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Combining ability Studies in the Selected Parents and Hybrids in Rice (*Oryza sativa* .L)

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ABSTRACT

The present investigation entitled "Combining ability studies in the selected parents and hybrids (Oryza sativa .L)" was undertaken to study the combining ability through L x T design of experimental hybrids for single plant yield and its components in Telangana .Five CMS lines were crossed with 13 R lines and the resultant 65 hybrids along with the parents and five checks viz.,KRH-2, DRRH-2, PA-6201 Jaya, and IR- 64 were evaluated for combining ability (Line x Tester design) at three locations viz., Kunaram (Karimnagar District),Warangal and Kampasagar (Nalgonda District) of Telangana .Among the lines APMS 6 A and among the testers JGL 8292, JGL 8605, JGL 17211, JGL 13515 and JGL 3844 are proved to be good combiners for majority of the characters including the yield, by exhibiting the high gca effects. Out of 65 hybrids, the top five hybrids based on sca effects are APMS 8 A x JGL 11110-2 (7.01), APMS 8 A x JGL 11110-1 (5.48), APMS 6 A x JGL 1111-2 (4.77), APMS 8 A x JGL 13515 (4.01) and APMS 8 A x JGL 8605 (3.93), while the mean performance ranged from 27.64 g/plant to 31.22 g/plant. Among the 65 hybrids tested at three locations 21 hybrids, recorded significant positive gca effects for single plant yield.

Key words: *Oryza sativa, heterosis, dominance and epistasis.*

INTRODUCTION

Rice occupies an important place in Indian agriculture, with 43.5 million ha of area which is the largest in the world, with an annual production of around 90 million tons which is the second largest in the world after China. To meet the demands of increasing population and to maintain self sufficiency, the present production levels needs to be increased up to 120 million tons by 2020. The production of rice needs to be increased by almost 2 million tons every year. For the development of rice hybrids through cytoplasmic genetic male sterility, identification of maintainers and restorers from the local elite lines is utmost important. The choice of suitable parents with favourable alleles, which on crossing could produce heterotic hybrids, is also important. Combining ability of the parents provides useful information on their selection for better performance of hybrids besides elucidating the nature and magnitude of gene action in the inheritance of a particular character. The line x tester analysis of combining ability proposed by Kempthorne (1957) is the most commonly used method to find out the general and specific combiners and to study the nature of gene action governing the inheritance of different characters.

MATERIALS

Among the restorers having more than 80% fertility restorability, 12 lines i.e. JGL11110-2, JGL 11160, JGL11110-1, JGL 8292, J GL 16284, JGL 11111, JGL 3844, JGL 3855, JGL 17211, JGL 11118, JGL 13515, JGL 8605 are selected and one line is selected i. e. JGL 1798 from group of partial restorers for further study to develop gall midge resistant, 65 hybrids by crossing with 5 CMS lines, by following same procedure of hybridization as done in earlier experiment. The parents and hybrids developed were used as material to study

List of male sterile and successful restorer lines and checks used to study combining ability, heterosis, gall midge resistance and stability.			
S. No	**CMS lines**	**Charecters**	**Source**
1	**IR-68897A**	Short duration, Long slender grain	**IRRI , Philippines (DRR)**
2	**APMS 8A**	Medium duration, Medium slender grain	**ANGRAU (RARS Maruteru)**
3	**CMS 16A**	Medium duration, Medium slender grain	**ANGRAU (RARS Maruteru)**
4	**APMS 6A**	Medium duration, Medium slender grain	**ANGRAU (RARS Maruteru)**
5	**IR-58025A**	Medium duration, Long slender grain	**IRRI , Philippines (DRR)**
Restorer lines			
1	**JGL 11110-2**	Medium duration , Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
2	**JGL 11110-1**	Medium duration , Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
3	**JGL 17211**	Medium duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
4	**JGL 16284**	Medium duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
5	**JGL 13515**	Medium duration , Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
6	**JGL 11160**	Medium duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
7	**JGL 11118**	Short duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
8	**JGL 11111**	Short duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
9	**JGL 8605**	Medium duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
10	**JGL 8292**	Medium duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
11	**JGL 3855**	Medium duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
12	**JGL 3844**	Short duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
13	**JGL 1798**	Short duration, Medium slender grain	**ANGRAU (R.A.R.S Jagtial)**
Checks			
1	**KRH-2**	Short duration, Long slender grain	**Directorate of Rice Research**
2	**DRRH-2**	Short duration , Medium slender grain	**Directorate of Rice Research**
3	**PA 6201**	Short duration, Long slender grain	**Private company (Pro-agro)**
4	**JAYA**	Medium duration, Medium slender grain	**Directorate of Rice Research**
5	**IR-64**	Short duration, Long slender grain	**Directorate of Rice Research**

hybrids and parents for Combining ability, Heterosis and response to gall midge resistance over locations along with six (5) checks.

METHODS

The 65, hybrids developed along with 13, lines with 5, testers and 5, checks were sown at three locations i.e, at Kunaram, Warangal, Kampasagar to transplant in LX T design with each entry in two rows of 2 m length with a spacing of 20x15 cm in three replications.

Observations recorded

Five plants were tagged at random for each entry in each replication and observations were recorded for yield and yield attributing characters viz., Days to 50 % flowering (DFF), Number of productive tillers per plant, Panicle length (cm), Spikelet fertility %, 1000 seed weight (g), Grain Yield per plant (g) from these tagged plants in all the genotypes in each replication. The data recorded on different traits were subjected to the following statistical analysis.

Analysis of variance

RBD Analysis: The adopted design was Randomized Complete Block Design (RCBD) replicated thrice. The analysis of variance was carried out by the method of Panse and Sukhatme (1985).

Line x Tester Analysis

The data recorded as per Line x Tester model of Kempthorne (1957) were subjected to analysis of variance as per the Line x Tester model given by Singh and Chaudhary (1985).

RESULTS AND DISCUSSIONS

Combining ability variances and gene action

General combining ability is associated with additive gene action, while specific combining ability is due to non-additive gene action i.e. dominance and epistasis. In the present investigation, it was found that SCA variances were higher than GCA variances for most of the characters, which indicated the predominance of non-additive gene action.

It is evident from the different studies, the predominance of non-additive gene action over the additive component, which is ideal for exploitation through heterosis breeding.

A comparison of the magnitude of variance components due to gca and sca confirmed the nature of gene action in controlling the expression of traits. The ratio of gca and sca variance was less than unity in pooled analysis indicating predominant role of non-additive gene action for all the characters under study.

Degree of dominance

The degree of dominance was estimated for all the twelve characters indicated that the degree of dominance was more than unity for all the traits except for plant height at Warangal is cause of the heterosis and spikelet fertility percentage at Kunaram location, which indicates over dominance.

The contribution of lines was not high for any triat investigated, while the contribution of testers was high for only two characters *i.e.*, gallmidge damage plants (%) and silver shoots (%). The contribution of line x tester interaction was high for all characters ranging between 49.87 (%) (plant height) to 89.61(%) gall midge silvershoots (%).

General and specific combining ability effects JGL 11160 had significant negative sca effect at all the three locations as well as in pooled analysis.

With respect to 50% flowering in pooled analysis, out of 65 hybrids, 20 hybrids recorded significant negative sca effect.The hybrids IR 58025A x JGL 11160 (-8.81), IR 68897A x JGL 3855 (-9.09), CMS 16A x JGL 11110-1 (-7.87), APMS 8A x JGL 16284 (-7.24) and IR 68897A x JGL 11110-1 (-6.32) recorded high significant negative sca effects.

The hybrid IR 58025A x JGL 11160 and APMS 8A x JGL 16284 had both parents with low gca effects resulted in high sca effect, the superiority of low x low combinations might be due to concentrations and interaction between favourable genes contributing by parents. The hybrids IR 68897A x JGL 3855 and APMS 8A x JGL 16284, the parents with high and low gca effects resulted in high sca effects in hybrids which may be due to high frequency of dominant alleles for earliness. While, the hybrid IR 68897A x JGL 11110-1 resulted in high sca effects, where the parents are also having high gca effects, may be due to predominance of additive gene action in the cross. It is noticed from the above results that there was no correlation to predict that, parents of significant negative gca effects combine to give rise to hybrids of significant negative sca effects in some crosses. The mean performance ranged between 86 to 95 days among top 5 hybrids (Table 4.25).

4.2.6.5 Number of productive tillers/plant :(a) gca effect Among the testers IR 58025A had significant gca effect at Warangal, Kampasagar and pooled analysis. APMS 6A and CMS 16A at Kunaram CMS 16A in pooled analysis also had significant gca effects.

Among the lines 4 at Kunaram, 6 at Warangal, 5 at Kampasagar and 4 in pooled analysis had significant positive gca effects. The lines JGL 11110-1, JGL 17211, JGL 16284 and JGL 11111 had high significant gca effects at two locations as well as in pooled analysis

(b) sca effects

Out of 65 hybrids one at Kunaram, 21 at Warangal, 15 at Kampasagar and 17 in pooled analysis had significant positive sca effects. The hybrids IR 68897A x JGL 8605, IR 68897A x JGL 1798, APMS 8A x JGL 11118, APMS 16 A x JGL 11110-2, APMS 16 A x JGL 111160, APMS 16 A x JGL 1798, APMS 6A x JGL 11110-1, APMS 6A x JGL 11111, APMS 6A x JGL 1798 and IR 58025A x JGL 17211, had significant sca effects at two locations as well as in pooled analysis.

For number of productive tillers per plant, 21hybrids in pooled analysis, had significant positive sca effects.The hybrids APMS 6A x JGL 8292 (3.19), IR 58025A x JGL 3855 (3.13), APMS 6A x JGL 1798 (3.09), IR 58025A x JGL 8292 (2.52) and CMS 16A x JGL 16284 (1.74), recorded high sca effects, in which the mean performance ranged from 9 to 16.

Among five top hybrids with high sca effects the parents of three IR 58025A x JGL 3855 (3.13), APMS 6A x JGL 1798 (3.09), IR 58025A x JGL 8292 (2.52) hybrids have one of the parents with high or low gca effects, resulting in high sca effects in the hybrids, may be due to predominance of dominant alleles.

One hybrid with parents APMS 6A x JGL 8292 (3.19) having low gca effects resulted in hybrid with high sca effect which may be due to accumulation of favourable alleles, while another hybrid, with parents CMS 16A x JGL 16284 (1.74) having high gca effects resulted in hybrid with high sca effect, may be due to predominance of additive gene action in the cross. However, it indicates that there is no correlation between the gca and sca effects of parent and hybrids respectively (Table 4.25). Similar results with high x low, or low x low or high x high gca combinations were reported by Raju *et al. (*2006), Hariprasanna *et al.* (2006), Salgotra *et al*. (2009), Gupta (1981) also observed that gca of the parents in general had no bearing on the sca effects of the cross i.e. the cross involving parents with high gca recorded less sca effects, while the parents with poor gca effect exhibited high sca effects. This may be due to genetic diversity in the form of number of heterozygous loci in the parents as reported by Pathak *et al.* (1993).

Panicle length

(a) gca effects

Among the testers CMS 16A at Kunaram, IR 58025A at Warangal and APMS 8A at Kunaram, Warangal and pooled analysis had significant positive gca effects.

Out of 13 lines, 4 lines at Kunaram 2 lines at Warangal, 2 lines at Kampasagar and 8 in pooled analysis had significant positive gca effects. The line JGL 11110-1 recorded positive significant gca effect at three locations and in pooled analysis.

(b) sca effects

At Kunaram 17 hybrids, at Warangal 10 hybrids, at Kampasagar 15 hybrids and in pooled analysis 15 hybrids had significant positive sca effects for panicle length. The hybrid IR 68897Ax JGL 11110-2 had significant positive gca effects at three locations and in pooled analysis. Seven hybrids (IR 68897A x JGL 11110-2, IR 68897A x JGL 11111, CMS 16A x JGL 11110-2, APMS 6A x JGL 11110-2, IR 58025A x JGL 11110-2, 58025A x JGL 17211, and 58025A x JGL 11111) recorded positive significant sca effect at two locations and in pooled analysis.

In pooled analysis 15 hybrids had significant positive sca effects for panicle length. The top 5 hybrids with high sca effects for panicle length are, IR 68897A x JGL 11110-2 (2.23), IR 58025A x JGL 11111 (2.16), CMS 16A x JGL 11110-2 (1.82), IR 58025 x JGL 3855 (1.70) and IR 68897A x JGL 11111 (1.52).

Among the five hybrids 4 hybrids with parents IR 68897A x JGL 11110-2, IR 58025A x JGL 11111, CMS 16A x JGL 11110-2 and IR 68897A x JGL 11111 having low x high gca effects, resulted in high sca effects for hybrids indicating the high frequency of dominant alleles contributing for panicle length, where as one hybrid is having parents IR 58025A x JGL 3855 with low x low gca effects resulted in high sca effect in hybrids, indicating no correlation between gca effects of parents and sca effects of hybrids.The mean performance of these top five hybrids for panicle length ranged between 23.78 to 25.83 cm (Table 4.25). In contrary to this, high x high and high x low gca effects were reported by Salgotra *et al.* (2009).

Spikelet fertility (%)

(a) gca effects Among the testers IR 68897A had positive significant gca effects for spikelet fertility per cent at all the three locations and in pooled analysis. While CMS 16A was positive and significant at Warangal, Kampasagar and pooled analysis

Among the lines, 7 at Kunaram, 7 at Warangal, 4 at Kampasagar and 6 in pooled analysis had significant positive gca effects. The line JGL 11110-2 had significant gca effect at Kunaram and Warangal and in pooled analysis for spikelet fertility percentage. The lines JGL 11118, JGL 8605 and JGL 3844 had significant positive gca effects at all the locations and in pooled analysis.

(b) sca effects

Out of 65 hybrids tested 26 at Kunaram, 25 at Warangal, 25 at Kampasagar and 30 in pooled analysis had significant positive sca effects for spikelet fertility percentage. The hybrids IR 68897A x JGL 172111, APMS 8A x JGL 13515, APMS 8A x JGL 8605,CMS 16A x JGL 8292, APMS 6A x JGL 11110-2 and IR 58025A x JGL 11160, recorded significant positive sca effects at two locations and in pooled analysis for spikelet fertility percentage. The hybrids APMS 8A x JGL 11110-2, APMS 8A x JGL 8292, CMS 16A x JGL 3855 and IR 58025A x JGL 3855 recorded significant positive sca effects at three locations and in pooled analysis for spikelet fertility percentage

Spikelet fertility is one of the important traits in rice as it is the deciding factor of the yield potential of rice hybrids. The hybrids CMS 16A x JGL 1798 (19.16), APMS 6A x JGL 1798 (14.71), CMS 16A x JGL 3855 (13.06), APMS 8A x JGL 11110-2 (12.34) and APMS 6A x JGL 11110-2 (11.89) recorded high sca effects among 65 hybrids. The mean performance of these hybrids ranged from 52.5(%) to 89.13(%). Among the top five hybrids the three hybrids have both parents having low gca effects resulted in hybrid with high sca effects, which may be due to accumulation of favourable alleles.

The one hybrid with parents CMS 16A x JGL 3855having with high gca effect resulted in high sca effect, while in another hybrid CMS 16A x JGL 1798 with parents having one of the parents with high or low gca effects resulted in a hybrid with high sca effect, other three hybrids APMS 6A x JGL 1798, APMS 8A x JGL 11110-2 and APMS 6A x JGL 11110-2 having both the parents with low x low gca effects resulted in high sca effect in hybrid indicating that there is no correlation between gca and sca effects of parents and hybrids(Table 4.25). However, parents with high x low, low x high or high x high gca and sca effects of parents and hybrids. However, parents with high x low, low x high or high x high gca effects were also reported by Salgotra *et al.* (2009).

4.2.6.12 1000 grain weight

(a) gca effects Among the testers IR 58025A at Warangal and pooled analysis, IR 68897A and APMS 8A at Kampasagar and pooled analysis showed significant positive gca effects.APMS 6A recoded significant negative gca effect at all the three locations and in pooled analysis.

Among the lines, 2 at Kunaram, 5 at Warangal, 6 at Kampasagar and 4 in pooled analysis had significant positive gca effects. The line JGL 11110-1 had significant positive gca effect at all the three locations and in pooled analysis. Three lines recorded negative gca effect at all the three locations and in pooled analysis.

(b) sca effects

Out of 65 hybrids tested 1 at Kunaram, 22 hybrids at Warangal, 26 hybrids at Kampasagar and 16 hybrids in pooled analysis shown significant positive sca effects. The hybrid IR 68897A x JGL 11110-2, IR 68897A x JGL 16284, IR 68897A x JGL 1798, APMS 8A x JGL 13515, APMS 8A x JGL 3844, CMS 16A x JGL 17211, CMS 16A x JGL 11160, CMS 16A x JGL 3844, APMS 6A x JL 3855 and IR 58025A x JGL 11111 were significant at Warangal, Kampasagar locations and in pooled analysis (Table 4.25).Three hybrids(IR 68897A x JGL 11110-1, IR 68897A x JGL 17211 and APMS 8A x JGL 1110-2) recorded significant negative sca effect at three locations and in pooled analysis.

In respect of 1000 grain weight, out of 65 hybrids, 16 hybrids in pooled analysis showed, significant positive sca effects. The hybrids, which recorded high sca effects are, IR 68897A x JGL 1798 (3.49), APMS 6A x JGL 17211 (3.11), IR 68897A x JGL 11110-2 (3.00), APMS 8A x JGL 13515 (2.78) and CMS 16A x JGL 17211 (2.76). The range of mean performance for 1000 grain weight ranged between 19.98 gm to 22.70 gm.

Among the top five hybrids, the three hybrids IR 68897A x JGL 1798, IR 68897A x JGL 11110-2 and APMS 8A x JGL 13515 have with one of the parent with high or low gca, resulted in hybrid with high gca effect, while in other two hybrids APMS 6A x JGL 17211 and CMS 16A x JGL 17211the parents recorded low gca effects, lead to a hybrid with high sca effect for the character 1000 grain weight. Hence, it could be suggested that information on gca effects should be supplemented by sca effects and *per se* performance of crosses for identifying the transgressive seggregants (Table 4.25). Similar results of high x low or low x high or low x low or high x high gca combinations were reported by Raju *et al.* 2006 and Hariprasanna *et al.* 2006.

4.2.6.13 Single plant yield

(a) gca effects

Among the testers APMS 6A had significant positive gca effects at all the three locations and in pooled analysis. Among the lines 5 at Kunaram, 6 at Warangal, 5 at Kampasagar and 6 in pooled analysis had significant positive gca effects for single plant yield. The lines JGL 17211, JGL 13515, JGL 8605 and JGL 3844 recorded the significant positive gca effects for single plant yield at all the three locations and in pooled analysis.

(b) sca effects

Among the 65 hybrids tested at three locations, 20 at Kunaram, 20 at Warangal 27 at Kampasagar and 29 in pooled analysis recorded significant positive sca effects for single plant yield . The hybrids IR 68897A x JGL 16284, IR 68897A x JGL 8292, APMS 8A x JGL 11110-2, APMS 8A x JGL 11110-1, APMS 8A x JGL 13515, APMS 8A x JGL 8605, CMS 16A x JGL 16284, APMS 6A x JGL 11110-2, APMS 6A x JGL 11111, IR 58025A x JGL 16284, APMS 8A x JGL 11111, CMS 16A x JGL 13515, CMS 16A x JGL 11118, APMS 6A x JGL 11111, APMS 6A x JGL 8605 and IR 58025A x JGL 8605 recorded significant positive sca effects at all the three locations and in pooled analysis. Single plant yield is the ultimate trait which determines the worthiness of a hybrid. The top five hybrids based on sca effects are APMS 8A x JGL 11110-2 (7.01), APMS 8A x JGL 11110-1 (5.48), APMS 6A x JGL 1111-2 (4.77), APMS 8A x JGL 13515 (4.01) and APMS 8A x JGL 8605 (3.93). The mean performance of these hybrids ranged from 27.64 g/plant to 31.22 g/plant. Among the 65 hybrids tested, 13 hybrids, recorded significant positive sca effects at all the three locations and in pooled analysis for single plant yield.

Three hybrids out of top five hybrids APMS 6A x JGL 11110-2, APMS 8A x JGL 13515 and APMS 8A x JGL 8605 have one of the parent with high gca another parent with low gca, resulted in hybrid with high sca effect, for the character single plant yield, which may be due to the predominance of dominat allele, while in other two hybrids, APMS 8A x JGL 11110-2 and APMS 8A x JGL 11110-1 the parents recorded low gca effects, led to a hybrid with high sca effect, which may be due to accumulation of favourable alleles and non-additive gene action(Table 4.25). Similar findings as observed in the present study were also reported by, Hariprasanna *et al.* 2006, Dalvi and Patel, 2009 and Salgotra *et al.* 2009.

The overall study of sca effects of different traits, in the present investigation reveals that sca effects and *per se* performance of the crosses were not closely related. The crosses with high *per se* performance need not be the one with high sca effects and *vice versa.* In majority of the crosses for all the characters investigated, high sca was either due to high x low or low x high or low x low combining parents, which further substantiate the operation of non-additive gene action (additive x dominance and dominance x dominance type of epistatic interaction). An ideal combination to be explored is one where high magnitude of sca is present, in addition to high gca effect in both or at least one of the parents. Similar results were reported by Banumurthy *et al.* 2003; Hariprasanna *et al.* 2006; Dalvi and Patel, 2009 and Salgotra *et al.* 2009.

The gca effects of the parents revealed that, the tester APMS 6A was the best general combiner for most of the traits like 1000 grain weight, panicle weight, filled grains per panicle, spikelet fertility (%), grain yield per plant and productivity per day, exhibiting significant positive gca effects.

Among the lines, JGL 8292, JGL 8605, JGL 17211, JGL 13515 and JGL 3844 were identified as best general combiners for majority of the yield and important yield components *viz*., JGL 8292 for plant height, productivity per day, panicle length, panicle weight, spikelet fertility, 1000 grain weight and grain yield per plant, JGL 8605 for plant height, flag leaf length, productive tillers per panicle, spikelet fertility, grain yield, per plant and productivity per day, JGL 17211 is best general combiner for the characters, flag leaf width, productive tillers per plant, 1000 grain weight, panicle weight, spikelet fertility, filled grains per panicle, grain yield per plant and productivity/day, JGL 13515 is best general combiner for the characters, days to 50% flowering, plant height, 1000 grain weight, panicle weight, spikelet fertility%, grain yield per plant and productivity per day and JGL 3844 is best general combiner for the characters, plant height, panicle length, panicle weight, filled grains per panicle, spikelet fertility, grain yield per plant and productivity per day, as these testers exhibited significant positive gca effects for the above characters. It was observed in certain instances that the lines and testers with good *per se* performance are not be good general combiners and vice versa, thus the association between per se performance and gca effects was evident in the present study indicated the effectiveness of choice of parents based on per se performance alone was not appropriate for predicting the combining ability of the parents.

Among the testers APMS 6A and among the lines JGL 8292, JGL 8605, JGL 17211, JGL 13515 and JGL 3844 are proved to be good combiners for majority of the characters including the yield, by exhibiting the high gca effects. Hence, these females and male parents could be considered as potential donors in improving single plant yield and its components need to be exploited in future breeding programme.

On the whole, among the testers APMS 8A and APMS 6A, among the lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 JGL 8292 and among hybrids APMS 8A x JGL11110-1, APMS 8A x JGL 11110-2, APMS 6A X JGL 11110-1, APMS 6A x JGL 11111, APMS 6A x JGL8605 and APMS 6A X JGL 8292 are found to be the best.

The gca effects are significant for panicle length in APMS 8A and significant for yield in APMS 6A.

The positive significant gca effects were recorded for productive tillers/ plant in JGL8605, JGL11110-1for panicle length in JGL11110-1, JGL11111, JGL 8605, JGL8292, JGL11110-2 for filled grains/ panicle, in JGL11111 for 1000 grain weight in JGL11110-1, for yield/ plant, in JGL8292, JGL11111 and JGL8605.

The hybrids APMS 6A x JGL8292, APMS 6A x JGL11110-1 recorded significant positive sca effects for productive tillers/ plant, similarly the hybrids APMS 6A x JGL11110-1, APMS 6A x JGL11111 recorded significant positive sca effects for panicle length, the hybrids APMS 8A x JGL11110-1, APMS 8A x JGL11110-2, APMS 6A x JGL11111 recorded significant positive sca effects for filled grains/ panicle and the hybrids APMS 8A x JGL11110-2, APMS 8A x JGL11110-1, APMS 6A x JGL11110-1 APMS 6A x JGL11111 recorded significant positive sca effects for yield/ plant.

Table 4.25. Top five crosses with high *sca* effects, *per se* performance and *gca* effects of parents for grain yield and its component traits in rice

Character/ cross			*Sca* effects	Mean performance	*Gca* effects		Gca status
					Female parent	Male parent	
Days to 50% flowering							
IR 58025A	X	JGL 11160	-8.81**	87	1.41**	5.08**	LXL
IR 68897A	X	JGL 3855	-8.09**	91	-1.53**	3.35**	HXL
CMS 16A	X	JGL 11110-1	-7.87**	95	0.28	-6.70**	LXH
APMS 8A	X	JGL 16284	-7.24**	94	0	5.09**	LXL
IR 68897A	X	JGL 11110-1	-6.32**	86	-1.53**	-6.70**	HXH
Plant height							
IR 68897A	X	JGL 11160	-7.79**	83	-0.46	-3.04**	HXL
IR 58025A	X	JGL 3844	-7.74**	91	0.11	6.16**	LXL
APMS 6A	X	JGL 11118	-7.58**	96	0.61*	-6.35**	LXH
IR 68897A	X	JGL 11110-1	-7.54**	79	-0.46	-2.88**	HXH
CMS 16A	X	JGL 3855	-6.87**	85	0.70**	7.78**	LXL
Panicle length							
IR 68897A	X	JGL 11110-2	2.23**	25.83	-0.28**	2.23**	LXH
IR 58025A	X	JGL 11111	2.16**	24.13	0.10	1.52**	LXH
CMS 16A	X	JGL 11110-2	1.82**	24.33	0.20*	2.23**	LXH
IR 58025A	X	JGL 3855	1.70**	23.78	0.10	0.43	LXL
IR 68897A	X	JGL 11111	1.52**	24.85	-0.28**	1.52**	LXH
Panicle weight							
IR 68897A	X	JGL 16284	1.06**	3.99	-0.02	1.06**	LXH
APMS 6A	X	JGL 17211	0.87**	3.90	-0.11**	-0.48**	LXL
APMS 8A	X	JGL 11110-1	0.80**	3.80	0.13**	-0.27**	HXL
APMS 6A	X	JGL 11110-2	0.70**	3.99	-0.11**	0.22**	LXH
CMS 16A	X	JGL 11118	0.63**	3.64	0.17**	-0.85**	HXL
Flag leaf length							
IR 58025A	X	JGL 3855	5.70**	32.25	-0.07	0.11**	LXH
APMS 8A	X	JGL11110-1	5.00**	35.79	-0.21	-0.09**	LXL

CMS 16A	X	JGL 8292	4.89**	35.54	-1.35**	-0.09**	LXL
CMS 16A	X	JGL 17211	4.20**	34.38	-0.21	-0.18**	LXL
APMS 6A	X	JGL 11111	4.15**	32.73	0.58**	0.02	HXL
Flag leaf width							
CMS 16A	X	JGL 11160	0.34**	1.97	-0.01	0.07	LXL
APMS 6A	X	JGL 1798	0.33**	1.79	0.01	-0.03	LXL
APMS 8A	X	JGL 8605	0.31**	1.72	-0.04**	-0.07	LXL
IR 68897A	X	JGL 16284	0.27**	1.31	-0.04**	0.27**	LXH
IR 58025A	X	JGL 13515	0.23**	1.52	-0.03*	0.05	LXH
Productive tillers per plant							
APMS 6A	X	JGL 8292	3.19**	16	0.20	0.98*	LXL
IR 58025A	X	JGL 3855	3.13**	15	0.71**	0.68	HXL
APMS 6A	X	JGL 1798	3.09**	15	0.20	2.80**	LXH
IR 58025A	X	JGL 8292	2.52**	9	0.71**	0.98*	HXL
CMS 16A	X	JGL 16284	1.74**	15	0.56**	1.41**	HXH
1000-grain weight							
IR 68897A	X	JGL 1798	3.49**	21.26	0.23*	3.49**	LXH
APMS 6A	X	JGL 17211	3.11**	21.20	-0.81**	-1.71**	LXL
IR 68897A	X	JGL 11110-2	3.00**	22.70	0.23*	3.00**	LXH
APMS 8A	X	JGL 13515	2.78**	19.98	0.30**	-1.63**	HXL
CMS 16A	X	JGL 17211	2.76**	20.26	-0.17	-1.71**	LXL
Spikelet fertility							
CMS 16A	X	JGL 1798	19.16**	52.57	9.42**	-24.23**	HXL
APMS 6A	X	JGL 1798	14.71**	67.91	-14.06**	-24.23**	LXL
CMS 16A	X	JGL 3855	13.06**	89.13	1.91**	3.24**	HXH
APMS 8A	X	JGL 11110-2	12.34**	87.22	-1.01**	-3.07**	LXL
APMS 6A	X	JGL 11110-2	11.89**	86.56	-1.91**	-3.07**	LXL
Filled grains per panicle							
APMS 8A	X	JGL 11110-1	69.69**	184	-11.40**	-44.00**	LXL
IR 58025A	X	JGL 8292	65.72**	353	9.93**	-44.00**	HXL
APMS 8A	X	JGL 17211	60.33**	239	-11.40**	-51.13**	LXL
IR 68897A	X	JGL 16284	61.43**	179	6.11**	-8.74	HXL
IR 68897A	X	JGL 11111	54.14**	239	6.11**	-8.74	HXL
Grain yield per plant							
APMS 8A	X	JGL 11110-2	7.01**	31.22	-0.33**	0.06	LXL
APMS 8A	X	JGL 11110-1	5.48**	29.95	-0.33**	-0.83**	LXL
APMS 6A	X	JGL 11110-2	4.77**	27.64	0.53**	0.06	HXL
APMS 8A	X	JGL 13515	4.01**	26.65	-0.33**	1.20**	LXH
APMS 8A	X	JGL 8605	3.93**	27.71	-0.33**	0.76**	LXH
Productivity per day							
APMS 8A	X	JGL 11110-2	15.64**	99.82	-1.10**	-4.37**	LXL
CMS 16A	X	JGL 13515	13.90**	87.30	-0.46	7.59**	LXH
CMS 16A	X	JGL 3855	13.72**	95.91	-0.46	-9.74**	LXL
IR 68897A	X	JGL 11118	13.20**	69.75	0.97**	13.20**	HXH
APMS 6A	X	JGL 11110-2	13.18**	93.94	1.90**	-4.37**	HXL

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