikelet fertility, test weight and grain yield plant$^{-1}$ indicating prevalence of additive variance for rest of the traits. The significance of mean square due to line × tester for all traits provides a direct test indicating that (i) non-additive variance and (ii) combining ability contributed heavily in the expression of these traits.

### Heritability in narrow sense :

The estimates of narrow sense heritability ($h^2_{ns}$) are presented in Table 2. The narrow sense heritability was classified into three groups following Robinson, 1966 as low (less than 10%), medium (10-30%) and high (more than 30%).

The estimated of heritability ($h^2_{ns}$) was low with number of leaves seedling$^{-1}$, spikelet fertility, test weight and grain yield plant$^{-1}$ indicating preponderance of non-additive gene action and suggesting that heterosis breeding may be more useful. Days to 50 per cent flowering$^{-1}$, spikelets panicle$^{-1}$ and harvest index shown moderate heritability whereas seedling height, flag leaf area, plant height, panicle bearing tillers plant$^{-1}$, panicle

length, and biological yield plant$^{-1}$ shown high heritability indicating that improvement can be done with phenotypic selection.

**Genetic components of variance :**

The estimates of components of variance ( $\sigma^2_A$ and $\sigma^2_D$ ) are presented in Table 2. Dominance variance ( $\sigma^2_D$ ) was greater than additive variance ( $\sigma^2_A$ ) for all characters except panicle bearing tillers plant$^{-1}$ and panicle length. The estimated of genetic parameters are indicative of preponderance of non-additive gene action in expression of the traits under study.

**General combining ability :**

Estimates of GCA effects showed that it was difficult to choose a good combiner for all the traits as the combining ability effects were not consistent for all the yield components. It might possible due to low negative association of characters. The GCA effects of parent have been presented in Table 3.

It is noted that top two males, NDRK 5095 and NDRK 5013 proved the best general combiner for seedling height and number of leaves seedling$^{-1}$; Sarjoo 52 and NDRK 5056 for days to 50 per cent flowering (earliness); 92-H 51-4 and IR 61920-3B-22-2-1 for flag leaf area; CST 7-1 and Sarjoo 52 for plant height (dwarf

**Table 1 : Analysis of variance for line x tester for 13 characters in rice**

| Source of variation | Replications | Tester (t) | Lines (l) | Crosses | LxT effect | Error |
|---|---|---|---|---|---|---|
| DF | 2 | 19 | 2 | 59 | 38 | 118 |
| Seedling height (cm) | 5.797** | 103.585 | 789.094** | 114.904** | 85.079** | 0.731 |
| Number of leaves per seedling | 0.414* | 0.644 | 1.095 | 0.821** | 0.895** | 0.149 |
| Days to 50 per cent flowering | 7.439 | 52.165 | 241.072* | 59.925** | 54.271** | 9.301 |
| Flag leaf area (cm$^2$) | 4.438* | 92.817** | 485.142** | 67.101** | 32.241** | 1.131 |
| Plant height (cm) | 5.295** | 282.055* | 4978.882** | 345.034** | 132.6375** | 0.845 |
| Panicle bearing tillers per plant | 5.650** | 49.957** | 49.245** | 21.996** | 6.581** | 0.608 |
| Panicle length (cm) | 6.049** | 30.044** | 107.760** | 20.652** | 11.370** | 1.023 |
| Spikelets per panicle | 363.491 | 2918.248 | 7222.535* | 2534.953** | 2096.590** | 245.698 |
| Spikelet fertility (%) | 15.066* | 537.895 | 234.141 | 466.865** | 443.598** | 4.876 |
| Test weight (g) | 2.154** | 27.208 | 6.349 | 27.794** | 29.215** | 0.317 |
| Biological yield per plant (g) | 11.963 | 5245.676 | 35838.850** | 5889.423** | 4635.010** | 40.715 |
| Harvest-index (% | 97.332** | 297.888 | 1047.005* | 299.558** | 261.054** | 7.834 |
| Grain yield per plant (g) | 157.004** | 1609.642 | 41.872 | 1089.803** | 885.038** | 20.152 |

* and ** indicate significant of values at P=0.05 and 0.01, respectively.

**Table 2 : Estimates of heritability broad ( $h^2_{bs}$ ) and narrow sense ( $h^2_{ns}$ ), additive ( $\sigma^2_A$ ) and dominance ( $\sigma^2_D$ ) genetic components of variance, for 13 characters in rice**

| Characters | Heritability (%) | | Genetic components of variance | |
|---|---|---|---|---|
| | $h^2_{bs}$ | $h^2_{ns}$ | $\sigma^2_A$ | $\sigma^2_D$ |
| Seedling height | 98.43 | 42.78 | 20.943 | 28.063 |
| Number of leaves per seedling | 59.90 | @ | -0.002 | 0.248 |
| Days to 50 per cent flowering | 66.69 | 22.84 | 5.354 | 15.051 |
| Flag leaf area (cm$^2$) | 93.19 | 58.70 | 14.883 | 10.285 |
| Plant height (cm) | 98.02 | 76.69 | 144.802 | 43.470 |
| Panicle bearing tillers per plant | 91.55 | 53.20 | 2.494 | 1.886 |
| Panicle length (cm) | 85.91 | 46.81 | 3.335 | 3.424 |
| Spikelets per panicle | 83.48 | 19.79 | 172.394 | 624.227 |
| Spikelet fertility (%) | 95.07 | @ | -3.338 | 145.614 |
| Test weight (g) | 96.04 | @ | -0.721 | 9.619 |
| Biological yield per plant (g) | 98.46 | 37.38 | 922.160 | 1534.241 |
| Harvest-index (%) | 91.17 | 21.57 | 23.849 | 84.025 |
| Grain yield per plant (g) | 94.68 | @ | -3.437 | 288.757 |

Legend: @ Negative estimates

**Table 3 : Estimates of general combining ability effects (GCA) of parent (males and females) for 13 characters in rice**

| Parental lines | Seedling height (cm) | Number of leaves per seedling | Days to 50% flowering | Flag leaf area ($cm^2$) | Plant height (cm) | Panicle bearing tillers per plant |
|---|---|---|---|---|---|---|
| **Male** | | | | | | |
| IR 70023-4B-R-12-3-1-1-B | 1.204** | -0.266* | 1.189 | 1.811** | 7.465** | -1.607** |
| IR 61920-3B-22-2-1 | -2.885** | 0.423** | -0.478 | 5.231** | 5.088** | -1.118** |
| PNL 1-8-5-17-2 | 3.571** | 0.090 | 3.522** | 1.778** | -3.963** | 0.326 |
| NDRK 5095 | 8.604** | 0.446** | -0.033 | -0.044 | 3.465** | -0.363 |
| NDRK 5056 | -1.896** | -0.243 | -4.256** | -1.233** | -2.624** | 0.859** |
| NDRK 5086 | 2.004** | 0.134 | -1.033 | -0.722 | -1.079* | 0.882** |
| NDR 9830119 | -2.418** | -0.310* | -1.033 | 3.400** | 2.099** | -0741* |
| NDRK 5013 | 5.648** | 0.312* | -1.033 | -1.122** | 2.432** | -2.918** |
| CST 7-1 | -1.374** | 0.112 | -0.033 | 2.311** | -11.190** | -0.629 |
| 21-2-5-B-1-1 | -0.174 | 0.290* | -1.811 | 2.836** | 5.965** | 0.259 |
| IR 64 | -1.385** | 0.001 | 0.744 | -3.756** | -3.924** | -1.918** |
| NDR 9830148 | 2.671** | 0.290* | -0.589 | -2.867** | 7.699** | -2.529** |
| CSRC(S) 14-1-4-0 | -4.363** | -0.354** | -1.922 | 0.200 | 9.354** | -1.896** |
| PNL 5-8-1-7-21 | -1.574** | -0.110 | -1.478 | -0.911* | -6.657** | 0.548 |
| IR 72048-B-R-2-2-2-1-B | 0.204 | -0.354** | 2.078* | -1.328** | 0.332 | 1.726** |
| IR 71829-3R-73-1-2-B | -4.485** | -0.332* | 2.856** | -3.933** | -2.213** | 1.348** |
| NDRK 5094 | 1.537** | 0.134 | 3.967** | 2.300** | -2.668** | -1.163** |
| 92-H 51-4 | -0.074 | -0.177 | 1.300 | 6.789** | 2.376** | -0.518 |
| Narendra Usar 3 | -0.152 | -0.154 | 3.078** | 0.360 | -3.613** | 1.171** |
| Sarjoo 52 | -4.663 | 0.068 | -5.033** | -6.478** | -8.346 | 8.282** |
| S.E. (gi) | 0.3145 | 0.1290 | 1.0066 | 0.3923 | 0.4974 | 0.3202 |
| S.E. (gi-gj) | 0.4448 | 0.1825 | 1.4235 | 0.5548 | 0.7034 | 0.4528 |
| C.D. (P=0.01) | 0.8234 | 0.3378 | 2.6354 | 1.0272 | 1.3022 | 0.8383 |
| C.D. (P.=0.05) | 0.6228 | 0.2555 | 1.9933 | 0.7769 | 0.9850 | 0.6341 |
| **Female** | | | | | | |
| IR 688897A | -2.379** | 0.088 | -2.239** | -1.449** | -4.410** | 1.036** |
| IR 58025 A | 4.174** | -0.156** | 0.611 | 3.276** | 10.444** | -0.646** |
| PUSA 6A | -1.794** | 0.068 | 1.628** | -1.827** | -6.304** | -0.389** |
| S.E. (gi) | 0.1218 | 0.0500 | 0.3899 | 0.1519 | 0.1926 | 0.1240 |
| S.E. (gi-gj) | 0.1723 | 0.0707 | 0.5513 | 0.2149 | 0.2724 | 0.1754 |
| C.D. (P=0.01) | 0.3189 | 0.1308 | 1.0207 | 0.3978 | 0.7133 | 0.3247 |
| C.D. (P=0.05) | 0.2412 | 0.0990 | 0.7720 | 0.3009 | 0.5395 | 0.2456 |

*Contd….. Table 3*

| Parental lines | Panicle length (cm) | Spikelets per panicle | Spikelet fertility (%) | Test weight (g) | Biological yield per plant (g) | Harvest index (%) | Grain yield per plant (g) |
|---|---|---|---|---|---|---|---|
| **Male** | | | | | | | |
| IR 70023-4B-R-12-3-1-1-B | 2.271** | -39.333** | 2.212* | -3.181** | -35.216** | -7.287** | -18.016** |
| IR 61920-3B-22-2-1 | -0.507 | -13.667** | -1.922* | -3.081** | 22.084** | -5.045** | -14.907** |
| PNL 1-8-5-17-2 | -3.129** | -6.089 | 3.167** | 0.053 | -23.612** | 5.736** | -0.601 |
| NDRK 5095 | 3.226** | -22.889** | 0.812 | 1.408** | -14.350** | 0.049 | -4.512** |
| NDRK 5056 | -0.318 | 16.669** | 7.189** | -2.003** | 3.128 | 2.126* | 5.401** |
| NDRK 5086 | -2.085** | -0.889 | -9.499** | -0.503* | 4.306* | -6.025** | -7.232** |
| NDR 9830119 | 1.759** | 28.111** | 9.045** | -1.459** | 38.306** | -5.230** | 3.079* |
| NDRK 5013 | -0.341 | -18.311** | -17.788** | 3.108** | -33.850** | -8.081** | -18.872** |
| CST 7-1 | -1.318** | -5.356 | 3.734** | 0.630** | 4.750* | 0.800 | 1.479 |
| 21-2-5-B-1-1 | -0.141 | 22.111** | 3.123** | 1.408** | 3.573 | 6.673** | 14.093** |

*Table 3 contd….*

*Contd. Table 3*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| IR 64 | -3.041** | -4.622 | 8.545** | -0.347 | -23.794** | 0.937 | -5.503** |
| NDR 9830148 | 1.193** | -17.533** | -5.855** | 0.130 | -32.672** | -7.074** | -17.194** |
| CSRC(S) 14-1-4-0 | -0.052 | 6.667 | -3.799** | 1.303** | 2.850 | -2.415* | --6.092** |
| PNL 5-8-1-7-21 | -1.429** | 2.667 | 6.223** | 0.253 | -2.627 | 5.296** | 6.735** |
| IR 72048-B-R-2-2-2-1-B | 3.782** | 7.155 | 1.712 | -0.322 | 9.517** | 3.707** | 7.975** |
| IR 71829-3R-73-1-2-B | -0.274 | 2.444 | -5.944** | -1.807** | -9.261** | -1.682 | -1.327 |
| NDRK 5094 | -0.496 | -2.311 | 8.556** | 2.453** | -13.841** | 6.743** | 4.673** |
| 92-H 51-4 | -0.274 | 10.044* | -14.688** | -0.081 | 38.028** | -6.353** | --4.079** |
| Narendra Usar 3 | 0.204 | 37.355** | 7.656** | -0.403* | 15.862** | 6.999** | 18.410** |
| Sarjoo 52 | 0.971** | -2.222 | -2.477** | 2.441** | 46.817** | 10.128** | 36.490** |
| S.E. (gi) | 0.3497 | 4.9879 | 0.8664 | 0.1996 | 1.8941 | 0.9988 | |
| S.E. (gi-gj) | 0.4945 | 7.0539 | 1.2253 | 0.2822 | 2.6786 | 1.4125 | |
| C.D. (P=0.01) | 0.9155 | 13.0590 | 2.2685 | 0.5225 | 4.9589 | 2.6150 | |
| C.D. (P.=0.05) | 0.6925 | 9.8774 | 1.7158 | 0.3952 | 3.7508 | 1.9779 | |
| **Female** | | | | | | | |
| IR 688897A | -0.839*** | -12.472*** | 0.541 | -0.340*** | -17.209*** | 3.153*** | -0.385 |
| IR 58025 A | 1.546*** | 8.161*** | -2.189*** | 0.308*** | 27.975*** | -4.738*** | 0.958 |
| PUSA 6A | -0.706*** | 4.311* | 1.649*** | 0.032 | -10.765*** | 1.585*** | -0.574 |
| S.E. (gi) | 0.1354 | 1.9318 | 0.3356 | 0.0773 | 0.7336 | 0.3868 | 05593 |
| S.E. (gi-gj) | 0.1915 | 2.7320 | 0.4746 | 0.1093 | 1.0374 | 0.5471 | 0.7909 |
| C.D. (P=0.01) | 0.3546 | 5.0577 | 08786 | 0.2023 | 1.9206 | 1.0128 | 1.4642 |
| C.D. (P.=0.05) | 0.2682 | 3.8255 | 06645 | 0.1530 | 1.4527 | 07660 | 1.1075 |

*, ** and *** indicate significance of values at P=0.05, 0.01 and 0.10, respectively

stature); Sarjoo 52 and IR 72048-B-R-2-2-2-1-B for panicle bearing tillers plant$^{-1}$; IR 72048-B-R-2-2-2-1-B and NDRK 5095 for panicle length; Narendra Usar 3 and NDR 9830119 for spikelets panicle$^{-1}$; NDR 9830119 and NDRK 5094 for spikelet fertility; NDRK 5013 and NDRK 5094 for test weight; Sarjoo 52 and NDR 9830119 for biological yield; Sarjoo 52 and Narendra Usar 3 for harvest index and grain yield plant$^{-1}$. Similar findings are also reported by Singh and Kumar (2004); Rosamma and Vijayakumar (2005); Priyanka *et al.* (2014) and Dorosti and Monajjem (2014).

Among the female parental lines, IR 58025 was observed as a good general combiner only for seedling height, panicle length, spikelets panicle$^{-1}$, test weight, biological yield palnt$^{-1}$. Whereas, IR 688897 A was good combiner for panicle bearing tillers plant$^{-1}$ and harvest index. Third CMS line PUSA 6A was shown good combining ability for the traits days to 50% flowering, plant height and spikelet fertility. These findings are supported by Saleem *et al.* (2010); Patial *et al.* (2016) and Prasad *et al.* (2013) also reported IR 58025 A as good general combiner for seedling vigour.

The GCA effects together with relative *per se* performance is useful for selecting desirable parent with favourable genes for different component of yield. The *per se* performance of the parent and their gca effects for all the characters (Table 5) were almost in close correspondence which indicates that the *per se* performance of the parent for these traits could possibly be taken as a criterion for selection of parent

**Specific combining ability effects :**

In general, specific combining ability is associated with interaction effects, which may be due to dominance and epistatic component of variation that are non-fixable in nature. Hence, it can be utilized in generation like $F_1$ in developing good $F_1$ hybrid. In the present investigation, none of the 60 hybrids manifested consistently high SCA effects for all the characters. Ghosh (1993) and Dwivedi *et al.* (1999) also observed that no specific combination was desirable for all the traits they studied. The SCA effects of parent have been presented in Table 4. The present findings reveled that cross IR 58025 A X 21-2-5-B-1-1, IR 58025 A X IR 71829-3R-73-1-2-B, IR 58025 A X CST 7-1, IR 58025 A X Narendra Usar 3 and IR 688897A X Sarjoo 52 exhibited high SCA effects for grain yield plant$^{-1}$. The desirable affect of IR 58025 A X 21-2-5-B-1-1 for grain yield plant$^{-1}$ was accompanied

**Table 4 : Estimates of specific combining ability effects (SCA) of hybrids for 13 characters in rice**

| Hybrids | Seedling height (cm) | Number of leaves seedling$^{-1}$ | Days to 50% flowering | Flag leaf length (cm) | Plant height (cm) | Panicle bearing tillers plant$^{-1}$ |
|---|---|---|---|---|---|---|
| IR 688897A X IR 70023-4B-R-12-3-1-1-B | -0.987 | 0.446* | -2.206 | -1.151 | -6.804** | -0.991 |
| IR 688897A X IR 61920-3B-22-2-1 | 0.835 | 0.290 | -5.872** | -4.011** | -6.693** | -1.213* |
| IR 688897A X PNL 1-8-5-17-2 | -1.821** | 0.223 | -6.539** | 1.016 | 0.273 | -0.191 |
| IR 688897A X NDRK 5095 | -3.454** | -0.466* | -0.650 | 1.171 | -0.804 | 0.031 |
| IR 688897A X NDRK 5056 | 0.779 | 0.223 | 0.239 | 1.527* | 3.151** | -0.924 |
| IR 688897A X NDRK 5086 | 1.479** | 0.046 | 0.017 | 0.649 | -1.893* | -0347 |
| IR 688897A X NDR 9830119 | -0.698 | 0.223 | 1.017 | -2.307** | -3.671** | 0.742 |
| IR 688897A X NDRK 5013 | 3.502** | -0.199 | -3.983* | 1.416* | -6.071** | -0.080 |
| IR 688897A X CST 7-1 | -6.809** | -0.332 | 1.017 | 0.871 | 7.551** | -0.302 |
| IR 688897A X 21-2-5-B-1-1 | -2.143** | 0.157 | 1.461 | -1.235 | -1.938* | -1.458** |
| IR 688897A X IR 64 | -6.798** | -0.488* | -1.428 | -1.051 | 6.284** | 1.587** |
| IR 688897A X NDR 9830148 | 0.146 | -0.557* | 4.906** | 1.660* | -3.338** | 1.631** |
| IR 688897A X CSRC(S) 14-1-4-0 | 5.179** | 0.601** | -0.094 | -1.840** | -1.027 | 1.431* |
| IR 688897A X PNL 5-8-1-7-21 | -0.676 | -0.310 | -1.206 | 1.771* | 5.018** | 0.053 |
| IR 688897A X IR 72048-B-R-2-2-2-1-B | 7.546** | 0.001 | 3.572* | 3.271** | 3.662** | 0.209 |
| IR 688897A X IR 71829-3R-73-1-2-B | 0.235 | -0.021 | 2.461 | 0.827 | -2.093* | 0.187 |
| IR 688897A X NDRK 5094 | -0.787 | -0.021 | 4.683** | -2.540** | 3.862** | -0.436 |
| IR 688897A X 92-H 51-4 | 1.091* | -0.043 | 3.550 | -2.362** | -4.016** | 0.053 |
| IR 688897A X Narendra Usar 3 | -1.032 | -0.399 | -3.094 | 0.447 | 3.307** | 0.631 |
| IR 688897A X Sarjoo 52 | 4.413** | 0.446* | 2.350 | 1.871 | 5.240** | -0.613 |
| IR 58025 A X IR 70023-4B-R-12-3-1-1-B | -2.141** | -0.178 | -0.389 | 1.424* | 7.678** | 0.491 |
| IR 58025 A X IR 61920-3B-22-2-1 | -1.252* | -0.867** | 6.278** | 8.204** | 10.256** | 1.668** |
| IR 58025 A X PNL 1-8-5-17-2 | 3.159** | 0.600** | 7.611** | -3.476** | -5.828** | -0.909 |
| IR 58025 A X NDRK 5095 | 0.859 | 0.578* | -3.500* | -1.921** | 6.745** | -0.554 |
| IR 58025 A X NDRK 5056 | -0.907 | -0.133 | -1.944 | -0.798 | -7.300** | 1.957** |
| IR 58025 A X NDRK 5086 | 0.326 | -0.178 | -5.833** | -0.976 | 7.289** | 1.935** |
| IR 58025 A X NDR 9830119 | -3.918** | -0.333 | -2.833 | 5.902** | 3.245** | -1.176* |
| IR 58025 A X NDRK 5013 | 4.948** | 1.044** | 4.500* | -3.576** | 7.978** | -1.732** |
| IR 58025 A X CST 7-1 | 8.971** | -0.022 | -3.500* | -2.987** | -10.266** | 1.379* |
| IR 58025 A X 21-2-5-B-1-1 | 5.771** | 0.200 | -2.389 | 1.366* | 4.378** | 2.357** |
| IR 58025 A X IR 64 | 11.215** | 0.889** | -0.278 | 1.124 | -8.733** | -2.598** |
| IR 58025 A X NDR 9830148 | 2.326** | 0.067 | -1.278 | -1.432* | 5.511** | -2.521** |
| IR 58025 A X CSRC(S) 14-1-4-0 | -10.707** | -1.156** | 0.722 | 4.168** | 2.456** | -1.554** |
| IR 58025 A X PNL 5-8-1-7-21 | 3.571** | 0.467* | 0.611 | -3.721** | -11.200** | -1.265* |
| IR 58025 A X IR 72048-B-R-2-2-2-1-B | -8.541** | -0.422 | 4.389* | -2.437** | -5.855** | -0.509 |
| IR 58025 A X IR 71829-3R-73-1-2-B | 1.082* | -0.044 | 0.278 | -2.565** | 4.356** | 2.068** |
| IR 58025 A X NDRK 5094 | -1.874** | 0.022 | 0.500 | 4.335** | -5055** | -0.421 |
| IR 58025 A X 92-H 51-4 | -1.329* | 0.067 | -3.167 | 4.446** | 8.900** | 0.268 |
| IR 58025 A X Narendra Usar 3 | -2.318** | -0.222 | 3.389 | -4.125** | -6.444** | 0.846 |
| IR 58025 A X Sarjoo 52 | -9.241** | -0.378 | -5.167** | -2.954** | -8.111** | 0.268 |
| PUSA 6A X IR 70023-4B-R-12-3-1-1-B | 3.128** | -0.268 | 2.594 | -0.273 | -0.874 | 0.501 |
| PUSA 6A X IR 61920-3B-22-2-1 | 0.417 | 0.577* | -0.406 | -4.193** | -3.563** | -0.455 |
| PUSA 6A X PNL 1-8-5-17-2 | -1.339** | -0.823** | -1.072 | 2.460** | 5.554** | 1.101* |
| PUSA 6A X NDRK 5095 | 2.594** | -0.112 | 4.150* | 0.749 | -5.940** | 0.523 |
| PUSA 6A X NDRK 5056 | 0.128 | -0.290 | 1.706 | -0.728 | 4.149** | -1.033 |
| PUSA 6A X NDRK 5086 | -1.806** | 0.132 | 5.817** | 0.327 | -5.396** | -1.588** |

*Contd. Table 4*

*Table 4 contd…*

| | | | | | | |
|---|---|---|---|---|---|---|
| PUSA 6A X NDR 9830119 | 4.617** | 0.110 | 1.817 | -3.595** | 0.426 | 0.434** |
| PUSA 6A X NDRK 5013 | -8.450** | -0.846** | 0.517 | 2.160** | -1.907* | 1.812** |
| PUSA 6A X CST 7-1 | -2.161** | 0.354 | 2.483 | 2.116** | 2.715** | -1.077 |
| PUSA 6A X 21-2-5-B-1-1 | -3.628** | -0.357 | 0.978 | -0.131 | -2.440** | -0.899 |
| PUSA 6A X IR 64 | -4.417** | -0.401 | 1.706 | -0.073 | 2.449** | 1.012 |
| PUSA 6A X NDR 9830148 | -2.472** | 0.510* | -3.628* | -0.228 | -2.174* | 0.889 |
| PUSA 6A X CSRC(S) 14-1-4-0 | 5.528** | 0.554* | -0.628 | -2.328** | -1.429 | 0.123 |
| PUSA 6A X PNL 5-8-1-7-21 | -2.894** | -0.157 | 0.594 | 1.949** | 6.182** | 1.212* |
| PUSA 6A X IR 72048-B-R-2-2-2-1-B | 0.994 | 0.421 | -7.661** | -0.834 | 2.193* | 0.301 |
| PUSA 6A X IR 71829-3R-73-1-2-B | -1.317* | 0.066 | -2.739 | 1.738* | -2.263** | -2.255** |
| PUSA 6A X NDRK 5094 | 2.661** | -0.001 | -7.183** | -1.795** | 1.193 | 0.856 |
| PUSA 6A X 92-H 51-4 | 0.239 | -0.023 | -0.183 | -2.084** | -4.885** | -0.322 |
| PUSA 6A X Narendra Usar 3 | 3.350** | 0.621** | -0.294 | 3.678** | 3.138** | -1.477** |
| PUSA 6A X Sarjoo 52 | 4.828** | -0.068 | -2.817 | 1.083 | 2.871** | 0.345 |
| S.E. (Sij) | 0.545 | 0.224 | 1.744 | 0.680 | 0.862 | 0.555 |
| S.E. (Sij-Skl) | 0.7704 | 0.3160 | 2.4656 | 0.9610 | 1.2183 | 0.7843 |
| C.D. (P=0.01) | 2.0169 | 0.8274 | 6.4554 | 2.5161 | 3.1898 | 2.0534 |
| C.D. (P=0.05) | 1.5255 | 0.6258 | 4.8827 | 1.9031 | 2.4126 | 1.5531 |

*Contd. Table 4*

| Hybrids | Panicle length (cm) | Spikelets per panicle | Spikelet fertility (%) | Test weight (g) | Biological yield per plant (g) | Harvest index (%) | Grain yield per plant (g) |
|---|---|---|---|---|---|---|---|
| IR 688897A X IR 70023-4B-R-12-3-1-1-B | -0.394 | 43.583** | 7.248** | 1.329** | 18.254** | 6.545** | 10.283** |
| IR 688897A X IR 61920-3B-22-2-1 | 1.151 | 32.583** | 4.515** | 1.962** | -46.713** | 7.803** | 8.167** |
| IR 688897A X PNL 1-8-5-17-2 | 1.206* | 22.339* | 4.259** | -1.471** | 27.263** | -2.098 | 5.874* |
| IR 688897A X NDRK 5095 | 0.384 | 10.139 | 4.048** | -1.026** | 5.087 | 1.952 | 2.732 |
| IR 688897A X NDRK 5056 | 0.695 | -31.752** | 1.471 | -1.582** | 0.743 | -8.821** | -12.995** |
| IR 688897A X NDRK 5086 | -1.072 | 6.139 | 2.559 | -2.115** | -15.535** | 4.140* | 0.305 |
| IR 688897A X NDR 9830119 | -0.449 | -19.528* | -1.318 | -0.726* | -26.502** | 2.628 | -2.760 |
| IR 688897A X NDRK 5013 | -1.616** | 15.561 | 0.782 | -0.360 | 9.587** | 2.129 | 3.605 |
| IR 688897A X CST 7-1 | -1.772** | -28.728** | -8.341** | -1.882** | -46.746** | -0.795 | -17.553** |
| IR 688897A X 21-2-5-B-1-1 | -1.583* | -20.194* | -4.129** | -1.626** | -10.635** | -9.539** | -20.446** |
| IR 688897A X IR 64 | 0.251 | -14.128 | 1.782 | 3.596** | 27.865** | 4.665** | 13.363** |
| IR 688897A X NDR 9830148 | -0.616 | 27.450** | -1.418 | 0.318 | 21.776** | 6.462** | 11.927** |
| IR 688897A X CSRC(S) 14-1-4-0 | 0.295 | -8.417 | 2.826 | -0.554 | -11.746** | 5.800** | 5.992* |
| IR 688897A X PNL 5-8-1-7-21 | -0.294 | -11.417 | 6.863** | 0.496 | 0.698 | -3.364 | -5.575* |
| IR 688897A X IR 72048-B-R-2-2-2-1-B | 1.462* | -16.239 | -12.385** | 0.070 | -18.346** | -3.699* | -11.802** |
| IR 688897A X IR 71829-3R-73-1-2-B | 0.751 | 1.806 | -15.729** | -3.644** | -7.668* | -10.803** | -18.400** |
| IR 688897A X NDRK 5094 | -0.627 | -0.772 | -1.563 | 1.096** | 12.645*** | -1.442 | 0.614 |
| IR 688897A X 92-H 51-4 | 3.351** | -9.128 | 18.715** | 3.829** | 1.876 | 2.141 | 11.438** |
| IR 688897A X Narendra Usar 3 | -0427 | -8.439 | -2.596 | -0.815* | 11.543** | -3.671 | -3.637 |
| IR 688897A X Sarjoo 52 | -0.694 | 9.139 | 6.137** | 3.107** | 46.554** | -0.033 | 18.869** |
| IR 58025 A X IR 70023-4B-R-12-3-1-1-B | 1.054 | -52.384** | -8.622** | -2.919** | -32.563** | -8.138** | -15.014** |
| IR 58025 A X IR 61920-3B-22-2-1 | 0.199 | -30.717** | -5.355** | -4.952** | 109.470** | -17.616** | -12.730** |
| IR 58025 A X PNL 1-8-5-17-2 | -2.479** | -19.228* | 7.823** | 1.114** | -42.168** | 8.547** | -2.483 |
| IR 58025 A X NDRK 5095 | 0.899 | -22.161* | -9.155** | 1.025** | -14.763** | -7.207** | -12.038** |
| IR 58025 A X NDRK 5056 | -0.157 | -0.046 | 3.801* | 2.170** | -21.508** | 13.643** | 14.108** |
| IR 58025 A X NDRK 5086 | 1.270* | -24.161** | -18.044** | 3.817** | -26.419** | -0.002 | -6.285* |
| IR 58025 A X NDR 9830119 | 0.699 | 13.505 | 2.678 | 1.359** | 16.848** | -0.978 | 0.950 |
| IR 58025 A X NDRK 5013 | 1.932** | -21.006* | 3.512* | 0.659 | -40.597** | 1.297 | -7.212** |

*Contd…. Table 4*

*Contd. Table 4*

| Hybrids | Panicle length (cm) | Spikelets per panicle | Spikelet fertility (%) | Test weight (g) | Biological yield per plant (g) | Harvest index (%) | Grain yield per plant (g) |
|---|---|---|---|---|---|---|---|
| IR 58025 A X CST 7-1 | 1.843** | 33.905** | 7.256** | 3.270** | 76.737** | 0.452 | 26.717** |
| IR 58025 A X 21-2-5-B-1-1 | 3.532** | 35.172** | 8.401** | 2.625** | 26.314** | 13.512** | 35.624** |
| IR 58025 A X IR 64 | -2.434** | 29.372** | 2.712 | -7.152** | -33.052** | -9.604** | -18.747** |
| IR 58025 A X NDR 9830148 | 1.266* | -24.117** | 18.378** | -1.164** | -27.908** | -2.250 | -8.503** |
| IR 58025 A X CSRC(S) 14-1-4-0 | -1.823** | 6.616 | -8.544** | 0.998** | 29.777** | -11.699** | -10.665** |
| IR 58025 A X PNL 5-8-1-7-21 | -1.552* | 25.283** | 5.167** | -0.286 | -2.286 | -0.363 | 1.375 |
| IR 58025 A X IR 72048-B-R-2-2-2-1-B | -1.657** | 26.261** | 10.345** | 1.199** | 37.570** | -0.428 | 14.062** |
| IR 58025 A X IR 71829-3R-73-1-2-B | 0.599 | -5.495 | 17.067** | 6.394** | 13.481** | 18.674** | 33.050** |
| IR 58025 A X NDRK 5094 | 2.554** | 31.994** | 3.234* | -0.286 | -15.846** | 6.656** | 6.084* |
| IR 58025 A X 92-H 51-4 | -5.534** | -14.628 | -40.322** | -6.086** | 27.525** | -17.804** | -31.112** |
| IR 58025 A X Narendra Usar 3 | -0.079 | 32.661** | 4.267** | 2.970** | -2.241 | 12.590** | 22.293** |
| IR 58025 A X Sarjoo 52 | -0.179 | -20.828* | -4.599** | -4.808** | -78.363** | 0.718 | -29.474** |
| PUSA 6A X IR 70023-4B-R-12-3-1-1-B | -0.661 | 8.800 | 1.373 | 1.590** | 14.310** | 1.593 | 4.731 |
| PUSA 6A X IR 61920-3B-22-2-1 | -1.349* | -1.867 | 0.840 | 2.990** | -62.757** | 9.812** | 4.562 |
| PUSA 6A X PNL 1-8-5-17-2 | 1.273* | -3.111 | -12.082** | 0.357 | 14.905** | -6.449** | -3.391 |
| PUSA 6A X NDRK 5095 | -1.283* | 12.022 | 5.107** | 0.001 | 9.676** | 5.254** | 9.307** |
| PUSA 6A X NDRK 5056 | -0.538 | 31.798** | -5.271** | -0.588 | 20.765** | -4.822** | -1.113 |
| PUSA 6A X NDRK 5086 | -0.205 | 18.022* | 15.484** | -1.755** | 41.954** | -4.138* | 5.980* |
| PUSA 6A X NDR 9830119 | -0.249 | 6.022 | -1.360 | -0.632 | 9.654** | -1.650 | 1.809 |
| PUSA 6A X NDRK 5013 | -0.316 | 5.445 | -4.293** | -0.299 | 31.010** | -3.426 | 3.607 |
| PUSA 6A X CST 7-1 | -0.072 | -5.178 | 1.084 | -1.388** | -29.990** | -0.343 | -9.164** |
| PUSA 6A X 21-2-5-B-1-1 | -1.949** | -14.978 | -4.271** | -0.999** | -15.679** | -3.973* | -15.178** |
| PUSA 6A X IR 64 | 2.184** | -15.244 | -4.493** | 3.557** | 5.187 | 4.940** | 5.385* |
| PUSA 6A X NDR 9830148 | -0.649 | -3.333 | -16.960** | 0.846* | 6.132 | -4.212* | -3.424 |
| PUSA 6A X CSRC(S) 14-1-4-0 | 1.528* | 1.800 | 5.718** | -0443 | -18.024** | 5.899** | 4.674 |
| PUSA 6A X PNL 5-8-1-7-21 | 1.806** | -13.867 | 1.696 | -0.210 | 1.587 | 3.728* | 4.200 |
| PUSA 6A X IR 72048-B-R-2-2-2-1-B | 0.195 | -10.022 | 2.040 | -1.269** | -19.224** | 4.127* | -2.260 |
| PUSA 6A X IR 71829-3R-73-1-2-B | -1.349* | 3.689 | -1.338 | -2.750** | -5.813 | -7.871** | -14.651** |
| PUSA 6A X NDRK 5094 | -1.927** | -31.222** | -1.671 | -0.810* | 3.201 | -5.213** | -6.698** |
| PUSA 6A X 92-H 51-4 | 2.184** | 23.756** | 21.607** | 2.257** | -29.402** | 15.663** | 19.674** |
| PUSA 6A X Narendra Usar 3 | 0.506 | -24.222 | -1.671 | -2.155** | -9.302** | -8.919** | -18.665** |
| PUSA 6A X Sarjoo 52 | 0.873 | 11.689 | -1.538 | 1.701** | 31.810** | -0.685 | 10.605** |
| S.E. (Sij) | 0.606 | 8.639 | 1.500 | 0.346 | 3.281 | 1.730 | 2.501 |
| S.E. (Sij-Skl) | 0.8566 | 12.2177 | 2.1223 | 0.4888 | 4.6395 | 2.4465 | 3.5371 |
| C.D. (P=0.01) | 2.2426 | 31.9878 | 5.5566 | 1.2798 | 12.1468 | 6.4053 | 9.2605 |
| C.D. (P=0.05) | 1.6962 | 24.1945 | 4.2028 | 0.9680 | 9.1874 | 4.8448 | 7.0044 |

* and ** indicate significance of values at P=0.05 and 0.01, respectively

by desirable SCA effects for seedling height, panicle bearing tillers palnt$^{-1}$, panicle length, spikelets panicle$^{-1}$, and harvest index. Similarly desirable SCA effect of IR 58025 A X IR 71829-3R-73-1-2-B was found to be related with desirable sca effect for spikelet fertility, test weight, harvest index.

The effect of IR 58025 A X CST 7-1 for grain yiled was due to desirable SCA effect of seedling height, plant height, spikelets panicle$^{-1}$, test weight and biological yiled plant$^{-1}$. The common crosses based on *per se* performance and SCA effects for all the characters (Table 6) were also in close correspondence. Similar pattern of association between SCA effects for grain yield plant$^{-1}$ with other yield attributing traits were reported by Hasan *et al.* (2013), Adilakshmi and Reddy (2012), Adilakshmi and Upendra (2014), Dorosti and Monajjem (2014) have suggested that about 20-30% standard heterosis may be considered sufficient to offset

**Table 5 : Ranking of five desirable parent on the basis of *per se* performance and GCA effects for 13 characters in rice**

| Characters | Desirable parent based on *per se* performance | Best general combiners | Best parent based on *per se* performance and gca effects |
|---|---|---|---|
| Seedling height (cm) | NDRK 5095 | NDRK 5095 | NDRK 5095 |
| | Narendra Usar 3 | NDRK 5013 | |
| | NDR 9830148 | IR 58025 A | |
| | 92-H 51-4 | PNL 1-8-5-17-2 | PNL 1-8-5-17-2 |
| | PNL 1-8-5-17-2 | NDR 9830148 | NDR 9830148 |
| Number of leaves per Seedling | PUSA 6A | NDRK 5095 | NDR 9830148 |
| | IR 58025 A | IR 61920-3B-22-2-1 | |
| | IR 688897A | NDRK 5013 | |
| | IR 64 | NDR 9830148 | |
| | NDR 9830148 | 21-2-5-B-1-1 | |
| Days to 50% flowering | IR 688897A | Sarjoo 52 | Sarjoo 52 |
| | IR 58025 A | NDRK 5056 | IR 688897A |
| | NDRK 5013 | IR 688897A | |
| | PNL 1-8-5-17-2 | CSRC(S) 14-1-4-0 | |
| | Sarjoo 52 | PUSA 6A | |
| Flag leaf area ($cm^2$) | 92-H 51-4 | 92-H 51-4 | 92-H 51-4 |
| | PNL 1-8-5-17-2 | IR 61920-3B-22-2-1 | |
| | 21-2-5-B-1-1 | CSRC(S) 14-1-4-0 | |
| | Narendra Usar 3 | NDR 9830119 | |
| | NDRK 5095 | IR 61920-3B-22-2-1 | |
| Plant height (cm) | PUSA 6A | CST 7-1 | PUSA 6A |
| | IR 58025 A | Sarjoo 52 | |
| | IR 688897A | PNL 5-8-1-7-21 | IR 688897A |
| | IR 71829-3R-73-1-2-B | PUSA 6A | |
| | CST 7-1 | IR 688897A | |
| Panicle bearing tillers per plant | IR 688897A | Sarjoo 52 | Sarjoo 52 |
| | Sarjoo 52 | IR 72048-B-R-2-2-2-1-B | IR 72048-B-R-2-2-2-1-B |
| | PUSA 6A | IR 71829-3R-73-1-2-B | |
| | IR 58025 A | Narendra Usar 3 | |
| | IR 72048-B-R-2-2-2-1-B | IR 688897A | IR 688897A |
| Panicle length (cm) | IR 72048-B-R-2-2-2-1-B | IR 72048-B-R-2-2-2-1-B | IR 72048-B-R-2-2-2-1-B |
| | 92-H 51-4 | NDRK 5095 | NDRK 5095 |
| | NDRK 5095 | IR 70023-4B-R-12-3-1-1-B | IR 70023-4B-R-12-3-1-1-B |
| | IR 70023-4B-R-12-3-1-1-B | NDR 9830119 | |
| | Sarjoo 52 | IR 58025 A | |
| Spikelets $panicle^{-1}$ | IR 58025 A | Narendra Usar 3 | Narendra Usar 3 |
| | NDR 9830119 | NDRK 5094 | |
| | PUSA 6A | 21-2-5-B-1-1 | |
| | Narendra Usar 3 | NDRK 5056 | |
| | IR 688897A | 92-H 51-4 | |
| Spikelet fertility (%) | Sarjoo 52 | NDR 9830119 | |
| | IR 688897A | NDRK 5094 | |
| | IR 58025 A | IR 64 | |
| | PUSA 6A | Narendra Usar 3 | |
| | CSRC(S) 14-1-4-0 | NDRK 5056 | |
| Test weight (g) | IR 688897A | NDRK 5094 | |
| | Sarjoo 52 | 21-2-5-B-1-1 | |
| | IR 58025 A | NDRK 5013 | NDRK 5013 |
| | NDRK 5013 | NDRK 5095 | |
| | PUSA 6A | 21-2-5-B-1-1 | |
| Biological yield per plant (g) | Sarjoo 52 | Sarjoo 52 | Sarjoo 52 |
| | PNL 5-8-1-7-21 | NDR 9830119 | |
| | Narendra Usar 3 | 92-H 51-4 | 92-H 51-4 |
| | 92-H 51-4 | IR 58025 A | |
| | NDRK 5094 | IR 61920-3B-22-2-1 | |
| Harvest index (%) | IR 58025 A | Sarjoo 52 | Sarjoo 52 |
| | IR 688897A | Narendra Usar 3 | |
| | Sarjoo 52 | 21-2-5-B-1-1 | |
| | PUSA 6A | PNL 1-8-5-17-2 | |
| | PNL 5-8-1-7-21 | PNL 5-8-1-7-21 | PNL 5-8-1-7-21 |
| Grain yield per plant (g) | Sarjoo 52 | Sarjoo 52 | Sarjoo 52 |
| | PNL 5-8-1-7-21 | Narendra Usar 3 | PNL 5-8-1-7-21 |
| | Narendra Usar 3 | 21-2-5-B-1-1 | Narendra Usar 3 |
| | 92-H 51-4 | IR 72048-B-R-2-2-2-1-B | |
| | NDRK 5094 | PNL 5-8-1-7-21 | |

**Table 6 : Ranking of five desirable hybrids on the basis of *per se* performance and SCA effects for 13 characters in rice**

| Characters | Desirable parent based on *per se* performance | Desirable crosses based on SCA | Common crosses based on *per se* performance and SCA |
|---|---|---|---|
| Seedling height (cm) | IR 58025 A X NDRK 5013 (47.400) | IR 58025 A X IR 64 (11.215) | IR 58025 A X IR 64 |
| | IR 58025 A X IR 64 (46.633) | IR 58025 A X CST 7-1 (8.971) | IR 58025 A X CST 7-1 |
| | IR 58025 A X NDRK 5095 (46.267) | IR 688897A X IR 72048-B-R-2-2-2-1-B (7.546) | |
| | IR 58025 A X CST 7-1 (44.400) | IR 58025 A X 21-2-5-B-1-1 (5.771) | |
| | IR 58025 A X PNL 1-8-5-17-2 (43.533) | PUSA 6A X CSRC(S) 14-1-4-0 (5.528) | |
| Number of leaves per Seedling | IR 58025 A X NDRK 5013 (4.933) | IR 58025 A X NDRK 5013 (1.044) | IR 58025 A X NDRK 5013 |
| | PUSA 6A X IR 61920-3B-22-2-1 (4.800) | IR 58025 A X IR 64 (0.889) | |
| | PUSA 6A X NDR 9830148 (4.600) | PUSA 6A X Narendra Usar 3 (0.621) | |
| | IR 58025 A X NDRK 5095 (4.600) | IR 58025 A X PNL 1-8-5-17-2 (0.600) | IR 58025 A X NDRK 5095 |
| | IR 688897A X IR 61920-3B-22-2- (4.533)1 | IR 58025 A X NDRK 5095 (0.578) | |
| Days to 50% flowering | IR 58025 A X Sarjoo 52 (91.333) | PUSA 6A X IR 72048-B-R-2-2-2-1-B (-7.661) | |
| | IR 688897A X IR 61920-3B-22-2-1 (92.333) | PUSA 6A X NDRK 5094 (-7.183) | IR 688897A X IR 61920-3B-22-2-1 |
| | IR 688897A X NDRK 5013 (93.667) | IR 688897A X PNL 1-8-5-17-2 (-6.539) | |
| | IR 688897A X NDRK 5056 (94.667) | IR 688897A X IR 61920-3B-22-2-1 (-5.872) | |
| | IR 58025 A X NDRK 5086 (94.667) | IR 58025 A X NDRK 5086 | IR 58025 A X NDRK 5086 |
| Flag leaf area ($cm^2$) | IR 58025 A X IR 61920-3B-22-2-1 (50.533) | IR 58025 A X IR 61920-3B-22-2-1 (8.204) | IR 58025 A X IR 61920-3B-22-2-1 |
| | IR 58025 A X 92-H 51-4 (48.333) | IR 58025 A X NDR 9830119 (5.902) | IR 58025 A X 92-H 51-4 |
| | IR 58025 A X NDR 9830119 (46.400) | IR 58025 A X 92-H 51-4 (4.446) | IR 58025 A X NDR 9830119 |
| | IR 58025 A X NDRK 5094 (43.733) | IR 58025 A X NDRK 5094 (4.335) | IR 58025 A X NDRK 5094 |
| | IR 58025 A X CSRC(S) 14-1-4-0 (41.467) | IR 58025 A X CSRC(S) 14-1-4-0 (4.168) | IR 58025 A X CSRC(S) 14-1-4-0 |
| Plant height (cm) | PUSA 6A X CST 7-1 (84.033) | IR 58025 A X PNL 5-8-1-7-21 (-11.200) | |
| | PUSA 6A X NDRK 5086 (86.033) | IR 58025 A X CST 7-1 (-10.266) | |
| | IR 58025 A X CST 7-1 (87.800) | IR 58025 A X IR 64 (-8.733) | IR 58025 A X CST 7-1 |
| | PUSA 6A X 92-H 51-4 (90.000) | IR 58025 A X Sarjoo 52 (-8.111) | |
| | PUSA 6A X NDRK 5095 (90.033) | IR 58025 A X NDRK 5056 (-7.300) | |
| Panicle bearing tillers per plant | IR 688897A X Sarjoo 52 (22.800) | IR 58025 A X 21-2-5-B-1-1 (2.357) | |
| | PUSA 6A X Sarjoo 52 (22.333) | IR 58025 A X IR 71829-3R-73-1-2-B (2.068) | IR 58025 A X IR 71829-3R-73-1-2-B |
| | IR 58025 A X Sarjoo 52 (22.000) | IR 58025 A X NDRK 5056 (1.957) | |
| | IR 58025 A X IR 71829-3R-73-1-2-B (16.8667) | IR 58025 A X NDRK 5086 (1.935) | IR 58025 A X NDRK 5086 |
| | IR 58025 A X NDRK 5086 (16.2667) | PUSA 6A X NDRK 5013 (1.812) | |
| Panicle length (cm) | IR 58025 A X NDRK 5095 (31.267) | IR 58025 A X 21-2-5-B-1-1 (3.532) | IR 58025 A X 21-2-5-B-1-1 |
| | IR 58025 A X 21-2-5-B-1-1 (30.533) | IR 688897A X 92-H 51-4 (3.351) | |
| | IR 58025 A X IR 70023-4B-R-12-3-1-1-B (30.467) | IR 58025 A X NDRK 5094 (2.554) | |
| | IR 688897A X IR 72048-B-R-2-2-2-1-B (30.000) | PUSA 6A X IR 64 (2.184) | |
| | IR 58025 A X NDR 9830119 (29.600) | PUSA 6A X 92-H 51-4 (2.184) | |
| Spikelets panicle$^{-1}$ | IR 58025 A X Narendra Usar 3 (285.733) | IR 688897A X IR 70023-4B-R-12-3-1-1-B (43.583) | IR 58025 A X Narendra Usar 3 |
| | IR 58025 A X 21-2-5-B-1-1 (273.000) | IR 58025 A X 21-2-5-B-1-1 (35.172) | IR 58025 A X 21-2-5-B-1-1 |
| | IR 58025 A X NDR 9830119 (257.333) | IR 58025 A X CST 7-1 (33.905) | |
| | IR 58025 A X IR 72048-B-R-2-2-2-1-B (249.133) | IR 58025 A X Narendra Usar 3 (32.661) | |
| | PUSA 6A X NDR 9830119 (246.000) | IR 688897A X IR 61920-3B-22-2-1 (32.583) | |

*Table 6 Contd….*

*Contd… Table 6*

| | | | |
|---|---|---|---|
| Spikelet fertility (%) | IR 688897A X IR 64 (92.333) | PUSA 6A X 92-H 51-4 (21.607) | |
| | IR 58025 A X NDR 9830148 (91.800) | IR 688897A X 92-H 51-4 (18.715) | IR 58025 A X NDR 9830148 |
| | IR 688897A X IR 70023-4B-R-12-3-1-1-B (91.467) | IR 58025 A X NDR 9830148 (18.378) | |
| | IR 58025 A X IR 72048-B-R-2-2-2-1-B (91.333) | IR 58025 A X IR 71829-3R-73-1-2-B (17.067) | |
| | IR 58025 A X Narendra Usar 3 (91.200) | PUSA 6A X NDRK 5086 (15.484) | |
| Test weight (g) | IR 688897A X Sarjoo 52 27.800) | IR 58025 A X IR 71829-3R-73-1-2-B (6.394) | IR 58025 A X IR 71829-3R-73-1-2-B |
| | IR 58025 A X IR 71829-3R-73-1-2-B (27.487) | IR 58025 A X NDRK 5086 (3.829) | |
| | IR 58025 A X 21-2-5-B-1-1 (26.933) | IR 688897A X 92-H 51-4 (3.810) | |
| | IR 58025 A X CST 7-1 (26.800) | IR 688897A X IR 64 (3.596) | IR 58025 A X CST 7-1 |
| | IR 58025 A X NDR 9830119 (26.667) | IR 58025 A X CST 7-1 (3.270) | |
| Biological yield per plant (g) | IR 58025 A X IR 61920-3B-22-2-1 (297.000) | IR 58025 A X IR 61920-3B-22-2-1 (109.470) | IR 58025 A X IR 61920-3B-22-2-1 |
| | IR 58025 A X CST 7-1 (246.933) | IR 58025 A X CST 7-1 (76.737) | IR 58025 A X CST 7-1 |
| | IR 58025 A X 92-H 51-4 (231.000) | IR 688897A X Sarjoo 52 (46.554) | IR 688897A X Sarjoo 52 |
| | IR 58025 A X NDR 9830119 (220.600) | IR 58025 A X IR 72048-B-R-2-2-2-1-B (37.570) | |
| | IR 688897A X Sarjoo 52 (213.633) | IR 58025 A X CSRC(S) 14-1-4-0 29.770) | |
| Harvest index (%) | IR 58025 A X 21-2-5-B-1-1 (49.143) | IR 58025 A X IR 71829-3R-73-1-2-B (18.674) | IR 58025 A X 21-2-5-B-1-1 |
| | IR 58025 A X Narendra Usar 3 (48.547) | PUSA 6A X 92-H 51-4 15.663) | IR 58025 A X Narendra Usar 3 |
| | IR 688897A X Sarjoo 52 (46.943) | IR 58025 A X NDRK 5056 (13.643) | |
| | IR 58025 A X IR 71829-3R-73-1-2-B (45.950) | IR 58025 A X 21-2-5-B-1-1 (13.512) | IR 58025 A X IR 71829-3R-73-1-2-B |
| | PUSA 6A X Sarjoo 52 (44.723) | IR 58025 A X Narendra Usar 3 (12.590) | |
| Grain yield per plant (g) | IR 688897A X Sarjoo 52 (100.2933) | IR 58025 A X 21-2-5-B-1-1 (35.624) | IR 688897A X Sarjoo 52 |
| | IR 58025 A X 21-2-5-B-1-1 (95.993) | IR 58025 A X IR 71829-3R-73-1-2-B (33.050) | IR 58025 A X 21-2-5-B-1-1 |
| | PUSA 6A X Sarjoo 52 (91.840) | IR 58025 A X CST 7-1 (26.717) | |
| | IR 58025 A X Narendra Usar 3 (86.980) | IR 58025 A X Narendra Usar 3 (22.293) | IR 58025 A X Narendra Usar 3 |
| | IR 58025 A X IR 71829-3R-73-1-2-B (78.000) | IR 688897A X Sarjoo 52 ( 18.869) | IR 58025 A X IR 71829-3R-73-1-2-B |

the extra cost of hybrid seeds. The favourable *per se* performances and higher significant positive SCA effects in related to grain yield plant$^{-1}$ were found in hybrid IR 688897A X Sarjoo 52 , IR 58025 A X 21-2-5-B-1-1, IR 58025 A X Narendra Usar 3 and IR 58025 A X IR 71829-3R-73-1-2-B. These combinations proved to be good hybrids based on CMS system in rice.

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