"DEVELOPMENT OF GALL MIDGE RESISTANT HYBRIDS IN RICE (*Oryza sativa* L.)"

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M.Sc. (Ag.)

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(GENETICS AND PLANT BREEDING)

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BY

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M.Sc. (Ag.)

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DECLARATION

I, **CHENNAMADHAVUNI DAMODAR RAJU**, hereby declare that the thesis entitled **"DEVELOPMENT OF GALL MIDGE RESISTANT HYBRIDS IN RICE (*Oryza sativa* L.)"**Submitted to the Acharya N.G. Ranga Agricultural University for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURE** in the major field of **GENETICS AND PLANT BREEDING** is the result of original research work done by me. I further declare that the thesis or any part thereof has not been published earlier elsewhere in any manner.

Date: -12-2011 **(CHENNAMADHAVUNI DAMODAR RAJU)**

Place: Hyderabad

CERTIFICATE

Mr. CHENNAMADHAVUNI DAMODAR RAJU has satisfactorily prosecuted the course of research and that the thesis entitled **"DEVELOPMENT OF GALL MIDGE RESISTANT HYBRIDS IN RICE (*Oryza sativa* L.)"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

Date : -12- 2011
Place: Hyderabad

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Chairman of the Advisory Committee

CERTIFICATE

This is to certify that the thesis entitled **"DEVELOPMENT OF GALL MIDGE RESISTANT HYBRIDS IN RICE (*Oryza sativa* L.)"** submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURE (GENETICS AND PLANT BREEDING)** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Mr. CHENNAMADHAVUNI DAMODAR RAJU** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of investigation have been duly acknowledged by the author of the thesis.

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(**CHENNAMADHAVUNI DAMODAR RAJU**)

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
σ^2_e	:	Environmental variance
σ^2_g	:	Genotypic variance
σ^2_p	:	Phenotypic variance
σ_p	:	Phenotypic standard deviation
ANOVA	:	Analysis of Variance
ASIN	:	Arc SIN
cm	:	Centimeters
CMS	:	Cytoplasmic Male Sterile
d.f.	:	Degrees of freedom
et al.	:	And others
etc	:	And more
F_1	:	First filial generation
F_2	:	Second filial generation
Fig.	:	Figure
G x E	:	Genotype x Environment
gca	:	General combining ability
gm	:	Gram
Kg	:	Kilogram
MS	:	Mean Sum of Squares
^oC	:	Degrees Centigrade
P_1	:	Parent 1
P_2	:	Parent 2
RBD	:	Randomized Block Design
S.E	:	Standard Error
sca	:	Specific combining ability
viz.,	:	Namely
vs.	:	Versus
χ^2	:	Chi-square

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ABSTRACT

The present investigation entitled **"Development of Gall midge Resistant Hybrids in Rice (*Oryza sativa* L.)"** was undertaken to identify the effective restorers and maintainers among the gall midge resistant lines, based on the results parents were selected and mated in Line x Tester mating design to study the combining ability, magnitude of heterosis and to assess the stability of experimental hybrids for single plant yield and yield contributing characters in Telangana region of Andhra Pradesh. Further, an attempt was made to understand the inheritance pattern of fertility restoration for four crosses.

Out of 120 lines screened for restorer and maintainer reaction 22 lines exhibited very high spikelet fertility (>80%), 18 lines exhibited partial fertility (60 to 80%), 35 lines resulted low fertility (10 to 60%) and 45 lines recorded complete sterility/very low fertility (<10%).From the above results, 13 R lines were identified as male parents and crossed with five CMS lines in Line x Tester mating design resulting in 65 hybrids. The 18 parents ,65 hybrids and six checks *viz.*, KRH-2, DRRH-2, PA-6201 Jaya, IR-64 and TN_1 were evaluated for gall midge resistance, combining ability, heterosis and stability of the hybrids at three locations *viz.*, Kunaram (Karimnagar District), Warangal and Kampasagar (Nalgonda District) of Telangana region of Andhra Pradesh during *Kharif*, 2009.

The reaction of genotypes towards the gallmidge at three locations is different; the incidence recorded was more at Warangal, followed by Kampasagar and Kunaram. This may be due to the different biotypes existing at three locations. The R lines used are taken from RARS, Jagtial, which may be resistant to gallmidge biotype 3, due to existence of different biotypes of gallmidge at Warangal as well as at Kampasagar, the incidence percentage varied. However, some hybrids exhibited resistance reaction at all the three locations indicating the resistance of hybrids to different biotypes. Among the gallmidge resistant hybrids based on *per se* performance, the top five hybrids identified

are, APMS 6A x JGL 11111, APMS 6A x JGL 8292, IR 58025A x JGL 16284, IR 68897A x JGL 16284 and APMS 6A x JGL 13515. Out of five hybrids 4 are of medium duration and one is of short duration type.

Segregation pattern for spikelet fertility in F_2 generation of four crosses were studied, the results revealed that the F_2 populations of all the four crosses *viz.*, APMS 6A x JGL 11110-2, APMS 6A x JGL 11110-1, APMS 6A x JGL 17211 and APMS 6A x JGL 16284 exhibited a segregating ratio of 15:1 indicating duplicate dominant epistasis.

On the whole based on the overall performance, among the testers APMS 8A and APMS 6A, among the lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 and JGL 8292, 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 in the present investigation.

The overall study of sca effects of different traits, in the present investigation reveals that sca effects of *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*. The reason ascribed is due to positive interaction between nuclear and cytoplasmic genes appear to be important that the interaction between nuclear genes alone. 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.

Out of 65 hybrids tested for single plant yield, 61 hybrids are categorized under group (I) i.e. stable over three environments; the other 4 hybrids are included in groups (II), which were unstable. The 100% of the parents, 94% of the crosses 100% of the checks exhibited the stability over three environments, for the important character single plant yield.

Keeping in view of the above facts, by considering all the factors like, *per se* performance, sca effect, standard heterosis over PA 6201and KRH-2, average heterosis, heterobeltiosis, stability, duration, grain type, LB ratio, the most promising hybrids identified were APMS 8A x JGL 11110-2, APMS 6A x JGL 11111 and APMS 6A x JGL 8292.

The hybrid APMS 8A x JGL 11110-2 recorded highest single plant yield of 31.22 gm/plant, high sca effect, and significant standard heterosis over check KRH-2 (23.15) with 136 days duration. This hybrid is stable over locations for grain yield, with medium slender grain type, with LB ratio of 3.5, but this was showing susceptibility reaction to gallmidge at Warangal.

The hybrid APMS 6A x JGL 11111 was the most promising gallmidge resistant hybrid identified. The duration of APMS 6A x JGL 11111 was 126 days, which recorded the yield of 28.65 gm/plant, significant sca effect, significant standard heterosis over KRH-2 (15.52). This hybrid was stable over three locations for grain yield per plant, with medium slender grain type, having LB ratio of 3.19.

Another gallmidge resistant hybrid identified was APMS 6A x JGL 8292 with 128 days duration, 26.32 gm/plant grain yield and significant standard heterosis (5.42) over check KRH-2. This hybrid is stable over three locations for grain yield, with medium slender grain type, having LB ratio of 2.89.

CHAPTER I

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. This increase in production has to be achieved in the backdrop of declining resource base such as land, water, labour and other inputs.

Rice is most important food crop of A.P and cultivated in nearly 4.0 million ha in varying climate and soil conditions in almost all the districts. The annual production and productivity ranges from 9.0 to13.0 million tones and 2.5 to 3.4 t ha^{-1}, respectively. Spectacular growth in rice production was achieved since 1960s through the adoption of semi-dwarf varieties coupled with other green revolution technologies that made the country self-sufficient in rice during 1980s. However, the productivity has come to stagnation since last two decades and efforts have failed to give tangible results to break the genetic yield barrier in rice.

Hybrid rice is one of the practically feasible and readily acceptable genetic options available to increase the production, as demonstrated in People's Republic of China. Currently, there is a need to increase the yield of rice per unit area per unit time in order to address the continual increases in demand by the country's population Among the available genetic approaches hybrid rice technology appears to be the most appropriate, eco-friendly and readily adoptable one. Results of the hybrid rice commercialization program in the China look promising. China has been able to produce 200 million tones rice annually from 30 million hectare. Following China's success in the commercialization of hybrid rice, India was one of the countries to start applied strategic research programme on hybrid rice during 1989.

The rate of adoption of hybrid rice technology is rather slow in India. The National Food Security Mission (NFSM) has set a target of expanding the hybrid rice cultivation to 3 million hectares by 2011-12 from around 1.5 million hectares at present. So far, 42 rice hybrids have been released for commercial cultivation in India including 14 hybrids from private sector. Hybrid rice is becoming popular in Uttar Pradesh, Bihar, Jharkhand, Punjab, Haryana, Maharashtra, Karnataka, Madhya Pradesh and Chattisgadh. Large scale hybrid rice seed production is concentrated in just two districts of Andhra Pradesh *viz.,* Karimnagar and Warangal. About 75-80 per cent of the total hybrid rice seed of the country is produced in this region where gall midge is an endemic pest.

The rice gall midge *Orseolia oryzeae* with different biotypes is a serious pest during the monsoon season in India. Due to the biotype variations, each local breeding programme must be aimed at screening and selecting its own resistant cultures. Field screening by planting the test materials to coincide with high pest populations has been highly successful technique. The gall midge resistance can be easily transferred to the otherwise desirable hybrids due to its simple inheritance.

The Andhra Pradesh was the first state in India to release two hybrids, APHR-1 and APHR-2 during the year 1994 from Agricultural Research Station, Maruteru. These hybrids could not make significant dent in farming community due to various reasons *viz.*, poor heterosis, inconsistent performance over the seasons and locations, poor grain quality and susceptibility to certain major pest and diseases. Hence, there is urgent need to develop hybrids with good grain quality with resistance to pests and diseases and acceptable level of heterosis.

For the development of rice hybrids through cytoplasmic genetic male sterility, identification of maintainers and restorers from the local elite lines is utmost important. Precise understanding of genetics of fertility restoration is useful in planning a sound breeding strategy for development of superior restorers in hybrid breeding programme. It would also help in the efficient transfer of restorer genes into other agronomically desirable genotypes.

In order to sustain the production level and to increase the productivity, there is an urgent need to share the technology to increase the magnitude of heterosis through development of genetically diverse parental lines (Viraktamath *et al.,* 2006).

Successful development of rice hybrids by utilizing the cytoplasmic genetic male sterility and fertility restoration system mainly depends on the availability of stable male sterile lines. 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.

To make the rice hybrids attractive and economically more beneficial, it is essential to increase the magnitude of heterosis to 20 – 30 per cent. Most of the commercial hybrids now in cultivation belong to intra sub-specific group (indica / indica or japonica / japonica). Standard heterosis in these hybrids is in the range of 10 – 20 per cent (0.75 to 1.5 t ha^{-1}) over the popular high yielding varieties. One of the strategies contemplated to further enhance the yield potential of hybrid rice is development of inter sub-specific (indica / japonica) hybrids. This strategy is based on the experience that the magnitude of heterosis as in the order of indica / japonica > indica / javanica > japonica > indica / indica > japonica / japonica (Yuan, 1994). Precise knowledge on the nature and magnitude of genotype x environment interactions is important in understanding the stability in yield of a particular hybrid before it is being recommended for a given situation. Testing of genotypes under different environments differing in unpredictable variation is an accepted approach for selecting stable genotypes (Eberhart and Russel, 1966).

Grain yield is a complex character and it depends on several yield component characters and it also confounded with the environment. Hence, knowledge of the association between yield and yield components under different environments will be useful for improvement of rice yield, for which direct selection is not so effective.

Keeping in view with the above aspects the present investigation is proposed with the following objectives.

1. To identify the spectrum of restorers / maintainers among the elite gallmidge resistant lines including WA based CMS lines and to study the genetics of fertility restoration in WA- CMS system.
2. To study the gall midge resistance, combining ability of parents and crosses to identify better parents and hybrids.
3. To estimate the magnitude of heterosis for yield and yield components
4. Identification of stable hybrids over locations.
5. Identification of better hybrids for gall midge resistance.

CHAPTER II

REVIEW OF LITERATURE

The present investigation was undertaken to identify the restorers and maintainers among the elite rice lines for WA-CMS lines, elucidate the inheritance pattern of fertility restorer gene (s) and study the gall midge resistance, combining ability, heterosis and stability of the selected hybrids over three locations. The literature available on these aspects is reviewed briefly section wise as under.

2.1 Identification of restorers and maintainers and study on inheritance of fertility restoration

2.2 Gall midge resistance

2.3 Combining ability and Heterosis

2.4 Stability

2.1 IDENTIFICATION OF RESTORERS AND MAINTAINERS AND STUDY ON INHERITANCE OF FERTILITY RESTORATION

Identification of the restorers and maintainers from among the large number of elite lines is the first and foremost step in hybrid rice breeding. High yield potential of CMS derived F_1 hybrids depends upon their high pollen fertility and spikelet fertility, which determined by the number and mode of action of restorer genes present in their restorer parent. Knowledge of the genetic control of fertility restoration and transfer of fertility restorer genes to promising breeding lines is important in hybrid breeding programme.

In rice, primarily, three types of CMS systems are deployed for commercial hybrid seed production. These are Wild Abortive (WA), Bao Tai (BT) and Honglian (HL). Among these three, the WA cytoplasm is the most widely used since it is a more stable system and the pollen sterility is almost complete (Shinjyo and Omura, 1966). Pollen abortion in WA-type CMS is sporophytic, forming typical abortive pollen (Huang *et al.* 2003). Earlier studies indicated that a major dominant gene controls fertility restoration of WA-cytoplasm (Anandakumar and Subramaniam, 1992). Later, it was discovered that fertility restoration is controlled by two independent dominant nuclear genes with one stronger in action than the other (Young and Virmani, 1984). Studies also indicated different types of gene interaction like recessive epistasis (Pradhan and Jachuck, 1999), semi-epistasis, epistasis with incomplete dominance (Sarkar *et al.*, 2002), epistasis with complete dominance (Sohu and Phul, 1995) or no interaction (Li and Yuan, 1986). Some studies have revealed that the two fertility restorer genes are additive in their inheritance giving rise to an F_2 segregation ratio of 15 fertile:1 sterile (Gao, 1981; Li and Yuan, 1986). Yao *et al.* (1997) reported two genes, Rf-3 and Rf-4, located on chromosome 1 and 10, respectively, which have a major influence on fertility restoration in many restorer lines for WA-CMS lines. Another gene called Rf-(ul) identified in a Basmati-type restorer line, PRR78 R located on chromosome 10 is also known to restore fertility for WA-CMS system (Mishra *et al.*, 2003).

Math *et al.* (1990), in their studies of ten families involving Zhenshan 97A and V 20A, eight complete restorers and two partial restorers, reported that the mode of inheritance was digenic (with 15:1 duplicate or 13:3 inhibitory fashion) and trigenic (with 63:1 duplicate dominant fashion) depending on the type of restorer used.

Mandal *et al.* (1990) identified cultivars Sita, Radha and Pankaj as restorers and Mahsuri, Br 8 and Br 51-46-5 as maintainers for WA-CMS line IR 46830A.

Pande *et al.* (1990) identified varieties Karjat 184, Vani, Saitri, Pusa 33, Aswathi, Prasad and IR 50 as effective restorers for CMS lines *viz.*, V20A, Zhenshan 97A, Wu 10A and Pankhari 203A and varieties MW 10, Krishna, Archana and Madhu as effective maintainers for the two WA cytosterile lines; V 20A and Zhenshan 97A. The restoration ability of 37 restorers identified for WA source was found to be different with different CMS lines in WA cytoplasm.

Bharaj *et al.* (1991) in their studies, reported that fertility restoration in PR103, WPR 106, PAU 502-94-1, PAU 1124-36-1 and PAU 1126-1-1 was controlled by two independently segregating dominant genes (9 fertile : 3 partially fertile : 3 partially sterile : 1 sterile plants) with additive effects and one of them being stronger than the other while in cross V20A x UPR 82-1-1, fertility restoration in UPR 82-1-1 was controlled by two independently segregating genes which exhibited recessive epistatic interaction (9:3:4 ratio).

Vijay Kumar *et al.* (1991) identified Vajram as restorer for V 20A, IR 54752A, IR 54753A, and IR 54754A, Swarna as restorer for V 20A and IR 54752A and Pratibha and MTU 2077 as restorers for IR 54753A.

Ramalingam *et al.* (1992), in their analysis of pollen as well as spikelet fertility in 20 F_2 populations, reported that the fertility restoration in all the restorer lines was governed by two independent dominant genes. The mode of action of two genes varied with the cross combinations displaying epistasis with dominance (12: 3:1), epistasis with recessive (9:3:4) and epistasis with incomplete dominance (9:6:1). The reasons attributed for the different type of gene interactions were the influence of genotype of female parent and the presence of modifier genes in female genotypes.

The F_2 segregating populations were classified based on spikelet fertility into monogenic (F_2 ratio of 3:1) and digenic (F_2 ratio of 9:3:3:1 and 12:3:1) due to the allelic differences (Anadkumar and Subramanaim, 1992). This indicated that crossability of the same group showed monogenic fertility restoration and crossability of different groups showed digenic segregation.

Yang *et al.* (1993) expressed that the mean spikelet fertility of F_1 hybrid was significantly influenced by the cytoplasm of female parent. The inheritance of spikelet fertility appeared to be governed by a single major gene with dominant effects.

Singh *et al.* (1994) studied the mode of action varied in four crosses *viz.*, the F_2 population of V20A/Rajshree, IR 58025A/Pankaj and IR 58025A/Rajshree segregated into 9:6:1 ratio revealing epistasis with incomplete dominance. The cross V20A/Pankaj showed dominant epistasis while V 20A/Pusa 33 and IR 58025A/Pusa 33 exhibited monogenic segregation (F_2 ratio of 3:1). It is concluded that two independent and dominant genes governing restoration ability of Pankaj and Rajshree and a single dominant gene in Pusa 33.

Jayamani *et al.* (1995) evaluated 101 hybrids involving five CMS lines of WA source and one CMS line of *O. perennis* source and identified 32 restorers and 8 maintainers for WA-CMS lines (IR 58025A, IR62829A, PMA 3A and MS 37A) and 11 maintainers for IR 66707A with *O. perennis* cytoplasm.

Based on 15,000 crosses evaluated at the 12 hybrid research network centers, Siddiq (1996) reported that on an average, the frequency of restorers was observed to be around 22 per cent, where as for maintainers it was 14 per cent. Hence, among the elite breeding lines and germplasm entries tested, there was an adequate frequency of restorers and maintainers for WA cytoplasm to develop improved female and male parents for three line heterosis breeding.

Bharaj *et al.* (1995), in their studies to locate fertility restorer genes of WA-CMS system on specific chromosomes of rice using primary trisomics of IR 36 restorer, IR 58025A and IR 58025B, indicated that fertility restoration was controlled by two independent dominant genes and one of the genes was stronger than the other. They pointed that the two restorer genes were located in chromosome 7 and 10. Stronger gene Rf-WA-1 was located on chromosome 7 and weaker gene Rf –WA-2 was located on chromosome 10.

Sohu and Phul (1995) indicated the presence of two independent dominant genes, while the mode of action of these two genes varied in different crosses revealing three types of interactions, i.e., epitasis with dominance, epitasis with recessive gene action and epitasis with incomplete dominance.

Shen *et al.* (1996) reported that the fertility of WA type CMS line Zhenshan 97A can be restored by one pair of genes possessed by T24 ‘fertile revertant’ obtained by irradiation of II-32A and the number of genes involved in fertility restoration of CMS line could vary on the nature of the restorer used.

Fertility restoration of CMS–Boro cytoplasm (gametophytic) was controlled by a dominant gene Rf1 carried by a restorer line and that of CMS–WA cytoplasm, fertility restoration was governed by two dominant genes with differential strength of restoration. One of the two fertility restorer genes was stronger than the other (Virmani *et al.*, 1997).

Singh *et al.* (1996) screened 39 F_1 test cross nurseries involving three WA-CMS lines *viz.*, V 20A, IR 54752A and IR 58025A and 13 elite male cultivars. Cultivars Rajshree, Pankaj, IET 6148, TCA 48, Pusa 33, Sujata and Surandha were identified as restorers for V20A and cultivar T 3 and Manasarovar as maintainers for V 20A.

Kumari *et al.* (1997) evaluated 107 F_1 hybrids involving three CMS lines of wild abortive origin –V 20A, IR 58025A and IR 62569A and 43 male parents from the source germplasm and identified 18 effective maintainers and found that partial restorers were very high among the red kernel rice varieties.

Leenakumari and Mahadevappa (1997) reported that the frequency of restorers was high among IRRI genotypes. Out of 90 rice genotypes screened for their fertility restoration ability with eight CMS lines belonging to two different cytoplasmic sources viz., WA and MS 577A and of the 44 genotypes tested with WA CMS lines, 20 were found to be complete restorers. Among the 77 genotypes test crossed with MS 577A lines, only five could restore the fertility satisfactorily, seven being partial restorers and the rest were maintainers.

Padmavathi *et al.* (1997) screened 44 genotypes for restoration ability with different CMS lines derived from WA and 577A cytosteriles. Five out of 31 genotypes were able to restore fertility of two CMS lines derived from WA cytosterile source and five were identified as effective maintainers. The frequency of maintainers was high compared to that of restorers for WA cytosteriles. Of the 24 genotypes test crossed with 577A cytosteriles, none was found to restore the fertility satisfactorily. However, 10 genotypes were identified as partial restorers and the rest as effective and weak maintainers. Some genotypes behaved differently with different CMS lines of the same source.

Vijaykumar *et al.* (1997) studied 1024 test crosses involving 128 elite genotypes and eight stable CMS lines viz., V20A, IR 46830A, IR 58025A, IR 62829A, PMS 3A, PMS 8A and PMS 10A from WA source of cytoplasm and IR 54755A from ARC source of cytoplasm. Out of 128 genotypes, 53 (41%) were restorers, 33 (25%) were maintainers and the rest 42 (34%) were partials. Frequency of restorers was highest in case of IR 62829A (24%) followed by IR 58025A (16%) and V20A (11%). In case of IR 54755A, frequency of maintainers was higher than the restorers.

Frequency of restorers was higher in *indica* lines than *japonica* types; aman and *boro* cultivars had higher frequency of restorers than *aus* types. *Balu* rices were weaker restorers than *tejebeh* cultivars of *java*. Frequency of restorer lines was generally higher in rice varieties originating from higher altitudes and in South and South East Asia and Southern China while no-restorers were concentrated in Northern China and Far Eastern Asia (Virmani *et al*. 1997).

Yadav *et al.* (1997) identified IR52250-117-1-1-3, Aditya, Cauvery, Annada, Annapurna, Narendra1, MW 85, Sarjoo52, T 23, 93-103, Narendra 359, NDR 84, NDR 407, NDR 1710, NDR 1725, NDRK 5027, 93-109, and 93-131 genotypes as effective restorers for different cytoplasmic male sterile lines *viz.*, IR 58025A, IR 64608A, 66707A, PMS 24A, PMS 4A and PMS 8A.

Sridhara *et al.* (1998), working with F_2 populations of five crosses involving three WA-CMS lines, reported that the fertility restoration of restorers was controlled by two independent and dominant genes exhibiting 15: 1 ratio of duplicate dominant epistasis.

Ganesan *et al.* (1998) studied 135 hybrids, obtained with four CMS lines and 80 testers and reported that IR 54742-19-3R, AS 781/3, CBT 04001 and PMK 2 were found to be effective restorers for WA source of CMS lines. No restorer could be identified for the CMS line IR 66707A with *Oryza perennis* source of cytoplasm.

Vijaykumar *et al.* (1998) reported that lines WGL 3962, MTU 7029, MTU 9992 and MTU 5249 were found to be restorers whereas, WGL 3010, MTU 4870 and WGL 45843 were found to be maintainers for four WA CMS lines viz., V 20A, IR 46830A, IR 58025A and IR 62829A. Other lines showed differential reaction indicating that, there were differences in interaction among the nuclear genes and cytoplasm even if the CMS lines were from the same source. Hence, there was a necessity for studying the maintaining/ Restoring ability of genotypes for a particular CMS line involved in the cross irrespective of source from which it was developed.

Vishwakarma *et al.* (1998) identified five genotypes *viz.*, Saket 1, IR 28, Saket 4, Mahsuri and NDRK 5026 as effective restorers for four CMS lines *viz.*, IR 62829A, IR 58025A, PMS 8A and PMS 10A.

Sudarshan (1999) studied 130 gall midge cultures for their fertility restoration reaction on IR 58025A, a WA source cytoplasmic genetic male sterile line. Fifteen genotypes were identified as maintainers, 104 as partial restorers and 11 as restorers.

Pradhan and Jachuk (1999) observed in their studies that the spikelet fertility restoration was governed by two independent dominant genes but the mode of action of the two genes, however, varied among crosses with 9:6:1, 9:3:4 and 12:6:1 ratios.

Hemareddy *et al.* (2000) evaluated 375 test crosses involving 100 genotypes and eight CMS lines – IR 58025A and IR 62829A of WA system, IR 66707A of *O perennis* system and Pushapa A, Managala A, ES 18A, Intan Mutant A and Madhuri A of MS 577A system. The genotypes ARC 11353, IR 9761-19-1R, IR 25924 -95, IR 29723-143-3-2 and IR 30864 R completely restored fertility in the two CMS lines of WA system. Except IR 50360-12-1, which restored the fertility completely in three CMS lines of MS 577A source other showed inconsistency. The genotypes IR 64, IR 2797-105R, IR 25294-95 and Mandya Vijaya were found to be maintainers for the MS 577A CMS system.

Ramalingam *et al.* (2000) analysed 30 hybrids for spikelet fertility reaction and reported that five promising genotypes *viz.*, IR 24, IR 54752-22-193, IR 29723-143-3-2-1, IR 9761-19-1 and ARC 11353 acted as restorers for four WA-CMS lines viz., V 20A, ZS 97A, IR 58025A and IR 62829A and as maintainers for IR 66707A (ARC source).

Sarial and Singh (2000) evaluated test crosses utilizing four CMS lines – IR 58025A, IR 62829A, PMS 10A and PMS 3A of wild abortive system and 27 aromatic and 18 non aromatic lines. The effective basmati restorers identified were Basmati 385, Chanda, P1031-8-8-5-1, HKR 241, IET-12020, SAF Khalsa 7 and Karnal local, while the maintainers identified were Basmati 370, Pusa Basmati 1, P 615-K-167-13 and P1173-4-1. The frequency of restorers obtained was higher in non-aromatic than in aromatic basmati type. The performance of restorers varied with CMS lines, location and season of testing. The differential ability to restore fertility in CMS line that has wild abortive (WA) cytosterile system could result from different nuclear backgrounds of the CMS lines.

Sharma *et al.* (2001) reported the digenic mode of inheritance in two crosses *viz.*, PMS 2A x IR 54 and PMS 2A x PRR 22 with the genes exhibiting recessive epistatic interaction (9:3:4 ratios).

Salgotra *et al.* (2002) screened 31 genotypes for the restoration ability of two CMS lines derived from WA source (V 20A and IR 62829A) and another CMS line derived from Assam Rice Collection (IR 54755A). Four genotypes could restore the fertility of both the CMS lines from WA source while 15 genotypes were identified as effective maintainers. The frequency of maintainers was much higher compared to restorers. For the CMS line from ARC, only one genotype could restore the fertility satisfactorily. The genotype IR 72 was an effective restorer for the CMS lines from both the sources. Some of the genotypes behaved differently with different CMS lines of the same source.

Yograj *et al.* (2002), while studying the F_2 populations of crosses between V 20A and ten restorer lines, reported that the fertility restoration was governed by two independent and dominant genes, one of which appeared to be stronger in action than the other. The mode of action of these genes was different in different restorer combinations, with three types of gene interactions in the F_2 as epistasis with incomplete dominance (9 fertile : 6 partial fertile : 1 sterile), dominance (12 fertile : 3 partially fertile/sterile : 1 sterile) and duplicate (15 fertile : 1 sterile) nature.

Malarvizhi *et al.*(2003) reported that, out of the 291 male parents used for crossing with six WA-CMS lines *viz.*, IR 58025A, IR 68888A, IR 68897A, IR 68281A, IR 69616A and PMS 3A, 30.4 per cent were identified as effective restorers, 13.7 per cent were identified as potential maintainers and the rest were grouped into partial restorers and partial maintainers.

Sharma and Singh (2003) reported that the segregation pattern in crosses: PMS 10A x HKR 120 and PMS 10A x PR 106 corresponded to digenic mode of inheritance of fertility restoration with dominant (12: 3: 1) and recessive (9: 3: 4) epistasis, respectively. The two dominant and independently segregating fertility restorer genes seemed to have additive effects, through one of them appeared to be stronger in fertility restoring action than the other. While, the segregating pattern of crosses: PMS 2A x P 1292 and PMS 1A x P 1347 fitted in trigenic epistatic ratio (27: 30: 7) revealing the involvement of a dominant gene, in addition to the major fertility restorer genes, which enabled or enhanced the expression of one of the two restorer genes.

Pollen fertility was studied utilizing 3 CMS lines and 53 testers and reported nine potential restores for IR 68281 R and six for IR 68888A. All these testers were found to be maintainers to COMS 9A (Jayamani and Rangaswamy, 2005).

Singh (2005) studied pollen and spikelet fertility of 75 hybrids and reported that a total of 41 potential restorers and 11 effective maintainers were identified for three CMS lines viz. IR 68891A, IR 68888A and IR 58025A.

Pradhan *et al.* (2006) evaluated sixty four crosses involving 3 CMS lines and 32 elite Basmati genotypes and identified 11 good complete restorers and five weak maintainers with Pusa 3A. Four genotypes were effective maintainers for both CMS lines. Few lines that were identified as maintainers for Pusa 3A behaved as partial restorers for IR 58025A.

Sharma *et al.* (2005) studied fertility restoration in F_2 population of the cross between PMS 2A and PRR 72 and revealed digenic mode of inheritance of fertility restoration with epistasis with incomplete dominance (9:6:1).

Sota Fujii and Kinya Toriyama (2005) evaluated ninety six plants of BC_1F_1 generation and 96 F_2 plants. They concluded that fertility restoration of WA type CMS is gametophytically controlled by a single gene.

Sawant *et al.* (2006) studied spikelet fertility in 28 cross combinations. His studies indicated the presence of two independent dominant fertility restoring genes. The mode of action of the two genes varied in different crosses revealing three types of interaction *viz.*, epistasis with dominance, incomplete dominance and recessive. Change in fertility restoration by same restorer with CMS lines of same source and different source could be due to the influence of genotype female parent has difference in penetrance of fertility restoring genes and the effect of modifier.

Haohua *et al.* (2006) studied the genetic basis of male sterility and fertility restoration using progeny populations created between Pingxiang male sterile rice (PMSR) and 11 fertile lines. It was found that the male sterility was determined by two interacting (epistatic) dominant nuclear genes, one for sterility and one for fertility restoration. The dominant sterile gene expresses as male-sterility when existing solely, but as normally fertile when coexisting with the restoration gene.

Tan *et al.* (2008) indicated in their studies that Boro-II (BT) and Honglinn (HL) are controlled by single dominant Rf gene and WA-CMS is controlled by one or two pairs of dominant Rf genes. It is concluded that there are at least three Rf loci in different accessions with Rf genes for each CMS type.

Sattary *et al.* (2008) studied an inheritance pattern showed that pollen fertility restoration in all three CMS systems was governed by two independent and dominant genes with classical duplicate gene action.

Sheeba *et al.* (2009) indicated in their studies that the trait of spikelet fertility segregated in the ratio of 15:1 and 3:1 (fertile: sterile), respectively in the crosses, IR 58025/KMR3 and IR62829A/IR10198R//IR62829A indicating that fertility restoration is governed by two independent dominant genes with duplicate gene interaction for F_2 and BC_1F_1 populations, respectively.

Sreedhar (2010) studied the genetics of fertility restoration of four crosses and reported that F_2 populations of all the four crosses *viz*., APMS 6A x IR-69702-52-3-3R, APMS 6A x IR-62161-189-3-1-3-2R, APMS 6A x KBNT-11 and APMS 6A x IR-59669-93-1-3R exhibited a segregating ratio of 15 fertile : 1 sterile indicated the digenic inheritance with dominant duplicate gene action governing fertility restoration in the WA-CMS system.

Bagheri and Babaeian-Jelodar (2011) studied inheritance of fertility restoration of WA type CMS in rice, (*Oryza sativa* L.) utilizing IR58025A, IR62829A and IR68899A CMS lines and three restorers *viz*., Amol-2, IR50 and Poya. The F1s showed pollen and spikelet fertility similar to the restorer parents, indicating that restoration ability were dominant and the cytoplasmic-genetic sterility system of CMS lines were sporophytic in nature. Evaluation of fertility in F_2 populations and testcross progenies (BC1) revealed that fertility restoration in Amol-2 and IR50 were controlled by two major dominant genes whereas, it was controlled by one dominant gene in Poya. Segregation for spikelet fertility in F_2 and backcross generation conformed to the results on pollen fertility.

It is clear from the foregone paragraphs that the fertility restoration is under the control of single, two, three or four genes, with its inheritance and mode of action varying with the restorers used in the material by different researchers.

2.2 Study on gall midge resistance

Singh (1990) tested 137 rice varieties for resistance to gall midge *Orseolia oryzae*. Eleven entries were highly resistant to the pest; these were R320-300, R321-108,

RP2436-79-22-2, WGL 18011-15, WGL 20471-97, WGL 26358, BPT3624, W1263, Aganni, T1477 and Banglei. A further 3 varieties showed moderate resistance.

Srinivas *et al.* (1994), studied rice gall midge *Orseolia oryzae* (Wood-Mason) biotype in Karimnagar District of Andhra Pradesh, India. The local gall midge (GM) population at Warangal, AP, has a biotype 1 pattern and a resistant reaction to all 3 groups of differential donors (Eswarakora, Siam 29 and Velluthacheera x Banglei derivatives). GM incidence was recorded on 11 differential donors, representing these 3 groups, and susceptible control TN_1 during the wet seasons (WS) of 1992-93. Damaged hills, total tillers and silvershoots were counted 50 days after transplanting in the field. In 1992 trials, group II differentials Phalguna, ARC5984 and Surekha were severely damaged (95-100%), with significant numbers of silver shoots on a tiller basis. Group I differentials W 1263 and ARC 6605, and those from group III differentials Velluthacheera, Aganni, Ptb10 and T 1477 were free of attack, except CR-MR1523, which had 40% damaged plants and 3% silvershoots. Similar trends were noticed during the 1993 WS trials. In multilocation trials during the 1992 WS in Karimnagar District, Siam 29 derivatives Phalguna, Surekha, WGL 3962 and WGL 3943 were susceptible, whereas 7 Eswarakora derivatives were resistant. A change in the pattern of GM reaction from biotype 1 to biotype 3 was indicated.

Pasalu *et al.* (1998) studied current status of rice gall midge biotypes in India and China. Biotypes of Asian rice gall midge *Orseolia oryzae* have been reported and distinguished based on the reaction of differential rice varieties. In India, six distinct biotypes have been characterized, whereas in South China four biotypes are recorded. A distinct link between the resistance gene in the host plant and biotypes exists. Based on reaction against resistance genes Gm1 and Gm2, Indian biotypes are designated as 1, 2, 3, and 4 show a similar pattern of reaction to that displayed by Chinese biotypes. Extensive cultivation of resistant varieties and mass migration appear to be the causes of biotype evolution.

Rao *et al.* (1998) studied, genetics and breeding for gall midge resistance in India. Sources of gall midge resistance in the primary pool of rice germplasm have been known for a long time. The systematic evaluation during the past three decades of more than 20,000 accessions of rice germplasm both in the field at pest-endemic locations and in greenhouses under artificial infestation has identified more than 250 sources of resistance. The majority of these are landraces from the northeastern states of India. Some accessions of wild species of the rice genus *Oryza* are also known to be resistant to the pest. After the detection of gall midge biotypes within the country, resistant germplasm accessions were screened against characterized biotypes to note the range in resistance. Multilocation testing of primary donors against all known biotypes revealed that none of the donors displayed resistance against all six biotypes. Only one of the donors tested, Orumundakan (mutant), showed resistance to five biotypes, whereas 10 donors had resistance to four biotypes. Studies on inheritance of resistance have, in general, indicated that resistance is governed by major genes. So far, five dominant genes and one recessive gene have been well characterized. Of these, one gene, Gm6 (t), is effective and confers resistance against all four biotypes in China but is not effective against Indian biotypes. An additional five genes are suspected to confer biotype-specific resistance in recent studies. The systematic breeding for gall midge resistance in India was boosted with the introduction of high-yielding varieties in 1965. Based on the performance of cultivars in multilocation testing, five cultures with built-in resistance to gall midge were released as varieties for commercial cultivation in the country during the 1970s, 28 during the 1980s, and more than 15 since then. The majority of these varieties carried a single gene from three known resistance sources. These varieties made a big impact on yield advantage and lowering of pest incidence during the first decade of cultivation. Subsequently, the development of virulent biotypes accompanied by a breakdown in resistance is being reported in many pest-endemic regions in the country. The initial response of breeders to this situation has been to look for alternate sources of resistance against new biotypes and incorporate the resistance into local popular varieties. Deploying a single gene in any variety and its wide cultivation, however, would only lead to a new cycle of boom and bust as evidenced in the past. Some alternative and promising strategies are being considered for the future.

Oudhia *et al.* (1999) studied, reaction of hybrid rice varieties to gall midge (*Orseolia oryzae*).Nine rice hybrids and the resistant control cv. Mahamaya, growing at Raipur, were observed for infestation by gall midge. Mahamaya was free from infestation, and in the hybrids percentage of infested tillers ranged from 5.23% (PAC831) to 12.32% (Proagro 6111).

Motiramani *et al.* (1999) studied genetics of resistance against biotype 1 of rice gall midge in some rice cultivars. Mode of inheritance and allelic relationships of resistance imparting gene(s) present in rice cultivars CR 410-3255, CR 392-5088-2, Kakatia and Samlei were investigated. Presence of single dominant gene for resistance to gall midge *Orseolia oryzae* in these parents was confirmed. CR 410-3225 and CR 392-5088-2 was found to possess the Gm 2 resistance gene, Kakatia confirmed the presence of the Gm 1 resistance gene.

Pani *et al.* (2000) studied, inheritance of resistance against biotype 2 of the Asian rice gall midge, *Orseolia oryzae*. The inheritance of resistance in the rice cultivars Phalguna, ARC 5984, ARC 5158, Veluthacheera, and T 1477 to the Asian rice gall midge biotype 2 (*Orseolia oryzae*) was studied under both natural and artificial infestation conditions against the susceptible cultivars Jaya and IR 20. A single recessive gene in Veluthacheera and two recessive complementary genes in T 1477 control resistance. Phalguna and ARC 5984 possess a single dominant gene while ARC 5158 has a single dominant and a single recessive gene for resistance. Allelism studies showed that genes for resistance in Veluthacheera and T 1477 are allelic but non-allelic to the resistance genes in Phalguna and ARC 5984, which are allelic to each other. Genes for resistance in ARC 5158 are allelic to resistance genes of the other four donors. There was no cytoplasmic inhibition of resistance by the susceptible parents.

Shalini Tiwari *et al.* (2005) studied reaction of gene differential rice varieties against gall midge *Orseolia oryzae* (Wood-Mason) biotypes in the greenhouse.A set of differential rice cultivars with known genes against gall midge (*Orseolia oryzae*) biotypes 1, 3 and 4 were screened under greenhouse conditions during 2004 and 2005. Plant damage was recorded 25 days after gall midge adult release when all the susceptible plants had galls. Pooled data of 2 years clearly indicated that gm3, Gm4 and Gm8 genes conferred resistance against all gall midge biotypes used in the test. Cultivars possessing Gm2, gm3, Gm4, Gm5, Gm6, Gm7, Gm8 and GM10 showed HR+ mechanism of reaction, while those having Gm1 and Gm9 showed HR reaction.

Lakshmi *et al.* (2006) studied a new biotype of the Asian rice gall midge *Orseolia oryzae* (Diptera: Cecidomyiidae) characterized from the Warangal population in Andhra Pradesh, India. Six distinct biotypes of the Asian rice gall midge, *Orseolia oryzae* (Wood-Mason), have been characterized so far from different parts of India and their geographical distribution has been well mapped and monitored annually through the national gall midge biotype studies. These studies have been showing minor changes in the virulence pattern of the pest population at Warangal in Andhra Pradesh state since 2000. Hence, a sample of the pest population from the site was collected during 2003 and selected subsequently in a greenhouse through 13 successive generations for virulence against diverse sources of plant resistance. This Warangal-derived population (WDP) was tested to record reactions of two sets of differential rice varieties used for biotype detection and known to carry one of the 10 known gall midge-resistance genes. The results revealed that WDP has acquired virulence against CR-MR1523, one of the biotype differential rice varieties, which derived resistance from the source Ptb21 cultivar. Since the virulence pattern noted for WDP was different from that noted for the six characterized biotypes, it is proposed to designate this new biotype, tentatively, as biotype 4M. Only three of the resistance genes, viz. Gm3, Gm4 and Gm8 confer resistance against this biotype.

Jiang Xian Bin *et al.* (2006) studied restoring ability test of rice varieties resistance to rice gall midge and resistance evaluation of F1 generation. The resistance of the F1 generation of rice cultivars crossed with male sterile rice lines against the rice gall midge (*Orseolia oryzae*) and the restoring ability of the rice cultivars were determined. F_1 generation derived from crossing rice cultivars Zhixuan No. 6, Zhixuan No. 8 and Kangwenqingxhan with male sterile rice lines were resistant to the pest, whereas those derived from the crossing rice cultivars Zhixuan No. 4, Zhixuan No. 5 and Zhixuan No. 7, with the male sterile lines were susceptible. Cultivars Zhixuan No. 8 and Kangwenqingxhan recorded high restoring ability and crosses using both cultivars recorded high seed setting rate and crop yield.

Jadhav *et al.* (2006) studied genetics of rice gall midge *Orseolia oryzae* (Wood Mason) resistance in some new donors, with the objectives to understand the mode of inheritance and allelic relationships of gene (s) for gall midge *Orseolia oryzae* (Wood Mason) resistance. Inheritance studies revealed the presence of single dominant gene for gall midge resistance in each of six donors *viz.*, JGL-384, RP-4108-44993, SKL-12-5-2-1-18, JGL-418, JGL-394 and Bhumansan. Allelic study revealed that the gene for gall midge resistance present in JGL-384 was non-allelic to the Gm 2 and Gm 4 genes present in differentials Phalguna and Abhaya respectively. But it was allelic to the Gm1 gene. Similarly, the gene for gall midge resistance present in RP 4108-44993 proved to be different from the known genes present in differentials Phalguna (Gm 2), Abhaya (Gm 4), ARC 5984 (Gm 5) RP-2333-156-8 (Gm 7) and Jhitipiti (Gm 8). The study further revealed the non-allelic nature of gene for gall midge resistance present in SKL 12-5-2-1-18 from the known genes Gm-1 and Gm 9 present in differential

Samridhi and Madhuri line 9 respectively. The resistant gene in JGL 418 was non allelic to Gm 7 (RP 2333-156-8) gene. The single resistant gene of JGL 394 was different from Gm 7 gene present in the differential RP 2333-156-8. The gene for gall midge resistance present in donor Bhumansan was non-allelic to the Gm 4 gene present in differential Abhaya.

Bentur *et al.* (2008) studied on monitoring virulence in Asian rice gall midge populations in India. Breeding resistant varieties and their cultivation has been the main approach to manage this pest. However, the breakdown of resistance conferred by the major genes, deployed one at a time, and through evolution of virulent biotypes has become a major setback to this approach. Development of polymerase chain reaction-based molecular markers for eight of the 10 resistance genes and their possible use in marker-assisted selection has enabled breeders to pyramid resistance genes for achieving durable resistance. However, the choice of resistance genes needs to be made with a better understanding of the virulence composition of the pest populations in the target area and the genetics of plant resistance and insect virulence, as the rice-gall midge interaction is a gene-for-gene one. We adopted a single-female test and coupled it with a modified F_2 screen test to note the virulence composition of gall midge populations and estimated the frequency of virulence alleles for adaptation at three pest endemic locations in India, namely, Warangal, Ragolu, and Raipur. Results on biotype composition showed heterogeneous pest populations in all the tests and at all the locations. Tests at Warangal repeated after 8 years showed a rapid increase in frequency of the virulence allele conferring adaptation to the plant resistance gene Gm2 as compared to that of the allele for adaptation to the resistance gene Gm1. This is probably the first direct measurement of a durability parameter of plant genes conferring insect resistance. Results supported earlier observations that sex-linked virulence against Gm2 makes it less durable. The sex ratio did not deviate from the expected 1:1 ratio at Warangal, but at Ragolu females outnumbered males.

Naikebawane *et al.* (2008) studied genetics of gall midge *Orseolia oryzae* (Wood Mason) resistance in some new donors of rice (*Oryza sativa L.*) at Chattisgarh, India, during 2001 and 2002. Results revealed the presence of a single dominant gene for gall midge resistance in 5 new donors, *i.e.*, INRC 202, Tellarigarikasunjavari, ARC 15831, JGL 384 and Bhumansan. The allelic study revealed that the resistant gene present in donor ARC 15831 was allelic to the Gm 2 gene present in differential Phalguna.

2.3 Combining ability studies

The ability of an inbred to transmit desirable performance to the hybrid progeny is referred to as combining ability and is very much useful in isolation of desirable / acceptable lines and their evaluation in hybrid development. Combining ability of the lines is the ultimate factor for determining the future usefulness of the lines. Combining ability is a general concept of classifying lines relative to their cross performance. The concept of combining ability was developed by Sprague and Tatum in 1942 through preliminary studies with maize and comprises of two parts (1) General Combining Ability (GCA), which is the average performance of a genotype in cross combinations involving a set of other genotypes, and is the result of additive gene

Table 2.1. Review of literature pertaining to gene action for different characters in rice

Gene action		
Additive	**Non additive**	**Additive and non additive**
1. Days to 50% flowering		
Ghosh (1993)	Dhaliwal and Sharma (1990)	Vijaya lakshmi *et al.* (2008)
Chakraborthy *et al.*(1994)	Ramalingam *et al.*(1993)	
Ram *et al.*(1998)	Ganesan *et al.*(1997)	
Ganesan and Rangaswamy (1998)	Ramalingam *et al.*(1997)	
Meenakshi and Devarathinam (1999)	Rogbell and Subbaraman (1997)	
Roy and Mandal (2001)	Manonmani and Ranganathan (1998)	
Patil *et al.*(2003)	Anand *et al.* (1999)	
Shanthi *et al.*(2003)	Babu *et al.*(2000)	
Shanthi *et al.*(2004)	Satyanarayana *et al.*(2000)	
Anand kumar *et al.* (2006)	Banumathy *et al.*(2003)	
Dhakar and Vinit Vyas (2006)	Swain *et al.*(2003)	
Gnana Sekaran *et al.* (2006)	Bisne and Motiramani (2005)	
Sharma *et al.* (2006)	Panwar (2005)	
Sanjeevkumar *et al.*(2007)	Raju *et al.* (2006)	
	Venkatesan *et al.*(2007)	
	Sharma and Mani (2008)	
	Shukla and Pandey (2008)	

Table 2.1(cont.)

Additive	**Non additive**	**Additive and non additive**
2. Plant height		
Lokaprakash *et al.*(1991)	Dhaliwal and Sharma (1990)	Reddy (2002)
Ghosh (1993)	Banumathy and Prasad (1991)	Vijaya lakshmi *et al.* (2008)
Vijayakumar *et al.*(1994)	Ramalingam *et al.*(1993)	
Ganesan *et al.*(1997)	Chakraborthy *et al.*(1994)	
Ramalingam *et al.*(1997)	Dhanakodi and Subramanian (1994)	
Ganesan and Rangaswamy (1998)	Rogbell and Subbaraman (1997)	
Ram *et al.*(1998)	Manonmani and Ranganathan (1998)	
Anand kumar *et al.* (2006)	Anand *et al.* (1999)	
Roy and Mandal (2001)	Babu *et al.*(2000)	
Shanthi *et al.*(2003)	Satyanarayana *et al.*(2000)	
Swain *et al.*(2003)	Banumathy *et al.*(2003)	
Sanjeevkumar *et al.*(2007)	Bisne and Motiramani (2005)	
Sarma *et al.*(2007)	Panwar (2005)	
Shanthi *et al.*(2004)	Sharma *et al.* (2006)	
Gnana Sekaran *et al.* (2006)	Venkatesan *et al.*(2007)	
Raju *et al.* (2006)	Yadav *et al.* (2007)	
Sharma and Mani (2008)		
3. No. of productive tillers per plant		
Banumathy and Prasad (1991)	Dhaliwal and Sharma (1990)	Meenakshi and Devarathinam (1999)
Dhanakodi and Subramanian (1994)	Lokaprakash *et al.*(1991)	Reddy (2002)
Vijayakumar *et al.*(1994)	Ghosh (1993)	Vijaya lakshmi *et al.* (2008)
Ram *et al.*(1998)	Ramalingam *et al.*(1993)	
Gnana Sekaran *et al.* (2006)	Chakraborthy *et al.*(1994)	
	Ganesan *et al.*(1997)	
	Ramalingam *et al.*(1997)	
	Rogbell and Subbaraman (1997)	
	Ganesan and Rangaswamy (1998)	
	Manonmani and Ranganathan (1998)	
	Anand *et al.* (1999)	
	Babu *et al.*(2000)	

	Satyanarayana *et al.*(2000)	
	Roy and Mandal (2001)	
	Banumathy *et al.*(2003)	
	Patil *et al.*(2003)	
	Shanthi *et al.*(2003)	
	Swain *et al.*(2003)	
	Shanthi *et al.*(2004)	
	Bisne and Motiramani (2005)	
	Panwar (2005)	
	Anand kumar *et al.* (2006)	
	Raju *et al.* (2006)	
	Sarma *et al.*(2007)	
	Yadav etal (2007)	
	Sharma and Mani (2008)	
4. Panicle length		
Banumathy and Prasad (1991)	Dhaliwal and Sharma (1990)	Vijaya lakshmi *et al.* (2008)
Ghosh (1993)	Lokaprakash *et al.*(1991)	
Ram *et al.*(1998)	Ramalingam *et al.*(1993)	
Swain *et al.*(2003)	Chakraborthy *et al.*(1994)	
Raju *et al.* (2006)	Dhanakodi and Subramanian (1994)	
Sarma *et al.*(2007)	Vijayakumar *et al.*(1994)	
	Ganesan *et al.*(1997)	
	Ramalingam *et al.*(1997)	
	Rogbell and Subbaraman (1997) Ganesan and Rangaswamy (1998)	
	Manonmani and Ranganathan (1998)	
	Anand *et al.* (1999)	
	Babu *et al.*(2000)	
	Satyanarayana *et al.*(2000)	
	Roy and Mandal (2001)	
	Banumathy *et al.*(2003)	
	Shanthi *et al.*(2003)	
	Shanthi *et al.*(2004)	
	Panwar (2005)	
	Bisne and Motiramani (2005)	

Table 2.1(cont.)		
Additive	**Non additive**	**Additive and non additive**
	Dhakar and Vinit Vyas (2006)	
	Gnana Sekaran *et al.* (2006)	
	Sharma *et al.* (2006)	
	Anand kumar *et al.* (2006)	
	Venkatesan *et al.* (2007)	
	Sanjeevkumar *et al.*(2007)	
	Shukla and Pandey (2008)	
5. No. of filled grains per panicle		
Chakraborthy *et al.*(1994)	Dhaliwal and Sharma (1990)	Swain *et al.* (2003)
Vijayakumar *et al.*(1994)	Lokaprakash *et al.*(1991)	
Ganesan and Rangaswamy (1998)	Banumathy and Prasad (1991)	
Ram *et al.*(1998)	Ramalingam *et al.*(1993)	
Shanthi *et al.*(2003)	Ghosh (1993)	
Shanthi *et al.*(2004)	Dhanakodi and Subramanian (1994)	
Anand kumar *et al.* (2006)	Ganesan *et al.*(1997)	
	Ramalingam *et al.*(1997)	
	Rogbell and Subbaraman (1997)	
	Manonmani and Ranganathan (1998)	
	Anand *et al.* (1999)	
	Babu *et al.*(2000)	
	Satyanarayana *et al.*(2000)	
	Roy and Mandal (2001)	
	Reddy (2002)	
	Banumathy *et al.*(2003)	
	Patil *et al.*(2003)	
	Panwar (2005)	
	Bisne and Motiramani (2005)	
	Sharma *et al.* (2006)	
	Raju *et al.* (2006)	
	Sharma and Mani (2008)	

Table 2.1(cont.)		
Additive	**Non additive**	**Additive and non additive**
6. Panicle weight		
	Prakash *et al.*(2003)	Sarma *et al.*(2007)
	Swain *et al.*(2003)	
7. Spikelet fertility %		
	Ghosh (1993)	
Shanthi *et al.* (2003)	Babu *et al.* (2000)	
	Lavanya (2000)	
	Satyanarayana *et al.* (2000)	
	Kalaiyarasi *et al.* (2002)	
	Banumathy *et al.* (2003)	
	Bisne and Motiramani (2005)	
8. 1000 grain weight		
Ramalingam *et al.*(1993)	Dhaliwal and Sharma (1990)	Patil *et al.*(2003)
Chakraborthy *et al.*(1994)	Lokaprakash *et al.*(1991)	
Vijayakumar *et al.*(1994)	Ghosh (1993)	
Ganesan and Rangaswamy (1998)	Chakraborthy *et al.*(1994)	
Ram *et al.*(1998)	Dhanakodi and Subramanian (1994)	
Roy and Mandal (2001)	Ramalingam *et al.*(1997)	
Reddy (2002)	Ganesan *et al.*(1997)	
Shanthi *et al.*(2003)	Rogbell and Subbaraman (1997)	
Swain *et al.*(2003)	Manonmani and Ranganathan (1998)	
Raju *et al.* (2006)	Anand *et al.* (1999)	
Shanthi *et al.* (2004)	Meenakshi and Devarathinam (1999)	
Gnana Sekaran *et al.* (2006)	Babu *et al.*(2000)	
	Satyanarayana *et al.*(2000)	
	Banumathy *et al.*(2003)	
	Panwar (2005)	
	Bisne and Motiramani (2005)	
	Dhakar and Vinit Vyas (2006)	
	Yadav *et al.* (2007)	
	Venkatesan *et al.* (2007)	
	Sarma *et al.*(2007)	
	Shukla and Pandey (2008)	

Table 2.1(cont.)

Additive	Non additive	Additive and non additive
9. Grain yield per plant		
Vijayakumar *et al.*(1994)	Dhaliwal and Sharma (1990)	Roy & Mandal (2001)
Ram *et al.*(1998)	Banumathy and Prasad (1991)	Sanjeevkumar *et al.*(2007)
Ganesan and Rangaswamy (1998)	Wilfred manuel and Prasad (1992)	Vijaya lakshmi *et al.* (2008)
Meenakshi and Devarathinam (1999)	Lokaprakash *et al.*(1991)	
Shanthi *et al.*(2003)	Ghosh (1993)	
Shanthi *et al.*(2004)	Ramalingam *et al.*(1993)	
Gnana Sekaran *et al.* (2006)	Chakraborthy *et al.*(1994)	
Sanjeevkumar *et al.*(2007)	Dhanakodi and Subramanian (1994)	
	Ganesan *et al.*(1997)	
	Ramalingam *et al.*(1997)	
	Rogbell & Subbaraman (1997)	
	Ganesan & Rangaswamy (1998)	
	Manonmani and Ranganathan (1998)	
	Anand *et al.* (1999)	
	Babu *et al.*(2000)	
	Satyanarayana *et al.*(2000)	
	Reddy (2002)	
	Banumathy *et al.*(2003)	
	Patil *et al.*(2003)	
	Swain *et al.*(2003)	
	Bisne and Motiramani (2005)	
	Panwar (2005)	
	Raju *et al.* (2006)	
	Dhakar and Vinit Vyas (2006)	
	Yadav *et al.* (2006)	
	Saravanan *et al.* (2006)	
	Anand Kumar *et al.* (2006)	
	Sharma *et al.* (2006)	
	Sarma *et al.*(2007)	
	Venkatesan *et al.*(2007)	
	Shukla and Pandey (2008)	
	Sharma and Mani (2008)	

action and (2) Specific Combining Ability (SCA), which is the expression of performance between any two inbred lines in relation to the average performance of all combinations and is the result of non-additive type of gene interaction. Several workers reported the nature of gene action through different biometrical methods in rice, which had been reviewed and the literature pertaining to combining ability is presented in tabular form in Table 2.1.

Lokaprakash *et al.* (1991) found that both GCA and SCA variances were highly significant for the traits like plant height, number of productive tillers per plant, panicle weight, number of fertile spikelets per panicle, thousand grain weight, yield per plant and harvest index indicating the importance of both additive and non additive gene action. However, preponderance of additive gene action was recorded for plant height, while for others non-additive type was prominent. The genotypes HP 19 and HP 11 were good general combiners for yield and yield components except plant height.

In a study, Wilfred Manuel and Prasad (1992) noticed that additive gene action was important for straw yield per plant, while both additive and non additive gene actions were important for the inheritance of dry matter production, harvest index and grain yield per plant. Parents ASD 16 and IR 50 were the best general combiners for grain yield, straw yield and dry matter production and their hybrid (ASD 16 x IR 50) recorded the highest *SCA* effects for the above three traits as well as harvest index.

Ghosh (1993) carried out combining ability analysis in rice for yield and its attributing traits. The parents *viz.,* Annada, IET 8674 and IET 7255 were identified as good general combiners for yield per plant. The crosses, IET 7255 x Prasanna, IET 8674 x Dular, IET 8674 x Annada, Dular x IET 10899, Annada x Prasanna and Annada x Dular exhibited higher SCA effects for yield per plant.

Chakraborthy *et al.* (1994) reported that additive gene action was predominant for days to 50% flowering, flag leaf length, spikelets per panicle and 100 grain weight, while non additive gene action was predominant for plant height, panicles per plant, grain weight per panicle and yield per plant. The cross combinations Mahsuri x Pankaj, Mahsuri x Monoharsali and Pankaj x Monoharsali showed positive specific combining ability effects for yield per plant.

Vijayakumar *et al.* (1994) observed predominance of additive gene action for plant height, productive tillers per plant, number of grains per panicle, grain yield per plant, grain elongation after cooking and 1000 grain weight. Based on the GCA effects, the lines MH/Prakash and Intan/Gowri were found as good general combiners for yield components. The hybrid (Intan/Gowri) x Mahsuri was identified as good specific combiner.

The study conducted by Rogbell and Subbaraman (1997) revealed that the magnitude of variance due to SCA was predominant over GCA for all the eight traits studied. Among the parents, CNA 4121, IR 61457-8-3-3-1, IR 10198-66-2 and IR 54717-C10-113-1-2-2-2 were found to be good general combiners for grain yield. Six crosses were identified as the best hybrids based on their *per se* performance, high heterosis and high *SCA* effects.

Manonmani and Ranganathan (1998) reported the importance of non additive gene action for days to flowering, plant height, number of productive tillers, panicle length, and number of grains per primary ear, 100 grain weight and grain yield. Among the parents, IR 50 and Kalyani II possessed high GCA effect for earliness and IR 50, CO 37 and ASD 17 for grain yield. The crosses ASD 16 x Kalyani II, IR 50 x ASD 8 and ASD 16 x ASD 17 were identified with good SCA effect for days to flowering, number of productive tillers and grain yield, respectively.

The combining ability studies on rice by Babu *et al.* (2000) indicated the importance of non additive gene action for the inheritance of all the characters studied. Two CMS lines *viz.*, IR 58025A and IR 62829A and three testers *viz.*, WGL 3962, IET 9762 and IET 10021 were found to be good general combiners for yield and other yield attributes. The hybrids, IR 62829A x WGL 3962, IR 62829A x IR 276-301-06-01R, IR 62829A x MTU 9992, APMS 2A x IET 9762, IR 58025A x IET 10021 and APMS 1A x IET 10021 were found to be good heterotic combinations for grain yield.

Lavanya (2000) studied the combining ability for yield and its components, and reported that dominance of gene effects for characters like productive tillers per plant, filled grains per panicle, per cent spikelet fertility, harvest index and grain yield. Additive gene effects for days to 50% flowering, plant height, panicle length and test weight. The lines IR 58025A and IR 62829A were identified as good general combiners for grain yield.

Swain *et al.* (2003) found that both GCA and SCA variances were highly significant for all the traits studied, indicating the importance of both additive and non-additive gene actions for expression of these traits. However, predominance of non additive gene action was recorded for days to flowering, number of panicles per plant and grain yield per plant, while additive type of gene action was predominant for plant height, panicle length, spikelets per panicle, 1000 grain weight, harvest index and straw yield per plant. Ketanangka ranked first as good general combiner, followed by Rahaspanjar for the yield and yield components except for plant height. CR 1006 appeared as good general combiner for plant height. The crosses Rahaspanjar x Swarna and CR-260-77 x Ketanangka appeared to be the best for grain yield, with high SCA effects.

Banumathy *et al.* (2003) reported the predominance of non-additive gene action over additive gene action in the inheritance of grain yield and the associated traits. The lines, IR 58025A, IR 69616A and IR 70364A and testers CB 95066, IR 10198-66-2R, IR 65515-47-2-1-19, TNAU 94241, TNAU 94301 and TNAU 841434 were good general combiners for grain yield per plant. The cross combinations, IR 68888A x CB 95066, IR 68888A x IR 10198-66-2R, IR 69616A x TNAU 841434, IR 70364A x TNAU 80030 and IR 70370 x CO 47 were exhibited high SCA effects for grain yield.

Bisne and Motiramani (2005) in their study reported the predominance of non additive gene action over additive gene action for plant height, effective tillers per plant, total number of spikelets per panicle, total number of filled spikelets per panicle, spikelet fertility percentage, grain yield per plant, days to 50% flowering, panicle length, total number of chaffy spikelets per panicle, 100 grain weight, harvest index, length and breadth of paddy. The lines DRR 2A and PMS 10A and testers BKP 232, R 827-287, R 1060-1674-2-103 and R 714-2-103 were good general combiners for grain yield. The crosses, DRR 2A x R 827-287 and DRR 2A x R 1060-1674-1-1 exhibited higher specific combining ability with high standard heterosis for grain yield.

Panwar (2005) studied the combining ability of parents and crosses in rice, and reported the importance of non-additive gene action controlling all the traits studied. The line IET 13846 and the testers Kasturi, Basmati 370, Pusa Basmati-1, Taraori Basmati and IR 64 were good general combiners for grain yield per plant. Fourteen cross combinations recorded significant *SCA* effects for grain per plant.

Singh *et al.* (2005) recorded that the GCA and SCA were significant for all the seven characters indicating the importance of both additive and non-additive genetic components for these traits. The *per se* performance was observed to be a good indication of GCA effects of the parents and SCA effects of the crosses. Among the parents studied, Vaidehi and Rajshree were observed to be good general combiners for grain yield. The superior specific cross combinations Saket 4 x Vaidehi, Rajshree x Kamini, Prabhat x Rajshree and Sita x Vaidehi appeared promising for further exploitation in rice breeding programme.

Anand Kumar *et al.* (2006) in line x tester interaction study, found that mean squares due to parent *vs.* crosses differed significantly for majority of the traits. Among the CMS lines, IR 68886A for earliness and IR 58025A for yield and its component traits were found to be superior general combiners. Four testers *viz.,* Pusa 1040, PSRM-1-16-48-11, RAU 1411-4 and RAU 1414-10 were rated as good general combiners for yield. The crosses IR 68886A x Pusa 1040, IR 58025A x RAU 1411-10 and IR 68886A x PSRM-1-16-48-11 recorded significant heterosis for yield and yield contributing traits.

Narasimman *et al.* (2007) revealed that ADT 44 was good general combiner for all the six traits studied. The parent CR 1009 was also observed to be good combiner for all the traits except harvest index. The cross ADT 44 x CR 1009 exhibited highly significant positive *sca* effects coupled with highly significant positive heterobeltiosis and standard heterosis for number of filled grains per panicle, biomass per plant and grain yield per plant.

Sanjeev Kumar *et al.* (2007) found that both GCA and SCA variances were highly significant for all the characters indicating the importance of both additive and non-additive gene actions. However, preponderance of additive gene action was recorded for the traits *viz.,* plant height, days to 50 per cent flowering and 100 seed weight. While both additive and non-additive gene effects were almost equally important for grain yield per plant and leaf area index, preponderance of non-additive gene action was recorded for panicle length and grain length. Parents HPR 2047, VL 93-3613 and J08 were good general combiners for grain yield and other related characters. Parents HPR 1164 and J08 were good general combiners for shorter plant height and earliness. The crosses involving the above mentioned parents were promising as revealed by their *sca* effects. The cross combinations HPR 2047 x VL93-

3613, HPR 1164 x IR 57893-8, VL 91-1754 x J08, VL 93-3613 x J08 and VL 91-1754 x VL 93-3613 showed significant positive specific effects for grain yield per plant and some associated characters.

In a line x tester analysis by Sarial *et al.* (2007), restorer Basmati 385 and HKR 241 were found to be good general combiners for grain yield / plant and 1000 grain weight, P 1037 for 1000 grain weight and effective tillers/plant while, Karnal local for 1000 grain weight. Among the CMS lines IR 58025A and PMS 3A were characterized as good general combiners for grain yield and other traits. The specific cross combinations characterized with highly significant *sca* effects were IR 58025A x Basmati 385, IR 62829A x Basmati 395, IR 62829A x HKR 241 and PMS 3A x P1031-8-5-1 for grain yield/plant and effective tillers per plant, IR 62829A x Karnal local for 1000 grain weight, PMS 10A x SAP Khalsa 7 for days to 50 per cent flowering and PMS 3A x HKR 241 for primaries per panicle. The gca effects of the parents were not reflected in the *sca* effects of the crosses.

Sarma *et al.* (2007) observed that additive genetic variance was higher in magnitude for plant height, panicle length and all other quality parameters. Non-additive gene action on the other hand was predominant for grain yield and its components *viz.,* effective tillers, panicle weight and grain weight.

Combining ability study by Venkatesan *et al.* (2007) revealed non additive gene action governing the characters *viz.*, days to first flower, plant height and grain yield per plant. Predominance of GCA variance was recorded for days to first flower, plant height and grain yield per plant. Among the parents, the lines AD 25137, AD 25157 and MDU 5 and testers ADT 36, ADT 43 and IR 50 were good combiners for grain yield and most of the other components studied.

Ashok *et al.* (2007) reported that out of four, two CMS lines, IR 58025A and PMS 3A were identified as good general combiners for grain yield and other traits. The specific combiners characterized with high *sca* effects were IR 58025A x Basmati 385, IR 62829A x Basmati 385, IR 62829A x HKR 241 and PMS 3A x P1031-8-5-1 for grain yield, biomass per plant and effective tillers per plant.

Tu *et al.* (2008) reported that eleven CMS lines and six restorer lines were crossed to study the specific combining ability (*sca*) and general combining ability (*gca*) for eight yield characters of indica rice. The GCA and SCA for eight yield characters were highly significant.

Shukla and Pandey (2008) observed that 120 hybrids derived from hybridization of 30 elite TG lines and four cultivars in line x tester mating design, and reported highly significant variances for lines. The TG line, 365-8S was good combiner for grain yield and its components studied. Preponderance of non-additive gene action suggested good prospects of hybrid breeding.

Pradhan and Singh, (2008) studied thirty hybrids generated from crossing three lines with ten testers along with parents for combining ability in basmati rice. The *gca* and *sca* effects were significant for all the characters, indicating the importance of both additive and non-additive genetic components. With predominance of non-additive genetic components for expression of different traits. Amongst the parental lines, RP 3392-75-5-11-1 and RP 3644-41-9-5-5 were best general combiners for grain yield along with other traits. The most specific combiners for grain yield and other traits were Pusa 3A x RP 3392-75-11-1, IR 68281A x BTCE 10-98, IR 58025A x HKR 97-401, Pusa x RP 3644-36-15-8-4 and IR 68281A x RP 3644-41-9-5-5.

Eighteen hybrids generated from crossing six basmati lines with three tester revealed predominance of additive gene action for flag leaf area, panicle length, grain weight per panicle and grain yield per plant, while days to flowering, panicle bearing tillers per plant, grains per panicle exhibited preponderance of non-additive gene action. Kasturi, Basmati 5853 and Haryana Basmati-1 among the lines and Pant Dhan 11 among the testers emerged as good general combiner for various traits. Basmati C 622 x TN 1, Basmati 5853 x Pant Dhan 11 and Pusa Basmati 1 x TN 1 crosses were emerged as most promising (Sharma and Mani, 2008).

Dalvi and Patel (2009) developed 60 hybrids from crossing four CMS lines with 15 restorer lines to study the specific combining ability (sca) and general combining ability (gca) for 13 yield characters of rice. Among the male parents, the lines BR-827-35-3-1, RTN-3 and IR-46 and the female parent, IR-58025A were good combiners for grain yield and most of the other components except plant height and L: B ratio. The specific combiners characterized with high sca effects were IR 58025A x BR-827-35-3-1, IR-58025A x RTN-3 and IR-68885A x RTN-3 for grain yield/hill.

Non-additive gene action was predominant for grain yield and its components except days to 50 per cent flowering and productive tillers per plant.

The study conducted by Salgotra *et al.* (2009) revealed that the magnitude of variance due to SCA was predominant over GCA for all the eight traits studied except days to fifty percent flowering for fifteen hybrids derived from crossing of five elite varieties with three cultivars in line x tester mating design. Among the parents, Pusa 2517-2-51-1, Sanwaal basmati, Super basmati, Ranbir basmati and Basmati 370 were found to be good general combiners for grain yield. Five crosses were identified as the best hybrids for yield and its components which can be used for exploitation of heterosis for yield.

Li GuiYong *et al.* (2010) studied the combining ability for yield and yield components characters with 9 male sterile lines and 8 restorer lines of Dian-type japonica hybrid rice widely used by the way of p x q incomplete diallel cross (NC II) design. Both general combining ability (GCA) and the specific combining ability (SCA) of these characters were significant or highly significant. The grain weight of per plant, the spikelets of per panicle and the panicles of per plant were mainly affected by the non-additive effect, while the 1000-grain weight was mainly controlled by the additive effect. And the filled spikelets of per panicle and the seed setting rate were controlled by both additive and non-additive effect. The other characters were influenced more greatly by restorer lines than by sterile lines, except the grain weight per plant, the spikelets of per panicle and the seed setting rate. Parents of high GCA and variance of SCA is important base of breeding advantage hybrid combinations, and the sterile lines choice is very important for breeding high-yield hybrid combinations.

2.4 Heterosis studies

Heterosis is expressed as percentage increase or decrease of F_1 hybrid over the mid parental value. The superiority of F_1 hybrid over the better parent is known as heterobeltiosis.

Non allelic interaction might be the cause of heterosis rather than the special relation between the genes at same locus (Jinks, 1955). Falconer (1960) explained heterosis as complementary to inbreeding depression. Heterosis is directly proportional to Σdy2 where'd' is the degree of dominance component of gene action and ‘y’ is the difference in the gene frequencies of the parents involved in the cross. The success of heterosis breeding depends on the amount of genetic diversity present in the material.

Genetically speaking, heterosis refers to the significant increase or decrease in the F_1 value over the mid parent value. However, from the plant breeding point of view, increase over better parent and /or the popular commercial variety hybrid is more relevant.

In rice heterosis was first reported by Jones (1926) who observed that some F_1 hybrids had more culms and higher yield than their parents. Since then several rice researchers also confirmed its occurrence for yield and yield contributing characters (Virmani, 1994). However, most of these reports were on relative heterosis and heterobeltiosis and are not on standard heterosis. It was only after the successful development and cultivation of F_1 rice hybrids in China in 1976 that the usefulness standard heterosis in commercial agriculture is being considered. Pertinent literature available on heterosis in rice has been reviewed and summarized in Table 2.2.

Tiwari *et al.* (2011) studied involving 3 CMS lines and 20 elite restorers to identify the best heterotic combination in line x tester mating design. The results indicated that the manifestation of heterobeltiosis for grain yield was significantly superiority of 43 hybrids ranging from 11.63 to 113.04% and 46 hybrids over standard variety (Sarjoo-52) ranging from 10.48 to 71.56%. Most of the crosses which exhibited superiority over better parent or standard variety for grain yield also showed significant heterosis for number of fertile spikelets and number of spikelets per panicle. These crosses also possessed about 80% pollen viability. Besides grain yield, considerable heterosis was observed for other characters also but its degree varied from character to

Table 2.2. Summary of review of literature on heterosis for various characters in rice

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
1. Days to 50 per cent flowering				
4	-	-	-31.90 to -10.90	Sharma and Mani (1990)
75	-16.00 to 14.00	-12.00 to 29.00	-27.00 to 19.00	Peng and Virmani (1991)
28	-16.80 to 12.00	-27.50 to 15.00	-	Ganesan *et al.* (1997)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
30	-	-19.50 to 18.40	-19.00 to 16.00	Mishra and Pandey (1998)
15	-16.16 to 4.10	-43.70 to 42.90	-	Ghosh (2002)
24	-16.21 to 13.51	-	-	Joshi *et al.* (2004)
30	-	-8.27 to 22.06	-	Verma *et al.* (2004)
2	5.70 to14.87	-1.70 to1.13	-	Yadav *et al.* (2004)
8	-	-14.70 to 11.50	-	Bhandarkar *et al.* (2005)
8	-10.71 to 12.19	-	-	Shanthala *et al.* (2006)
36	-	19 to 47	-25 to 21	Singh *et al.* (2006a)
5	-9.62 to -1.6	-6.4 to -1.3	-16.3 to -3.3	Anjuchaudhary *et al.* (2007)
45	-11.59 to 17.74	-10.95 to 19.35	-5.53 to 16.99	Deoraj *et al.* (2007)
33	-	-	-2.67 to -2	Eradasappa *et al.* (2007)
25	-	-	-8.2 to 13.6	Rosamma and Vijayakumar (2007)
48	-	-24.35 to 8.16	-3.33 to 8.89	Akarsh Parihar and Pathak (2008)
20	-16.16 to 15.29	-18.64 to 11.21	-	Roy *et al.* (2009)
2. Plant height				
75	-8.00 to 24.00	-4.00 to 55.00	-21.00 to 27.00	Peng and Virmani (1991)
17	-	-27.52 to 14.40	-25.52 to 57.52	Lokaprakash *et al.* (1992)
21	-4.19 to 5.97	-3.99 to 20.45	-	Singh *et al.* (1992)
36	-7.10 to 15.50	10.10 to 12.80	-7.52 to 0.40	Pandey *et al.* (1995)
8	0.00 to18.70	-18.70 to 6.70	-	Reddy and Nerkar (1995)
8	6.32 to 29.03	-21.55 to 20.07	41.47 to 85.59	Ganesan *et al.* (1997)
28	0.40 to 11.80	-14.20 to 9.80	-	Jayamani *et al.* (1997)
30	-	-37.00 to 29.80	-26.50 to 15.20	Mishra and Pandey (1998)
8	1.20 to 18.90	-16.80 to 7.20	-	Tiwari and Sarathe (2000)
15	-6.30 to 30.30	-11.50 to 5.20	-	Ghosh (2002)
24	-32.01 to 21.15	-	-	Joshi *et al.* (2004)
30	-	-26.75 to 28.08	-	Verma *et al.* (2004)
2	17.63 to 24.90	9.03 to 22.67	-	Yadav *et al.* (2004)
8	-	-19.73 to 22.81	-	Bhandarkar *et al.* (2005)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
8	-35.96 to -3.98	-	-	Shanthala *et al.* (2006)
36	-	-19 to 47	-25 to 21	Singh *et al.* (2006a)
12	-	5.23 to 72.73	-19.18 to 28.88	Singh *et al.* (2006b)
5	-12 to -1.5	-11.92 to 0.6	-5.32 to 2.5	Anjuchaudhary *et al.* (2007)
45	-23.14 to 53.32	-16.15 to 89.76	-25.41 to 85.11	Deoraj *et al.* (2007)
33			-4.71to -1.77	Eradasappa *et al.* (2007)
24	-	-	-11.2 to 34.4	Rosamma and Vijayakumar (2007)
48	-	-37.41 to 13.46	-17.86 to 14.75	Akarsh Parihar and Pathak (2008)
10	-13.69 to 51.23	-25.28 to 41.68	-	Hari Ramakrishnan *et al.* (2009)
20	-16.31 to 50.88	-23.86 to 29.18	-	Roy *et al.* (2009)
3. Panicle length				
17	-	-13.13 to 18.00	-31.20 to 7.55	Singh *et al.* (1992)
50	-	-	-14.25 to 19.4	Bobby and Nadarajan (1994)
36	-4.50 to 24.80	-6.50 to 20.40	-12.50 to 46.90	Pandey *et al.* (1995)
8	-3.51 to 29.51	-9.92 to 27.91	-3.18 to 33.64	Ganesan *et al.* (1997)
28	-9.50 to13.00	-12.50 to 7.40	-	Jayamani *et al.* (1997)
30	-	-22.6 to 30.90	-0.60 to 35.10	Mishra and Pandey (1998)
15	7.20 to 59.20	1.60 to 46.20	-	Ghosh (2002)
30	-	-27.37 to 42.29	-	Joshi *et al.* (2004)
28	-20.30 to 28.30	-24.50 to 24.40	-	Vanaja and Babu (2004)
2	0.97 to 3.90	-0.77 to 2.05	-	Verma *et al.* (2004)
24	-6.08 to 32.44	-	-	Yadav *et al.* (2004)
8	-	-22.02 to 3.20	-	Bhandarkar *et al.* (2005)
8	-20.82 to 7.43	-	-	Shanthala *et al.* (2006)
25	-	-18 to 34	-24 to 19	Singh *et al.* (2006a)
45	-10.09 to 37.61	-18.42 to 36.84	-14.03 to 43.85	Deoraj *et al.* (2007)
33	-	-	38.92 to 40.37	Eradasappa *et al.* (2007)
60	-	-43.88 to 30.56	-31.98 to 70.67	Singh *et al.* (2007)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
48	-	-31.73 to 43.21	-31.73 to 8.15	Akarsh Parihar and Pathak (2008)
20	-2.09 to 28.46	-6.89 to 26.23	-	Roy *et al.* (2009)
10	-0.10 to 39.00	-4.40 to 34.95	-	Hari Ramakrishnan *et al.* (2009)
4. Panicle weight				
21	-43.97 to 62.73	-50.24 to 57.83	-	Lokaprakash *et al.* (1992)
32	-	-	-37.89 to140.52	Lingaraju (1997)
15	-14.2 to 88.33	-26.0 to 105.9	-	Ghosh (2002)
4. No. of productive tillers per plant				
21	-34.65 to 48.86	-36.84 to 47.71	-	Lokaprakash *et al.* (1992)
50	-	-	5.60 to 43.4	Bobby and Nadarajan (1994)
36	12.70 to 117.60	13 60 to117.60	9.80 to109.40	Pandey *et al.* (1995)
8	-6.60 to 100.90	-15.60 to 61.20	-	Reddy and Nerkar (1995)
8	12.00 to116.00	0.00 to 92.86	55.56 to 222.22	Ganesan *et al.* (1997)
28	3.80 to 40.90	5.60 to 29.70	-	Jayamani *et al.* (1997)
30	-	-17.20 to 226.80	-34.60 to 79.10	Mishra and Pandey (1998)
45	13.30 to 83.80	-	-	Singh and Haque (1999)
15	14.60 to 63.80	-11.10 to 48.30	-	Ghosh (2002)
22	-	-	-14.84 to 89.14	Panwar *et al.* (2002)
24	-21.73 to 82.60	-	-	Joshi *et al.* (2004)
2	2.47 to 2.70	1.47 to 2.47	-	Verma *et al.* (2004)
30	-	-31.51 to 45.27	-	Yadav *et al.* (2004)
8	-	-22.87 to 74.29	-	Bhandarkar *et al.* (2005)
8	-26.29 to 55.26	-	-	Shanthala *et al.* (2006)
36	-	-42 to 64	-45 to 105	Singh *et al.* (2006a)
21	-21.25 to 25.42	-24.59 to 22.60	-	Singh *et al.* (2006b)
45	-27.87 to 96.5	-28.57 to 97.05	-59.68 to 37.09	Deoraj *et al.* (2007)
33	-	-	34.54 to 36.15	Eradasappa *et al.* (2007)
3	-	35.63 to 167.29	137.58 to 329.09	Narasimman *et al.* (2007)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
48	-	-34.08 to 3.29	-13.52 to 50.33	Akarsh Parihar and Pathak (2008)
10	-6.58 to 50.66	-10.27 to 26.09	-	Hari Ramakrishnan *et al.* (2009)
20	3.53 to 226.76	-10.28 to 194.88	-	Roy *et al.* (2009)
5.Flag leaf length				
39	-	-41.8 to 31.3	-33.1 to 28.5	Mishra and Pandey (1998)
30	-	-25.15 to 80.54	-	Yadav *et al.* (2004)
6. Spikelet fertility percentage				
32	-	-	-138.14 to 60.2	Vidyachandra (1991)
25	-	-	-252.56 to 33.8	Radhakrishna (1992)
10	-	-	8.32 to 124.59	Patil (1993)
0	-	-	-16.70 to -1.84	Yolanda and Vijendradas (1995)
8	-	-	-56.66 to 65.80	Lingaraju (1997)
13	-	-	-81.30 to 25.10	Emanuel *et al.*(1998)
30	-	-72.90 to 82.00	-81.30 to 25.10	Mishra and Pandey (1998)
28	-	-	-0.77 to 5.14	Singh and Maurya (1999)
15	-	-	-20.00 to 9.90	Udayashetty (1999)
31	-	-	-99.64 to 37.99	Balasundara (2000)
22	-	-	-23.89 to 14.98	Panwar *et al.* (2002)
100	-	-	-38.07 to 31.21	Banumathy *et al.* (2003)
24	-34.37 to 25.67	-	-	Joshi *et al.* (2004)
10	-12.70 to 7.35	-12.91 to 3.16	-	Hari Ramakrishnan *et al.* (2009)
7. No. of filled grain per panicle				
21	-56.73 to 64.84	-64.03 to 47.12	-59.06 to 76.59	Sreedhar and Kulkarni (1993)
4	-	-24.7 to 35.1	-8.1 to 35.2	Sharma and Mani (1996)
32	-	-	-44.30 to 59.11	Lingaraju (1997)
24	-9.08 to 10.25	-14.63 to 5.77	-5.66 to 48.29	Sathya *et al.* (1999)
35	-2.85 to 85.75	-21.72 to 78.74	-4.46 to 28.74	Annadurai and Nandarajan (2001)
22	-	-	-16.04 to 43.28	Panwar *et al.* (2002)
100	-	-	-59.72 to 62.96	Banumathy *et al.* (2003)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
30	-	-91.77 to 25.31	-	Yadav *et al.* (2004)
63	-	-90 to 71	-91 to 63	Singh *et al.* (2006a)
12	-	9.21 to 24.43	10.34 to 37.67	Singh *et al.* (2006b)
45	-2.87 to 55.1	-17.08 to 57.57	-15.06 to -46.02	Deoraj *et al.* (2007)
33	-	-	3.69 to 45.11	Eradasappa *et al.* (2007)
3	-	61.55 to 138.15	256.13 to 299.28	Narasimman *et al.* (2007)
24	-	-	-25.5 to 47	Rosamma and Vijayakumar (2007)
48	-	-32.80 to 26.79	-30.60 to 18.64	Akarsh Parihar and Pathak (2008)
10	-16.01 to 20.11	-20.44 to 15.83	-	Hari Ramakrishnan *et al.* (2009)
8. 1000 grain weight				
21	-5.26 to 61.74	-7.05 to 57.89	-8.06 to17.06	Sreedhar and Kulkarni (1993)
4	-	-11.2 to 31.9	-27.4 to 22.7	Sharma and Mani (1996)
36	-	-	-29.60 to 6.50	Yolanda and Vijendradas (1995)
60	-	-30.33 to 12.62	-41.63 to -5.83	Vishwakarma *et al.* (1998)
15	-	-	-10.17 to 10.59	Devasia and Rangaswamy (1999)
32	-	-	-55.90 to 8.91	Lingaraju (1997)
24	-33.84 to 28.04	-37.25 to 14.24	-26.84 to 25.01	Sathya *et al.* (1999)
14	-	-	-46.46 to 26.66	Singh and Maurya (1999)
35	-10.42 to 51.60	-14.19 to 37.62	-8.94 to 33.41	Annadurai and Nandarajan (2001)
22	-	-	-34.55 to -5.82	Panwar *et al.* (2002)
10	-	-	24.4 to 37.18	Banumathy et al. (2003)
24	-32.95 to 31.82	-	-	Joshi *et al.* (2004)
28	-27.40 to 1.28	-34.40 to -0.60	-	Vanaja and Babu (2004)
2	2.90 to 4.20	-0.33 to 4.20	-	Verma *et al.* (2004)
8	-9.27 to 12.61	-	-	Shanthala *et al.* (2006)
36	-	26 to 48	-23 to 23	Singh *et al.* (2006a)
12	-	-9.32 to 25.68	-11.51 to 27.77	Singh *et al.* (2006b)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
60	-	-28.62 to 42.48	-56.31 to 0	Singh *et al.* (2007)
33	-	-	-23.65 to 57.94	Eradasappa *et al.* (2007)
3	-	-5.83 to 7.78	-3.75 to 11.82	Narasimman *et al.* (2007)
24	-	-	-29.4 to -0.7	Rosamma and vijayakumar (2007)
45	-22.29 to 45.92	-44 to 24.78	-34.21 to 51.76	Deoraj *et al.* (2007)
48	-	-29.12 to 13.12	-37.07 to 28.55	Akarsh Parihar and Pathak (2008)
10	3.70 to 49.19	-6.81 to 43.81	-	Hari Ramakrishnan *et al.* (2009)
20	5.11 to 81.66	-11.91 to 48.51	-	Roy *et al.* (2009)
9. Single plant yield				
4	-	-	-13.20 to 26.10	Sharma and Mani (1990)
75	-45.00 to 157.0	-59.00 to 98.00	-59.00 to34.00	Peng and Virmani (1991)
12	-6.50 to 81.30	-8.40 to 45.00	-4.50 to 46.30	Sahai and Chaudhary(1991)
21	-48.71 to 77.14	-54.54 to72.22	-	Lokaprakash *et al.* (1992)
0	-	-	-12.50 to16.40	Bobby and Nadarajan (1994)
36	-5.60 to 268.20	-8.60 to 258.20	-5.60 to 301.60	Pandey *et al.* (1995)
8	0.10 to 127.80	-40.60 to 6.89	-	Reddy and Nerkar (1995)
28	-10.20 to 108.90	-12.80 to 106.90	-	Ganesan *et al.* (1997)
8	-60.78 to 104.9	-66.67 to 40.00	-14.00 to 320.0	Jayamani *et al.* (1997)
30	-	-99.80 to 230.80	-91.30 to 92.00	Mishra and Pandey (1998)
45	-5.60 to131.70	-	-	Singh and Haque (1999)
8	1.00 to 130.00	-34.40 to 68.30	-	Tiwari and Sarathe (2000)
103	-	-	-4.52 to 30.00	Pandey *et al.* (2001)
15	-	-5.80 to 119.30	-24.10 to 91.90	Ghosh (2002)
22	-	-	-0.57 to 54.75	Panwar *et al.* (2002)
24	-43.33 to 93.16	-	-	Joshi *et al.* (2004)
28	-90.40 to 457.30	-93.3 to 356.00	-	Vanaja and Babu (2004)

Table 2.2 (cont.).

Number of crosses studied	Range of heterosis per cent over			Reference
	Mid parent	Better parent	Commercial check	
2	1.93 to 16.89	-1.60 to 14.29	-	Verma *et al.* (2004)
30	-	-97.31 to 114.60	-	Yadav *et al.* (2004)
8	-	13.79 to 70.98	-	Bhandarkar *et al.* (2005)
8	-	-	38.01	Salgotra *et al.* (2005)
27	-	-33.93 to 237.33	-33.93 to111.28	Anandkumar *et al.* (2006)
8	-61.81 to 14.79	-	-	Shanthala *et al.* (2006)
36	-	-72 to152	-74 to 80	Singh *et al.* (2006a)
12	-	11.72 to 89.29	18.48 to 104.7	Singh *et al.* (2006b)
5	-164.2 to 281.6	124.9 to 211	65.3 to 211	Anjuchaudhary *et al.* (2007)
45	31 to 121.38	-42.24 to 104.06	-52.13 to 33.38	Deoraj *et al.* (2007)
33	-	-	-51.57 to 57.94	Eradasappa *et al.* (2007)
3	-75.14 to 90.50	-181.57 to 270.98		Narasimman *et al.* (2007)
24	-	-	-38.3 to 70.6	Rosamma and Vijayakumar(2007)
60	-	-54.69 to 69	-60.35 to 22.64	Singh *et al.* (2007)
48	-	-21.53 to 29.53	-13.56 to 41.17	Akarsh Parihar and Pathak (2008)
10	-4.09 to 36.30	-5.17 to 31.21	-	Hari Ramakrishnan *et al.* (2009)
20	40.58 to 403.21	12.23 to 362.96	-	Roy *et al.* (2009)

character. The best cross combination in order of merit grain yield and other yield components were IR58025A x IR48749-53-2-2-2R, NMS4A x IR633-76-1R, IR58025A x IR54853-43-1-3R, IR58025A x IR19058-107-1R and PMS10A x IR54853-43-1-3R.

2.5 Stability of hybrids and parents

The phenotypic performance of a genotype is not necessarily be the same under diverse agro-ecological conditions and all the genotypes may not reach the same level of phenotypic expression under all environmental conditions. Some genotypes may fare well in some environment but not so well in other, is an indicative of the phenomenon of GE interaction. The GE interaction implies differential behaviour of genotypes under varied environments.

The interaction between the genotype and the environment indicates the objectives of the plant breeder to select genotypes either for limited conditions or for a wide range of environments. In case the breeder desires to evolve genotypes to a very narrow range of agro-ecological situations, the study of genotype - environment interactions will be beneficial and some important land marks are presented here.

Yates and Cochran (1938) sub-divided genotype environment interaction into linear and non-linear components. Sprague and Federer (1951) in an analysis of maize data obtained over many environments presented evidence that double crosses interact with environments less than the single crosses. Lewis (1954) employed only the mean values under the high and low yielding environments as a measure. Johnson *et al.*(1955) analysed the GE interactions using ANOVA. Comstock and Mill (1963) also analysed the GE interactions using ANOVA.

Finlay and Wilkinson (1963) using regression analysis for the first time proposed the analysis of Genotype, Environment interaction at phenotypic level. Allard and Bradshaw (1964) quoted the term stability as “well buffered” capacity of genotypes.

Allard and Bradshaw (1964) stated that the nature of Genotype Environment interactions were extremely complex. Eberhart and Russel (1966) made a slight improvement over Finlay and Wilkinson’s Model (1963), which includes three parameters namely genotypic mean, regression and deviation from linearity. Despite the development of several models, the one developed by Eberhart and Russel (1966) is being used widely and is considered to be a standard method. Perkins and Jinks (1968) proposed the analysis of Genotype, Environment interaction at genotypic level.

Eberhart and Russel (1966) proved that GE interactions usually exist, irrespective of the fact whether the varieties are pure lines, single crosses / double crosses, hybrids, test crosses and segregating populations or any other material with which the breeder may be working.

The hybrid rice is being the new answer to the growing hunger of world population, by the way of its increased yield potential, release of hybrids is due in many rice growing states. But, before releasing of these hybrids, for cultivation, estimation of their adaptability and suitability for those areas is a prime step, as hybrids show considerable amount of genotype, environment interaction. One of the reasons for slow progress in developing rice varieties / hybrids is the prevalence of large genotype, environment interactions which results from differences in the genotypic adaption and the heterogenous environments (Fukai and Cooper, 1993). Genotypes grown in varied environments encounter the local effect, seasonal fluctuations and their interaction had its influence in the performance of genotypes / hybrids. Knowledge on the interaction and stability is essential in breeding varieties for greater adaption, particularly in rice, which is grown in diverse agro-climatic conditions. Virmani *et al.* (1982) found variable yield heterosis in indica hybrids grown in the tropics both in wet and dry seasons. Patnaik *et al.* (1990) studied heterosis in 136 rice hybrids for four seasons and found that only two hybrids were stable over the seasons.

Young and Virmani (1990) evaluated one hundred and forty rice hybrids along with 17 parents for yield, days to flowering and plant height over six environments created by three fertilizer levels (0, 60 and 120 kg N/ha) applied in three different fields over two seasons (dry and wet) during 1986. Stability of hybrids and parents was assessed using Eberhart and Russel model. Selected hybrids not only showed yield advantage over parents but also better response over environments. Hybrids also tended to flower earlier and were slightly taller than parents but still within the range of semi-dwarf plant type. Considering values of regression (bi) and deviation from regression (S^2di), hybrids showed less stability than parents and their performance over environments was relatively less predictable than the parents. Nine out of the 10 top yielding hybrids showed significant deviations from regression line. One hybrid (IR 54752A / IR 54) showed average response to environments and was stable. Both parents of this hybrid were also stable. However, two other stable parents A6 (IR 54753A) and R6 (IR 46) gave an unstable hybrid. It appeared that stable hybrids can be developed from stable parents but such parents do not necessarily generate a stable hybrid.

Leenakumary (1994) evaluated seven hybrids along with four check varieties over four seasons for stability. Dry seasons were conducive for expression of most of the characters. Hybrids were found to be homeostatic or well buffered and showed better response over environmental changes compared to check varieties.

Further, the hybrids IR 58025A x IR 30864R, IR 58025A x IR 13419-113-3R and IR 58025A x IR 9761-19-1R were found promising.

Wilfredmanuel and Rangaswamy (1994) studied 16 hybrids for their stability performance under four-nutrio-environmental conditions for six characters. Hybrids – IR 58025A / TNAU 77013 and V 20A / TNAU 88013 were identified as the most stable and consistent genotypes for grain yield in all the nutrio-environments. The former also showed stability for plant height, spikelet fertility and dry matter production, while the latter for plant height. Hybrids – IR 58025A / TM 4309, IR 62829A / TKM 6 and IR 62829A / TM 4309 though top yielders were found to be unstable.

Lavanya *et al.* (1997) evaluated 32 rice hybrids at different nitrogen levels tested in two different seasons. Based on stability parameters, only one hybrid IR–62829A / Vajram which ranked third in grain yield, was stable over the environments with predictable performance (bi = 1.57). Based on linear regression coefficients, however, the IR 58025A / Swarna hybrid with highest yield (1125 gm^{-2}) and high heterosis for yield (85.8%) was found to be most suitable for specific environment. The other hybrids, IR 58025A / Vajram and IR 62829A / Swarna, showed above average yield (1004 and 857 gm^{-2}) and average response (bi = 0.63 and 2.06) though unpredictable for yield.

Hedge and Vidyachandra (1998) evaluated five experimental rice hybrids along with four standard check varieties of different durations for their stability for grain yield components and other morphological characters over seven locations in Karnataka. Significant Genotype – Environment (GE) interactions were observed for all the characters under study. The results indicated that the presence of both linear and nonlinear component of GE interactions for all the characters. The hybrids IR 58025A / KMR-3 with medium duration and IR 58025A / IR 9761 with short duration were promising in various locations. The correlation analysis between stability parameters (bi and S^2 di) for grain yield and its components revealed that stability parameters in rice hybrids appeared to be governed by different genes and gene combinations.

Ilyas Ahmed *et al.* (1998) examined the stability of hybrids for yield in two sets of environment (low and high yield in comparison to the average yield). Grain yield data was recorded for eight hybrids in the 1994-95 wet season and dry season using the inbreds Jaya, Rasi and IR 36 as controls at five locations. The results indicated that the stability of rice hybrids for grain yield is comparable to the best inbred control variety Jaya. Further, hybrids IR 58025A x IR 34686 and IR 58025A x IR 29723 showed better yield stability over seasons than Jaya.

Lohithaswa *et al.* (1999) carried out analysis of variance for ten quantitative traits on fifteen genotypes and four check varieties and the study revealed significant genotypic differences in all the four seasons for all the traits except number of tillers per plant, number of productive tillers per plant and panicle length. Genotypes x Season interactions were found to be significant for all the seven characters considered for stability analysis. The effect due to season (linear) was significant for days to 50 per cent flowering, number of filled spikelets per panicle and grain yield per plant. The variance due to genotype x season (linear) was non significant for all the traits. Non linear component was found to be significant for all the characters. Among the fifteen genotypes studied, eleven showed stability for yield of which three (IR 58025A x IR 29723, IR 58025A x IR 13419 and Jaya) had average stability (bi=1). The hybrid IR 58025 x IR 13419 was found to be stable for most of the characters. Significant positive correlations between mean and S^2di for grain yield per plant and mean and bi for per day production per plant were observed.

Deshpande *et al.* (2002) evaluated 11 rice hybrids for their stability performance in respect of three characters over the locations. For grain yield, the hybrids *viz.*, Sahyadri, PHB 1 and PA 6201 and for days to 50% flowering the hybrids *viz.*, Sahyadri, NSD 2, PA 6201, CNRH 3 and PHB 71 exhibited stability. All the 11 hybrids exhibited stability for spikelet fertility per cent over different environments. The hybrids *viz.*, Sahyadri, PHB 71 and PA 6201 were found to be most stable over the locations for their yield and yield contributing characters.

Deshpande *et al.* (2003) estimated stability parameters of yield per plant, days to 50% flowering, spikelets per panicle and spikelet fertility % in 12 rice hybrids at five locations of Maharashtra. Sahyadri hybrid with very high mean yield (9.34 t/ha), regression coefficient more than unity and minimum deviation from regression was recommended for favourable environments. Hybrids PHB 71, NSD 2 and KRH 2 were the other hybrids rated as promising. For yield, deviation from regression magnitudes of all the hybrids, were non significant and regression coefficient magnitudes of all the hybrids except DRRH 1 and KRH 2 were significant, suggesting that the yield behaviour in all the genotypes except in those two hybrids was highly predictable. For days to 50% flowering, the magnitudes of bi were non significant and the magnitudes of S^2di were significant for most of the hybrids, suggesting that the flowering behavior was unpredictable. Predominance of non-linear component was observed for spikelet fertility per cent.

Sarkar *et al*. (2003) reported that stability analysis on fertility restoration, yield and other attributes revealed that fertility restoration in hybrids from different CMS lines was highly sensitive to the changes in the environment with gradual delay of sowing dates. Estimates of stability parameters showed that the hybrids were unstable over the environments for both fertility restoration and grain yield. The results indicated the specificity of the hybrids to various environmental conditions.

Babu *et al.* (2005) studied twenty seven rice hybrids for their stability with respect to yield and its components at three different salt affected environments. Significant genotype x environment interaction showed differential behavior of genotypes under different conditions for all the traits studied. Significant linear and non-linear components of GE interaction for number of grains / panicle and spikelet fertility suggests that the genotypes differed from their linear response to environment. Based on the stability parameters, hybrids TS 6 / Vytilla 1 for 100 grain weight and spikelet fertility and TS 29 / CSR 13 and TS 29 / BTS 24 for single plant yield were found to be stable.

Lavanya *et al.* (2005) studied thirty rice hybrids and their parents for their stability in two seasons with different nitrogen levels. The study indicated that a substantial portion of the GE interaction was due to the linear component for tiller number, plant height, panicle length, spikelet fertility percentage, and test weight and harvest index. Hybrids were less stable than parents except for the hybrid IR 62829A x Vajram. Several high yielding hybrids and parents were identified for favourable and poor environments. The present study revealed that stable hybrids were developed from stable parents but stable parents may not necessarily generate a stable hybrid.

Shanmuganathan and Ibrahim (2005) evaluated eleven rice hybrids in six different environments for their stability. Significant mean sum of square due to genotypes, environments and GE interaction was observed. Both linear and non-linear components of G x E interaction were important for the expression of most of the traits;

however, linear component was larger in magnitude than the non-linear component. The hybrid CORH 2 was found to be stable for most of the characters

Eleven hybrids released prior to 1999 were extensively evaluated in multilocational trials during three seasons *viz., kharif* 1999 (64 locations), *rabi* 1999-2000 (15 locations) and *kharif,* 2000 (46 locations).KRH 2 hybrid topped in both the *kharif* (wet) seasons, whereas, Sahyadri hybrid was found to be better during *rabi* (dry) seasons. On the overall basis, the hybrids KRH 2, PHB 71, Sahyadri, 6201, NSD 2 and DRRH 1 were found promising and widely adapted (Viraktamath *et al.* 2006).

Deshpande and Dalvi (2006) evaluated the performance of 12 rice hybrids in respect of grain yield and other characters under five environments in Maharastra and revealed that stability in the yield of the hybrid appeared to differ in respect of level of stability in the component traits. It was found that stability in grain yield was due to stability in yield components only and plasticity in others. This pattern of stability and plasticity in component traits differ from hybrid to hybrid. The yield behavior in almost all the genotypes except KRH 2 and DRRH 1 were highly predictable. The hybrid KRH 2 was found to be stable for yield as it had average yield performance; regression coefficient is near to unity and minimum deviation from regression. The hybrids PHB 71 and NSD 2 can be rated as promising hybrids. Sahyadri may be rated as most promising hybrid under favourable environment.

Panwar *et al.* (2008) studied Genotype environment interaction for grain yield, its components and grain quality traits in 10 parents and their 45 F_1s of scented rice under four environments created by four different dates of transplanting during wet season, 2003. Significant genotype, environment interactions was observed for all the eleven characters having homogenous error variance in environments. Among the linear and non-linear components of GE interaction, linear component was predominant for most of the characters, suggesting variation in the performance of different genotypes grown over environments could be predicted. Mean squares due to environment (linear) was also found significant for all the characters, indicating differences between environments and their influence on genotypes for expression of these characters. Based on stability parameters and overall mean, genotypes IET 13549 and Pusa Basmati-1 were most stable under different environments, while IET 13846 was suitable for poor environments and the crosses Taroari Basmati x IET 16320, IET 13549 x IET 13846 and Pusa Basmati-1 x IET 13846 were more suitable for favourable environments with respect to these characters.

Saidaiah (2008) studied 115 hybrids and reported that CRMS 32 A x 517, APMS 6A x 118, PUSA x IR 55, PUSA x 124 and APMS 6A x GQ 120 are stable with the desirable *sca* effects, heterosis and *per se* performance for grain yield and other important attributes.

Forty eight hybrid combinations were studied along with their 14 parents and two standard checks for their stability performance at three locations in Andhra Pradesh for eight quantitative characters. The GE interaction was significant for days to 50 per cent flowering, plant height, number of productive tillers per plant, panicle length, number of grains per panicle and grain yield per plant. Linear component was also significant for above mentioned characters, while non-linear component found significant for all the traits studied (Gouri Shanker *et al.,* 2008).

Bhadru (2010) studied stability of hundred rice hybrids and reported that IR-79156A x R-52 and IR-79156A x IR-13419 possessed stability for wider environments and DRR-14A x R-47, IR-79156A x R-49 and IR-80555A x IR-66 exhibited suitability for favourable environments with the desirable *sca* effects, heterosis and *per se* performance for grain yield and quality and other important attributes.

CHAPTER III

MATERIAL AND METHODS

The present investigation in rice was undertaken to identify suitable restorers and maintainers with the background of Wild Abortive (WA) male sterile cytoplasm , to study the inheritance of fertility restoration and to estimate GCA and SCAeffects, heterosis, heterobeltiosis, standard heterosis and to evaluate the stability and gall midge resistance of experimental hybrids across the locations. The material utilized and the methodologies adopted in the investigation to achieve the desired objectives are described under the following major heads.

3.1 Identification of restorers and maintainers and study on inheritance of fertility restoration

3.2 Gall midge resistance, Combining ability and Heterosis

3.3 Stability of the hybrids

3.1 IDENTIFICATION OF RESTORERS AND MAINTAINERS AND STUDY ON INHERITANCE OF FERTILITY RESTORATION

3.1.1 Materials

The basic material comprised of one cytoplasmic male sterile (CMS) line of WA source APMS 6A and 120 elite diverse lines (Table 3.1) obtained from R.A.R.S, Jagtial, R.A.R.S,.Warangal of ANGRAU and Directorate of Rice Research (DRR), Hyderabad.

3.1.2 Methods

The CMS line APMS 6A was crossed with 120 male fertile lines to obtain 120 F_1 hybrids during *rabi,* 2007-2008 at Rice Research Scheme, Regional Agricultural Research Station, Jagtial, Karimnagar Dist, A.P. Twenty eight days old seedlings of each parent were transplanted in 2 rows of 4 m length with a spacing of 20 x 15 cm in the main field.

3.1.2.1 Hybridization: Crossing was affected by following clipping method to get the required quantity of the seed for the proposed experiment during Kharif 2008-09. Healthy CMS line with just emerged panicles were uprooted from the field, labeled

Table 3.1. List of material used for identification of the suitable restorers and maintainers with the background of Wild Abortive (WA) male sterility

Sl. No.	Female line used	Pedigree of male line used	Source of male line
1	JGL 8644	JGL 384 X GEDANGIBETON	ANGRAU (R.A.R.S, Jagtial)
2	JGL 8609	JGL 418 X GEDANGIBETON	ANGRAU (R.A.R.S, Jagtial)
3	JGL 8605	JGL 418 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
4	JGL 8293	JGL 385 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
5	JGL 8292	JGL 385 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
6	JGL 7045	JGL 384 X VAJRAM	ANGRAU (R.A.R.S, Jagtial)
7	JGL 533	SWARNA X CR 309-260	ANGRAU (R.A.R.S, Jagtial)
8	JGL 4147	PHALGUNA X WGL 48937 (BG)	ANGRAU (R.A.R.S, Jagtial)
9	JGL 410	BPT 5204 X KAVYA	ANGRAU (R.A.R.S, Jagtial)
10	JGL 402	BPT 5204 X KAVYA	ANGRAU (R.A.R.S, Jagtial)
11	JGL 3866	BPT 5204 X ARC 5984 // KAVYA	ANGRAU (R.A.R.S, Jagtial)
12	JGL 3855	BPT 5204 X ARC 5984 // KAVYA	ANGRAU (R.A.R.S, Jagtial)
13	JGL 3844	BPT 5204 X ARC 5984 // KAVYA	ANGRAU (R.A.R.S, Jagtial)
14	JGL 384	BPT 5204 X KAVYA	ANGRAU (R.A.R.S, Jagtial)
15	JGL 245	BPT 5204 X CR 311-34	ANGRAU (R.A.R.S, Jagtial)
16	JGL 1853	BPT 5204 X POTHANA	ANGRAU (R.A.R.S, Jagtial)
17	JGL 1798	BPT 5204 X KAVYA	ANGRAU (R.A.R.S, Jagtial)
18	JGL 17223	JGL 1798 X SWARNA	ANGRAU (R.A.R.S, Jagtial)
19	JGL 17221	JGL 1798 X SWARNA	ANGRAU (R.A.R.S, Jagtial)
20	JGL 17216	JGL 1798 X SWARNA	ANGRAU (R.A.R.S, Jagtial)
21	JGL 17211	JGL 3827 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
22	JGL 17206	JGL 1797 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
23	JGL 17204	JGL 1797 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
24	JGL 17203	JGL 1797 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
25	JGL 17196	JGL 326 X MTU1010	ANGRAU (R.A.R.S, Jagtial)
26	JGL 17194	JGL402 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
27	JGL 17190	JGL 1798 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
28	JGL 17189	JGL 1798 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
29	JGL 17187	JGL 1798 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
30	JGL 17183	JGL 1798 X MTU 1010	ANGRAU (R.A.R.S, Jagtial)
31	JGL 17025	WGL 14377 X JGL 3855	ANGRAU (R.A.R.S, Jagtial)
32	JGL 17004	WGL 14377 X JGL 3855	ANGRAU (R.A.R.S, Jagtial)
33	JGL 16284	JGL 384 X CR 311-34	ANGRAU (R.A.R.S, Jagtial)
34	JGL 16280	JGL 1798 X TWIN RICE	ANGRAU (R.A.R.S, Jagtial)
35	JGL 16279	JGL 1798 X TWIN RICE	ANGRAU (R.A.R.S, Jagtial)
36	JGL 16277	JGL 384 X TWIN RICE	ANGRAU (R.A.R.S, Jagtial)
37	JGL 16274	JGL 384 X TWIN RICE	ANGRAU (R.A.R.S, Jagtial)
38	JGL 16269	JGL 410 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
39	JGL 16264	JGL382 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
40	JGL 16261	JGL 382 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
41	JGL 16259	JGL 1851 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
42	JGL 16258	JGL 1851 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
43	JGL 16257	JGL 1851 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
44	JGL 15663	JGL 410 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
45	JGL 15660	JGL 410 X BETAGABMLIN	ANGRAU (R.A.R.S, Jagtial)
46	JGL 15660	JGL 410 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
47	JGL 15658	JGL 410 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
48	JGL 15656	JGL 410 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)

Table 3.1(cont.)			
Sl. No.	Male lines used	Pedigree of male line used	Source of male line
49	JGL 15649	JGL382 X BETAGAMBLIN	ANGRAU (R.A.R.S, Jagtial)
50	JGL 15329	JGL 384 X GODAVARIISUKASLU	ANGRAU (R.A.R.S, Jagtial)
51	JGL 15324	JGL 410 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
52	JGL 15324	JGL 384 X GODAVARIISUKASLU	ANGRAU (R.A.R.S, Jagtial)
53	JGL 15283	MTU 4870 X GODAVARIISUKALU	ANGRAU (R.A.R.S, Jagtial)
54	JGL 15281	MTU 4870 X GODAVARIISUKALU	ANGRAU (R.A.R.S, Jagtial)
55	JGL 15247	JGL 1798 X GODAVARIISUKASLU	ANGRAU (R.A.R.S, Jagtial)
56	JGL 15246	JGL 1798 X GODAVARIISUKASLU	ANGRAU (R.A.R.S, Jagtial)
57	JGL 15219	MTU 4870 X JGL 420	ANGRAU (R.A.R.S, Jagtial)
58	JGL 15208	MTU 4870 X JGL 1798	ANGRAU (R.A.R.S, Jagtial)
59	JGL 15185	MTU 4870 X JGL 1798	ANGRAU (R.A.R.S, Jagtial)
60	JGL 13621	JGL 418 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
61	JGL 13597	MTU 4870 X JGL 418	ANGRAU (R.A.R.S, Jagtial)
62	JGL 13595	MTU 4870 X JGL 418	ANGRAU (R.A.R.S, Jagtial)
63	JGL 13549	MTU 4870 X GODAVARIISUKALU	ANGRAU (R.A.R.S, Jagtial)
64	JGL 13515	MTU 4870 X JGL 420	ANGRAU (R.A.R.S, Jagtial)
65	JGL 13445	JGL 384 X IET 11769	ANGRAU (R.A.R.S, Jagtial)
66	JGL 13418	JGL 385 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
67	JGL 13398	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
69	JGL 13392	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
70	JGL 13391	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
71	JGL 13376	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
72	JGL 13375	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
73	JGL 11728	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
74	JGL 11725	JGL 420 X VIJETHA	ANGRAU (R.A.R.S, Jagtial)
75	JGL 11690	MTU 4870 X JGL 418	ANGRAU (R.A.R.S, Jagtial)
76	JGL 11689	MTU 4870 X JGL 418	ANGRAU (R.A.R.S, Jagtial)
77	JGL 11679	MTU 4870 X JGL 418	ANGRAU (R.A.R.S, Jagtial)
78	JGL 11650	JGL 384 X GODAVARIISUKASLU	ANGRAU (R.A.R.S, Jagtial)
79	JGL 11609	MTU 4870 X GODAVARIISUKALU	ANGRAU (R.A.R.S, Jagtial)
80	JGL 11605	MTU 4870 X GODAVARIISUKALU	ANGRAU (R.A.R.S, Jagtial)
81	JGL 11470	JGL 418 X GEDANGIBETON	ANGRAU (R.A.R.S, Jagtial)
82	JGL 11459	JGL 1796 X GEDANGIBETON	ANGRAU (R.A.R.S, Jagtial)
83	JGL 11459	JGL 1798 X GEDANGIBETON	ANGRAU (R.A.R.S, Jagtial)
84	JGL 11160	JGL 383 X IET 8585	ANGRAU (R.A.R.S, Jagtial)
85	JGL 11118	IET 8585 X JGL 1798	ANGRAU (R.A.R.S, Jagtial)
86	JGL 11111	IET 8585 X JGL 384	ANGRAU (R.A.R.S, Jagtial)
87	JGL 11110-2	IET 8585 X JGL 384	ANGRAU (R.A.R.S, Jagtial)
88	JGL 11110-1	IET 8585 X JGL 384	ANGRAU (R.A.R.S, Jagtial)
89	JGL 11097	IET 8585 X JGL 384	ANGRAU (R.A.R.S, Jagtial)
90	ERRAMALLELU	BC 5-55 X W 12708	R.A.R.S,Warangal
91	BADRAKALI	Phalguna x IR 36	R.A.R.S,Warangal
92	60 R	IR 71604-4-4-1-4-4-4-2-2-2R	Directorate of Rice Research
93	52 R	IR 65912-90-1-6-3-2-3R	Directorate of Rice Research
94	44 R	IR 63877-43-2-1-3-1R	Directorate of Rice Research
95	3 R	IR 23352-7R	Directorate of Rice Research
96	29 R	IR616114-38-19-3-2R	Directorate of Rice Research
97	2 R	IR 10198-66-2R	Directorate of Rice Research
98	19 R	IR 57298-174-2-2R	Directorate of Rice Research

Table 3.1(cont.)			
Sl. No.	**Male lines used**	**Pedigree of male line used**	**Source of male line**
99	18 R	IR 56381-139-2-2R	Directorate of Rice Research
100	118 R		Directorate of Rice Research
101	RIL 64		Directorate of Rice Research
102	RIL 55		Directorate of Rice Research
103	RIL 46		Directorate of Rice Research
104	RIL 38		Directorate of Rice Research
105	RIL 35		Directorate of Rice Research
106	RIL 32		Directorate of Rice Research
107	RIL 27		Directorate of Rice Research
108	RIL 23		Directorate of Rice Research
109	RIL 17		Directorate of Rice Research
110	RIL 16		Directorate of Rice Research
111	RIL 138		Directorate of Rice Research
112	RIL 134		Directorate of Rice Research
113	RIL 129		Directorate of Rice Research
114	RIL 127		Directorate of Rice Research
115	RIL 126		Directorate of Rice Research
116	RIL 12		Directorate of Rice Research
117	RIL 117		Directorate of Rice Research
118	RIL 108		Directorate of Rice Research
119	MP 200		Directorate of Rice Research
120	GQ 70		Directorate of Rice Research

and potted in the morning hours of the day in earthen pots filled with mud which were latter transferred to the net house. Further, spikelets that have completed anthesis and the young spikelets to be opened lately at the bottom were removed. The only matured spikelets which were about to flower on the next day alone were used for crossing. Top one-quarter to one-half of the glumes of each spikelet was clipped off with fine scissors without causing any damage to stigma. The panicle was properly labeled and bagged with butter paper bag to avoid unwanted cross pollination. The clipping process was carried out during evening hours of the previous day of crossing.

On the following morning between 9 to 11 am the panicles which were ready for anthesis were selected from healthy male parents and brought to the crossing chamber, wherein temperature, relative humidity and light conducive for anthesis were maintained. When the mature anthers were ready for dehiscence, the CMS lines were brought inside the crossing chamber, butter paper bags covering clipped panicles of the female parents were removed. Further, the panicles were gently shaken so that the sterile extruded anthers fell off. Viable pollen from panicles of male parents was then gently shaken over the female parents until adequate pollen was deposited on the stigmas of the female spikelets. The pollinated spikelets were then covered with fresh butter paper bags to prevent the foreign pollen and the panicles duly labeled. The process of pollination was continued up to 11.00 am.

Crossed seeds were collected after four weeks from the plants maintained in the pots in the net house. The seeds were then sun dried, counted and placed in small labeled envelops. In each envelop a small pieces of naphthalene ball was kept for protection against stored grain pests. The number of crossed seed collected from each cross varied from 500-650.

Kharif 2008-09: The 120 F_1 hybrids developed during *rabi* 2007-08 were transplanted with a spacing of 20x15 cm during *kharif*, 2008-09 at Rice Research Scheme, RARS, Jagtial to study the fertility restoration reaction.

The data on gall midge damaged plants (%), silver Shoots (%) days to 50 percent flowering (DFF), number of filled grains per panicle, number of unfilled grains, total grains and single plant yield (gm) was recorded.

The matured panicles were harvested and ratio of fertile spikelets to the total number of spikelets was expressed in percentage (spikelet fertility per cent.). Based on the spikelet fertility percentage of F_1 hybrids, the male parental lines were classified as good restorers (>80 % fertility), partial restorers (60-80 % fertility), partial maintainers (10-60% fertility) and maintainers (<10 % fertility). Based on the fertility reaction the lines will be selected for further crossing with 5 CMS lines (Testers).

3.1.2.2 Inheritance of fertility restoration: The F_2 progeny of four cross combinations *viz.*, APMS 6A x JGL 11110-2, APMS 6A x JGL 11110-1, APMS 6A x JGL 17211 and APMS 6Ax JGL 16284 along with their parents and F_1s were evaluated during *rabi*, 2009-10.

Twenty five grams of F_2 seed of each of the four crosses were sown and more than 1000 population of F_2 was raised by planting single seedling per hill with 15 x 15 cm spacing. At maturity, 1000 single plants were harvested separately from each cross. Data on per cent seed set was recorded on single plant basis.

Classification of F_2 progeny on the basis of spikelet fertility	
Class	***Spikelet fertility per cent***
Fertile	> 80 %
Partially fertile/ partially sterile	10 to 80 %
Sterile	<10

The data, thus generated, were subjected to Chi-Square (χ^2) test. Chi-Square is a test of significance to test the goodness of fit between observed values and expected values based on hypothesis. The null hypothesis (Ho) was that there is no significant difference between observed and expected frequencies.

The significance of Ho is tested using the formula:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where, O = Observed frequency and E = Expected frequency.

The computed value is compared with the table value at (n-1) degrees of freedom for significance, where n = total number of classes into which the data were divided.

3.2 GALLMIDGE RESISTANCE, COMBINING ABILITY AND HETEROSIS STUDIES OVER THREE LOCATIONS

3.2.1 Materials

***Kharif* 2009-10** : Based on the successful maintainer/restorer reaction and other characters like, damage plants (%), silver shoots (%), days to 50 percent flowering, number of filled grains per panicle, number of un filled grains, total grains, spikelet fertility (%), single plant yield the restorer lines are selected.

From the results of fertility restoration,12 lines (*i.e.*, JGL 11110-2, JGL 11160, JGL11110-1, JGL 8292, JGL 16284, JGL 11111, JGL 3844, JGL 3855, JGL 17211, JGL 11118, JGL 13515, JGL 8605) with more than 80 (%) fertility restoration were selected and one line was selected (*i.e.*, JGL 1798) from partial restorers to study the combining ability, heterosis and stability. The 13 lines were crossed with 5 CMS lines (IR 6897A, APMS 8A, APMS 6A, CMS 16A and IR 58025A) to develop 65 hybrids, by following the same procedure of hybridization as done in earlier experiment. The 18 parents and 65 hybrids developed were used as material to study combining ability, heterosis and response to gall midge resistance over locations along with six (6) checks (Table 3.2).

3.2.2 Methods

The 65 hybrids developed along with 13 lines and 5 testers and 6 checks were sown at three locations *i.e.*, at Kunaram, Warangal and Kampasagar. Crossed seed of hybrids were treated with Carbendazim solution (0.1%) and directly sown in earthen pots filled with mud. Satisfactory germination was observed on the 4th and 5th day of sowing. Care was taken to avoid water logging and complete drying up of pots. Top dressing was given with urea for raising vigorous seedlings. Such strong and vigorous

Table 3.2. List of male sterile and successful restorer lines and checks used to study gall midge resistance, combining ability, heterosis and stability.

S. No	CMS lines	Characters	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**
6	**TN1** (Susceptible check for gall midge)	Highly susceptible to gall midge	**Directorate of Rice Research**

seedlings of 30 days old were used for transplanting in the main field. A total of 89 entries (65 hybrids, 13 lines, 5 testers and 6 checks) were grown in RBD with three replications. Each entry was planted in two rows of two meters length with a spacing of 20 x 15 cm. All the necessary recommended package of practices of ANGRAU was followed to raise the good crop.The plant protection measures were not taken so as to record the incidence of gall midge.

3.2.3 Observations recorded

Five plants were tagged at random for each entry in each replication and observations were recorded for yield and yield attributing characters from these tagged plants in all the genotypes in each replication. The data for the character, days to 50 per cent flowering was recorded on plot basis. The method of recording data for each trait is described below.

3.2.3.1 Gall midge damaged plants (%): The incidence of silver shoots in randomly selected 15 plants was recorded and expressed in percentage on population basis.

3.2.3.2 Silver shoots (%): Data recorded on the number of silver shoots and total tillers present in randomly selected 15 hills and expressed as damaged tillers to total tillers in percentage.

3.2.3.3 Days to 50 (%) flowering (DFF): The total number of days taken from the date of sowing to extrusion of the panicle tip above the sheath of the flag leaf in 50 per cent of plants in a plot.

3.2.3.4 Plant height (cm): The plant height was recorded by measuring the total height from the base of the plant to the tip of the main panicle and excluding awn if present and is expressed in cm.

3.2.3.5. Number of productive tillers per plant: The numbers of tillers in a plant, which bear panicles, were recorded as number of productive tillers per plant at the time of maturity.

3.2.3.6 Length of flag leaf (cm): Flag leaf length was measured in centimeters from the base of leaf blade to its tip during flowering

3.2.3.7 Width of flag leaf (cm): Flag leaf width was measured in centimeters at broader place of leaf blade during flowering

3.2.3.8 Panicle length (cm): It was measured from the base of the panicle to tip of panicle in centimeters.

3.2.3.9 Panicle weight (gm): Weight of the single panicle of the main tiller was expressed as panicle weight in grams.

3.2.3.10 Number of filled grains per panicle: Filled spikelets of five panicles of the hill were counted and averaged to single panicle.

3.2.3.11 Spikelet fertility (%): Spikelet fertility was calculated as the ratio of fertile grains per panicle to the total number of grains in a panicle and was expressed as percentage.

3.2.3.12 1000 seed weight (gm): One thousand well filled grains were counted from a random sample of each entry in each replication and weighed with the help of electronic balance in grams.

3.2.3.13 Grain Yield per plant (gm): Panicles from a single plant were harvested at maturity, threshed, cleaned and dried to 12-14 per cent moisture content and the weight was recorded in grams.

3.2.3.14 per day productivity (kg/ha): It is the ratio of grain yield in kilograms of a parent /hybrid per hectare to days to its maturity and expressed in kilograms per hectare.

3.2.3.15 L/B ratio: Ten grains with intact tips from each replication of the bulk samples of each entry were measured for their length and breadth using a Satake Grain. Shape Tester. Average of length and breadth were recorded in millimeters and L/B ratio was calculated

The data recorded on different traits were subjected to the following statistical analysis.

3.2.4. Statistical Analysis

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).

$$Y_{ij} = m + g_i + r_j + e_{ij}$$

Where,

Y_{ij} = Phenotypic observation of i^{th} genotype in j^{th} replication

m = General mean

g_i = Effect of i^{th} genotype

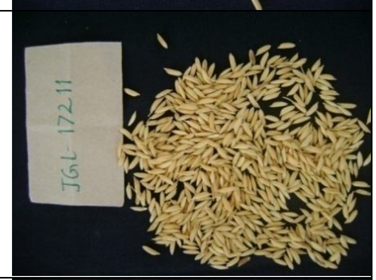
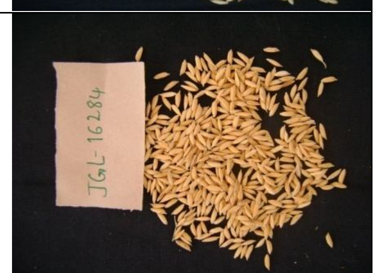
r_j = Effect of j^{th} replication

e_{ij} = Random error

Plate 3.1. Evaluation of parents, hybrids along with checks at Agriculture Research Station, Kunaram Dist:Karimnagar (A.P).

Plate 3.2. R, Lines used in the present investigation

R,LINE	Panicle	Grains

JGL 11110-2		
JGL 11110-1		
JGL 17211		
JGL 16284		
JGL 13515		
JGL 11160		
R,LINE	**Panicle**	**Grains**

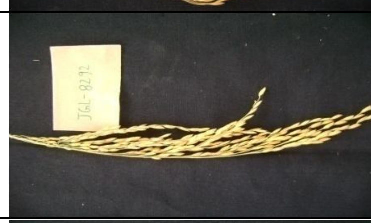
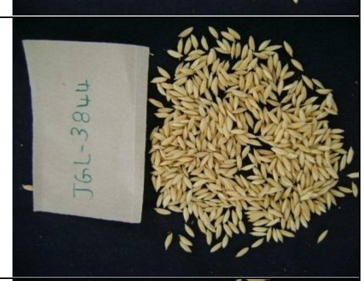
JGL 11118		
JGL 11111		
JGL 8605		
JGL 8292		
JGL 3855		
JGL 3844		
JGL 1798		

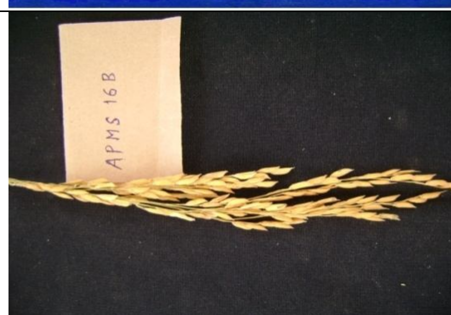
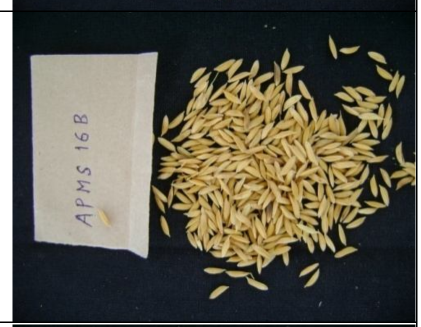
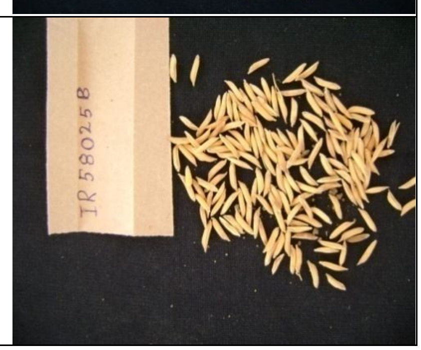
Plate 3.3. B Lines of corresponding male sterile lines used in the present investigation		
B,LINE	**Panicle**	**Grains**
IR 68897 B		
AP MS 8 B		
CMS 16 B		
AP MS 6 B		
IR 58025 B		

Plate 3.4. Checks used in the present investigation		
Check	**Panicle**	**Grains**
KRH-2		
DRRH-2		
PA 6201		
JAYA		
IR-64		

The analysis of variance (ANOVA) was carried out for each character as indicated below

ANOVA			
Source	**d.f.**	**MS**	**F calculated**
Replications (r)	(r-l)	Mr	Mr/Me
Treatments (t)	(t-l)	Mt	Mt/Me
Error (e)	(r-l) (t-l)	Me	
Total	(rt-l)		

Where,

r = number of replications

t = number of treatments (genotypes)

Mr = mean sum of squares of replications

Mt = mean sum of squares of treatments

Me = mean sum of squares of error

DF = degrees of freedom

MS = mean sum of squares

The significance of mean sum of squares for each character was tested against the corresponding error degrees of freedom using 'F' test (Fisher and Yates, 1967).

3.2.4.2 Line x Tester Analysis

The data recorded on the material generated 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).

ANOVA for Line x Tester analysis:

Source	d.f	MS
Replications (r)	(r-l)	
Genotypes (a)	(a-l)	
Parents (p)	(p-l)	
Crosses (c)	(c-l)	
Parents vs. crosses	l	
Males (m)	(m-l)	Mm
Females (f)	(f-l)	Mf
Males x females (m x f)	(m-l) (f-l)	M (m x f)
Error	(r-l) (a-l)	Me

Where,

r = number of replications

a = number of genotypes

p = number of parents

c = number of crosses

m = number of males

f = number of females

Mm = mean sum of squares of males

Mf = mean sum of squares of females

M (m x f) = mean sum of squares of males and females

Me = mean sum of squares of error

d.f = degrees of freedom

MS = mean sum of squares

The significant differences among the genotypes and replications were verified by applying ‘F’ test (Fisher and Yates, 1967).

Estimation of combining ability: Combining ability was estimated based on the method of Kempthorne (1957). The estimates of general and specific combining ability and their variances were obtained by using covariance of half sibs and full sibs.

ANOVA

Source	d.f	SS	MS	Expected mean squares
Replications	(r-l)	$\frac{X^2\ldots_k}{mf} - \frac{X^2\ldots}{mfr}$		
Hybrids	(mf-l)	$\frac{X^2_{ij.}}{r} - \frac{X^2\ldots}{mfr}$		
Males	(m-l)	$\frac{X^2_{i\ldots}}{fr} - \frac{X^2\ldots}{mfr}$	M_1	σ^2 + r [Cov (F.S) - 2Cov (H.S) + fr Cov (H.S)]
Females	(f-l)	$\frac{X^2_{.j.}}{mr} - \frac{X^2\ldots}{mfr}$	M_2	σ^2 + r [Cov (F.S) – 2Cov (H.S) + mr Cov (H.S)]

Males x Females	(m-l)(f-l)	$\frac{X^2_{(ij)}}{r} - \frac{X^2_{i..}}{fr} - \frac{X^2_{.j.}}{mr} + \frac{X^2_{...}}{mfr}$	M_3	σ^2 + r [Cov(F.S) – 2 Cov (H.S)]
Error	(r-l)(mf-l)	By difference	M_4	σ^2
Total	(mfr-l)	$X^2_{(ij)k} - \frac{X^2_{...}}{mfr}$		

Where,

$X_{...}$ = Sum of all the (ij) hybrid combinations

$X_{...k}$ = Sum of k^{th} replication

$X_{(ij)}$ = Sum of ij^{th} hybrid combination over all replications

$X_{.j.}$ = Sum of j^{th} female parent over all males and replications

X_{ijk} = ijth observation in k^{th} replication

Covariance of full sibs and covariance of half sibs were estimated by using the formula (Kempthorne, 1957) given below:

$$\text{Covariance of half sibs} = \frac{1}{r\,(2mf - f - m)} \left(\frac{(f-1)\,(M_1) + (m-1)\,(M_2)}{f + m - 2} \right) - M3$$

$$\text{Covariance of full sibs} = \frac{(M_1 - M_4) + (M_2 - M_4) + (M_3 - M_4)}{3r}$$

$$+ \frac{6\,r\,\text{Cov (H.S)} - r\,(m + f)\,\text{Cov (H.S)}}{3r}$$

Estimation of variances: Using the covariances of half sibs and full sibs which were estimated by the above equations, variance due to general combining ability (σ^2 *gca*) and variance due to specific combining ability (σ^2 *sca*) were estimated as :

σ^2 *GCA* = Covariance of half sibs

σ^2 *sca* = Covariance of full sibs – 2 Covariance of half sibs

Estimation of combining ability effects: The additive model used to estimate the *gca* and *sca* effects of the ijk observations were

$$X_{ij} = \mu + g_i + g_j + s_{ij} + e_{ijk}$$

Where

μ = population mean

g_i = *gca* effect of i^{th} male parent

g_j = *gca* effect of j^{th} female parent

s_{ij} = *sca* effect of ij^{th} combination

e_{ijk} = error associated with the observation X_{ijk}

i = number of male parents

j = number of female parents

k = number of replications

The estimation of individual effects was as follows:

$$\mu = \frac{X\ldots}{mfr}$$

Where,

X… = Total of all hybrid combinations over all replications

(i) Lines:

$$g_i = \frac{X_{i}..}{fr} - \frac{X\ldots}{mfr}$$

Where

Xi = Total of i^{th} male parent over all females and replications

(ii) Testers :

$$g_j = \frac{X_{.j.}}{mr} - \frac{X_{...}}{mfr}$$

Where,

$X_{.j.}$ = Total of j[th] female parent over all male parents and replications

(iii) **Crosses**

$$S_{ij} = \frac{X_{ij.}}{r} - \frac{X_{i..}}{fr} - \frac{X_{.j.}}{mr} + \frac{X_{...}}{mfr}$$

Where

$X_{ij.}$ = ijth combination total over all replications

Standard errors for combining ability effects: The standard errors (SE) pertaining to *gca* and *sca* effects of different combinations were calculated as follows :

$$\text{SE } (g_i) \text{ males } (gca \text{ for line}) = \left(\frac{\text{Error of variance}}{rf} \right)^{½}$$

$$\text{SE } (g_j) \text{ females } (gca \text{ for tester}) = \left(\frac{\text{Error of variance}}{rm} \right)^{½}$$

$$\text{SE } (s_{ij}) \text{ male x female combination} = \left(\frac{\text{2 error of variance}}{r} \right)^{½}$$

where

r = number of replications

m = number of males

f = number of females

3.2.4.3 Estimation of heterosis

Heterosis was estimated for 65 hybrids for 12 characters using the following formulae.

Heterosis over mid parent: Heterosis was expressed as per cent increase or decrease observed in the F_1 over the mid-parent as per the following formula.

$$\text{Heterosis (\%)} \ (h_1) = \frac{\overline{F}_1 - \overline{MP}}{\overline{MP}} \text{x}100$$

Where,

$\overline{F}_1$ = Mean of F_1

$\overline{MP}$ = Mean of mid parents

Heterosis over better parent: Heterobeltiosis was expressed as per cent increase or decrease observed in F_1 over the better parent as per the formula of Liang *et al.* (1971).

$$\text{Heterobeltiosis \% } (h_2) = \frac{\overline{F}_1 - \overline{BP}}{\overline{BP}} \text{x}100$$

Where,

$\overline{BP}$ = Mean of better parent (for the characters like days to 50% flowering, earliness is desirable so the early parents are taken as better parents).

Heterosis over standard checks: Standard heterosis was expressed as per cent increase or decrease observed in F_1 over standard checks.

$$\text{Standard heterosis \% } (h_3) = \frac{\overline{F}_1 - \text{Mean of check}}{\text{Mean of check}} \text{x}100$$

Test of significance of heterosis: To test the significance for different types of heterosis needs computation of standard error (SEm). For relative heterosis and heterobeltiosis, SEm were calculated based on error mean squares (EMS) from the ANOVA tables consisting parents and crosses, whereas, EMS from the RBD ANOVA (σ^2 e) table based on all treatments (parents, crosses and check) was used for standard heterosis.

The significance of heterosis *viz.*, heterosis over mid parent , heterobeltiosis and standard heterosis was then tested by comparing the calculated ‘t’ value with the tabulated student’s ‘t’-value for appropriate error degrees of freedom at 5 per cent and 1 per cent level of significance (0.05 and 0.01 level of probability), respectively.

‘t’$_{cal}$ for Heterosis and heterobeltiosis = $\dfrac{\overline{F}_1 - \text{Mean of mid parents or better parent}}{\text{SEM}}$

Where, SEm = $\sqrt{2\text{EMS}/r}$

EMS = Error mean of squares

r = Number of replications

t’$_{cal}$ for Standard heterosis = $\dfrac{\overline{F}_1 - \text{Mean of check}}{\text{SEM}\,\overline{\text{SC}}}$

Where, SEm $\overline{\text{SC}} = \sqrt{2\sigma e^2 / r}$

Least significance difference (critical difference) for heterosis: The significance of the difference between two estimates of heterosis were tested by computing the least significant difference (LSD) by multiplying the S.E.m with the appropriate student’s ‘t’ value of respective error degrees of freedom at desired level of probability.

CD = SE m x ‘t’ table value at error degrees of freedom

3.3 Stability Analysis

Eberhart and Russell (1966) identified three parameters of stability namely (i) overall mean of each genotype over a range of environments, (ii) the regression of each genotype on the environmental index and (iii) a function of the squared deviation from the regression were estimated.

The model proposed by Eberhart and Russell (1966) as follows:

$$Y_{ij} = \mu + b_i I_j + \delta_{ij}$$

Where,

(i = 1, 2, ….. g and j = 1, 2, ….., e)

Y_{ij} = Mean of i^{th} genotype in j^{th} environment

μ = Mean of all the genotypes over all the environments

b_i = The regression coefficient of the i^{th} genotype on the environmental index which measures the response of this genotype to varying environments

I_j = The environmental index is defined as the deviation of the mean of all the genotypes at a given location from overall mean

δ_{ij} = The deviation from the regression of i^{th} genotype at j^{th} environment

Analysis of variance of stability

The analysis of variance as proposed by Eberhart and Russell (1966) is given below:

Source	df	S.S	M.S
Total	ge-1	$\Sigma_i \Sigma_j Y^2_{ij}$ – C.F	
Genotype	g-1	$1/e\ \Sigma_i Y^2_i$ – C.F	MS_1
Environment + (Genotype x Environment)	g (e-1)	$\Sigma_i \Sigma_j Y^2_{ij} - \Sigma_i Y_i^2/e$	
Environment (Linear)	1	$1/g\ (\Sigma_j Y_j I_j)^2/\Sigma_j I_j^2$	
Genotype x Environment (linear)	g-1	$\Sigma_i [(\Sigma_j Y_{ij} I_j)^2/\Sigma_j I_j^2]$- $[1/g\ (\Sigma_j Y_j I_j)^2/\Sigma_j I^2_j]$	MS_2
Pooled deviations	g (e-2)	$\Sigma_i (\Sigma_j \delta^2_{ij})$	MS_3
Deviation due to			
Genotype ……1	e-2	$[\Sigma_j Y^2_{Ij} - (Y_i^2)/e]$- $(\Sigma_j Y_{Ij} I_j)^2 / \Sigma_j I^2_j = \Sigma_j \delta_{ij}^2$	MS_3-1
Genotype …….g	e-2	$[\Sigma_j Y^2_{gj} - (Y_g^2)/e]$- $(\Sigma_j Y_j I_j)^2 / \Sigma_j I_j^2 = \Sigma_j \delta_{ij}^2$	MS_3-g
Pooled error	e (r-1) (g-1)		

g = number of genotypes: e = number of environments; CF = Correction factor

Estimation of stability parameters

The two stability parameters, regression coefficient (b_i) and deviation from regression (S^2d_i) were estimated as follows:

a) Regression coefficient

$$b_i = \Sigma_j Y_{ij} I_j / \Sigma_j I_j^2$$

Where,

$\Sigma_j Y_{ij} I_j$ = The sum of products of environmental index (I_j) with corresponding mean of that genotype at each environment (Y_{ij})

$\Sigma_j I^2_j$ = The sum of squares of the environmental index I_j

Mean square deviations (S^2d_i) **from linear regression**

$$S^2d_i = [\Sigma_j \delta^2_{Ij} / (e-2)] - S^2_e/r$$

Where,

$\Sigma_j \delta^2_{Ij}$ = $[\Sigma_j Y^2_{ij} - (Y^2_i/g)] - [(\Sigma_j Y_{ij} I_j)^2 / (\Sigma_j I^2_j)]$

= Variance due to deviation from regression for a genotype

$\Sigma_j Y^2_{ij} - (Y^2_i/g)$ = Variance due to dependent variable and

$[(\Sigma_j Y_{ij} I^2_j)^2/(\Sigma_j I^2_j)]$ = Variance due to regression

S^2_e = the estimate of pooled error

e = number of environments

r = number of replications

The various computational steps involved in the estimations are as follows:

Computation of environmental index (I_j)

$$I_j = (\Sigma j\ Y_{ij}/g) - (\Sigma_i \Sigma j\ Y_{ij}/ge)$$

$$= \frac{\text{Total of all the genotypes at } j^{th} \text{ environment}}{\text{Number of genotypes}} - \frac{\text{Grand total}}{\text{Total number of observations}}$$

Check $\Sigma_j I_j = 0$

Thus, I_j, environmental index is obtained by substracting the grand mean from the mean of all the varieties at j^{th} environment.

Computation of regression coefficient (b_i) for each genotype

$$b_i = \Sigma_j Y_{ij} I_j / \Sigma_j I^2_j$$

Where,

$\Sigma_j Y_{ij} I_j$	=	The sum of products of environmental index (I_j) with corresponding mean of that genotype at each environment (Y_{ij})
$\Sigma_j I^2_j$	=	The sum of squares of the environmental index I_j

Computation of S^2d_i

In regression analysis, it is possible to partition the variance of the dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (Variance due to regression) and the other which explains variance due to deviation from linearity, symbolically:

$$\sigma^2 Y = \sigma^2 \text{ (regression)} + \sigma^2 \text{ (deviation from the regression)}$$

Obviously, by subtracting the variance due to regression from $\sigma^2 Y$, the variance due to deviation from regression can be obtained which in turn can be used for estimating S^2d_i values. The variance of the mean over different locations with regard to individual genotype may be obtained in the following way:

$$\sigma^2 g_i = \Sigma_j Y^2_{ij} - (Y_i^2/g)$$

Where, Y_{ij} and Y_i are the mean values of genotypes in each location and total value of a variety in all the locations respectively.

The variance due to deviations from regressions ($\Sigma_j \delta^2_{ij}$) for genotype being

$$\Sigma_j \delta^2_{ij} = [(\Sigma_j Y^2_{ij} - Y^2_i/g)] - [(\Sigma_j Y_{ij} I_j^2 / \Sigma_j I^2_j]$$

Where,

$$\Sigma_j Y^2_{ij} - Y^2_i/g = \text{variance due to dependent variable}$$

$(\Sigma_i\ Y_{ij}\ I_j)^2\ /\ (\Sigma_j\ I^2_j)$ = variance due to regression

because

$(\Sigma_j\ Y_{ij}\ I_j)^2\ /\ \Sigma_j\ I^2_j = (\Sigma_j\ Y_{ij}\ I_j)\ (\Sigma_j\ Y_{ij}\ I_j)\ /\ \Sigma_j\ I^2_j = b_i\ \Sigma\ Y_{ij}\ I_j$

From $\Sigma_j\ \delta_{ij}^2$ values, the stability parameter S^2d_i for each variety is computed as follows:

$S^2d_i\ = [\Sigma_j\ \delta^2_{ij}\ /\ (e\text{-}2)] - (S^2_e/r)$

$$\text{Mean square deviation} = \frac{\text{Deviation from regression}}{\text{d.f. for environment}} - \frac{\text{Pooled error}}{\text{No. of replications}}$$

The variance due to genotypes, environment and the pooled error were the same as those calculated in the pooled analysis of the data except that the total sum of squares was mainly partitioned into three main components *viz.*, (1) sum of squares due to genotypes; (2) sum of squares due to environments + (genotype x environment) and (3) pooled error. Again sum of squares due to G x E was further partitioned into two parts *viz.*, (a) S.S. due to G x E (linear) which is in fact sum of squares due to regression and (b) sum of squares due to deviation from linearity of response (i.e., sum of squares due to deviation).

Sum of squares due to environment + (genotype x environment) =

$$\Sigma_i\ \Sigma_j\ Y_{ij}^2 - (\Sigma_i\ Y^2_i/e)$$

Sum of squares due to environment (linear) = $(1/g)\ (\Sigma_j\ Y_j\ I_j)^2/\Sigma_j\ I_j^2$

Sum of squares due to genotype x environment (linear)

$= \Sigma_j\ [(\Sigma_j\ Y_{ij}\ I_j)^2/(\Sigma_j\ I_j^2) - [(1/g)\ (\Sigma_j\ Y_j\ I_j)^2/\Sigma_j\ I^2_j]$

Where,

$(\Sigma_j\ Y_{ij}\ I_j)^2\ /\ (\Sigma_j\ I^2_j) = b_i\ \Sigma_j\ Y_{ij}\ I_j$

Tests of significance

In order to estimate the significance of difference, the following tests were carried out:

(i) To test the significance of the difference among genotype means i.e.:

$H_o = \mu_1 = \mu_2 \ldots\ldots \mu_n$, the 'F' test used was

$$F = \frac{\text{Mean squares due to genotype}}{\text{Mean squares due to pooled deviation}} = MS1 / MS_3$$

(ii) To test that the genotypes did not differ due to regression on environmental index, i.e.,

$H_o = b_1 = b_2 = b_3 \ldots\ldots\ldots b_n$, the 'F' test used was

$$F = \frac{\text{MS due to genotype x environment (linear)}}{\text{MS due to pooled deviation}} = \frac{MS_2}{MS_3}$$

(iii) Individual deviation from linear regression was tested as follows:

$F = [(\Sigma_j \delta_{ij}^2)/(e\text{-}2)/\text{pooled error}]$

Hypothesis that any regression coefficient does not differ from unity or from zero was tested by appropriate't' test i.e.,

For testing H0 = b = 0

$t = b\text{-}0 / SE\ (b_i)$ at (g-2) df 5% level of probability

For testing H0 = b = 1

$t = 1\text{-}b / SE\ (b_i)$ at (g-2) df 5% level of probability

$$SE\ bi = \sqrt{\sum_j \delta^2 ij / (e-2) / \sum_j Ij^2}$$

Stable genotype

A genotype with unit regression coefficient (b=1) and the deviation not significantly differing from zero ($S^2d_i = 0$) was taken to be stable genotype with unit response:

Mean and standard error of 'b':

Mean of b = $\bar{b} = \Sigma_i b_i/g$

$$SE(b) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\sum_j I_j^2}}$$

$$\text{Similarly, } SE(b_i) = \sqrt{\frac{\text{M.S. due to pooled deviation of } i^{th} \text{ variety}}{I_j^2}}$$

Where, M.S pooled deviation of i^{th} genotype = $\frac{\delta^2_{ij}}{s-2}$ with e-2 d.f.

Population mean

Population mean (μ) and standard error were calculated as:

$$\text{Population mean } (\mu) = \frac{\text{Grand total}}{\text{No. of observations}}$$

$$S.E(\text{mean}) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\text{Number of environments} - 1}}$$

CHAPTER IV

RESULTS AND DISCUSSION

Rice is the stable food for nearly 68 per cent of the total population in India. Indian rice production target for 2020 AD is 140 million tones. Achievement of this targeted production would be tough task in coming years. One of the methods to break the yield plateau is to go for hybrid rice. Introduction of semi dwarf varieties like IR 8 in mid sixties exhibited upward trend in rice production. From last few years stagnation in yield is due to slow growth in yield. The current rice production needs to be strengthened with a scope for additional yield to the tune of 2 million tones every year. However, availability of cytoplasmic genetic male sterility and presence of heterosis and successful cultivation of rice hybrids in China inspired researchers in India to adopt heterosis breeding.

Hence, concerted research efforts are needed to identify and improve the diverse parental lines suited to local conditions. Development and evaluation of highly heterotic hybrids having resistance to major insect pests, studying their stability over locations will go a long way in identifying the appropriate hybrids to meet the research gaps.

The feedback received from cultivators indicates certain limitations such as susceptibility to pests and diseases, inadequate yield heterosis have impeded the rapid spread of hybrid rice in India (Paroda, 1998).

Gall midge is a serious insect pest of rice in Northern Telangana Zone of Andhra Pradesh. Comprehensive programme of rice breeding and testing for gall midge resistance at Regional Agricultural Research Station, Jagtial and Warangal has resulted in release of several varieties besides developing promising gallmidge resistant cultures with high yield. There is no information about these cultures for their fertility reaction on WA source of CMS lines for developing locally suitable heterotic rice hybrids with gallmidge resistance.Therefore; the study was taken up with an objective to identify gallmidge resistant restorers/maintainers for WA source CMS lines. Further, to study the combining ability of parents and hybrids through L x T mating design, and to study the nature of gene action for yield and yield components, and the stability of hybrids over locations, to identify high yielding stable gallmidge resistant hybrids. The three locations used in present investigation were, Agricultural Research Station, Kunaram, District Karimnagar, Regional Agricultural Research Station, Warangal and Agricultural Research Station, Kampasagar, District Nalgonda.

An attempt has been made in the present investigation to identify restorers and maintainers among 120 lines taken from Regional Agricultural Research Station, Jagtial, Regional Agricultural Research Station, Warangal and Directorate of Rice Research, Hyderabad. Five CMS lines taken from Directorate of Rice Research, Hyderabad and Regional Agricultural Research Station, Maruteru and were crossed with 13 R lines to develop 65 F_1 hybrids. The 65 hybrids, 18 parents along with 6 checks were grow at three locations of Telangana region, for studying gall midge resistance , gene action, combining ability, heterosis and stability.

The results obtained are critically analyzed, interpreted and discussed below under different heads. The experimental results obtained from the present investigation on different characters are presented under the following heads.

4.1 Identification of effective restorers and maintainers and study on genetics of fertility restoration

4.2 Study on gall midge resistance, combining ability and heterosis over locations

4.3 Stability of hybrids and parents over locations

4.1 IDENTIFICATION OF EFFECTIVE RESTORERS AND MAINTAINERS AND STUDY ON GENETICS OF FERTILITY RESTORATION.

A total of 120 crosses, involving CMS line APMS 6A and 120 male lines were evaluated for fertility restoration reaction during *kharif* 2008. The performance of the test cross hybrids (Table 4.1) and the grouping of lines based on fertility reaction (Table 4.2) are presented below.

Spikelet fertility recorded among the hybrids ranged from 0 to 97 per cent (AP MS 6A X 3R). Among 120 crosses studied at Jagtial, 22 crosses exhibited very high spikelet fertility (>80%), 18 crosses exhibited partial fertility (60 to 80%), 35crosses resulted low fertility (10 to 60%) and 45 crosses recorded complete sterility/very low fertility (<10%).

Among the restorers having more than 80% fertility restorability, 12 lines 9 *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 and JGL 8605) are selected and one line *i.e.*, JGL 1798 is selected from group of partial restorers for further study to develop gall midge resistant hybrids by crossing with 5 CMS lines, based on the characters like gall midge resistance, duration, grain type and single plant yield.

Among 120 lines screened 45 lines exhibited maintainer reaction. Therefore, these 45 lines should be further screened for maintaining ability and effective maintainer lines can be converted into gallmidge resistant cytoplasmic lines through back cross breeding. This helps in avoiding the genetic vulnerability of CMS lines. Paroda (1998) advocated development and use of CMS lines in place of widely used IR 58025A. He also recommended to improve these lines in respect to pests and disease resistance.

The varied performance of restorers with CMS line, location and season of testing were also reported by Hema Reddy *et al.* (2000), Sarial and Singh (2000), Singh (2000), Salgotra *et al.* (2002) and Malarvizhi *et al.* (2003). The variation in the behavior of fertility restoration indicated that either the fertility restoring genes are different or their penetrance and expressivity varied with the genotypes of the parental lines or modifiers (Pande *et al.* 1990). Similar results of differential reaction of few rice lines with CMS lines of the same cytoplasmic source was also reported by Viraktamath (1987), Vijay Kumar *et al.* (1998), Sarial and Singh (2000), Salgotra *et al.* (2002). Differential response of the genotypes of the CMS lines of the same WA cytosterlity source may also be due to the interaction between the nuclear/remnant genes of the maintainer lines with the genes of the male parents (Viraktamath, 1987).

The identified 13 good restorer lines were utilized in the present investigation by crossing with 5 WA source CMS lines viz., IR 68897A, IR 58025A, APMS 6A, APMS 8A and CMS 16A. The crosses were affected in L x T mating design to produce 65 hybrids.

4.1.1 Inheritance of fertility restoration

Segregation pattern for spikelet fertility in F_2 generation of four crosses involving the CMS line APMS 6A and four restorer lines *viz.,* JGL 11110-1, JGL11110-2, JGL 17211 and JGL 16284 along with their F_1s and parents is presented in Table 4.3. Individual plants were classified as fertile (>80%), partially fertile/partially sterile (10-80%) and sterile (< 10%) groups based on percent of spikelet fertility.

Table 4.1. Effective restorers and maintainers identified among the 120 lines test crossed with AP MS 6A

	Hybrid			Damage Plants %	Silver Shoots%	Days to 50 % flowering (DFF)	Number of filled grains per panicle	No of un filled grains	Total grains	Spikelet fertility %	Single plant yield (gm)	Fertility reaction
1	APMS 6A	x	3 R	24	22	101	96	3	99	97	10.12	R
2	APMS 6A	x	JGL 11110-2	0	0	102	247	15	262	94	27.68	R
3	APMS 6A	x	JGL 11160	0	0	111	196	16	212	92	21.85	R
4	APMS 6A	x	JGL 7045	0	0	111	92	8	100	92	10.98	R
5	APMS 6A	x	60 R	11	12	102	100	11	111	90	11.50	R
6	APMS 6A	x	JGL 16269	0	0	108	128	15	143	90	14.14	R
7	APMS 6A	x	JGL 13621	0	0	101	149	20	169	88	10.65	R
8	APMS 6A	x	JGL 15660	0	0	111	97	15	112	87	10.45	R
9	APMS 6A	x	JGL 11110-1	0	0	111	175	29	204	86	19.75	R
10	APMS 6A	x	JGL 8292	0	0	99	175	30	205	85	19.25	R
11	APMS 6A	x	JGL 16284	0	0	99	175	33	208	84	19.48	R
12	APMS 6A	x	44 R	50	42	101	37	7	44	84	4.50	R
13	APMS 6A	x	MP 200	0	0	99	125	24	149	84	14.23	R
14	APMS 6A	x	JGL 11111	0	0	98	187	40	227	82	20.78	R
15	APMS 6A	x	JGL 11097	0	0	114	86	19	105	82	9.63	R
16	APMS 6A	x	JGL 3844	0	0	113	167	38	205	81	18.25	R
17	APMS 6A	x	JGL 3855	0	0	106	172	40	212	81	19.24	R
18	APMS 6A	x	JGL 13597	0	0	102	145	34	179	81	16.55	R
19	APMS 6A	x	JGL 17211	0	0	103	190	46	236	81	21.46	R
20	APMS 6A	x	JGL 11118	0	0	107	136	33	169	80	15.24	R
21	APMS 6A	x	JGL 13515	0	0	101	195	48	243	80	21.81	R
22	APMS 6A	x	JGL 8605	0	0	101	175	45	220	80	19.63	R
23	APMS 6A	x	29 R	56	45	106	89	24	113	79	10.23	PR
24	APMS 6A	x	2 R	22	18	101	87	25	112	78	9.22	PR
25	APMS 6A	x	118 R	18	22	103	86	25	111	77	9.11	PR
26	APMS 6A	x	19 R	21	20	100	98	29	127	77	11.28	PR
27	APMS 6A	x	JGL 1798	0	0	98	162	50	212	76	18.66	PR
28	APMS 6A	x	52 R	11	10	100	87	28	115	76	6.35	PR
29	APMS 6A	x	18 R	11	10	102	86	28	114	75	10.78	PR
30	APMS 6A	x	JGL 11459	0	0	105	135	44	179	75	15.36	PR
31	APMS 6A	x	RIL 108	0	0	99	98	33	131	75	12.45	PR
32	APMS 6A	x	JGL 15219	0	0	99	112	38	150	75	9.66	PR
33	APMS 6A	x	JGL 11470	0	0	111	145	54	199	73	16.25	PR
34	APMS 6A	x	JGL 15283	0	0	100	227	88	315	72	25.12	PR
35	APMS 6A	x	JGL 8293	0	0	108	105	41	146	72	11.76	PR
36	APMS 6A	x	JGL 15329	0	0	111	111	50	161	69	12.65	PR
37	APMS 6A	x	JGL 8644	0	0	102	185	90	275	67	20.79	PR
38	APMS 6A	x	JGL 17196	0	0	104	114	61	175	65	12.55	PR
39	APMS 6A	x	JGL 8609	0	0	104	52	30	82	63	5.69	PR
40	APMS 6A	x	JGL 16261	0	0	98	120	70	190	63	13.45	PR
41	APMS 6A	x	JGL 17223	0	0	112	58	44	102	57	6.55	PM
42	APMS 6A	x	JGL 11690	0	0	100	59	53	112	53	6.61	PM
43	APMS 6A	x	JGL 17206	0	0	106	26	28	54	48	6.98	PM
44	APMS 6A	x	JGL 402	0	0	117	73	80	153	48	8.15	PM
45	APMS 6A	x	JGL 15649	0	0	102	144	160	304	47	16.45	PM

Table 4.1(cont.)

	Hybrid			Damage Plants %	Silver Shoots%	Days to 50 % flowering (DFF)	Number of filled grains per panicle	No of un filled grains	Total grains	Spikelet fertility %	Single plant yield (gm)	Fertility reaction
46	APMS 6A	x	JGL 13375	0	0	111	140	162	302	46	15.25	PM
47	APMS 6A	x	BADRAKALI	10	10	110	80	94	174	46	8.96	PM
48	APMS 6A	x	JGL 13595	0	0	103	90	110	200	45	10.45	PM
49	APMS 6A	x	JGL 3866	0	0	118	112	146	258	43	12.45	PM
50	APMS 6A	x	RIL 27	0	0	98	58	80	138	42	6.87	PM
51	APMS 6A	x	JGL 15281	0	0	106	68	98	166	41	7.56	PM
52	APMS 6A	x	JGL 17025	0	0	102	99	157	256	39	11.89	PM
53	APMS 6A	x	JGL 11689	0	0	100	100	168	268	37	11.23	PM
54	APMS 6A	x	JGL 13398	0	0	118	63	129	192	33	7.25	PM
55	APMS 6A	x	JGL 1853	0	0	100	71	163	234	30	7.56	PM
56	APMS 6A	x	JGL 13376	0	0	119	75	175	250	30	8.56	PM
57	APMS 6A	x	RIL 134	0	0	98	63	150	213	30	7.23	PM
58	APMS 6A	x	JGL 17204	0	0	125	42	100	142	30	4.70	PM
59	APMS 6A	x	JGL 410	0	0	125	33	82	115	29	3.65	PM
60	APMS 6A	x	JGL 13392	0	0	114	33	90	123	27	3.70	PM
61	APMS 6A	x	JGL 17189	0	0	102	73	216	289	25	8.13	PM
62	APMS 6A	x	JGL 17187	0	0	74	68	210	278	24	7.69	PM
63	APMS 6A	x	JGL 17194	0	0	105	66	240	306	22	7.56	PM
64	APMS 6A	x	JGL 15663	0	0	97	21	80	101	21	2.65	PM
65	APMS 6A	x	RIL 38	0	0	100	15	60	75	20	1.62	PM
66	APMS 6A	x	JGL 15324	0	0	103	19	80	99	19	2.54	PM
67	APMS 6A	x	JGL 13445	0	0	103	44	200	244	18	4.98	PM
69	APMS 6A	x	GQ 70	0	0	103	17	92	109	16	1.78	PM
70	APMS 6A	x	RIL 117	0	0	101	20	120	140	14	2.56	PM
71	APMS 6A	x	JGL 13418	0	0	109	33	200	233	14	3.89	PM
72	APMS 6A	x	JGL 15246	0	0	100	14	97	111	13	1.52	PM
73	APMS 6A	x	JGL 16274	0	0	107	10	85	95	11	1.16	PM
74	APMS 6A	x	JGL 16277	0	0	113	26	230	256	10	2.68	PM
75	APMS 6A	x	JGL 13391	0	0	112	18	169	187	10	2.05	PM
76	APMS 6A	x	JGL 17004	0	0	98	21	202	223	9	2.65	M
77	APMS 6A	x	JGL 11679	0	0	101	11	111	122	9	1.54	M
78	APMS 6A	x	JGL 16257	0	0	115	7	93	100	7	0.73	M
79	APMS 6A	x	JGL 11650	0	0	104	9	133	142	6	1.06	M
80	APMS 6A	x	JGL 15658	0	0	111	10	155	165	6	1.15	M
81	APMS 6A	x	JGL 17190	0	0	103	10	158	168	6	1.14	M
82	APMS 6A	x	JGL 16258	0	0	119	12	237	249	5	1.36	M
83	APMS 6A	x	JGL 16264	0	0	115	11	220	231	5	1.45	M
84	APMS 6A	x	RIL 35	0	0	97	4	80	84	5	0.48	M
85	APMS 6A	x	JGL 4147	0	0	104	4	80	84	5	0.45	M
86	APMS 6A	x	JGL 15247	0	0	107	9	205	214	4	1.03	M
87	APMS 6A	x	JGL 11605	0	0	107	6	150	156	4	0.75	M
88	APMS 6A	x	RIL 129	0	0	101	4	110	114	4	0.48	M
89	APMS 6A	X	ERRAMALLEL	0	0	102	7	230	237	3	0.75	M
90	APMS 6A	x	RIL 78	0	0	101	2	75	77	3	0.23	M

Table 4.1(cont.)

	Hybrid			Damage Plants %	Silver Shoots%	Days to 50 % flowering (DFF)	Number of filled grains per panicle	No of un filled grains	Total grains	fertility %	Single plant yield (gm)	Fertility reaction
91	APMS 6A	x	JGL 16279	0	0	101	5	190	195	3	0.65	M
92	APMS 6A	x	RIL 23	0	0	99	5	238	243	2	0.57	M
93	APMS 6A	x	JGL 17221	0	0	108	4	194	198	2	0.49	M
94	APMS 6A	x	JGL 11609	0	0	110	4	194	198	2	0.42	M
95	APMS 6A	x	JGL 16280	0	0	118	2	189	191	1	0.24	M
96	APMS 6A	x	JGL 16259	0	0	119	2	280	282	1	0.23	M
97	APMS 6A	x	RIL 55	0	0	99	0	189	189	0	0.00	M
98	APMS 6A	x	RIL 46	0	0	101	0	91	91	0	0.00	M
99	APMS 6A	x	RIL 32	0	0	103	0	140	140	0	0.00	M
100	APMS 6A	x	RIL 17	0	0	101	0	125	125	0	0.00	M
101	APMS 6A	x	RIL 16	0	0	103	0	174	174	0	0.00	M
102	APMS 6A	x	RIL 138	0	0	97	0	137	137	0	0.00	M
103	APMS 6A	x	RIL 127	0	0	105	0	90	90	0	0.00	M
104	APMS 6A	x	RIL 126	0	0	98	0	177	177	0	0.00	M
105	APMS 6A	x	RIL 12	0	0	98	0	108	108	0	0.00	M
106	APMS 6A	x	JGL 384	0	0	112	0	212	212	0	0.00	M
107	APMS 6A	x	JGL 245	0	0	99	0	197	197	0	0.00	M
108	APMS 6A	X	JGL 533	0		103	0	186	186	0	0.00	M
109	APMS 6A	x	JGL 17216	0	0	114	0	159	159	0	0.00	M
110	APMS 6A	x	JGL 17203	0	0	102	0	152	152	0	0.00	M
111	APMS 6A	x	JGL 17183	0	0	102	0	213	213	0	0.00	M
112	APMS 6A	x	JGL 15660	0	0	120	0	209	209	0	0.00	M
113	APMS 6A	x	JGL 15656	0	0	98	0	158	158	0	0.00	M
114	APMS 6A	x	JGL 15324	0	0	102	0	145	145	0	0.00	M
115	APMS 6A	x	JGL 15208	0	0	122	0	211	211	0	0.00	M
116	APMS 6A	x	JGL 15185	0	0	114	0	180	180	0	0.00	M
117	APMS 6A	x	JGL 13549	0	0	100	0	101	101	0	0.00	M
118	APMS 6A	x	JGL 11728	0	0	118	0	75	75	0	0.00	M
119	APMS 6A	x	JGL 11725	0	0	122	0	99	99	0	0.00	M
120	APMS 6A	x	JGL 11459	0	0	102	0	189	189	0	0.00	M

R Restorer, **PR** Partial Restorer, **PM** Partial Maintainer, **M** Maintainer

Table 4.2. Classification of lines used in the study based on fertility reaction of test cross hybrids

Class	Spikelet fertility (%)	No of genotypes identified	
Maintainers	<10	45	JGL 17004,JGL 11679,JGL 16257,JGL 11650,JGL 15658,JGL 17190,JGL 16258,JGL 16264,RIL 35,JGL 4147,JGL 15247,JGL 11605,RIL 29,ERRAMALLELU,RIL 78,JGL 16279,RIL 23,JGL 17221JGL 11609,JGL 16280,JGL 16259,RIL 55,RIL 46,RIL 32,RIL 17, RIL 16,RIL 138,RIL 127,RIL 126,RIL 12,JGL 384,JGL 245,JGL 17216,JGL 17203,JGL 17183,JGL 15660,JGL 15656,JGL 15324,JGL 15208,JGL 15185.JGL 13549,JGL 11728,JGL 11725,JGL 11459
Partial Maintainers	10-59	35	JGL 17223,JGL 11690,JGL 17206,JGL 402,JGL 15649,JGL 13375,BADRAKALI,JGL 13595,JGL 3866,RIL 27,JGL 15281,JGL 17025,JGL 11689,JGL 13398,JGL 1853,JGL 13376,RIL 134,JGL 17204,JGL 410,JGL 13392,JGL 17189,JGL 1718,JGL 17194,JGL 15663,RIL 38,JGL 15324,JGL 13445GQ 70,RIL 117,JGL 13418,JGL 15246,JGL 16274,JGL 16277,JGL 13391
Partial Restorers	60 - 80	18	29 R,2 R,118 R,19 R,JGL 1798,52 R,18 R,JGL 11459,RIL 108,JGL 15219,JGL 11470,JGL 15283,JGL 8293,JGL 15329,JGL 8644,JGL 17196,JGL 8609,JGL 16261
Restorers	> 80	22	3 R,JGL 11110-2,JGL 11160,JGL 7045,60 R,JGL 16269,JGL 13621,JGL 15660,JGL 11110-1,JGL 8292,JGL 16284,44 R,MP 200,JGL 11111,JGL 11097,JGL 3844,JGL 3855,JGL 13597,JGL 17211,JGL 11118,JGL 13515,JGL 8605

In the cross APMS 6A x JGL 11110-2, all the 32 F_1 plants were fertile and exhibited more than 80 % fertility, while the male parent, JGL11110-2 recorded 100 per cent fertile plants and the CMS line APMS 6A was sterile. While, out of 960 plants evaluated in F_2, 902 plants were fertile, and the remaining 58 plants were sterile.

In cross APMS 6A x JGL11110-1, 46 F_1 plants out of 48 plants were fertile, JGL 11110-1 recorded fertility on 100 per cent plants and the CMS line APMS 6A was totally sterile, while 94.1 per cent of the F_1 plants were totally fertile. Out of 940 plants evaluated in F_2, 885 were fertile, and the remaining 55 plants were sterile

In cross APMS 6A x JGL 17211, all the 40 F_1 plants out of 48 plants exhibited restorability, JGL 17211 recorded total fertility and 100 per cent plants of the CMS line APMS 6A were totally sterile, while, 93.36 per cent of the F_1 plants were totally fertile. Out of 859 plants evaluated in $F_{2,}$ 802 plants were fertile, 57 plants were sterile.

In cross APMS 6A x JGL 16284, 41 F_1 plants out of 44 plants exhibited restorability, JGL 16284, recorded complete fertility and 100 per cent plants of the CMS line APMS 6A were totally sterile, while 93.98 per cent of the F_1 plants were totally fertile. Out of 1014 plants evaluated in F_2, 953 plants were fertile, 61 plants were sterile.

The varied performance of restorers with CMS line, location and season of testing were also reported by Hema Reddy *et al.* (2000), Sarial and Singh (2000), Singh (2000), Salgotra et al. (2002) and Malarvizhi *et al.* (2003).

The results indicated that the CMS lines APMS 6A is completely sterile, where as restorers JGL 1110-2, JGL 11110-1, JGL 17211 and JGL 16284 were fully fertile. The spikelet fertility of F_1 hybrids was more than 94 per cent in all four crosses studied indicating that fertility restoration in the relevant pollinators is under dominant gene control.

The results further revealed that the F_2 populations of all the four crosses viz., APMS 6A x JGL 11110-2, APMS 6A x JGL 11110-1, APMS 6A x JGL 17211 and APMS 6A x JGL 16284 exhibited a segregating ratio of 15:1 indicating dominant epistasis.

Similar results of fertility restoration by two genes in different crosses combinations were also reported by Sreedhar (2010). Zhou *et al.* (1983), Ren and Hao (1984), Young and Virmani (1984), Hu and Li (1985), Li and Yuan (1986), Virmani *et al.* (1986), Singh and Sinha (1988), Bharaj *et al.* (1991), Ramalingam *et al.* (1992), Singh *et al.* (1994), Bharaj *et al.* (1995), Viramani *et al.* (1997), Siridhara *et al.* (1998), Pradhan and Jachuk (1999), Sharma *et al.* (2001), Yogaraj *et al.* (2002), Sharma and Singh (2003) and Sawant *et al.* (2006), Tan *et al.*(2008), Sattary *et al.* (2008), Sheeba *et al.* (2009). Suggesting that the fertility restoration of WA CMS lines was under the control of two independently segregating dominant genes.The use of restorers with more than one independent gene for fertility restoration is likely to produce the hybrids with higher fertility restoration and consequently increased yield. The identified restorers would be useful for future hybrid breeding programmes to develop more restorers with diverse genetic background.

Table 4.3. Segregation pattern of male fertile (F) and male sterile (S) plants in P_1, P_2, F_1 and F_2 populations of four crosses in rice

		Observed frequencies			Expected frequencies				
Generations	Total plants	Fertile (F) >80%	Partial Fertile 10-80%	Sterile (S) <10%	Fertile (F)	Sterile (S)	Ratio F:S	X^2	X^2 table value
APMS 6A x JGL 11110-2									
P_1	40	-	-	40	-	-	-	-	-
P_2	40	40	-	-	-	-	-	-	-
F_1	32	32	-	-	-	-	-	-	-
F_2	960	902	-	58	900	60	15:1	0.007	3.841
APMS 6A x JGL 11110-1									
P_1	40	-	-	40	-	-	-	-	-
P_2	40	40	-	-	-	-	-	-	-
F_1	48	46	2	-	-	-	-	-	-
F_2	940	885	-	55	881.25	58.75	15:1	0.011	3.841
APMS 6A x JGL 17211									
P_1	40	-	-	40	-	-	-	-	-
P_2	40	40	-	-	-	-	-	-	-
F_1	48	40	8	-	-	-	-	-	-
F_2	859	802	-	57	805.31	53.69	15:1	0.001	3.841
APMS 6A x JGL 16284									
P_1	40	-	-	40	-	-	-	-	-
P_2	40	40	-	-	-	-	-	-	-
F_1	44	41	3	-	-	-	-	-	-
F_2	1014	953	-	61	950.62	63.38	15:1	0.004	3.841

4.2 GALL MIDGE RESISTANCE, COMBINING ABILITY AND HETEROSIS STUDIES OVER THREE LOCATIONS

The rice gall midge *Orseolia oryzeae with* different biotypes is a serious pest during the monsoon season in India. Due to the biotype variations, each local breeding programme must be at aimed screening and selecting its own resistant cultures. Field screening by planting the test materials to coincide with high pest populations has been highly successful technique. The gall midge resistance can be easily transferred to the otherwise desirable varieties due to its simple inheritance. The gall midge resistant rice hybrids can be developed, by identifying suitable gall midge resistant parental lines.

In self pollinated crop like rice combining ability analysis is of special importance, since it leads to the identification of potential lines that can be used to develop hybrids and varieties. In recent years, yield improvement in rice has been achieved by exploiting heterosis. Heterotic performance of a hybrid combination depends upon the combining ability of its parents. It is therefore, necessary to access the genetic potentialities of the hybrid combination through systematic studies in relation to general and specific combining ability which are due to additive and non-additive gene action respectively.

Combining ability studies attempted in individual environment, may not provide precise information on gene action as the environment plays an important role and influence the combining ability estimates. Hence, the estimates of general combining ability of 18 parents and specific combining ability of 65 hybrids for yield and its components were investigated at three locations and pooled analysis.

In order to sustain the production level and to increase the productivity, there is an urgent need to share the technology to increase the magnitude of heterosis through development of genetically diverse parental lines. Hence the heterosis studies are also conducted to know the magnitude of heterosis in different cross combinations.

The experimental material comprising of 65 F_1’s, 18 parents (5 testers and 13 lines) and six checks (KRH-2, DRRH-2, PA 6201, JAYA, IR 64 and TN_1) were evaluated during *Kharif 2009-10* at three locations of Kunaram, Warangal and Kampasagar.

4.2.1 Analysis of variance for gall midge resistance

Data on gallmidge damaged plants and silver shoots pertaining to 65 hybrids, 13 parents and 6 checks over three locations i.e. Kunaram, Warangal and Kampasagar

Table 4.4. Analysis of variance for gall midge damaged plants and silver shoots in parents and hybrids

		Kunaram		Warangal		Kampasagar	
Source of Variations	**d.f**	**Damaged Plants % (ASIN)**	**Silver Shoots % (ASIN)**	**(Damaged Plants % (ASIN)**	**(Silver Shoots% (ASIN)**	**(Damaged Plants % (ASIN)**	**Silver Shoots% (ASIN)**
Replicate	2	0	0.35**	161.64*	21.22**	1.97*	2.77**
Treatments	88	202.32**	11.69**	425.19**	26.44**	492.82**	29.08**
Error	176	0.04	0.04	35.6	1.98	0.44	0.13

Table 4.5. Analysis of variance for gall midge damaged plants (%) and gall midge silver shoots(%) in parents and hybrids (pooled)

Gall midge damaged Plants %						
Source of Variations	**d.f**	**Sum of Squares**	**Mean Squares**	**F Ratio**	**Probability**	
Replicate	2	87.43	43.72	0.91	0.4	
Locations	2	11267.61	5633.8	93.98	0	**
Interactions	4	239.78	59.95	1.25	0.29	
Overall Sum	8	11594.82	1449.35	30.28	0	**
Treatments	88	71244.77	809.6	16.92	0	**
Error	704	33693.95	47.86			
Gall midge Silver Shoots%						
Source of Variations	**d.f**	**Sum of Squares**	**Mean Squares**	**F Ratio**	**Probability**	
Replicate	2	14.04	7.02	2.64	0.07	
Locations	2	495.15	247.58	28.59	0	**
Interactions	4	34.63	8.66	3.25	0.01	*
Overall Sum	8	543.83	67.98	25.52	0	**
Treatments	88	4418.01	50.2	18.85	0	**
Error	704	1875.03	2.66			

were collected and transformed into angular values (0^0) and analyzed statistically for each environment. The mean data (Angular Values) collected on gallmidge damaged plants (%) and silver shoots (%) were analyzed and mean sum of squares are presented in table 4.4 and 4.5. The mean values and their corresponding angular values of damaged plants (%) and silver shoots (%) in 65 hybrids, 13 parents and 5 checks are presented in table 4.6.

In the analysis of variance the genotypic differences were highly significant at Kunaram, Warangal and Kampasagar as well as in pooled analysis indicating that the reaction of genotypes are different for gallmidge resistance at all the three locations.The differences over locations was also significant indicating that the gall midge incidence was different at three locations(Table 4.4 and 4.5).

Srinivas *et al. (*1994) reported the existence of biotype 3 at Jagtial and biotype 1 and 3 at Warangal due to which the gall midge incidence at these two locations was different. Pasalu *et al.* (1998) reported the existence of six different biotypes of gall midge in India, due to which the hybrids react differently at various locations.

4.2.2 Study of mean performance

The mean values of 14 characters recorded on parents, hybrids and checks over locations and their pooled are presented character wise.

4.2.2.1 Gallmidge infested plants (%): At Kunaram the damaged plants ranged from 0 to 58 % with a general mean of 0.53(%) (Table 4.7) The mean damaged plants for testers varied from 0 (APMS 8A and CMS 16A) to 15.50 (APMS 6A), while in lines and hybrids the damage was not observed. The check PA 6201 recorded 43.5 %, while susceptible check TN1 recorded 58(%) plant damage.

At Warangal the damaged plants ranged from 0 to 81.67(%), with a general mean of 9.30 (%) for genotypes. The mean damaged plants in testers ranged from 0 (APMS 8A and CMS 16A) to 22.33(%) (APMS 6A), while in lines it was 0 (JGL 17211, JGL 11118, JGL 8605, JGL 8292 and JGL 3844) to 30.48 (%) (JGL 3855). The mean value of hybrid ranged from 0 to 34.96 (APMS 6A x JGL 11110-2). The check PA 6201 recorded 42.67(%) damage while susceptible check TN_1 recorded 81.67(%) plant damage.

Genotypes at Kampasagar recorded a general mean of 5.20 (%) plant damage with a range from 0 to 75.33 (%). The mean damaged plants for testers ranged from 0 (APMS 8A and CMS 16A) to 30.67 (%) (IR 68897A), while in lines, no damage was recorded. Among the hybrids the damage of plants ranged from 0 to 52.04(%) (APMS 6A X JGL 11110-2). The check (PA 6201) recorded 40 (%) damage, while susceptible check TN1 recorded 75.33 (%) plant damage.

Genotypes in pooled analysis recorded a general mean of 4.68 (%) plant damage with a range from 0 to 30.62 (%). The mean damaged plants for testers ranged from 0 (APMS 8A and CMS 16A) to 21.83 % (IR 68897A), while in lines, it ranged from 0 to 10.16 (%) damage was recorded. Among the hybrids the damage of plants ranged from 0 to 30.62(%) (IR 58025A X JGL 11111). The check (PA 6201) recorded 30.63 (%) damage, while susceptible check TN1 recorded 71.67 (%) plant damage.

4.2.2.2 Silver Shoots (%): The development of silver shoots due to gallmidge infestation in general was very high in susceptible check TN1, PA 6201 and in testers at all the three locations. Whereas in lines and hybrids the silver shoots (%) is more at Warangal. Silver shoots ranged from 0 to 7.32(%) with general mean of 0.53(%) at Kunaram. Testers recorded a range of 0 (APMS 8A and CMS 16A) to 1.96 (APMS 6A). The lines and hybrids were free from silver shoots. The check PA 6201 and TN1 recorded 5.50(%) and 7.32(%) silver shoots, respectively (Table 4.7).

The silver shoots at Warangal ranged from 0 to 12.50(%) with a general mean of 1.37. In testers the range was from 0 (APMS 8A and CMS 16A) to 3.01 (APMS 6A). Of the thirteen lines five lines were free from silver shoots while in other eight cultures it ranged from 1.31 (JGL 17211 and JGL 8605) to 3.75 (JGL 3844). Among the hybrids the range was 0 to 5.83 (IR 58025A x JGL 11111). The check PA 6201 and TN1 recorded 12.03(%) and 20.69(%) silver shoots, respectively.

General mean of silver shoots at Kampasagar was 0.90% with a range from 0 to 9.87(%). Testers recorded 0 (APMS 8A and CMS 16A) to 3.75(%) (IR 68897A). All the thirteen lines were resistant to gallmidge, while in hybrids it ranged from 0 to 6.38(%) (APMS 6A x JGL 11110-2). The check, PA 6201 recorded 5.05(%) followed by TN1 9.87(%) silver shoots.

General mean of silver shoots in pooled analysis was 0.58(%) with a range from 0 to 3.81(%). Testers recorded 0 (APMS 8A and CMS 16A) to 2.73(%) (APMS 6A). While in lines it ranged from 0 to 1.25 (%), while in hybrids it ranged from 0 to 3.81(%) (IR 58025AX JGL 11111). The check, PA 6201 recorded 3.83(%) followed by TN1 9.91(%) silver shoots.

Rao *et al.* (1998) screened 20,000 accessions of rice germplasm both has identified more than 250 sources of resistance. After the detection of gall midge biotypes within the country, resistant germplasm accessions were screened against characterized biotypes to note the range in resistance.Multilocation testing of primary donors against all known biotypes revealed that none of the donors displayed resistance against all six biotypes.Oudhia *et al.* (1999) studied, reaction of hybrid rice varieties to gall midge (*Orseolia oryzae*). Nine rice hybrids and the resistant control cv. Mahamaya, growing at Raipur, were observed for infestation by gall midge. Mahamaya was free from infestation, and in the hybrids percentage of infested tillers ranged from 5.23(%) to 12.32(%). Naikebawane *et al.* (2008) studied genetics of gall midge *Orseolia oryzae* (Wood Mason) resistance in some new donors of rice (*Oryza sativa L.*) at Chattisgarh, India. Results revealed the presence of a single dominant gene for gall midge resistance in 5 new donors, i.e. INRC 202, Tellarigarikasunjavari, ARC 15831, JGL 384 and Bhumansan.

Table 4.6. Gall midge damaged plant (%) in parents and hybrids over three locations

Crosses	Damage Plant %	*Damage Plant % (ASIN)*	Damage Plant %	Damage Plant % (ASIN)	Damaged Plant %	*Damage Plant % (ASIN)*	Damage Plant %	*Damage Plant % (ASIN)*
Testers	**KNM**		**WGL**		**KSR**		**POOLED**	
IR 68897A	14.50	***22.36***	20.33	***26.76***	30.67	***33.59***	21.83	***27.57***
APMS 8A	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A	15.50	***23.18***	22.33	***28.19***	25.67	***30.44***	21.17	***27.27***
IR 58025A	14.00	***21.96***	10.70	***19.07***	24.33	***29.55***	16.34	***23.53***
Mean	8.80	***15.12***	10.67	***16.43***	16.13	***20.34***	11.87	***17.30***
Lines							0.00	
JGL 11110-2	0.00	***4.05***	26.67	***31.07***	0.00	***4.05***	8.89	***13.06***
JGL 11110-1	0.00	***4.05***	21.33	***27.49***	0.00	***4.05***	7.11	***11.87***
JGL 17211	0.00	***4.05***	10.67	***19.05***	0.00	***4.05***	3.56	***9.05***
JGL 16284	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 13515	0.00	***4.05***	11.85	***20.10***	0.00	***4.05***	3.95	***9.40***
JGL 11160	0.00	***4.05***	23.70	***29.11***	0.00	***4.05***	7.90	***12.41***
JGL 11118	0.00	***4.05***	21.33	***27.49***	0.00	***4.05***	7.11	***11.87***
JGL 11111	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 8605	0.00	***4.05***	10.67	***19.05***	0.00	***4.05***	3.56	***9.05***
JGL 8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 3855	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 3844	0.00	***4.05***	30.48	***33.50***	0.00	***4.05***	10.16	***13.87***
JGL 1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
Mean	0.00	***4.05***	12.05	***17.47***	0.00	***4.05***	4.02	***8.53***
Parental Mean		***7.13***		***17.18***		***8.58***	6.20	***10.96***
IR 68897A X JGL11110-2	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 68897A X JGL11110-1	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 68897A X JGL17211	0.00	***4.05***	7.62	***14.44***	0.00	***4.05***	2.54	***7.52***
IR 68897A X JGL16284	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 68897A X JGL13515	0.00	***4.05***	5.93	***12.84***	11.41	***19.73***	5.78	***12.21***
IR 68897A X JGL11160	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
IR 68897A X JGL11118	0.00	***4.05***	5.93	***12.84***	0.00	***4.05***	1.98	***6.98***
IR 68897A X JGL11111	0.00	***4.05***	16.00	***23.37***	0.00	***4.05***	5.33	***10.49***
IR 68897A X JGL8605	0.00	***4.05***	16.00	***23.37***	0.00	***4.05***	5.33	***10.49***
IR 68897A X JGL8292	0.00	***4.05***	11.85	***17.85***	23.41	***28.93***	11.75	***16.94***
IR 68897A X JGL3855	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
IR 68897A X JGL3844	0.00	***4.05***	26.67	***27.42***	47.33	***43.47***	24.67	***24.98***
IR 68897A X JGL1798	0.00	***4.05***	10.67	***19.05***	0.00	***4.05***	3.56	***9.05***
APMS 8A X JGL11110-2	0.00	***4.05***	7.62	***14.44***	0.00	***4.05***	2.54	***7.52***
APMS 8A X JGL11110-1	0.00	***4.05***	10.67	***19.05***	0.00	***4.05***	3.56	***9.05***
APMS 8A X JGL17211	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL16284	0.00	***4.05***	10.67	***16.96***	0.00	***4.05***	3.56	***8.36***
APMS 8A X JGL13515	0.00	***4.05***	10.67	***16.96***	0.00	***4.05***	3.56	***8.36***
APMS 8A X JGL11160	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL11118	0.00	***4.05***	32.00	***34.43***	0.00	***4.05***	10.67	***14.18***
APMS 8A X JGL11111	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
APMS 8A X JGL8605	0.00	***4.05***	17.78	***21.95***	0.00	***4.05***	5.93	***10.02***
APMS 8A X JGL8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL3855	0.00	***4.05***	16.00	***23.37***	0.00	***4.05***	5.33	***10.49***
APMS 8A X JGL3844	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL1798	0.00	***4.05***	17.78	***21.95***	0.00	***4.05***	0.00	***10.02***

Table 4.7.(cont.)

Crosses	Damage Plant %	*Damage Plant % (ASIN)*	Damage Plant %	Damage Plant % (ASIN)	Damaged Plant %	*Damage Plant % (ASIN)*	Damage Plant %	*Damage Plant % (ASIN)*
	KNM		**WGL**		**KSR**		**POOLED**	
CMS 16A X JGL11110-2	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A X JGL11110-1	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
CMS 16A X JGL17211	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A X JGL16284	0.00	***4.05***	21.33	***24.21***	0.00	***4.05***	7.11	***10.77***
CMS 16A X JGL13515	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
CMS 16A X JGL11160	0.00	***4.05***	16.00	***23.37***	0.00	***4.05***	5.33	***10.49***
CMS 16A X JGL11118	0.00	***4.05***	5.93	***12.84***	0.00	***4.05***	1.98	***6.98***
CMS 16A X JGL11111	0.00	***4.05***	10.67	***16.96***	0.00	***4.05***	3.56	***8.36***
CMS 16A X JGL8605	0.00	***4.05***	5.93	***12.84***	0.00	***4.05***	1.98	***6.98***
CMS 16A X JGL8292	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
CMS 16A X JGL3855	0.00	***4.05***	5.33	***12.22***	0.00	***4.05***	1.78	***6.78***
CMS 16A X JGL3844	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A X JGL1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A X JGL11110-2	0.00	***4.05***	34.96	***35.16***	52.04	***46.19***	29.00	***28.47***
APMS 6A X JGL11110-1	0.00	***4.05***	17.19	***24.20***	20.81	***27.11***	12.67	***18.45***
APMS 6A X JGL17211	0.00	***4.05***	17.19	***24.20***	19.41	***26.11***	12.20	***18.12***
APMS 6A X JGL16284	0.00	***4.05***	10.67	***16.96***	20.67	***27.04***	10.44	***16.02***
APMS 6A X JGL13515	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A X JGL11160	0.00	***4.05***	11.26	***19.59***	10.74	***19.12***	7.33	***14.26***
APMS 6A X JGL11118	0.00	***4.05***	5.93	***12.84***	10.74	***19.12***	5.56	***12.00***
APMS 6A X JGL11111	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A X JGL8605	0.00	***4.05***	10.67	***19.05***	10.00	***18.43***	6.89	***13.85***
APMS 6A X JGL8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A X JGL3855	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A X JGL3844	0.00	***4.05***	21.33	***27.49***	20.00	***26.57***	13.78	***19.37***
APMS 6A X JGL1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL11110-2	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL11110-1	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL17211	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL16284	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL13515	0.00	***4.05***	21.33	***27.49***	20.00	***26.57***	13.78	***19.37***
IR 58025A X JGL11160	0.00	***4.05***	10.67	***19.05***	10.00	***18.43***	6.89	***13.85***
IR 58025A X JGL11118	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL11111	0.00	***4.05***	47.41	***43.49***	44.44	***41.78***	30.62	***29.78***
IR 58025A X JGL8605	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL3855	0.00	***4.05***	32.00	***34.43***	30.00	***33.21***	20.67	***23.90***
IR 58025A X JGL3844	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A X JGL1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
Crosses mean	0.00	***4.05***	8.64	***13.87***	5.40	***9.61***	4.68	***9.18***
Grand mean	0.53	***4.72***	9.30	***14.59***	5.20	***9.38***	5.01	***9.56***
KRH - 2	10.00	***29.33***	10.67	***4.05***	10.00	***29.11***	10.22	***20.83***
DRRH - 2	23.00	***18.43***	35.56	***19.05***	33.33	***18.43***	30.63	***18.64***
PA 6201	43.50	***28.66***	42.67	***36.57***	40.00	***35.24***	42.06	***33.49***
JAYA	22.22	***41.26***	23.70	***40.77***	22.22	***39.23***	22.72	***40.42***
IR - 64	24.00	***28.11***	0.00	***29.11***	23.67	***28.11***	15.89	***28.44***
TN1	58.00	***49.60***	81.67	***64.71***	75.33	***60.26***	71.67	***58.19***
Mean	2.52	***6.60***	10.85	***15.79***	7.15	***11.12***	6.84	***11.17***
S.E.		***0.12***		***3.44***		***0.38***		***2.31***
C.V.		***3.09***		***37.80***		***5.95***		***61.95***
C.D. 5%		***0.33***		***9.61***		***1.07***		***6.40***

Values in italics are angular transformed values

Table 4.7. Gall midge silver shoots (%) in parents and hybrids over three locations

Parent/Cross	Silver Shoots %	*Silver Shoots % (ASIN)*	Silver Shoots %	*Silver Shoots % (ASIN)*	Silver Shoots %	*Silver Shoots % (ASIN)*	Silver Shoots %	*Silver Shoots % (ASIN)*
TESTERS	**KNM**		**WGL**		***KSR***		**POOLED**	
IR 58025A	1.77	***7.78***	1.47	***8.95***	3.04	***11.15***	2.09	***9.30***
IR 68897A	1.82	***7.78***	2.42	***8.95***	3.75	***11.15***	2.66	***9.30***
APMS 6A	1.96	***8.06***	3.01	***10.01***	3.22	***10.29***	2.73	***9.45***
APMS 8A	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
Mean	1.11	***6.31***	1.38	***6.82***	2.00	***7.92***	1.50	***7.02***
LINES							0.00	
JGL 11110-2	0.00	***4.05***	3.28	***10.39***	0.00	***4.05***	1.09	***6.17***
JGL 11110-1	0.00	***4.05***	2.62	***9.26***	0.00	***4.05***	0.87	***5.79***
JGL 17211	0.00	***4.05***	1.31	***6.61***	0.00	***4.05***	0.44	***4.91***
JGL 16284	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 13515	0.00	***4.05***	1.46	***6.86***	0.00	***4.05***	0.49	***4.99***
JGL 11160	0.00	***4.05***	2.91	***9.84***	0.00	***4.05***	0.97	***5.98***
JGL 11118	0.00	***4.05***	2.62	***9.26***	0.00	***4.05***	0.87	***5.79***
JGL 11111	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 8605	0.00	***4.05***	1.31	***6.61***	0.00	***4.05***	0.44	***4.91***
JGL 8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 3855	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
JGL 3844	0.00	***4.05***	3.75	***11.16***	0.00	***4.05***	1.25	***6.42***
JGL 1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
Mean	0.00	***4.05***	1.48	***6.94***	0.00	***4.05***	0.49	***5.02***
Parental Mean		***4.68***		***6.91***		***5.13***	0.77	***5.57***
IR 68897A X JGL11110-2	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 68897A X JGL11110-1	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 68897A X JGL17211	0.00	***4.05***	0.99	***6.02***	0.00	***4.05***	0.33	***4.71***
IR 68897A X JGL16284	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 68897A X JGL13515	0.00	***4.05***	0.77	***5.43***	1.46	***6.95***	0.74	***5.48***
IR 68897A X JGL11160	0.00	***4.05***	0.62	***4.96***	0.00	***4.05***	0.21	***4.36***
IR 68897A X JGL11118	0.00	***4.05***	0.77	***5.43***	0.00	***4.05***	0.26	***4.51***
IR 68897A X JGL11111	0.00	***4.05***	2.01	***8.01***	0.00	***4.05***	0.67	***5.37***
IR 68897A X JGL8605	0.00	***4.05***	2.01	***8.01***	0.00	***4.05***	0.67	***5.37***
IR 68897A X JGL8292	0.00	***4.05***	1.37	***6.81***	2.92	***9.85***	1.43	***6.90***
IR 68897A X JGL3855	0.00	***4.05***	0.69	***5.24***	0.00	***4.05***	0.23	***4.45***
IR 68897A X JGL3844	0.00	***4.05***	3.47	***10.14***	5.83	***13.94***	3.10	***9.38***
IR 68897A X JGL1798	0.00	***4.05***	1.31	***6.61***	0.00	***4.05***	0.44	***4.91***
APMS 8A X JGL11110-2	0.00	***4.05***	0.99	***6.02***	0.00	***4.05***	0.33	***4.71***
APMS 8A X JGL11110-1	0.00	***4.05***	1.31	***6.61***	0.00	***4.05***	0.44	***4.91***
APMS 8A X JGL17211	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL16284	0.00	***4.05***	1.39	***6.88***	0.00	***4.05***	0.46	***5.00***
APMS 8A X JGL13515	0.00	***4.05***	1.23	***6.54***	0.00	***4.05***	0.41	***4.88***
APMS 8A X JGL11160	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL11118	0.00	***4.05***	3.94	***11.41***	0.00	***4.05***	1.31	***6.51***
APMS 8A X JGL11111	0.00	***4.05***	0.62	***4.96***	0.00	***4.05***	0.21	***4.36***
APMS 8A X JGL8605	0.00	***4.05***	2.06	***8.08***	0.00	***4.05***	0.69	***5.40***
APMS 8A X JGL8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL3855	0.00	***4.05***	2.01	***8.01***	0.00	***4.05***	0.67	***5.37***
APMS 8A X JGL3844	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 8A X JGL1798	0.00	***4.05***	2.31	***8.50***	0.00	***4.05***	0.00	***5.54***

Table 4.7.(cont.)

Crosses		Silver Shoots %	*Silver Shoots % (ASIN)*	Silver Shoots %)	*Silver Shoots % (ASIN)*	Silver Shoots %	*Silver Shoots % (ASIN)*	Silver Shoots % (ASIN)	*Silver Shoots % (ASIN)*
		KNM		**WGL**		**KSR**		**POOLED**	
CMS 16A	X JGL11110-2	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A	X JGL11110-1	0.00	***4.05***	0.69	***5.24***	0.00	***4.05***	0.23	***4.45***
CMS 16A	X JGL17211	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A	X JGL16284	0.00	***4.05***	2.78	***9.15***	0.00	***4.05***	0.93	***5.75***
CMS 16A	X JGL13515	0.00	***4.05***	0.62	***4.96***	0.00	***4.05***	0.21	***4.36***
CMS 16A	X JGL11160	0.00	***4.05***	2.01	***8.01***	0.00	***4.05***	0.67	***5.37***
CMS 16A	X JGL11118	0.00	***4.05***	0.77	***5.43***	0.00	***4.05***	0.26	***4.51***
CMS 16A	X JGL11111	0.00	***4.05***	1.23	***6.54***	0.00	***4.05***	0.41	***4.88***
CMS 16A	X JGL8605	0.00	***4.05***	0.69	***5.16***	0.00	***4.05***	0.23	***4.42***
CMS 16A	X JGL8292	0.00	***4.05***	0.62	***4.96***	0.00	***4.05***	0.21	***4.36***
CMS 16A	X JGL3855	0.00	***4.05***	0.62	***4.96***	0.00	***4.05***	0.21	***4.36***
CMS 16A	X JGL3844	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
CMS 16A	X JGL1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A	X JGL11110-2	0.00	***4.05***	4.48	***11.56***	6.38	***14.57***	3.62	***10.06***
APMS 6A	X JGL11110-1	0.00	***4.05***	2.16	***8.31***	2.55	***9.19***	1.57	***7.18***
APMS 6A	X JGL17211	0.00	***4.05***	2.07	***8.25***	2.53	***9.15***	1.53	***7.15***
APMS 6A	X JGL16284	0.00	***4.05***	1.23	***6.54***	2.59	***9.26***	1.28	***6.62***
APMS 6A	X JGL13515	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A	X JGL11160	0.00	***4.05***	1.39	***6.77***	1.34	***6.70***	0.91	***5.84***
APMS 6A	X JGL11118	0.00	***4.05***	0.77	***5.43***	1.34	***6.70***	0.70	***5.40***
APMS 6A	X JGL11111	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A	X JGL8605	0.00	***4.05***	1.31	***6.61***	1.26	***6.45***	0.86	***5.71***
APMS 6A	X JGL8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A	X JGL3855	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
APMS 6A	X JGL3844	0.00	***4.05***	2.62	***9.26***	2.53	***9.14***	1.72	***7.49***
APMS 6A	X JGL1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL11110-2	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL11110-1	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL17211	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL16284	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL13515	0.00	***4.05***	2.62	***9.26***	2.53	***9.14***	1.72	***7.49***
IR 58025A	X JGL11160	0.00	***4.05***	1.31	***6.61***	1.26	***6.45***	0.86	***5.71***
IR 58025A	X JGL11118	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL11111	0.00	***4.05***	5.83	***13.94***	5.61	***13.67***	3.81	***10.56***
IR 58025A	X JGL8605	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL8292	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL3855	0.00	***4.05***	3.94	***11.41***	3.79	***11.23***	2.57	***8.90***
IR 58025A	X JGL3844	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
IR 58025A	X JGL1798	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***	0.00	***4.05***
Crosses mean		0.00	***4.05***	1.07	***6.05***	0.68	***5.31***	0.58	***5.14***
Grand mean		0.07	***4.19***	1.15	***6.24***	0.65	***5.27***	0.62	***5.23***
KRH - 2		1.26	***10.00***	1.31	***4.05***	1.26	***10.02***	1.28	***8.03***
DRRH - 2		2.91	***6.46***	4.37	***6.61***	4.21	***6.45***	3.83	***6.51***
PA 6201		5.50	***9.83***	5.25	***12.03***	5.05	***11.86***	5.27	***11.24***
JAYA		2.81	***13.55***	2.91	***13.19***	2.81	***12.95***	2.84	***13.23***
IR - 64		3.03	***9.66***	0.00	***9.84***	3.03	***9.68***	2.02	***9.73***
TN1		7.32	***15.67***	12.52	***20.69***	9.87	***18.30***	9.91	***18.22***
Mean		0.32	***4.64***	1.37	***6.56***	0.90	***5.69***	0.86	***5.63***
S.E.			***0.12***		***0.81***		***0.21***		***0.54***
C.V.			***4.48***		***21.43***		***6.36***		***28.97***
C.D. 5%			***0.33***		***2.27***		***0.58***		***1.51***

Values in italics are angular transformed values

The studies indicate that the range in resistance, reaction of hybrid rice varieties to gall midge was different due to various biotypes existing in India, genetics of gall midge *Orseolia oryzae* resistance and host plant resistance.

4.2.2.3 Days to 50% flowering: The mean values of parents and hybrids for days to 50 per cent flowering are presented in table 4.9. At Kunaram days to 50 per cent flowering ranged from 84 to 108 days with an overall mean of 100 days. Among testers the range was from 94 days (IR 68897A) to 108 days (APMS 6A and PMS 8A). The range was from 106 days (JGL 3855, JGL 16284 and JGL 13515) to 91 days (JGL 11118) in lines, among the hybrids the range was from 84 days (IR 58025 x JGL 11160) to 106 days (IR 58025A x JGL 8605) .The hybrid IR 58025A x JGL 11160 (84 days) was earliest followed by IR 68897A x JGL 11118 (85 days). Three hybrids were superior to the earliest flowered check KRH-2 (87 days) by recording less than 85 days for flowering.

At Warangal, the mean number of days to 50 per cent flowering was 97 days with a range of 78 to 108 days. Testers recorded a mean range of 100 days (IR 58025 A) to 105 days (IR 68897A and APMS 8A) and among lines, JGL 11111 exhibited the lowest value of 91 days and JGL 13515 recorded highest value of 108 days. Hybrids ranged from 78 days (IR 58025A x JGL 3855) to 108 days (CMS 16A x JGL 1798).

At Kampasagar, days to 50 per cent flowering ranged from 86 to 108 days with an overall mean of 99 days. Among testers the range was from 92 days (IR 68897A) to 106 days (APMS 6A). The range was from 105 days (JGL 13515) to 92 days (JGL 11118) in lines, among the hybrids the range was from 84 days (IR 68897 x JGL 11160) to 106 days 9IR 58025A x JGL 8605) .The hybrid IR 58025A x JGL 11118 (84 days) was earliest. The earliest check DRRH-2 took 86 days for flowering.

In pooled analysis the range for days to 50 % flowering was from 84 days to 106 days. For testers, the days to 50 per cent flowering ranged from 97 days (IR 68897A) to 106 days (APMS 6A and APMS 8A) and for lines the range was between 93 days (JGL 11118) to 106 days (JGL 13515), while in hybrids, the range varied from 84 days (IR 68897A x JGL 11118) to 106 days (APMS 8A x JGL 11110-2; APMS 8A x JGL 13515; APMS 8A x JGL 11160 and APMS 8A x JGL 1798). The earliest flowered check was DRRH-2 (92 days) (Table 4.8).

4.2.2.4 Plant height (cms): The plant height of genotypes at Kunaram ranged from 65 cm to 133 cm, with a mean of 101 cm, (Table 4.9). The mean plant height for testers ranged from 70 (IR 58025A) to 109 cm (IR 68897A), while in lines the range was 92 cm (JGL 3844) to 108 (JGL 13515). In case of hybrids, the mean plant height ranged

Table 4.8. Mean performance of parents and hybrids for days to 50% flowering and plant height (cm) over three locations and pooled

Parent/Cross			Days to 50% Flowering				Plant Height			
TESTERS			KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
IR 58025A			106.33	100.33	103.60	103.42	69.67	94.33	89.60	84.53
IR 68897A			93.67	105.00	92.40	97.02	109.00	98.83	91.40	99.74
APMS 6A			107.67	104.33	105.67	105.89	99.00	94.33	94.33	95.89
APMS 8A			108.00	105.00	105.47	106.16	97.00	115.83	92.47	101.77
CMS 16A			107.00	103.33	104.87	105.07	102.33	121.83	93.87	106.01
Mean			104.53	103.60	102.40	103.51	95.40	105.03	92.33	97.59
LINES										
JGL 11110-2			102.33	103.33	101.00	102.22	110.67	106.83	112.33	109.94
JGL 11110-1			101.00	105.00	99.13	101.71	110.00	120.83	102.80	111.21
JGL 17211			102.67	103.33	102.00	102.67	104.00	121.33	95.67	107.00
JGL 16284			104.67	100.33	103.93	102.98	99.67	94.33	99.93	97.98
JGL 13515			106.33	108.00	104.67	106.33	108.00	105.83	94.33	102.72
JGL 11160			101.00	105.33	100.13	102.16	92.67	125.83	89.47	102.66
JGL 11118			91.00	95.00	91.80	92.60	95.67	117.83	87.47	100.32
JGL 11111			103.67	91.00	102.20	98.96	107.33	112.83	95.53	105.23
JGL 8605			106.33	104.00	103.87	104.73	99.33	127.33	101.53	109.40
JGL 8292			101.67	103.33	101.00	102.00	104.33	104.33	90.67	99.78
JGL 3855			106.00	105.33	102.67	104.67	97.33	126.83	89.33	104.50
JGL 3844			97.67	104.00	102.20	101.29	91.67	123.33	86.87	100.62
JGL 1798			97.67	99.00	96.27	97.64	100.67	96.83	89.93	95.81
Mean			101.69	102.08	100.84	101.54	101.64	114.18	95.07	103.63
Parental Mean			108.29	102.50	101.27	102.08	105.21	111.64	94.31	101.95
IR 68897A	X	JGL11110-2	97.00	104.00	102.47	101.16	114.00	76.33	99.47	96.60
IR 68897A	X	JGL11110-1	91.67	80.33	87.00	86.33	86.00	72.83	77.67	78.83
IR 68897A	X	JGL17211	105.00	83.00	94.20	94.07	96.67	63.83	87.87	82.79
IR 68897A	X	JGL16284	96.33	103.33	97.40	99.02	104.00	73.33	93.73	90.36
IR 68897A	X	JGL13515	97.67	83.00	90.40	90.36	98.00	71.33	87.40	85.58
IR 68897A	X	JGL11160	85.67	89.33	89.40	88.13	97.00	68.33	84.73	83.36
IR 68897A	X	JGL11118	85.00	82.33	84.40	83.91	99.00	79.33	83.73	87.36
IR 68897A	X	JGL11111	97.00	97.33	99.13	97.82	104.33	82.83	104.80	97.32
IR 68897A	X	JGL8605	87.33	92.00	89.80	89.71	104.33	78.33	90.47	91.04
IR 68897A	X	JGL8292	93.67	97.33	98.60	96.53	107.00	87.33	93.93	96.09
IR 68897A	X	JGL3855	90.33	91.00	91.33	90.89	103.67	80.33	90.67	91.56
IR 68897A	X	JGL3844	89.33	92.33	97.87	93.18	114.67	73.33	99.87	95.96
IR 68897A	X	JGL1798	93.67	94.33	94.27	94.09	97.33	78.33	87.60	87.76
APMS 8A	X	JGL11110-2	104.00	106.33	106.27	105.53	103.00	87.83	101.93	97.59
APMS 8A	X	JGL11110-1	103.67	104.00	104.87	104.18	102.00	84.33	104.53	96.96
APMS 8A	X	JGL17211	102.00	106.33	104.27	104.20	99.33	75.33	98.60	91.09
APMS 8A	X	JGL16284	101.00	91.33	90.40	94.24	65.00	65.83	77.07	69.30
APMS 8A	X	JGL13515	104.33	106.00	106.73	105.69	107.00	81.83	105.73	98.19
APMS 8A	X	JGL11160	104.67	107.33	105.93	105.98	92.00	82.33	99.60	91.31
APMS 8A	X	JGL11118	105.00	104.33	105.47	104.93	106.67	81.33	103.47	97.16
APMS 8A	X	JGL11111	102.33	83.33	105.60	97.09	105.33	84.33	99.60	96.42
APMS 8A	X	JGL8605	102.33	98.00	100.00	100.11	102.67	77.83	91.67	90.72
APMS 8A	X	JGL8292	102.67	82.00	93.73	92.80	93.33	79.33	87.73	86.80
APMS 8A	X	JGL3855	100.00	82.33	93.47	91.93	100.33	71.33	88.80	86.82
APMS 8A	X	JGL3844	101.33	94.00	100.80	98.71	110.00	79.33	95.80	95.04
APMS 8A	X	JGL1798	106.00	104.33	108.20	106.18	98.33	70.83	94.87	88.01

Table 4.8. (cont.)

Cross	Days to 50% Flowering				Plant Height			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
CMS 16A X JGL11110-2	103.67	106.00	105.60	105.09	100.67	78.33	93.93	90.98
CMS 16A X JGL11110-1	106.00	81.33	97.60	94.98	96.00	76.83	94.93	89.26
CMS 16A X JGL17211	102.33	105.33	104.20	103.96	100.67	83.83	93.53	92.68
CMS 16A X JGL16284	103.67	105.33	105.47	104.82	96.67	84.83	98.80	93.43
CMS 16A X JGL13515	105.33	81.33	92.80	93.16	100.67	73.33	93.47	89.16
CMS 16A X JGL11160	101.33	103.00	103.87	102.73	101.67	80.83	94.87	92.46
CMS 16A X JGL11118	104.33	99.33	103.73	102.47	102.67	72.83	97.40	90.97
CMS 16A X JGL11111	102.00	82.33	90.73	91.69	86.67	73.33	80.73	80.24
CMS 16A X JGL8605	103.67	81.33	101.60	95.53	96.00	68.33	90.60	84.98
CMS 16A X JGL8292	100.67	103.33	105.67	103.22	116.00	82.33	103.33	100.56
CMS 16A X JGL3855	88.00	80.33	85.53	84.62	94.67	67.83	93.87	85.46
CMS 16A X JGL3844	97.67	102.00	99.00	99.56	104.67	81.83	95.33	93.94
CMS 16A X JGL1798	102.33	108.00	102.20	104.18	97.67	80.33	90.87	89.62
APMS 6A X JGL11110-2	95.67	102.33	100.00	99.33	104.33	81.33	97.33	94.33
APMS 6A X JGL11110-1	99.67	103.00	104.20	102.29	107.67	79.83	96.87	94.79
APMS 6A X JGL17211	100.33	101.00	104.00	101.78	103.33	77.83	93.67	91.61
APMS 6A X JGL16284	103.67	103.33	103.20	103.40	103.67	81.33	94.53	93.18
APMS 6A X JGL13515	99.67	97.33	96.47	97.82	101.00	79.33	90.47	90.27
APMS 6A X JGL11160	95.00	101.00	90.60	95.53	103.33	72.33	87.93	87.87
APMS 6A X JGL11118	99.00	101.33	97.07	99.13	107.00	87.83	94.40	96.41
APMS 6A X JGL11111	102.33	85.00	101.40	96.24	113.33	120.33	98.73	110.80
APMS 6A X JGL8605	102.00	101.00	101.07	101.36	88.33	121.83	104.40	104.86
APMS 6A X JGL8292	101.33	94.00	98.80	98.04	100.00	120.83	90.47	103.77
APMS 6A X JGL3855	101.67	103.00	99.07	101.24	97.00	124.33	89.40	103.58
APMS 6A X JGL3844	102.67	95.33	101.67	99.89	96.67	120.83	91.33	102.94
APMS 6A X JGL1798	103.00	104.00	100.80	102.60	95.00	106.83	98.47	100.10
IR 58025A X JGL11110-2	104.67	102.00	102.80	103.16	102.33	110.83	99.47	104.21
IR 58025A X JGL11110-1	104.33	101.00	103.00	102.78	105.33	112.83	95.67	104.61
IR 58025A X JGL17211	103.33	90.00	100.47	97.93	97.67	101.33	90.80	96.60
IR 58025A X JGL16284	102.33	102.00	99.87	101.40	97.33	102.83	91.53	97.23
IR 58025A X JGL13515	104.33	104.00	102.33	103.56	96.00	116.83	95.33	102.72
IR 58025A X JGL11160	83.67	82.00	94.07	86.58	98.00	116.83	88.73	101.19
IR 58025A X JGL11118	95.00	83.33	91.27	89.87	96.33	112.83	86.93	98.70
IR 58025A X JGL11111	102.67	85.00	101.27	96.31	109.67	94.33	97.60	100.53
IR 58025A X JGL8605	106.33	104.00	103.13	104.49	84.67	111.33	86.47	94.16
IR 58025A X JGL8292	106.33	84.33	105.27	98.64	133.33	112.83	109.60	118.59
IR 58025A X JGL3855	104.33	78.33	102.13	94.93	99.33	102.83	92.80	98.32
IR 58025A X JGL3844	100.33	81.33	95.47	92.38	82.67	110.83	80.47	91.32
IR 58025A X JGL1798	98.33	81.00	94.07	91.13	92.00	115.83	85.40	97.74
Crosses mean	99.88	94.90	98.98	97.92	100.32	87.84	93.57	93.91
Grand mean	100.44	94.04	97.06	96.36	100.23	90.26	91.13	92.99
KRH - 2	86.67	104.00	87.07	92.58	114.67	115.83	93.40	107.97
DRRH - 2	87.67	102.33	86.47	92.16	107.67	121.33	97.80	108.93
PA 6201	97.00	92.33	96.67	95.33	107.67	111.33	93.33	104.11
JAYA	101.00	106.00	99.20	102.07	97.67	116.33	90.87	101.62
IR - 64	93.67	101.00	92.07	95.58	100.00	94.33	87.40	93.91
Mean	100.03	96.81	99.07	98.63	100.53	94.07	93.66	96.09
S.E.	1.33	0.55	2.53	1.73	1.04	419.66	2.89	3.58
C.V.	2.30	0.99	4.42	5.26	1.80	1.71	5.34	11.18
C.D. 5%	3.71	1.54	7.06	4.80	2.91	419.66	8.06	9.94

Table 4.9. Mean performance of parents and hybrids productive tillers/ Plant and flag leaf length over three locations and pooled

Parent/cross			Productive Tillers/ Plant				Flag Leaf Length			
TESTERS			KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
IR 58025A			6.00	10.33	10.33	8.89	21.87	25.00	24.00	23.62
IR 68897A			6.33	9.00	10.83	8.72	29.75	24.50	24.50	26.25
APMS 6A			7.33	10.33	13.83	10.50	21.85	24.50	21.50	22.62
APMS 8A			7.33	22.00	16.33	15.22	23.97	33.00	22.50	26.49
CMS 16A			9.00	18.00	16.83	14.61	27.63	28.00	28.00	27.88
Mean			7.20	13.93	13.63	11.59	25.01	27.00	24.10	25.37
LINES										
JGL 11110-2			10.33	13.33	9.83	11.17	30.63	28.00	26.50	28.38
JGL 11110-1			9.00	20.33	10.83	13.39	35.43	36.00	29.50	33.64
JGL 17211			9.00	14.33	15.33	12.89	30.70	29.00	29.50	29.73
JGL 16284			8.67	8.00	11.33	9.33	32.03	21.50	31.00	28.18
JGL 13515			8.33	16.00	9.83	11.39	23.37	28.00	22.50	24.62
JGL 11160			6.67	16.00	8.83	10.50	33.47	31.00	29.00	31.16
JGL 11118			6.33	16.00	11.83	11.39	25.85	25.50	27.00	26.12
JGL 11111			8.00	8.33	9.83	8.72	37.57	22.00	34.00	31.19
JGL 8605			7.67	13.00	15.83	12.17	29.83	22.50	31.00	27.78
JGL 8292			8.00	12.00	10.33	10.11	32.40	24.50	30.00	28.97
JGL 3855			6.33	8.00	10.33	8.22	23.07	30.00	21.50	24.86
JGL 3844			7.00	9.00	9.83	8.61	22.08	20.00	20.50	20.86
JGL 1798			9.00	10.33	8.83	9.39	26.40	25.00	26.00	25.80
Mean			8.03	12.67	10.99	10.56	29.45	26.38	27.54	27.79
Parental Mean			8.20	13.02	11.72	10.85	29.61	26.56	26.58	27.12
IR 68897A	X	JGL11110-2	6.33	18.00	15.83	13.39	24.12	33.00	27.50	28.21
IR 68897A	X	JGL11110-1	7.67	11.33	8.33	9.11	24.17	25.50	24.00	24.56
IR 68897A	X	JGL17211	6.00	8.33	7.83	7.39	22.33	26.00	20.00	22.78
IR 68897A	X	JGL16284	7.33	16.00	9.83	11.06	29.73	27.50	29.50	28.91
IR 68897A	X	JGL13515	8.67	10.33	13.83	10.94	28.08	35.00	25.50	29.53
IR 68897A	X	JGL11160	8.00	15.33	24.83	16.06	40.40	33.00	35.50	36.30
IR 68897A	X	JGL11118	8.67	18.00	14.83	13.83	25.00	31.00	29.00	28.33
IR 68897A	X	JGL11111	10.00	14.33	19.33	14.56	27.67	35.00	25.00	29.22
IR 68897A	X	JGL8605	10.67	21.33	24.83	18.94	29.53	27.00	28.50	28.34
IR 68897A	X	JGL8292	9.67	22.33	21.33	17.78	26.45	30.50	29.00	28.65
IR 68897A	X	JGL3855	7.33	23.00	22.33	17.56	26.17	28.00	28.50	27.56
IR 68897A	X	JGL3844	8.67	22.00	19.33	16.67	25.50	33.50	26.50	28.50
IR 68897A	X	JGL1798	8.33	23.33	25.83	19.17	24.52	31.00	29.00	28.17
APMS 8A	X	JGL11110-2	6.33	14.00	16.83	12.39	28.07	33.50	31.50	31.02
APMS 8A	X	JGL11110-1	10.33	17.33	17.33	15.00	35.63	37.00	34.75	35.79
APMS 8A	X	JGL17211	7.00	14.00	10.83	10.61	31.27	41.50	31.00	34.59
APMS 8A	X	JGL16284	6.67	12.00	8.83	9.17	30.48	41.50	26.00	32.66
APMS 8A	X	JGL13515	7.67	17.00	17.83	14.17	29.50	31.00	32.50	31.00
APMS 8A	X	JGL11160	5.33	15.00	18.33	12.89	30.45	36.00	29.00	31.82
APMS 8A	X	JGL11118	8.33	26.33	20.83	18.50	31.70	34.50	35.00	33.73
APMS 8A	X	JGL11111	9.33	26.33	22.33	19.33	38.78	25.50	29.00	31.09
APMS 8A	X	JGL8605	8.67	17.33	13.83	13.28	31.93	30.50	22.50	28.31
APMS 8A	X	JGL8292	5.00	13.00	11.33	9.78	27.18	26.50	23.50	25.73
APMS 8A	X	JGL3855	6.67	12.00	18.33	12.33	27.93	24.00	25.50	25.81
APMS 8A	X	JGL3844	7.67	26.33	16.33	16.78	25.03	34.00	27.50	28.84
APMS 8A	X	JGL1798	8.00	14.00	10.83	10.94	30.33	35.00	27.00	30.78

Table 4.10. (cont.)

Cross	Productive Tillers/ Plant				Flag Leaf Length			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
CMS 16A X JGL11110-2	7.00	22.33	14.83	14.72	31.37	30.50	29.00	30.29
CMS 16A X JGL11110-1	6.67	10.00	16.33	11.00	32.12	30.00	26.00	29.37
CMS 16A X JGL17211	9.33	16.00	10.83	12.06	35.63	34.00	33.50	34.38
CMS 16A X JGL16284	9.33	25.00	10.83	15.06	32.40	33.00	33.00	32.80
CMS 16A X JGL13515	8.00	14.00	14.83	12.28	29.45	28.50	27.75	28.57
CMS 16A X JGL11160	8.00	22.00	17.83	15.94	32.32	30.00	34.00	32.11
CMS 16A X JGL11118	8.00	21.00	11.83	13.61	28.63	28.50	31.50	29.54
CMS 16A X JGL11111	8.00	14.00	11.83	11.28	25.22	25.50	23.00	24.57
CMS 16A X JGL8605	6.33	18.00	9.83	11.39	30.00	34.00	26.00	30.00
CMS 16A X JGL8292	8.33	18.33	12.83	13.17	40.12	32.50	34.00	35.54
CMS 16A X JGL3855	8.00	8.00	14.33	10.11	29.47	24.50	24.50	26.16
CMS 16A X JGL3844	8.67	21.33	15.83	15.28	31.87	33.00	31.00	31.96
CMS 16A X JGL1798	8.00	19.33	20.83	16.06	30.22	20.50	28.00	26.24
APMS 6A X JGL11110-2	10.33	16.00	18.83	15.06	28.33	30.50	25.50	28.11
APMS 6A X JGL11110-1	11.33	26.00	22.33	19.89	32.85	32.00	30.50	31.78
APMS 6A X JGL17211	9.67	14.33	21.33	15.11	28.53	30.50	33.00	30.68
APMS 6A X JGL16284	9.33	18.33	24.33	17.33	28.90	35.00	31.50	31.80
APMS 6A X JGL13515	10.00	11.00	9.83	10.28	21.40	33.00	22.00	25.47
APMS 6A X JGL11160	8.00	25.00	9.33	14.11	27.80	23.00	24.05	24.95
APMS 6A X JGL11118	9.67	15.00	17.83	14.17	32.78	25.50	30.00	29.43
APMS 6A X JGL11111	15.33	10.33	10.83	12.17	37.20	30.50	30.50	32.73
APMS 6A X JGL8605	7.00	16.00	13.83	12.28	29.67	31.00	28.00	29.56
APMS 6A X JGL8292	12.00	22.33	12.83	15.72	33.95	22.50	30.50	28.98
APMS 6A X JGL3855	9.33	12.33	14.33	12.00	26.67	16.50	24.50	22.56
APMS 6A X JGL3844	10.67	13.00	9.83	11.17	30.90	18.00	26.50	25.13
APMS 6A X JGL1798	10.33	16.33	17.33	14.67	31.43	20.50	30.50	27.48
IR 58025A X JGL11110-2	8.33	15.33	13.83	12.50	27.43	34.00	21.50	27.64
IR 58025A X JGL11110-1	10.33	10.33	8.33	9.67	30.00	21.50	29.50	27.00
IR 58025A X JGL17211	7.33	12.00	21.33	13.56	36.30	22.50	32.00	30.27
IR 58025A X JGL16284	6.67	11.33	24.33	14.11	30.13	19.50	28.00	25.88
IR 58025A X JGL13515	7.67	14.33	16.33	12.78	27.23	30.50	27.00	28.24
IR 58025A X JGL11160	7.33	25.00	16.33	16.22	29.12	21.00	28.00	26.04
IR 58025A X JGL11118	9.33	11.00	17.83	12.72	26.32	20.50	24.00	23.61
IR 58025A X JGL11111	9.33	12.00	10.83	10.72	39.45	33.00	36.50	36.32
IR 58025A X JGL8605	4.67	19.33	13.83	12.61	26.00	29.50	24.50	26.67
IR 58025A X JGL8292	8.33	9.00	8.83	8.72	34.67	16.50	29.50	26.89
IR 58025A X JGL3855	8.67	23.00	14.33	15.33	32.25	34.50	30.00	32.25
IR 58025A X JGL3844	9.67	13.33	9.83	10.94	25.00	23.00	24.50	24.17
IR 58025A X JGL1798	6.67	13.00	17.33	12.33	26.55	21.00	24.00	23.85
Crosses mean	8.39	16.66	15.56	13.53	29.87	29.02	28.30	29.07
Grand mean	8.26	15.46	14.48	12.66	29.51	27.72	27.25	27.90
KRH - 2	11.00	12.00	12.33	11.78	21.72	30.50	27.50	26.57
DRRH - 2	8.33	14.33	21.83	14.83	23.67	27.50	31.50	27.56
PA 6201	11.00	13.00	10.83	11.61	28.10	24.00	21.50	24.53
JAYA	7.00	17.33	10.33	11.56	30.77	32.50	28.00	30.42
IR - 64	10.33	10.00	10.83	10.39	22.75	20.00	22.50	21.75
Mean	8.33	15.72	14.64	12.90	29.28	28.40	27.83	28.50
S.E.	0.93	0.68	0.91	1.12	0.97	1.80	1.49	1.32
C.V.	19.39	7.50	10.81	26.14	5.72	10.98	9.25	13.89
C.D. 5%	2.60	1.90	2.55	3.12	2.70	5.02	4.15	3.66

from 65 cm (APMS 8A x JGL 16284) to 133 cm (IR 58025A x JGL 8292), while in check the lowest plant height was recorded in Jaya (98 cm).

At Warangal the mean plant height ranged from 64 cm to 127 cm with a general mean of 94 cm. The plant height in testers ranged from 94 cm (IR 58025A and APMS 6A) to 122 cm (CMS 16A) and for lines it was from 94 cm (JGL 16284) to 127 cm (JGL 8605 and JGL 3855). The mean plant height in hybrids ranged from 64 cm (IR 68897A x JGL 17211) to 124 cm (APMS 6A x JGL 3855), while in check the lowest plant height was recorded in IR 64 (94 cm).

In Kampasagar, a general mean of 94 cm is recorded with a range from 77 cm to 112 cm. Testers were in the range of 90 cm (IR 58025A) to 94 cm (APMS 6A and CMS 16A), while in lines the range was from 87 cm (JGL 11118 and JGL 3844) to 112 cm (JGL11110-2). In hybrids plant height ranged from 77 cm (APMS 8A x JGL 16284) to 110 cm (IR 58025A x JGL 8292) the check IR 64 recorded lowest height (87 cm).

In pooled data of three locations the plant height ranged from 69 cm to 119 cm with a mean of 96 cm. The testers recorded a range of 85 cm (IR 58025A) to 106 cm (CMS 16A), while in lines the range was 96 cm (JGL 1798) to 111 cm (JGL 11110-1). In hybrids the plant height ranged from 69 cm (APMS 8A x JGL 16284) to 119 cm (IR 58025A x JGL 8292). The lowest height recorded was in check IR 64 (94 cm) (Table 4.9).

4.2.2.5 Productive tillers: The range of productive tillers recorded at Kunaram was 5 to 15 with a mean of 8, (Table 4.10). The testers recorded productive tillers in the range of 6 (IR 58025A and IR 68897A) to 9 (CMS 16A), while in lines the range was 6 (JGL 11118 and JGL 3855) to 10 (JGL 11110-2). In hybrids the productive tillers ranged from 5 (APMS 8A x JGL 11160 and APMS 8A x JGL 8292) to 15 (APMS 6A x JGL 1111). The highest productive tillers were recorded in KRH-2 and PA 6201(11.0).

At Warangal the range of productive tillers was 8 to 26, with a mean of 16. The productive tillers in testers ranged from 9 (IR 68897A) to 22 (APMS 8A), while in lines ranged from 8 (JGL 16284, JGL 11111 and JGL 3855) to 20 (JGL 11110-1). In hybrid the productive tillers ranged from 8 (IR 68897A) 26 (APMS 8A x JGL 11118, APMS 8A x JGL 11111, APMS 8A x JGL 3844 and APMS 6A x JGL 11110-1). The highest number of productive tillers (17) was recorded in check Jaya.

The range of productive tillers at Kampasagar was 8 to 26 with a mean of 15. The range of productive tillers in testers was 10 (IR 58025A) to 17 (CMS 16A), while in lines the productive tillers ranged from 9 (JGL 11160 and JGL 1798) to 16 (JGL 8605). In hybrids the productive tillers ranged from 8 (IR 68897A x JGL 11110-1 and

IR 688997 A x JGL 17211) to 26 (IR68897A x JGL 1798). The check DRRH-2 recorded the highest number of productive tillers (21.83).

The range of productive tillers in pooled data was 7 to 20 with a mean of 13. The productive tillers in testers ranged from 9 (IR 58025A and IR 68897A) to 15 (APMS 8A and CMS 16A), while in lines the range was from 8 (JGL 3855) to 13 (JGL 11110-1 and JGL 17211). In hybrids the productive tillers ranged from 7 (IR 68897A x JGL 17211) to 20 (APMS 6A x JGL 11110-1). The highest number of productive tillers was recorded in the check DRRH-2(14.83). Eight hybrids were on par with the hybrid (APMS 6A x JGL 11110-1) which recorded highest number of productive tillers.

4.2.2.6 Flag leaf length (cm): At Kunaram, the flag leaf length ranged from 21.40 to 40.40, with a mean of 29.28 (Table 4.10). In testers the range was from 21.85 (APMS 6A) to 29.75 (IR 68897A), while in lines the range of flag leaf length was from 22.08 (JGL 3844) to 35.43 (JGL 11110-1). In hybrids the range was from 21.40 (APMS 6A x JGL 13515) to 40.40 (IR 68897A x JGL 11160). The check Jaya recorded the maximum flag leaf length of 30.77.

The range of flag leaf length was from 16.50 to 41.50 at Warangal with a mean of 28.40. The flag leaf length in testers ranged from 25.00 (IR 58025A) to 33.00 (APMS 8A), while in lines the range of flag leaf length was from 20.00 (JGL 3844) to 36.0 (JGL 11110-1). In hybrids flag leaf length ranged from 16.50 (APMS 6A x JGL 3855) to 41.50 (APMS 8A x JGL 17211 and APMS 8A x JGL 16284). The check Jaya recorded the longest flag leaf length (32.50).

At Kampasagar the flag leaf length ranged from 20.00 to 36.50, with a mean of 27.83. The flag leaf length in testers ranged from 21.50 (APMS 6A) to 28.00 (CMS 16A), while in lines the range of flag leaf length was from 21.50 (JGL 3855) to 34.00 (JGL 11111). In hybrids flag leaf length ranged from 20.00 (IR 68897A x JGL 17211) to 36.50 9IR 58025A x JGL 11111). The checkDRRH-2, recorded the highest flag leaf length (31.50).

The range of flag leaf length in pooled data was 20.86 to 36.82 with a mean of 28.50. The flag leaf length in testers ranged from 22.62 (APMS 6A) to 27.88 (CMS 16A), while in lines the range of flag leaf length recorded from 20.86 (JGL 3844) to 33.64 (JGL 11110-1). In hybrids the flag leaf length ranged from 22.56 (APMS 6A x JGL 3855) to 36.32 (IR 58025A x JGL 11111). Nine hybrids were on par with the hybrid which recorded highest flag leaf length of 36.32 cm. The check Jaya recorded the highest flag leaf length (30.42) (Table 4.9).

Table 4.10. Mean performance of parents and hybrids for flag leaf width (cm) and panicle length (cms)over three locations and pooled

Parent/Cross	Flag leaf width (cm)				Panicle length (cms))			
TESTERS	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
IR 58025A	1.00	1.42	1.17	1.19	15.90	16.17	19.50	17.19
IR 68897A	1.04	0.82	1.02	0.96	23.13	16.67	22.50	20.77
APMS 6A	1.34	1.47	1.27	1.36	23.93	20.17	21.50	21.87
APMS 8A	1.32	1.62	1.27	1.40	21.90	21.67	20.50	21.36
CMS 16A	1.20	2.22	1.43	1.62	22.87	15.67	22.50	20.34
Mean	1.18	1.51	1.23	1.31	21.55	18.07	21.30	20.30
LINES								
JGL 11110-2	1.23	0.97	1.49	1.23	23.43	17.17	24.00	21.53
JGL 11110-1	1.43	1.87	1.54	1.61	27.07	28.17	25.00	26.74
JGL 17211	1.45	1.87	1.57	1.63	24.43	22.67	23.00	23.37
JGL 16284	1.45	1.47	1.72	1.55	23.10	21.67	22.00	22.26
JGL 13515	1.36	1.42	1.63	1.47	23.87	26.17	22.00	24.01
JGL 11160	1.28	1.32	1.57	1.39	22.63	21.67	21.00	21.77
JGL 11118	1.07	0.97	1.47	1.17	22.20	23.17	22.00	22.46
JGL 11111	1.32	0.92	1.30	1.18	23.73	18.17	23.00	21.63
JGL 8605	1.61	1.42	1.67	1.57	21.80	21.67	22.00	21.82
JGL 8292	1.52	1.62	1.47	1.54	26.57	20.67	24.50	23.91
JGL 3855	1.34	1.42	1.47	1.41	21.77	24.67	22.50	22.98
JGL 3844	1.18	0.97	1.22	1.12	20.27	17.67	20.50	19.48
JGL 1798	1.18	0.97	0.97	0.99	21.63	22.17	22.00	21.93
Mean	1.18	1.32	1.47	1.37	23.27	21.97	22.58	22.61
Parental Mean	1.18	1.37	1.40	1.35	23.99	20.89	22.22	21.97
IR 68897A X JGL11110-2	1.18	0.97	0.92	0.97	28.33	23.17	26.00	25.83
IR 68897A X JGL11110-1	1.18	0.87	0.74	0.80	24.13	21.17	22.50	22.60
IR 68897A X JGL17211	1.18	0.97	0.97	0.98	23.60	19.67	22.00	21.76
IR 68897A X JGL16284	1.18	0.92	1.46	1.31	26.93	21.17	25.50	24.53
IR 68897A X JGL13515	1.18	0.87	1.07	1.03	25.67	18.67	24.00	22.78
IR 68897A X JGL11160	1.18	0.97	1.22	1.15	24.73	23.17	23.50	23.80
IR 68897A X JGL11118	1.18	0.72	0.97	0.90	20.67	22.67	21.00	21.44
IR 68897A X JGL11111	1.18	1.07	1.37	1.26	27.87	21.18	25.50	24.85
IR 68897A X JGL8605	1.18	0.87	1.10	1.04	24.77	19.70	23.50	22.66
IR 68897A X JGL8292	1.18	1.07	1.11	1.14	26.37	24.67	24.00	25.01
IR 68897A X JGL3855	1.18	0.97	0.92	0.98	23.80	23.67	22.50	23.32
IR 68897A X JGL3844	1.18	0.97	0.97	0.98	25.20	21.17	24.00	23.46
IR 68897A X JGL1798	1.18	1.07	0.97	1.04	23.43	15.17	21.50	20.03
APMS 8A X JGL11110-2	1.18	0.97	1.47	1.24	23.70	22.67	24.00	23.46
APMS 8A X JGL11110-1	1.18	0.92	1.62	1.28	26.27	20.17	24.50	23.64
APMS 8A X JGL17211	1.18	1.07	1.77	1.50	24.73	21.17	23.00	22.97
APMS 8A X JGL16284	1.18	0.82	1.19	1.10	27.53	18.67	25.00	23.73
APMS 8A X JGL13515	1.18	0.92	1.62	1.35	24.37	19.17	23.00	22.18
APMS 8A X JGL11160	1.18	1.07	1.49	1.31	23.33	22.17	23.00	22.83
APMS 8A X JGL11118	1.18	1.07	1.54	1.26	22.57	21.67	22.50	22.24
APMS 8A X JGL11111	1.18	0.97	1.17	1.11	24.10	19.67	21.50	21.76
APMS 8A X JGL8605	1.18	0.92	1.72	1.53	25.53	16.17	24.50	22.07
APMS 8A X JGL8292	1.18	1.07	0.82	0.89	23.30	20.17	21.50	21.66
APMS 8A X JGL3855	1.18	0.87	1.29	1.16	24.70	18.67	23.00	22.12
APMS 8A X JGL3844	0.90	1.27	0.97	1.05	25.60	18.17	23.50	22.42
APMS 8A X JGL1798	1.64	0.97	1.67	1.42	21.67	20.17	20.00	20.61

Table 4.10. (cont.)

CROSS	Flag leaf width (cm)				Panicle length (cms)			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
CMS 16A X JGL11110-2	1.27	1.12	1.17	1.18	26.33	21.67	25.00	24.33
CMS 16A X JGL11110-1	1.48	1.07	1.57	1.37	26.40	18.20	24.50	23.03
CMS 16A X JGL17211	1.31	1.07	1.37	1.25	26.67	20.70	25.00	24.12
CMS 16A X JGL16284	1.50	1.27	1.62	1.46	22.90	20.70	22.00	21.87
CMS 16A X JGL13515	1.56	0.87	1.74	1.39	23.80	22.67	22.50	22.99
CMS 16A X JGL11160	1.99	0.97	1.97	1.64	25.87	20.67	23.50	23.34
CMS 16A X JGL11118	1.27	0.92	1.34	1.18	21.43	16.17	24.00	20.53
CMS 16A X JGL11111	1.30	0.87	1.32	1.16	24.13	23.67	22.00	23.27
CMS 16A X JGL8605	0.71	0.82	0.72	0.75	25.03	19.67	24.00	22.90
CMS 16A X JGL8292	1.18	0.97	1.07	1.07	23.97	20.17	22.50	22.21
CMS 16A X JGL3855	1.99	0.97	1.84	1.60	23.30	19.67	23.00	21.99
CMS 16A X JGL3844	1.40	1.02	1.32	1.24	24.03	22.20	20.50	22.24
CMS 16A X JGL1798	1.80	1.07	1.72	1.53	22.50	16.20	21.00	19.90
APMS 6A X JGL11110-2	1.70	1.07	1.29	1.35	24.63	20.18	22.00	22.27
APMS 6A X JGL11110-1	1.64	0.97	1.62	1.41	25.77	21.67	24.50	23.98
APMS 6A X JGL17211	1.34	0.97	1.29	1.20	22.80	19.18	21.00	20.99
APMS 6A X JGL16284	1.46	0.97	1.34	1.26	24.10	21.17	23.00	22.76
APMS 6A X JGL13515	1.69	1.07	1.73	1.50	24.23	17.67	24.00	21.97
APMS 6A X JGL11160	1.11	0.97	1.07	1.05	24.47	19.67	23.00	22.38
APMS 6A X JGL11118	1.21	0.77	1.19	1.06	22.90	20.17	22.00	21.69
APMS 6A X JGL11111	1.41	0.97	1.52	1.30	23.20	22.17	22.00	22.46
APMS 6A X JGL8605	1.30	0.92	1.47	1.23	20.37	18.17	24.50	21.01
APMS 6A X JGL8292	1.34	0.82	1.32	1.16	24.43	20.17	22.50	22.37
APMS 6A X JGL3855	1.09	1.07	1.17	1.11	23.03	19.67	21.50	21.40
APMS 6A X JGL3844	1.39	0.97	1.27	1.21	21.00	19.17	20.50	20.22
APMS 6A X JGL1798	1.59	1.87	1.79	1.75	23.00	22.17	23.50	22.89
IR 58025A X JGL11110-2	1.18	1.37	1.40	1.32	25.47	21.67	21.50	22.88
IR 58025A X JGL11110-1	1.37	0.97	1.67	1.33	25.53	19.67	23.50	22.90
IR 58025A X JGL17211	1.21	0.97	1.12	1.10	22.53	20.67	20.50	21.23
IR 58025A X JGL16284	1.23	0.97	1.18	1.13	23.87	21.33	23.50	22.90
IR 58025A X JGL13515	1.36	1.92	1.29	1.52	14.37	22.67	13.50	16.84
IR 58025A X JGL11160	0.80	0.97	1.57	1.11	25.10	19.67	22.50	22.42
IR 58025A X JGL11118	1.00	0.97	1.02	0.99	23.87	20.17	23.50	22.51
IR 58025A X JGL11111	1.34	1.47	1.22	1.34	26.73	21.17	24.50	24.13
IR 58025A X JGL8605	0.57	1.37	0.80	0.91	20.07	23.17	20.00	21.08
IR 58025A X JGL8292	0.78	0.97	1.22	0.99	23.50	20.17	23.00	22.22
IR 58025A X JGL3855	0.94	0.87	1.07	0.96	26.17	20.67	24.50	23.78
IR 58025A X JGL3844	0.60	0.87	0.89	0.79	23.20	20.17	22.50	21.96
IR 58025A X JGL1798	1.08	1.22	1.17	1.16	23.77	21.17	22.50	22.48
Crosses mean	1.25	1.02	1.30	1.20	24.11	20.46	22.82	22.46
Grand mean	1.28	1.06	1.28	1.20	23.83	20.01	22.10	21.78
KRH - 2	1.15	1.97	1.47	1.53	27.43	21.67	23.50	24.20
DRRH - 2	0.95	0.97	1.17	1.03	23.87	21.17	23.50	22.84
PA 6201	1.32	1.37	1.07	1.25	24.00	18.67	22.50	21.72
JAYA	1.18	1.42	1.29	1.30	19.67	23.67	21.00	21.44
IR - 64	1.22	1.92	1.07	1.40	23.67	21.17	24.00	22.94
Mean	1.27	1.12	1.32	1.24	23.82	20.59	22.70	22.37
S.E.	0.08	0.04	0.12	0.08	0.46	0.68	0.60	0.60
C.V.	11.27	5.93	16.14	19.61	3.34	5.75	4.54	7.99
C.D. 5%	0.23	0.11	0.34	0.22	1.28	1.91	1.66	1.65

4.2.2.7 Flag leaf width (cm): At Kunaram the flag leaf width ranged from 0.57 to 1.99, with a mean of 1.27 (Table 4.10). In testers the flag leaf width was from 1.00 (IR 58025A) to 1.34 (APMS 6A), while in lines the range of flag leaf width ranged from 1.07 (JGL 11118) to 1.61 (JGL 8605). In hybrids the flag leaf width recorded from 0.57 (IR 58025A x JGL 8605) to 1.99 (CMS 16A x JGL 3855). The check PA6201 recorded the highest flag leaf width (1.32).

At Warangal the flag leaf width ranged from 0.72 to 2.22, with a mean of 1.12. In testers the flag leaf width ranged from 0.82 (IR 68897A) to 2.22 (CMS 16A), while in lines the flag leaf width ranged from 0.92 (JGL 11111) to 1.87 (JGL 11110-1 and JGL 17211). In hybrids the flag leaf width ranged from 0.72 (IR 68897A x JGL 11118) to 1.92 (IR 58025A x JGL 13515). The check KRH-2 recorded the highest flag leaf width (1.97).

At Kampasagar the flag leaf width ranged from 0.72 to 1.97, with a mean of 1.32. In testers the range was from 1.02 (IR 68897A) to 1.43 (CMS 16A), while in lines the flag leaf width ranged from 0.97 (JGL 1798) to 1.72 (JGL 16284). In hybrids the flag leaf width ranged from 0.72 (CMS 16A x JGL 8605) to 1.97 (CMS 16A x JGL 11160). The checks KRH-2 recorded highest flag leaf width (1.47).

The range of flag leaf width in pooled data ranged from 0.75 to 1.75 with a mean of 1.24, while in the testers the range recorded from 0.96 9IR 68897A) to 1.62 (CMS 16A). In lines the range of flag leaf width recorded from 0.99 (JGL 1798) to 1.63 (JGL 17211). In hybrids the flag leaf width ranged from 0.75 (CMS 16A x JGL 8605) to 1.75 (APMS 6A x JGL 1798). Nine hybrids were on par with APMS 6A x JGL 1798 which recorded highest flag leaf width.The check KRH-2 recorded the highest flag leaf width (1.53).

4.2.2.8 Panicle length (cms): At Kunaram the panicle length ranged from 14.37 to 28.33, with a mean of 23.82 (Table 4.10). In testers the panicle length ranged from 15.90 (IR 58025A) to 23.93 (APMS 6A), while in lines the panicle length ranged from 20.27 (JGL 3844) to 27.07 (JGL 11110-1). In hybrids the panicle length ranged from 14.37 (IR 58025A x JGL 13515) to 28.33 (IR 68897A x JGL 11110-2). The check KRH-2 recorded the longest panicle length (27.43).

At Warangal the panicle length ranged from 15.17 to 28.17, with a mean of 20.59. In testers the panicle length ranged from 16.17 (IR 58025A) to 21.67 (APMS 8A), while in lines, panicle length ranged from 17.17 (JGL 11110-2) to 28.17 (JGL 11110-1). In hybrids panicle length ranged from 15.17 (IR 68897A x JGL 1798) to 24.67 (IR 68897A x JGL 8292). The check Jaya recorded the longest panicle length (23.67).

At Kampasagar the panicle length ranged from 13.50 to 26.00, with a mean of 22.70. In testers the panicle length ranged from 19.50 (IR 58025A) to 22.50 (IR 68897A and CMS 16A), while in lines the panicle length ranged from 20.50 (JGL 3844) to 25.00 (JGL 11110-1). In hybrids the panicle length ranged from 13.50 (IR 58025A x JGL 13515) to 26.00 (IR 68897A x JGL 11110-2). The check IR 64 recorded the longest panicle length (24.00).

The range of panicle length in pooled data was 16.84 to 26.74, with a mean of 22.37. In testers the panicle length ranged from 17.19 (IR 58025A) to 21.87 (APMS 6A), while in lines the panicle length ranged from 19.48 (JGL 3844) to 26.74 (JGL 11110-1). In hybrids highest panicle length (25.83) was recorded by IR 68897A x JGL 11110-2 and three hybrids (IR 68897A x JGL11111, IR 68897A x JGL 8292 and CMS 16A x JGL 11110-2) were on par with the highest hybrid for panicle length. The check KRH-2 recorded the longest panicle length of 24.20 cm (Table 4.10).

4.2.2.9 Panicle weight (gm): The range of panicle weight recorded at Kunaram was from 1.83 to 5.70, with a mean of 3.54 (Table 4.11). In testers the panicle weight ranged from 1.83 (APMS 6A) to 3.43 (IR 68897A), while in lines the panicle weight ranged from 1.87 (JGL 3844) to 5.33 (JGL 1798). In hybrids the panicle weight ranged from 2.10 (IR 58025A x JGL 8605) to 5.70 (APMS 8A x JGL 11160). The tester KRH-2 recorded highest panicle weight (4.93).

At Warangal panicle weight ranged from 1.60 to 4.83, with a mean of 2.61. In testers the panicle weight ranged from 1.70 (IR 58025A) to 2.93 (APMS 8A), while in lines the panicle length varied from 1.60 (JGL 13515) to 4.83 (JGL 17211). In hybrids the panicle weight ranged from 1.60 (CMS 16A X JGL 3855) to 4.60 (APMS 6A x JGL 11110-2). The check KRH-2 recorded highest panicle weight (3.50).

At Kampasagar the panicle weight ranged from 1.60 to 5.20, with a mean of 3.10. In testers the panicle weight ranged from 2.47 (IR 58025A) to 4.07 (CMS 16A), while in lines it ranged from 1.67 (JGL 3855) to 3.47 (JGL 11113). In hybrids the panicle weight ranged from 1.60 (APMS 6A x JGL 8605) to 5.20 (CMS 16A x JGL 17211). The check DRRH-2 recorded highest panicle weight (3.47).

In pooled data of three locations the range of panicle weight varied from 1.90 to 4.39, with a mean of 3.08. In testers the panicle weight ranged from 2.10 (IR 58025A) to 3.31 (CMS 16A), while in lines the panicle weight varied from 2.19 (JGL 11110-2) to 3.80 (JGL 11118). In hybrids the panicle weight ranged from 1.90 (APMS 6A x JGL8605) to 4.39 (APMS 6A x JGL 17211). Nine hybrids were on par with APMS 6A

Table 4.11. Mean performance of parents and hybrids for panicle weight (gm) filled grains per panicle over three locations and pooled

Parent/Cross	Panicle weight (gm)				Filled grains per panicle			
TESTERS	**KNM**	**WGL**	**KSR**	**POOLED**	**KNM**	**WGL**	**KSR**	**POOLED**
IR 58025A	2.13	1.70	2.47	2.10	102	120	149	124
IR 68897A	3.43	2.40	3.07	2.97	125	121	188	145
APMS 6A	1.83	2.43	3.27	2.51	118	146	184	149
APMS 8A	2.00	2.93	3.07	2.67	139	204	196	179
CMS 16A	3.07	2.80	4.07	3.31	194	372	215	260
Mean	2.49	2.45	3.19	2.71	136	193	186	171
LINES								
JGL 11110-2	2.47	1.93	2.17	2.19	172	220	189	194
JGL 11110-1	3.67	4.43	2.17	3.42	238	307	328	291
JGL 17211	3.97	4.03	3.20	3.73	238	306	197	247
JGL 16284	2.80	4.83	2.10	3.24	288	328	327	315
JGL 13515	3.67	1.60	2.00	2.42	204	126	154	161
JGL 11160	4.20	4.10	1.97	3.42	257	236	110	201
JGL 11118	3.50	4.43	3.47	3.80	196	347	222	255
JGL 11111	3.27	2.53	2.37	2.72	188	132	196	172
JGL 8605	3.33	4.40	2.30	3.34	261	307	204	257
JGL 8292	3.33	2.20	2.20	2.58	279	188	270	246
JGL 3855	4.23	3.03	1.67	2.98	283	278	117	226
JGL 3844	1.87	2.50	2.47	2.28	103	104	213	140
JGL 1798	5.33	2.43	2.50	3.42	222	189	141	184
Mean	3.51	3.27	2.35	3.04	225	236	205	222
Parental Mean	3.37	3.04	2.58	2.95	208	224	200	208
IR 68897A X JGL11110-2	3.37	2.40	4.30	3.36	151	148	175	158
IR 68897A X JGL11110-1	2.67	2.60	3.07	2.78	134	146	160	147
IR 68897A X JGL17211	2.57	2.43	2.37	2.46	154	135	113	134
IR 68897A X JGL16284	5.43	2.43	4.10	3.99	243	199	179	207
IR 68897A X JGL13515	3.77	1.63	2.67	2.69	143	109	165	139
IR 68897A X JGL11160	3.90	2.70	5.10	3.90	164	137	220	173
IR 68897A X JGL11118	2.13	2.00	3.37	2.50	102	109	124	111
IR 68897A X JGL11111	4.33	2.43	4.27	3.68	214	138	239	197
IR 68897A X JGL8605	3.63	3.30	3.00	3.31	168	179	156	168
IR 68897A X JGL8292	4.37	2.83	2.97	3.39	128	169	107	134
IR 68897A X JGL3855	2.43	2.20	2.30	2.31	122	111	121	118
IR 68897A X JGL3844	3.47	2.20	3.20	2.96	175	128	123	142
IR 68897A X JGL1798	3.57	1.93	2.17	2.56	132	130	41	101
APMS 8A X JGL11110-2	3.83	1.83	3.67	3.11	216	189	184	196
APMS 8A X JGL11110-1	5.20	2.60	4.07	3.96	267	221	227	238
APMS 8A X JGL17211	4.40	3.03	5.20	4.21	259	268	239	255
APMS 8A X JGL16284	4.20	2.53	4.10	3.61	221	167	180	189
APMS 8A X JGL13515	4.37	3.10	1.67	3.04	208	226	68	167
APMS 8A X JGL11160	5.70	2.53	2.77	3.67	235	149	162	182
APMS 8A X JGL11118	3.70	2.63	2.77	3.03	152	120	120	131
APMS 8A X JGL11111	3.63	2.73	3.10	3.16	229	236	176	213
APMS 8A X JGL8605	3.50	2.00	2.97	2.82	257	127	186	190
APMS 8A X JGL8292	3.30	2.30	2.17	2.59	232	132	177	180
APMS 8A X JGL3855	2.93	2.20	2.47	2.53	172	169	124	155
APMS 8A X JGL3844	2.33	2.73	3.47	2.84	213	188	215	205
APMS 8A X JGL1798	2.30	2.30	2.17	2.26	150	155	99	135

Table 4.11. (cont.)

Cross	Panicle weight (gm)				Filled grains per panicle			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
CMS 16A X JGL11110-2	4.80	2.93	3.67	3.80	247	259	189	232
CMS 16A X JGL11110-1	3.93	2.10	4.07	3.37	267	166	196	210
CMS 16A X JGL17211	2.67	2.50	5.20	3.46	154	237	213	201
CMS 16A X JGL16284	2.47	3.10	4.10	3.22	137	229	179	182
CMS 16A X JGL13515	4.30	2.00	3.80	3.37	211	304	255	256
CMS 16A X JGL11160	3.40	2.60	4.20	3.40	170	162	328	220
CMS 16A X JGL11118	5.00	2.83	3.10	3.64	247	159	224	210
CMS 16A X JGL11111	2.90	1.70	3.37	2.66	164	126	215	168
CMS 16A X JGL8605	3.30	1.80	2.57	2.56	143	137	257	179
CMS 16A X JGL8292	3.90	2.63	2.17	2.90	261	150	177	196
CMS 16A X JGL3855	4.67	1.60	2.87	3.04	216	146	165	175
CMS 16A X JGL3844	3.20	2.50	3.07	2.92	110	123	130	121
CMS 16A X JGL1798	2.13	2.00	3.97	2.70	103	110	146	120
APMS 6A X JGL11110-2	3.70	4.60	3.67	3.99	236	408	153	265
APMS 6A X JGL11110-1	3.93	3.43	4.07	3.81	241	250	131	207
APMS 6A X JGL17211	5.20	3.20	4.77	4.39	284	167	249	233
APMS 6A X JGL16284	3.90	2.40	4.07	3.46	264	103	222	196
APMS 6A X JGL13515	2.30	1.80	2.47	2.19	154	152	124	143
APMS 6A X JGL11160	4.33	2.73	4.20	3.76	259	311	236	269
APMS 6A X JGL11118	5.60	1.80	3.10	3.50	271	100	304	225
APMS 6A X JGL11111	4.10	2.50	2.67	3.09	254	190	229	224
APMS 6A X JGL8605	2.20	1.90	1.60	1.90	136	94	138	123
APMS 6A X JGL8292	3.23	2.60	2.17	2.67	176	167	107	150
APMS 6A X JGL3855	4.23	2.80	2.87	3.30	224	147	121	164
APMS 6A X JGL3844	3.73	2.63	2.30	2.89	193	132	140	155
APMS 6A X JGL1798	3.00	2.30	2.00	2.43	150	170	99	140
IR 58025A X JGL11110-2	2.70	2.10	3.67	2.82	143	113	189	149
IR 58025A X JGL11110-1	3.80	1.73	4.07	3.20	129	111	196	145
IR 58025A X JGL17211	3.77	1.83	4.77	3.46	149	146	213	169
IR 58025A X JGL16284	3.53	2.43	4.07	3.34	245	181	179	202
IR 58025A X JGL13515	2.30	2.53	2.47	2.43	117	181	136	145
IR 58025A X JGL11160	2.30	3.50	5.10	3.63	144	230	124	166
IR 58025A X JGL11118	2.30	2.20	3.37	2.62	126	146	304	192
IR 58025A X JGL11111	5.20	2.23	4.27	3.90	252	137	229	206
IR 58025A X JGL8605	2.10	3.10	1.60	2.27	109	170	138	139
IR 58025A X JGL8292	5.27	1.63	2.17	3.02	266	86	353	235
IR 58025A X JGL3855	3.43	2.03	2.87	2.78	239	146	121	168
IR 58025A X JGL3844	2.93	2.23	2.30	2.49	115	130	140	128
IR 58025A X JGL1798	2.50	2.80	2.00	2.43	118	217	99	145
Crosses mean	3.59	2.45	3.26	3.10	189	167	176	177
Grand mean	3.51	2.50	3.06	3.00	191	173	175	178
KRH - 2	4.93	3.50	2.17	3.53	174	166	151	163
DRRH - 2	4.27	3.10	3.47	3.61	158	121	148	142
PA 6201	3.67	3.00	3.07	3.24	146	108	144	133
JAYA	3.83	3.00	3.07	3.30	137	114	134	128
IR - 64	3.40	3.00	2.60	3.00	119	132	163	138
Mean	3.54	2.61	3.10	3.08	189	177	179	181
S.E.	0.11	0.10	0.07	0.24	15	6.72	5.61	15.53
C.V.	5.19	6.66	4.11	23.57	14	6.58	5.43	25.67
C.D. 5%	0.30	0.28	0.21	0.67	42	18.75	15.67	43.11

x JGL 17211, which recorded highest panicle weight. The check DRRH-2 recorded highest panicle weight (3.61).

4.2.2.10 Filled grains per panicle: At Kunaram, the number of filled grains per panicle ranged from 102 to 288, with a mean of 189 (Table 4.11). In testers the filled grains per panicle ranged from 102 (IR 58025A) to 194 (CMS 16A), while in lines the number of filled grains ranged from 103 (JGL 3844) to 288 (JGL 16284). In hybrids, the range varied from 102 (IR 68897A x JGL 11118) to 284 (APMS 6A x JGL 17211). The check KRH-2 recorded the highest number of filled grains per panicle (174).

At Warangal the number of filled grains per panicle ranged from 86 to 408, with a mean of 177. In testers the number of filled grains per panicle ranged from 120 (IR58025A) to 372 (CMS 16A), while in lines the filled grains per panicle ranged from 104 (JGL 3844) to 347 (JGL 11110). In hybrids the number of filled grains per panicle varied from 86 (IR 58025A x JGL 8292) to 408 (APMS 6A x JGL 11110-2). The check KRH-2 recorded the highest number of filled grains per panicle (166).

At Kampasagar, the number of filled grains per panicle ranged from 41 to 353, with a mean of 179. In testers the filled grains ranged from 149 (IR 58025A) to 215 (CMS 16A), while in lines, the number of filled grains ranged from 110 (JGL 11160) to 328 (JGL 11110-1). In hybrids the number of filled grains per panicle ranged from 41 (IR 68897A x JGL 1798) to 353 (IR 58025A x JGL 8292). The check IR 64 recorded the highest number filled grains per panicle (163).

Pooled data for number of filled grains per panicle ranged from 101 to 315 with a mean of 181. In testers the filled grains ranged from 124 (IR 58025A) to 260 (CMS 16A), while in lines the range varied from 140 (JGL 3844) to 315 (JGL 16284). In hybrids the range varied from 101 (IR 68897A x JGL 1798) to 269 (APMS 6A x JGL 11160). The check KRH-2 recorded highest number of filled grain per panicle (163) (Table 4.11).The line JGL 16284 recorded highest number of filled grains per panicle and was significantly superior to all the hybrids.

4.2.2.11 Spikelet fertility (%): At Kunaram the spikelet fertility percentage ranged from 37.50 to 99.00, with a mean of 82.67(Table 4.12). In testers it ranged from 73.13 (APMS 6A) to 95.14 (APMS 8A), while in lines it ranged from 77.82 (JGL 11110-2) to 97.00 (JGL 11160). In hybrids the spikelet fertility percentage ranged from 37.50 (IR 58025A x JGLM 1798) to 93.04 (APMS 8A xJGL8292). The check IR 64 recorded highest spikelet fertility percentage (99).

At Warangal the spikelet fertility percentage ranged from 43.17 to 96.67, with a mean of 84.57. In testers it ranged from 79.17 (IR 68897A) to 91.20 (APMS 8A),

Table 4.12. Mean performance of parents and hybrids for spikelet fertility (%) and 1000 grain weight (gm) over three locations and pooled

Parent/Cross	Spikelet fertility %				1000 grain weight (gm)			
TESTERS	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
IR 58025A	85.44	80.58	96.00	87.34	19.33	14.28	21.33	18.31
IR 68897A	81.44	79.17	93.50	84.70	21.67	18.28	22.33	20.76
APMS 6A	73.13	85.80	88.50	82.48	18.67	19.78	16.33	18.26
APMS 8A	95.14	91.20	90.50	92.28	16.00	16.28	14.83	15.70
CMS 16A	90.38	89.17	89.00	89.52	17.33	16.28	16.83	16.81
Mean	85.11	85.18	91.50	87.26	18.60	16.98	18.33	17.97
LINES								
JGL 11110-2	77.82	95.67	67.00	80.16	18.00	17.28	17.33	17.54
JGL 11110-1	91.13	93.09	83.00	89.07	17.00	14.28	17.33	16.20
JGL 17211	79.70	86.42	90.50	85.54	16.33	16.28		16.15
JGL 16284	89.97	91.24	87.50	89.57	17.67	15.28	18.33	17.09
JGL 13515	90.50	93.27	92.50	92.09	16.67	14.28	16.83	15.93
JGL 11160	97.64	92.24	88.00	92.63	16.67	14.78	17.33	16.26
JGL 11118	87.00	96.67	92.50	92.06	17.67	14.28	18.83	16.93
JGL 11111	93.00	90.17	92.50	91.89	18.33	15.78	18.83	17.65
JGL 8605	92.50	88.17	89.00	89.89	17.67	14.78	18.33	16.93
JGL 8292	95.84	88.17	90.00	91.34	19.67	13.78	21.83	18.43
JGL 3855	93.66	84.90	90.50	89.69	19.00	19.28	18.33	18.87
JGL 3844	78.36	85.67	92.50	85.51	17.33	15.28	17.33	16.65
JGL 1798	95.35	95.17	90.50	93.67	21.33	14.28	24.33	19.98
Mean	89.42	90.83	88.15	89.47	17.95	15.35	18.53	17.28
Parental Mean	92.95	89.26	89.08	88.86	19.16	15.81	18.47	17.47
IR 68897A X JGL11110-2	88.00	85.17	68.50	80.56	21.00	20.28	26.83	22.70
IR 68897A X JGL11110-1	77.17	94.17	90.50	87.28	17.33	13.78	20.83	17.31
IR 68897A X JGL17211	89.00	95.17	86.50	90.22	17.00	13.28	19.83	16.70
IR 68897A X JGL16284	89.86	88.17	76.00	84.68	21.00	19.28	25.83	22.04
IR 68897A X JGL13515	76.50	91.67	92.50	86.89	19.67	14.28	18.33	17.43
IR 68897A X JGL11160	86.50	80.17	95.00	87.22	19.67	19.78	28.33	22.59
IR 68897A X JGL11118	79.50	81.67	84.50	81.89	19.00	17.78	27.83	21.54
IR 68897A X JGL11111	72.07	71.17	87.00	76.75	17.33	14.28	17.83	16.48
IR 68897A X JGL8605	90.72	79.67	60.50	76.96	18.67	17.28	28.33	21.43
IR 68897A X JGL8292	89.50	80.17	81.50	83.72	21.67	19.28	27.83	22.93
IR 68897A X JGL3855	89.38	70.17	71.00	76.85	19.67	17.28	17.83	18.26
IR 68897A X JGL3844	81.00	69.67	90.00	80.22	18.67	17.28	23.83	19.93
IR 68897A X JGL1798	42.56	66.17	40.50	49.74	20.67	16.78	26.33	21.26
APMS 8A X JGL11110-2	84.00	85.67	92.00	87.22	15.67	14.28	22.33	17.43
APMS 8A X JGL11110-1	92.61	86.67	77.00	85.43	16.00	13.28	18.83	16.04
APMS 8A X JGL17211	92.53	63.17	80.00	78.56	15.67	14.78	25.83	18.76
APMS 8A X JGL16284	91.80	95.67	82.50	89.99	17.67	14.28	19.83	17.26
APMS 8A X JGL13515	90.52	88.67	92.50	90.56	17.33	16.78	25.83	19.98
APMS 8A X JGL11160	86.96	85.17	95.00	89.04	16.67	15.28	15.83	15.93
APMS 8A X JGL11118	90.59	75.17	80.00	81.92	15.33	15.78	23.33	18.15
APMS 8A X JGL11111	58.12	95.17	82.50	78.60	15.33	13.78	19.83	16.31
APMS 8A X JGL8605	92.22	88.67	88.50	89.80	15.33	14.28	19.33	16.31
APMS 8A X JGL8292	93.04	95.17	91.00	93.07	14.33	12.78	13.33	13.48
APMS 8A X JGL3855	75.63	84.17	73.50	77.76	15.00	13.78	19.83	16.20
APMS 8A X JGL3844	85.98	89.17	75.50	83.55	16.67	16.28	20.83	17.93
APMS 8A X JGL1798	70.00	59.67	48.50	59.39	16.33	14.28	16.83	15.81

Table 4.12 (cont.)

Cross	Spikelet fertility %				1000 grain weight (gm)			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
CMS 16A X JGL11110-2	85.50	75.67	82.50	81.22	16.67	14.28	22.33	17.76
CMS 16A X JGL11110-1	75.50	89.67	88.00	84.39	16.00	12.78	18.83	15.87
CMS 16A X JGL17211	87.50	61.67	86.50	78.56	18.67	16.28	25.83	20.26
CMS 16A X JGL16284	86.50	91.67	76.00	84.72	15.67	13.28	19.83	16.26
CMS 16A X JGL13515	74.50	88.17	85.00	82.56	15.67	15.78	18.83	16.76
CMS 16A X JGL11160	86.21	95.17	89.50	90.29	17.67	16.28	14.33	16.09
CMS 16A X JGL11118	83.99	76.17	82.50	80.89	16.67	15.78	13.83	15.43
CMS 16A X JGL11111	83.40	90.67	91.00	88.36	16.00	13.28	17.83	15.70
CMS 16A X JGL8605	92.52	94.17	94.50	93.73	16.33	13.78	19.83	16.65
CMS 16A X JGL8292	77.32	74.67	73.50	75.16	19.00	17.78	14.83	17.20
CMS 16A X JGL3855	80.22	96.17	91.00	89.13	17.33	13.28	24.83	18.48
CMS 16A X JGL3844	42.39	61.17	77.50	60.35	17.00	18.78	21.83	19.20
CMS 16A X JGL1798	47.56	43.17	67.00	52.57	16.67	15.78	25.83	19.43
APMS 6A X JGL11110-2	84.00	92.67	83.00	86.56	17.00	14.28	15.83	15.70
APMS 6A X JGL11110-1	89.50	76.17	90.00	85.22	20.67	15.28	16.83	17.59
APMS 6A X JGL17211	82.98	85.67	86.50	85.05	19.00	18.78	25.83	21.20
APMS 6A X JGL16284	81.50	83.17	88.50	84.39	16.33	14.28	19.83	16.81
APMS 6A X JGL13515	90.04	94.67	88.00	90.90	17.00	17.28	17.83	17.37
APMS 6A X JGL11160	90.00	91.17	89.50	90.22	17.67	16.78	14.33	16.26
APMS 6A X JGL11118	80.00	67.17	82.50	76.56	18.67	16.78	13.83	16.43
APMS 6A X JGL11111	89.42	90.95	80.50	86.96	17.00	17.28	18.83	17.70
APMS 6A X JGL8605	81.33	44.20	65.50	63.68	15.67	15.28	13.33	14.76
APMS 6A X JGL8292	82.54	69.17	73.50	75.07	18.00	15.78	17.83	17.20
APMS 6A X JGL3855	82.80	75.54	91.00	83.11	18.33	17.78	19.83	18.65
APMS 6A X JGL3844	88.87	87.17	77.50	84.51	18.00	19.78	16.83	18.20
APMS 6A X JGL1798	41.57	95.17	67.00	67.91	17.67	16.78	13.83	16.09
IR 58025A X JGL11110-2	87.50	75.17	83.00	81.89	19.00	16.78	17.83	17.87
IR 58025A X JGL11110-1	77.17	89.67	90.00	85.61	17.67	15.28	13.83	15.59
IR 58025A X JGL17211	48.74	94.80	86.50	76.68	17.33	15.78	16.33	16.48
IR 58025A X JGL16284	90.85	95.67	88.50	91.67	17.00	14.78	17.83	16.54
IR 58025A X JGL13515	83.41	85.17	88.00	85.53	18.33	16.28	14.83	16.48
IR 58025A X JGL11160	92.41	93.17	89.50	91.69	16.67	13.78	15.83	15.43
IR 58025A X JGL11118	82.01	94.67	82.50	86.39	17.00	15.78	17.83	16.87
IR 58025A X JGL11111	83.69	79.67	80.50	81.28	18.67	16.78	18.83	18.09
IR 58025A X JGL8605	82.03	79.17	65.50	75.56	18.00	17.78	18.83	18.20
IR 58025A X JGL8292	92.63	92.67	84.50	89.93	16.33	15.28	17.83	16.48
IR 58025A X JGL3855	84.86	91.67	92.50	89.67	15.33	14.28	17.33	15.65
IR 58025A X JGL3844	45.50	91.17	91.00	75.89	18.00	18.28	17.83	18.04
IR 58025A X JGL1798	37.50	92.67	77.50	69.22	17.67	14.28	18.33	16.76
Crosses mean	80.18	82.95	81.99	81.71	17.48	15.82	19.67	17.66
Grand mean	81.92	82.04	81.72	81.22	17.62	15.44	18.99	17.21
KRH - 2	94.43	87.71	94.50	92.21	24.33	22.28	24.83	23.81
DRRH - 2	91.27	90.36	93.00	91.54	26.67	23.28	26.83	25.59
PA 6201	93.75	82.83	92.50	89.69	23.67	24.78	22.83	23.76
JAYA	96.50	90.60	92.50	93.20	27.67	25.78	28.33	27.26
IR - 64	99.00	91.91	92.00	94.30	25.00	29.28	22.83	25.70
Mean	82.67	84.57	84.06	83.77	18.06	16.35	19.74	18.05
S.E.	1.56	1.04	1.35	2.78	1.09	0.37	0.59	0.76
C.V.	3.26	2.12	2.78	9.96	10.49	3.96	5.20	12.63
C.D. 5%	4.34	2.89	3.76	7.72	3.05	1.04	1.65	2.11

while in lines the fertility percentage ranged from 85.67 (JGL 3844) to 96.67 (JGL 11118). In hybrids the fertility percentage ranged from 43.17 (CMS 16A x JGL 1798) to 96.17 (CMS 16A x JGL 3855). The check IR 64 recorded the highest spikelet fertility percentage (91.91).

The spikelet fertility percentage ranged from 40.50 to 96.00, with a mean of 81.72 at Kampasagar. In testers the fertility percentage ranged from 88.50 (APMS 6A) to 96.00 (IR 58025A), while in lines the spikelet fertility ranged between 67.00 (JGL 11110-2) to 92.50 (JGL 13515, JGL 11118 and JGL 3844). In hybrids it varied from 40.50 (IR 68897A x JGL 1798) to 95.00 (APMS 8A x JGL 11160). The check KRH-2 recorded the highest spikelet fertility percentage (94.50).

The range of spikelet fertility percentage varied from 49.74 to 94.30, with a mean of 83.77 in pooled data of three locations. In testers the fertility percentage varied from 82.48 (APMS 6A) to 92.28 (APMS 8A), while in lines it varied from 80.16 (JGL 11110-2) to 93.67 (JGL 1798) (Table 4.12). In hybrids the fertility percentage was from 49.74 (IR 68897A x JGL 1798) to 93.73 (CMS 16A x JGL 8605).The check IR 64 recorded highest fertility percentage (94.30).

4.2.2.12 1000 grain weight (gm): At Kunaram the 1000 grain weight ranged from 14.33 to 27.67, with a mean of 18.60(Table 4.12). In testers it ranged from 16.00 (APMS 8A) to 21.67 (IR 68897A), while in lines it ranged from 16.33 (JGL 17211) to 21.3 (JGL 1798). In hybrids the 1000 grain weight ranged from 14.33 (APMS 8A x JGL 8292) to 21.67 (IR68897A x JGL 8292). The check Jaya recorded the highest 1000 grain weight (27.67).

The 1000 grain weight ranged from 12.78 to 29.28, with a mean of 16.35 at Warangal (Table 4.12). In testers the 1000 grain weight ranged from 14.28 (IR 58025A) to 19.78 (APMS 6A), while in lines it ranged from 13.78 (JGL 8292) to 19.28 (JGL 3855). In hybrids the 1000 grain weight ranged from 12.78 (CMS 16A x JGL 11110-1) to 20.28 (IR 68897A x JGL 11110-2). The check IR-64 recorded the highest 1000 grain weight (29.28).

At Kampasagar, the 1000 grain weight ranged from 13.33 to 28.33, with a mean of 19.74. In testers it ranged between 14.83 (APMS 8A) to 22.33 (IR 68897A), while in lines the range was 16.83 (JGL 13515) to 24.33 (JGL 1798). In hybrids the 1000 grain weight ranged from 13.33 (APMS 6A x JGL 8605) to 28.33 (IR68897A x JGL 11160. The check Jaya recorded highest 1000 grain weight (28.33).

In pooled data of three locations 1000 grain weight ranged from 13.48 to 27.26 with a mean of 18.05. In testers it was between 15.70 (APMS 8A) to 20.76 (IR

68897A), while in lines it ranged between 15.93 (JGL 13595) to 19.98 (JGL 1798). In hybrids 1000 grain weight varied between 13.48 (APMS 8A x JGL 8292) to 22.70 (IR 68897A x JGL 11110-2). The check Jaya recorded highest 1000 grain weight (27.26.

4.2.2.13 Yield/plant (gm): At Kunaram the yield/plant ranged from 18.36 to 33.24, with a mean yield of 24.33 (Table 4.13). In testers the yield varied between 18.57(CMS 16A) to 20.21 (APMS 8A), while in lines the yield/plant ranged between 22.36 (JGL 11160) to 27.73 (JGL 11110-2. Among the hybrids APMS 8A x JGL1110-2 recorded significantly higher yield than other hybrids followed by APMS 8A x JGL 11110-1 (31.98), APMS 6Ax JGL 11111 (31.0) and APMS 6A x JGL 11110-1 (30.83). Among the check PA 6201 recorded highest yield per plant (29.91).

The yield/plant ranged from 9.48 to 31.34, with a mean yield of 22.22 at Warangal. In testers it was between 16.67 (CMS 16A) to 18.31 (APMS 8A), while in lines the yield/plant ranged from 20.46 (JGL 11160) to 25.83 (JGL 11110-2). In hybrids highest yield was recorded by APMS 8A x JGL 11110-2 (31.34) and the hybrid APMS 8A x JGL11110-1 (30.08) was on par with highest yielding hybrid.Among the check PA 6201 recorded highest yield/plant (28.01).

At Kampasagar the yield/plant varied from 14.17 to 29.08, with a mean yield of 20.18.In testers the range was between 14.41(CMS 16A) to 16.06 (APMS 8A). In hybrids the yield/plant ranged between 14.17 (APMS 8A x JGL 1798) to 29.08 (APMS 8A x JGL 11110-2). Among the check PA 6201 recorded highest yield/plant (25.75).

In pooled data of three locations, the yield per plant ranged from 15.55 to 31.22, with a mean yield of 22.25(Table 4.13). In testers it ranged from 16.55 (CMS 16A) to 18.19 (APMS 8A). In lines it ranged from 20.39 (JGL 8605) to 23.96 (JGL 11111). Among hybrids highest yield per plant was recorded by APMS 8A x JGL 11110-2 (31.22) and it was significantly superior to other hybrids followed by APMS 8A x JGL 11110-1 (29.95), APMS 6A x JGL 11110-1, APMS 6A x JGL 16284, APMS 6Ax JGL 11111 and APMS 6A x JGL 8605. The check PA 6201 recorded highest yield per plant (27.89).

4.2.2.14 Productivity/day (kg/ha): At Kunaram the productivity per day ranged from 44.55 to 81.85, with a mean of 61.93. In testers it ranged from 44.74 (APMS 8A) to 52.28 (IR 68897A), while in lines it ranged from 54.26 (JGL 8605) to 69.14 (JGL 11110-2). In hybrids, the productivity per day ranged from 44.55 (APMS 8A x JGL 1798) to 81.85 (APMS 8A x JGL 11110-2). Among the check PA 6201 recorded the highest yield per day (77.71).

Table 4.13. Mean performance of parents and hybrids for yield/plant (gm)and productivity/day (kg/ha) over three locations and pooled

Parent/Cross	Yield/plant (gm)				Productivity/day (kg/ha)			
TESTERS	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
IR 58025A	19.18	17.28	15.01	17.16	46.42	86.84	47.86	60.37
IR 68897A	19.59	17.69	15.40	17.56	52.28	85.67	55.20	64.38
APMS 6A	19.70	17.80	15.51	17.67	47.21	86.27	48.47	60.65
APMS 8A	20.21	18.31	16.06	18.19	48.32	87.62	50.29	62.07
CMS 16A	18.57	16.67	14.41	16.55	44.74	83.24	45.41	57.80
Mean	19.45	17.55	15.28	17.43	47.79	85.93	49.45	61.06
LINES								
JGL 11110-2	27.73	25.83	23.53	25.69	69.14	112.46	77.01	86.20
JGL 11110-1	24.32	22.42	20.13	22.29	61.27	100.57	67.24	76.36
JGL 17211	26.47	24.57	22.27	24.44	65.83	108.45	72.19	82.16
JGL 16284	25.53	23.63	21.35	23.50	62.55	107.71	67.95	79.40
JGL 13515	23.44	21.54	19.23	21.40	56.72	95.90	60.73	71.12
JGL 11160	22.36	20.46	18.17	20.33	56.32	94.09	59.99	70.13
JGL 11118	22.95	21.05	18.78	20.93	62.60	103.24	67.84	77.89
JGL 11111	25.99	24.09	21.81	23.96	64.15	117.49	70.51	84.05
JGL 8605	22.42	20.52	18.24	20.39	54.26	95.19	57.99	69.15
JGL 8292	23.09	21.19	18.88	21.05	57.86	97.66	61.82	72.45
JGL 3855	25.97	24.07	21.78	23.94	63.00	105.40	70.05	79.48
JGL 3844	25.32	23.42	21.14	23.29	65.43	104.39	68.30	79.38
JGL 1798	24.11	22.21	19.92	22.08	62.31	104.16	68.38	78.28
Mean	24.59	22.69	20.40	22.56	61.65	103.59	66.92	77.39
Parental Mean	24.24	21.26	18.98	21.13	60.45	98.69	62.07	72.85
IR 68897A X JGL11110-2	23.90	22.00	19.71	21.87	62.09	99.92	63.63	75.21
IR 68897A X JGL11110-1	23.06	21.16	18.89	21.03	62.55	116.92	71.84	83.77
IR 68897A X JGL17211	21.77	19.87	17.57	19.74	53.22	109.24	62.27	74.91
IR 68897A X JGL16284	25.87	23.97	21.67	23.83	67.56	106.55	73.51	82.54
IR 68897A X JGL13515	25.07	23.17	20.87	23.04	64.80	122.40	76.88	88.03
IR 68897A X JGL11160	24.57	22.67	20.37	22.54	70.10	113.76	75.36	86.40
IR 68897A X JGL11118	18.81	16.91	14.63	16.78	53.98	97.88	57.39	69.75
IR 68897A X JGL11111	24.93	23.03	20.74	22.90	64.77	108.11	69.19	80.69
IR 68897A X JGL8605	24.41	22.51	20.21	22.38	68.64	110.88	74.47	84.67
IR 68897A X JGL8292	27.16	25.26	22.97	25.13	72.48	115.66	77.01	88.38
IR 68897A X JGL3855	21.49	19.59	17.29	19.45	58.92	101.19	62.60	74.23
IR 68897A X JGL3844	23.68	21.78	19.48	21.64	65.48	107.87	65.96	79.77
IR 68897A X JGL1798	22.44	20.54	18.25	20.41	59.84	101.81	64.00	75.22
APMS 8A X JGL11110-2	33.24	31.34	29.08	31.22	81.85	127.25	90.36	99.82
APMS 8A X JGL11110-1	31.98	30.08	27.79	29.95	78.96	125.62	87.51	97.36
APMS 8A X JGL17211	24.87	22.97	20.68	22.84	62.18	101.26	65.51	76.31
APMS 8A X JGL16284	24.37	22.47	20.17	22.33	61.38	111.28	74.08	82.25
APMS 8A X JGL13515	28.68	26.78	24.49	26.65	70.45	113.55	75.76	86.59
APMS 8A X JGL11160	22.42	20.52	18.21	20.38	54.93	93.06	56.74	68.24
APMS 8A X JGL11118	20.32	18.42	16.12	18.29	49.67	88.29	50.50	62.82
APMS 8A X JGL11111	27.21	25.31	23.02	25.18	67.85	130.19	72.02	90.02
APMS 8A X JGL8605	29.75	27.85	25.54	27.71	74.17	123.92	84.36	94.15
APMS 8A X JGL8292	23.71	21.81	19.51	21.67	58.98	117.97	69.43	82.13
APMS 8A X JGL3855	26.26	24.36	22.07	24.23	66.66	127.59	78.47	90.91
APMS 8A X JGL3844	22.32	20.42	18.11	20.28	56.08	101.79	59.39	72.42
APMS 8A X JGL1798	18.36	16.46	14.17	16.33	44.55	82.00	43.23	56.59

Table 4.13 (cont.)

Cross	Yield/plant (gm)				Productivity/day (kg/ha)			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
CMS 16A X JGL11110-2	21.49	19.59	17.30	19.46	53.04	91.12	54.11	66.09
CMS 16A X JGL11110-1	22.50	19.63	18.30	20.14	54.59	109.66	68.19	77.48
CMS 16A X JGL17211	19.01	9.48	18.17	15.55	47.55	59.69	57.57	54.94
CMS 16A X JGL16284	24.07	21.20	19.88	21.72	59.41	96.41	62.25	72.69
CMS 16A X JGL13515	25.60	22.73	21.42	23.25	62.42	122.34	77.15	87.30
CMS 16A X JGL11160	22.88	20.01	18.68	20.52	57.49	94.23	59.40	70.37
CMS 16A X JGL11118	25.30	22.43	21.10	22.95	62.16	104.54	67.18	77.96
CMS 16A X JGL11111	21.25	17.65	17.04	18.65	53.10	100.79	62.99	72.29
CMS 16A X JGL8605	18.89	17.85	14.68	17.14	46.64	102.43	47.74	65.60
CMS 16A X JGL8292	21.46	21.18	17.29	19.98	54.18	97.65	54.11	68.64
CMS 16A X JGL3855	26.32	23.96	22.11	24.13	73.59	128.51	85.62	95.91
CMS 16A X JGL3844	24.96	21.91	20.77	22.55	64.51	100.91	69.37	78.27
CMS 16A X JGL1798	21.53	22.29	17.32	20.38	53.66	98.28	55.96	69.30
APMS 6A X JGL11110-2	29.53	28.06	25.32	27.64	77.53	120.51	83.76	93.94
APMS 6A X JGL11110-1	30.83	27.44	26.63	28.30	78.52	118.07	84.41	93.67
APMS 6A X JGL17211	26.35	25.90	22.17	24.81	66.73	114.79	70.41	83.97
APMS 6A X JGL16284	30.71	27.20	26.52	28.14	76.48	116.86	84.88	92.74
APMS 6A X JGL13515	25.90	23.83	21.69	23.81	65.91	110.84	74.46	83.73
APMS 6A X JGL11160	25.40	23.45	21.21	23.35	67.07	106.72	77.99	83.93
APMS 6A X JGL11118	29.03	26.16	24.84	26.68	74.28	115.22	84.57	91.36
APMS 6A X JGL11111	31.00	28.13	26.81	28.65	77.29	139.43	87.40	101.37
APMS 6A X JGL8605	30.79	27.92	26.59	28.43	76.98	121.39	87.04	95.14
APMS 6A X JGL8292	28.68	25.81	24.47	26.32	72.06	120.77	81.89	91.57
APMS 6A X JGL3855	23.46	20.59	19.26	21.10	58.77	96.09	64.18	73.01
APMS 6A X JGL3844	21.66	18.79	17.48	19.31	53.88	95.07	56.85	68.60
APMS 6A X JGL1798	22.03	19.16	17.84	19.68	54.65	90.89	58.45	68.00
IR 58025A X JGL11110-2	23.19	21.29	19.00	21.16	56.82	99.00	61.03	72.28
IR 58025A X JGL11110-1	22.74	20.84	18.54	20.71	55.86	98.23	59.52	71.20
IR 58025A X JGL17211	22.91	21.01	18.72	20.88	56.74	107.21	61.68	75.21
IR 58025A X JGL16284	27.85	25.95	23.69	25.83	69.44	114.07	78.33	87.28
IR 58025A X JGL13515	25.93	24.03	21.77	23.91	63.70	106.39	70.30	80.13
IR 58025A X JGL11160	25.45	23.55	21.29	23.43	73.89	124.96	75.96	91.60
IR 58025A X JGL11118	24.14	22.24	19.97	22.12	63.85	118.06	72.51	84.81
IR 58025A X JGL11111	25.29	23.39	21.09	23.25	62.90	120.96	68.80	84.22
IR 58025A X JGL8605	20.21	18.31	16.03	18.18	48.91	88.17	51.28	62.79
IR 58025A X JGL8292	21.99	20.09	17.80	19.96	53.22	108.57	55.88	72.56
IR 58025A X JGL3855	21.91	20.01	17.72	19.88	53.83	114.27	57.31	75.14
IR 58025A X JGL3844	19.19	17.29	14.99	17.16	48.66	100.14	52.13	66.98
IR 58025A X JGL1798	20.42	18.52	16.23	18.39	52.55	105.62	57.09	71.75
Crosses mean	24.50	22.31	20.36	22.39	62.38	108.23	68.33	79.65
Grand mean	24.21	21.50	19.53	21.54	61.39	103.59	65.23	76.21
KRH - 2	27.37	25.47	23.21	25.35	77.41	110.93	88.38	92.24
DRRH - 2	24.64	22.74	20.47	22.62	69.09	103.34	78.42	83.62
PA 6201	29.91	28.01	25.75	27.89	77.71	130.07	88.09	98.63
JAYA	25.97	24.07	21.79	23.94	65.43	105.05	72.54	81.00
IR - 64	24.16	22.26	19.97	22.13	64.46	102.83	71.68	79.66
Mean	24.33	22.22	20.18	22.25	61.93	106.40	67.70	78.68
S.E.	0.41	0.54	0.23	0.29	1.22	1.86	2.13	1.64
C.V.	2.89	4.19	1.94	3.85	3.42	3.02	5.46	6.26
C.D. 5%	1.13	1.50	0.63	0.79	3.41	5.18	5.95	4.55

Warangal. In testers it ranged from 83.24 (CMS 16A) to 87.62 (APMS 8A), while in lines it ranged between 94.09 (JGL 11160) to 117.49 (JGL 11111). In hybrids, the productivity/day ranged from 59.69 (CMS 16A x JGL 17201) to 139.43 (APMS 6A x JGL 11111). Among the check PA 6201 recorded the highest productivity/day (130.07).

At Kampasagar, the productivity/day ranged from 43.23 to 90.36, with a mean of 67.70. In testers it ranged between 45.41 (CMS 16A) to 55.20 (IR 68897A), while in lines it ranged from 57.99 (JGL 11160) to 77.01 (JGL 11110-2). In hybrids the productivity/day ranged from 43.23 (APMS 8A x JGL 1798) to 90.36 (APMS 8A x JGL 11110-2). Among the checks KRH-2 recorded the highest yield per day (88.38).

In pooled data of three locations the productivity/day ranged from 54.94 to 101.37, with a mean of 78.68(Table 4.13). In testers it ranged between 57.80 (CMS 16A) to 64.38 (IR 68897A), while in lines it ranged from 69.15 (JGL 8605) to 86.20 (JGL 11110-2). In hybrids the productivity/day ranged from 54.94 (CMS 16Ax JGL 17211) to 101.37 (APMS 6A x JGL 11111).Among the check PA 6201 recorded the highest yield/day (98.63).

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 tester APMS 8A showing gall midge resistance at all the three locations i.e Kunaram, Warangal and Kampasagar, where as the tester APMS 6A was susceptible at all the three locations. The line JGL 8292 showing gall midge resistance at all the three locations i.e Kunaram, Warangal and Kampasagar,where as the lines JGL 11110-2, JGL 11110-1 and JGL 8605 were showing resistance at Kunaram ,Kampasagar and susceptible at Warangal location.

The hybrids APMS 6A x JGL11111 and APMS 6A x JGL8292 showing gall midge resistance at all the three locations i.e Kunaram, Warangal and Kampasagar hence identified as good gall midge resistant hybrids,where as the hybrid APMS 8A x JGL 11110-2 and APMS 8A x JGL 11110-1 were showing resistance at Kunaram ,Kampasagar and susceptible at Warangal location and the hybrid APMS 6A x JGL 8605 was showing resistance at Kunaram only, among these APMS 8A x JGL 11110-2 was identified as good yielding hybrid though it was susceptible at Warangal

The yield and other important yield attributing characters for the testers APMS 8A and APMS 6A are good confirming the results obtained.The two testers are of medium duration with high productive tillers, long panicle length with good number of filled grains per panicle. Among the lines the yield and other important yield attributing characters for JGL 11110-2, JGL11110-1, JGL11111, JGL 8605 JGL 8292 are good confirming the results obtained. The lines JGL11110-1, JGL11110-2 and JGL8605 recorded high productive tillers, JGL11110-1 recorded longer panicle length, JGL 8292, JGL11111, JGL 11110-2 recorded high 1000 grain weight, JGL8605, JGL11110-1, recorded high filled Grains/ Panicle, JGL11111, JGL11110-2 recorded high yield and all the lines are of medium duration.

The 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 recorded good yield and other yield attributing characters confirming the results obtained.

The hybrids APMS 6A x JGL11110-1, APMS 6A x JGL8292, APMS 8A x JGL11110-1 recorded more number of productive tillers/ plant, similarly the hybrids APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL11110-1, APMS 8A x JGL11110-2 recorded more number of filled grains/ Panicle and the hybrids APMS 8A x JGL11110-2, APMS 8A x 11110-1, APMS 6A x JGL11111,APMS 6A x JGL 8605, APMS 6A x JGL11110-1 recoded high yield/ Plant.

Figure 4.1. Top ten hybrids for grain yield per plant in the present investigation

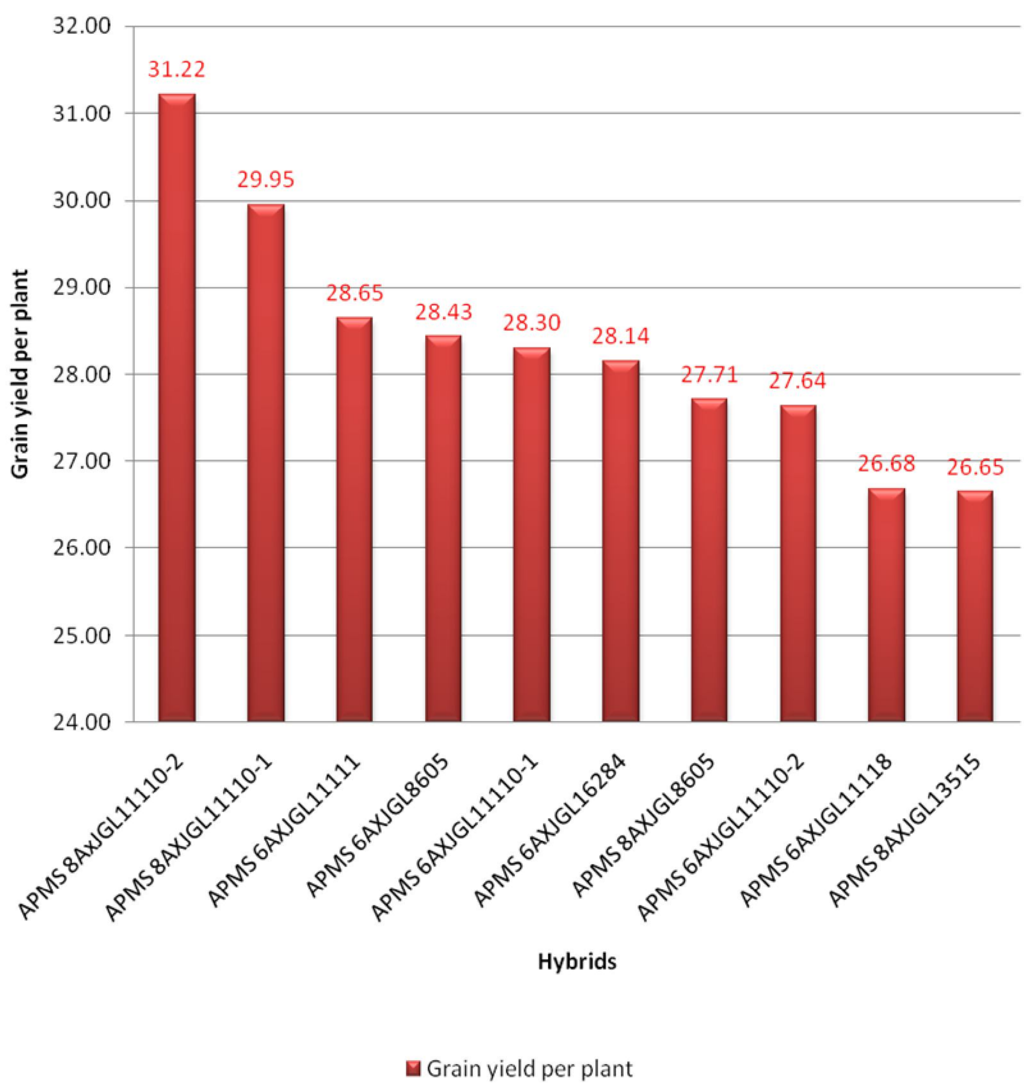
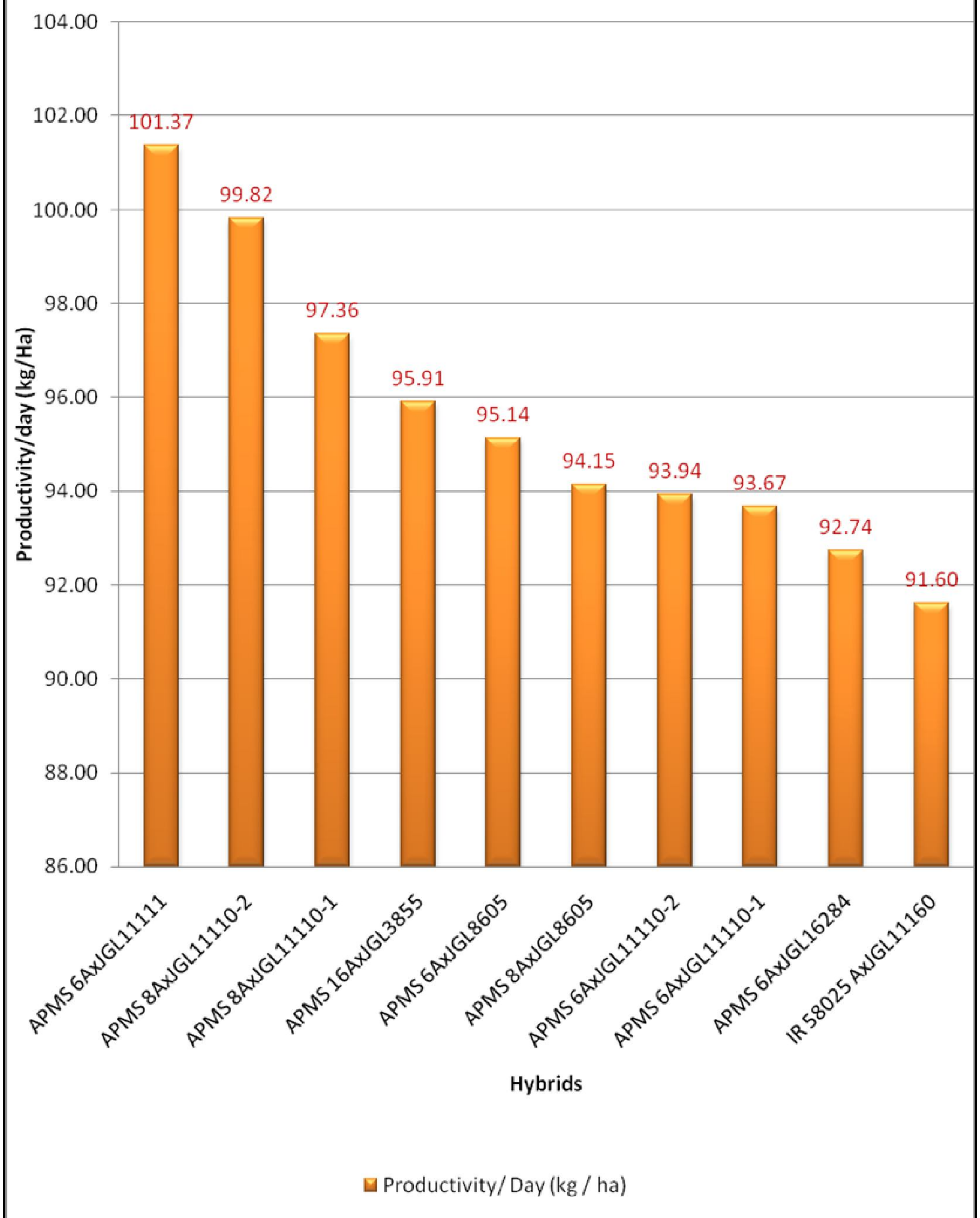


Figure 4.2.Top ten hybrids recorded high productivity/ day (kg / ha) in the present investigation

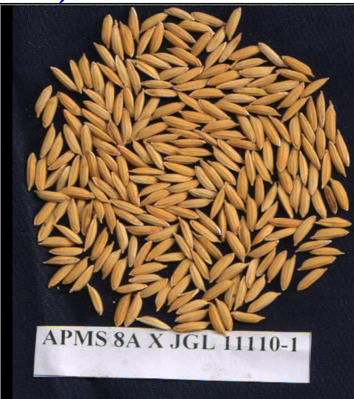


Hybrid	**Hybrid**	**Hybrid**
APMS 6A X JGL 8605	***APMS 8A X*** **JGL11110-1**	**APMS 6A X JGL 11110-1**
		

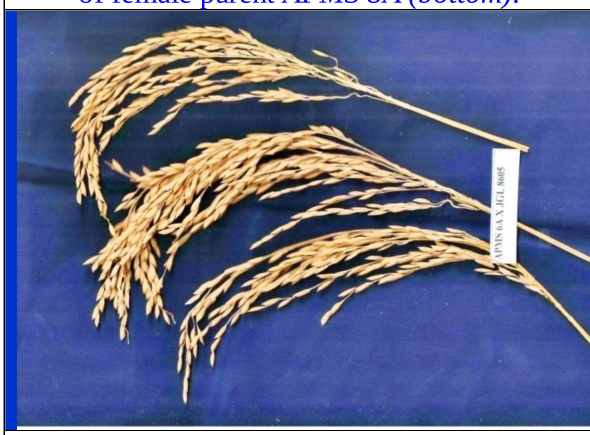
Plate 4.1. Better experimental hybrids identified in the present investigation based on per se performance

Plate 4.2. Better experimental hybrids identified in the present investigation based on per se performance (Panicles & Grains)

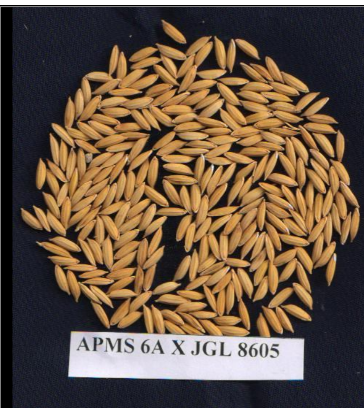
Panicle of experimental hybrid *APMS 8*A X JGL11110-1 (middle), male parent JGL11110-1 (top) and corresponding B line of female parent *APMS 8A (bottom)*.



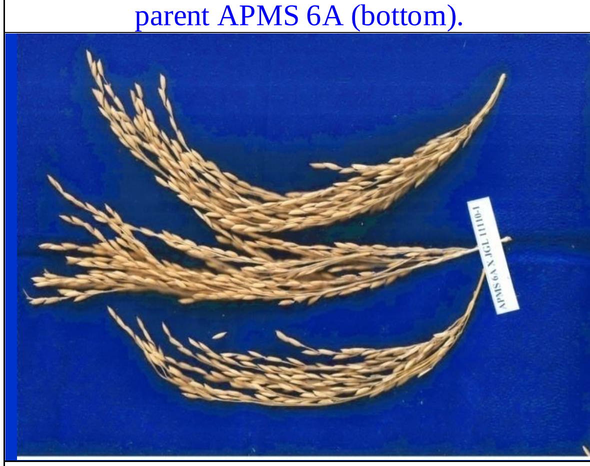
Grains of the promising experimental hybrid
APMS 8A X JGL11110-1



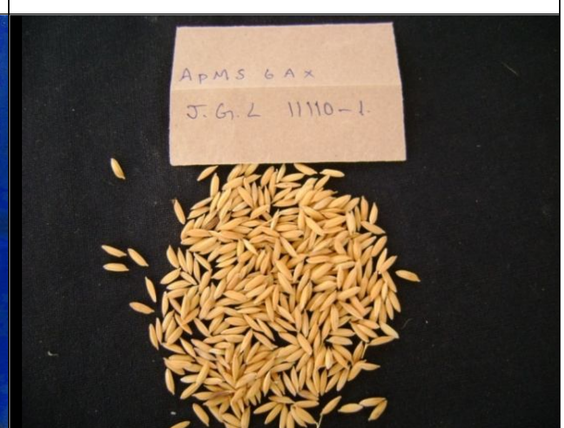
Panicle of experimental hybrid APMS 6A X JGL8605 (middle), male parent JGL 8605 (top) and corresponding B line of female parent APMS 6A (bottom).



Grains of the promising experimental hybrid
APMS 6A X JGL 8605



Panicle of experimental hybrid APMS 6A X JGL11110-1 (middle), male parent JGL 11110-1 (top) and corresponding B line of female parent APMS 6A (bottom).



Grains of the promising experimental hybrid
APMS 6A X JGL 11110-1

4.2.3. Analysis of variance for yield and yield attributing characters

The data on yield and yield attributes *viz.*, days to 50 per cent flowering, plant height, productive tillers/plant, flag leaf length, flag leaf width, panicle length, panicle weight, filled grains per panicle, spikelet fertility% and 1000 grain weight, grain yield per plant and productivity/day were collected and analyzed.

The Line x Tester analysis was utilized to derive the analysis of variance for combining ability. The analysis was carried out for three locations *viz.,* Kunaram, Warangal and Kampasagar during *Kharif 2009-10* and also pooled over the locations.

The pooled analysis of variance for combining ability during *Kharif 2009-10* (Table 4.15) revealed significant differences for locations and replications for all the characters. Significant differences were also recorded for replications/locations for all the characters except for filled grains/ panicle and flag leaf width. The differences among the parents and hybrids were observed to be significant for all the characters studied. Comparison of parent's *vs.* hybrids found to be significant for all the characteristics except for 1000 grain weight. Partitioning of hybrids into females, males and females x males revealed that differences among the females and males and interaction of females and males were significant for all the characters except for flag leaf width. Interaction effects of (Parents *Vs*. hybrid) x locations were significant for all the traits except for flag leaf length and yield per plant. Significant variance for parents x locations interaction and hybrid x locations were observed for all the characters studied except for yield/ plant and productivity/ day (kg / ha).

Further partitioning of hybrids x locations indicated that the interaction of females x locations and interaction effects of males x locations showed significant differences for all the characters except for yield/ plant and productivity/ day (kg / ha). Females x males and locations were significant for all the traits except 50 per cent flowering and yield/ plant. Suggesting the sensitivity of *gca* effects of parents to environmental fluctuations in the above said traits. The *sca* variances are more sensitive to environmental fluctuations as evident by interaction effects of lines x testers x locations were significant for all the characters studied. These results emphasized the importance of combining ability studies which indicates the existence of wide variability in the material studies and there is a good scope for identifying promising parents and hybrids combinations and improving the yield through its components.

Table 4.15. Pooled analysis of variance for combining ability (L X T) for yield and yield components in rice rice

Source	d.f	Days to 50% Flowering	Plant Height cm	Productive Tillers/ Plant	Panicle Length cm	Panicle Weight gm	Flag Leaf Length cm
Replicates	2.00	646.33**	361.00**	164.73**	73.84**	1.99**	201.73**
Environments	2.00	1024.38**	3948.31**	4189.20**	688.87**	54.96**	160.70**
Rep * Env.	4.00	187.24**	401.92**	28.72**	13.39**	0.51**	95.54**
Treatments	82.00	289.65**	593.51**	75.86**	21.23**	2.76**	104.08**
Parents	17.00	116.73**	356.36**	40.41**	35.96**	2.58**	93.34**
Parents (Line)	12.00	111.91**	206.26**	25.10**	26.49**	2.73**	102.17**
Parents(Testers)	4.00	128.66**	599.34**	87.81**	30.30**	1.89**	42.64**
Parents (L vs T)	1.00	126.91**	1185.72**	34.42**	172.28**	3.57**	190.25**
Parent vs Crosses	1.00	2202.94**	8203.26**	917.01**	31.39**	2.83**	480.70**
Crosses	64.00	305.69**	537.60**	72.13**	17.16**	2.81**	101.05**
Line effect	12.00	527.76*	1417.83**	125.16*	16.99	3.24	142.18
Tester effect	4.00	129.35	58.66	57.64	6.50	1.89	96.89
Line * Tester effect	48.00	264.87**	357.46**	60.08**	18.09**	2.78**	91.11**
Env * Treat	164.00	75.48**	434.57**	38.77**	9.60**	2.09**	44.00**
Env * Parents	34.00	27.39**	243.68**	20.42**	11.83**	2.25**	39.36**
Env * Parents (L)	24.00	23.24**	236.83**	19.10**	10.33**	2.04**	40.34**
Env * Parents (T)	8.00	45.19**	297.24**	21.21**	13.90**	0.66**	26.87**
Env * PAR (L vs T)	2.00	6.08	111.71**	33.10**	21.48**	11.18**	77.53**
Env * Parent vs Cross	2.00	375.37**	7888.63**	139.62**	32.86**	18.64**	8.65
Env * Crosses	128.00	83.57**	368.81**	42.06**	8.65**	1.79**	45.79**
Env * Line effect	24.00	179.72**	1439.06**	49.11	6.76	1.95	88.31**
Env * Tester effect	8.00	42.53	125.87	39.67	14.07	0.48	34.26
Env * L * T effect	96.00	62.96**	121.49**	40.50**	8.67**	1.85**	36.12**
Error	492.00	8.82	9.84	2.14	1.04	0.03	6.55
Total	746.00	59.73	180.98	30.10	7.25	0.94	26.92
Replicates	2.00	489.10**	235.75**	120.44**	54.73**	1.40**	156.68**
Environments	2.00	1372.94**	7612.63**	3929.54**	670.26**	67.66**	120.50**
Rep * Env.	4.00	120.21**	259.59**	27.53**	10.71**	0.42**	51.58**
Crosses	64.00	305.69**	537.60**	72.13**	17.16**	2.81**	101.05**
Line effect	12.00	527.76*	1417.83**	125.16*	16.99	3.24	142.18
Tester effect	4.00	129.35	58.66	57.64	6.50	1.89	96.89
Line * Tester effect	48.00	264.87**	357.46**	60.08**	18.09**	2.78**	91.11**
Env * Crosses	128.00	83.57**	368.81**	42.06**	8.65**	1.79**	45.79**
Env * Line effect	24.00	179.72**	1439.06**	49.11	6.76	1.95	88.31**
Env * Tester effect	8.00	42.53	125.87	39.67	14.07	0.48	34.26
Env * L * T effect	96.00	62.96**	121.49**	40.50**	8.67**	1.85**	36.12**
Error	384.00	10.69	8.31	2.16	1.01	0.02	5.41
Total	584.00	66.05	173.87	32.61	7.00	0.95	25.97

* Significant at 5% level; ** significant at 1% level

Table 4.15 (cont.)

Source	d.f	Flag Leaf Width cm	Filled Grains/ Panicle	Spikelet Fertility %	1000 Grain Weight gm	Yield/ Plant gm	Productivity/ Day (kg / ha)
Replicates	2.00	0.78**	3502.04**	452.76**	234.88**	53.70**	1034.14**
Environments	2.00	3.51**	10129.27**	370.56**	803.09**	1071.81**	148204.80**
Rep * Env.	4.00	0.05	279.24	135.67**	27.15**	84.63**	1056.00**
Treatments	82.00	0.44**	18905.63**	699.67**	33.53**	101.13**	1018.54**
Parents	17.00	0.42**	28111.99**	130.24**	17.75**	69.68**	704.34**
Parents (Line)	12.00	0.40**	24262.99**	126.54**	13.01**	26.17**	257.76**
Parents(Testers)	4.00	0.55**	25731.30**	134.39**	32.52**	3.37**	52.53**
Parents (L vs T)	1.00	0.14*	83822.83**	158.11**	15.65**	857.08**	8670.42**
Parent vs Crosses	1.00	3.08**	120893.6**	6484.55**	4.50	199.58**	5857.33**
Crosses	64.00	0.41**	14866.63**	760.54**	38.17**	107.94**	1026.40**
Line effect	12.00	0.74*	16406.26	1109.16	84.06**	263.02**	2659.86**
Tester effect	4.00	0.23	16163.43	717.61	30.60	12.20	225.86
Line * Tester effect	48.00	0.34**	14373.65**	676.96**	27.33**	77.16**	684.75**
Env * Treat	164.00	0.15**	8200.01**	274.45**	15.42**	1.50**	66.48**
Env * Parents	34.00	0.13**	9200.63**	107.90**	9.00**	0.00	15.91*
Env * Parents (L)	24.00	0.08**	9647.55**	99.49**	7.47**	0.00	15.06
Env * Parents (T)	8.00	0.17**	6672.96**	96.28**	13.59**	0.00	9.96
Env * PAR (L vs T)	2.00	0.54**	13948.29**	255.27**	8.94**	0.00	49.91**
Env * Parent vs Cross	2.00	1.30**	22676.77**	31.61**	37.19**	1.38	268.84**
Env * Crosses	128.00	0.14**	7708.02**	322.49**	16.79**	1.90**	76.75**
Env * Line effect	24.00	0.26**	7368.21	460.94	39.22**	2.60	132.50**
Env * Tester effect	8.00	0.15	8056.90	252.58	7.90	1.07	45.29
Env * L * T effect	96.00	0.11**	7763.90**	293.70**	11.93**	1.79**	65.43**
Error	492.00	0.02	309.86	5.43	1.60	0.53	9.90
Total	746.00	0.11	4123.18	143.76	11.06	15.27	538.87
Replicates	2.00	0.62**	4314.79**	353.99**	170.83**	40.42**	822.42**
Environments	2.00	4.62**	22455.75**	385.42**	726.61**	836.37**	121195.29**
Rep * Env.	4.00	0.08**	455.91	106.61**	21.19**	61.66**	822.45**
Crosses	64.00	0.41**	14866.63**	760.54**	38.17**	107.94**	1026.40**
Line effect	12.00	0.74*	16406.26	1109.16	84.06**	263.02**	2659.86**
Tester effect	4.00	0.23	16163.43	717.61	30.60	12.20	225.86
Line * Tester effect	48.00	0.34**	14373.65**	676.96**	27.33**	77.16**	684.75**
Env * Crosses	128.00	0.14**	7708.02**	322.49**	16.79**	1.90**	76.75**
Env * Line effect	24.00	0.26**	7368.21	460.94	39.22**	2.60	132.50**
Env * Tester effect	8.00	0.15	8056.90	252.58	7.90	1.07	45.29
Env * L * T effect	96.00	0.11**	7763.90**	293.70**	11.93**	1.79**	65.43**
Error	384.00	0.02	287.73	5.68	1.19	0.66	12.30
Total	584.00	0.11	3602.64	161.02	11.87	16.10	560.89

* Significant at 5% level; ** significant at 1% level

The mean squares due to parents were significant for seed yield and all the component traits, this justifying their use in the present investigation. Similarly, hybrids also varied considerably between themselves. This suggests that the wide variability in genetic basis were present among the crosses. The interaction between lines and testers were significant for all the traits studied. This was illustrated when the proportional contribution of each character was studied. These results emphasized the importance of combining ability studies for indicating the variability in the material studied and there is a good scope for identifying promising parents and hybrids combinations and improving yield through its components.

4.2.4 Combining ability variances and gene action

The estimates of GCA and SCA variances and their ratios are presented in the table 4.15.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 (Table 4.16). Similar to the present findings, the role of non-additive gene action was documented by other researchers in rice for different traits such as days to 50 per cent flowering (Bhanumurthy *et al.,* 2003; Swain *et al.,* 2003; Bisne and Motiramani, 2005; Panwar, 2005, Venkatesan *et al*., 2007; Shukla and Pandey, 2008, Sharma and Mani, 2008 and Pradhan and Singh, 2008). Plant height (Bhanumathy *et al.,* 2003; Bisne and Motiramani, 2005; Panwar, 2005; Venkatesan *et al.,* 2007; Pradhan and Singh, 2008; Dalvi and Patel, 2009; Salgotra *et al.,* 2009), panicle length (Roy and Mandal, 2001; Banumathy *et al.,* 2003; Shanthi *et al.,* 2003; Bisne and Motiramani, 2005 and Sanjeev Kumar *et al.,* 2007; Shukla and Pandey, 2008; Pradhan and Singh, 2008; Dalvi and Patel, 2009 and Salgotra *et al.,* 2009), panicle weight (Prakash *et al,*. 2003 and Swain *et al.,* 2003), productive tillers per plant (Panwar *et al.* 2005 Sarma *et al.,* 2007; Shukla and Pandey, 2008; Pradhan and Singh, 2008 and Salgotra *et al.,* 2009), number of filled grains per panicle (Roy and Mandal, 2001; Banumathy *et al.,* 2003; Bisne and Motiramani, 2005; Shukla and Pandey, 2008; Pradhan and Singh, 2008; Dalvi and Patel, 2009 and Salgotra *et al.,* 2009), spikelet fertility percentage (Ghosh Kalaiyarasi *et al.,* 2002; Banumathy *et al.,* 2003 and

Bisne and Motiramani, 2005;Pradhan and Singh, 2008; Dalvi and Patel, 2009; Salgotra *et al.*, 2009), 1000-grain weight (Dhaliwal and Sharma, 1990; Ghosh, 1993; Ramalingam *et al.* 1997; Meenakshi and Devarathinam, 1999; Bhanumathy *et al.*, 2003; Panwar, 2005; Sarma *et al.*, 2007; Shukla and Pandey, 2008; Pradhan and Singh, 2008; Dalvi and Patel, 2009 and Salgotra *et al.*, 2009), single plant yield (Reddy, 2002 ; Banumathy *et al.*, 2003 ; Patil *et al.*, 2003 ; Swain *et al.*, 2003; Bisne and Motiramani, 2005, Panwar, 2005; Sarma *et al.*, 2007; Venkatesan *et al.*, 2007; Shukla and Pandey, 2008; Pradhan and Singh, 2008; Dalvi and Patel, 2009; Salgotra *et al.*, 2009). However, contrary to the present findings certain workers reported the importance of additive components in rice for days to 50 per cent flowering, (Shanthi *et al.*, 2003; Sanjeev Kumar *et al.*, 2007; Dalvi and Patel, 2009; Salgotra *et al.*, 2009), plant height (Shanthi *et al.*, 2003; Sanjeevkumar *et al.*, 2007; Sharma *et al.*, 2007; Sharma and Mani, 2008), panicle length (Swain *et al.*, 2003; Sarma *et al.*, 2007; Sharma and Mani, 2008), number of productive tillers per plant (Dalvi and Patel, 2009), number of filled grains per panicle (Swain *et al.* 2003 and Anand kumar *et al.*, 2006), spikelet fertility percentage (Shanti *et al.* 2003), 1000-grain weight (Ram *et al.*, 1998; Reddy *et al.*, 2002; Swain *et al.*, 2003 and Sanjeev Kumar *et al.*, 2007), single plant yield (Vijayakumar *et al.*, 1994; Ganesan and Rangaswamy, 1998; Meenakshi and Devarathinam, 1999; Shanti *et al.*, 2003). Additive gene action was reported by above said workers for panicle length and 1000-grain.

Yet, interestingly the role of both additive and non-additive gene action was documented by other workers in rice for plant height (Reddy, 2002), 1000-grain weight (Patil *et al.*, 2003) and single plant yield (Roy and Mandal, 2001; Sanjeev Kumar *et al.*, 2007). The discrepancy among the results reported may be due to the differences in the material used for the study.

4.2.5 Degree of dominance

The degree of dominance was estimated for all the twelve characters and presented in the table 4.16. In the present investigation, it was observed 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 (%)(Table 4.17). The contribution of line x tester interaction was high for all the characters ranging between 49.87 (%) (plant height) to 89.61(%) gallmidge silver shoots (%).

Table 4.16. Estimates of general and specific combining ability variances and proportionate gene action in rice for twelve characters in rice

Character	Location	Source of variation			Degree of dominance
		σ^2gca	σ^2sca	σ^2gca/ σ^2sca	$\sqrt{\sigma^2}$sca/ $\sigma^2$2gca
Days to 50% Flowering	Kunaram	5.25	17.46	0.30	1.29
	Warangal	11.21	79.10	0.14	1.88
	Kampasagar	2.96	24.87	0.12	2.05
	Pooled	3.92	28.24	0.14	1.90
Plant Height cm	Kunaram	4.20	95.26	0.04	3.37
	Warangal	77.11	53.31	1.45	0.59
	Kampasagar	2.90	41.72	0.07	2.68
	Pooled	9.01	38.79	0.23	1.47
Productive Tillers/ Plant	Kunaram	0.39	1.55	0.25	1.42
	Warangal	2.80	25.59	0.11	2.14
	Kampasagar	3.25	17.74	0.18	1.65
	Pooled	1.10	6.43	0.17	1.71
Panicle Length cm	Kunaram	0.34	4.67	0.07	2.61
	Warangal	0.53	2.83	0.19	1.63
	Kampasagar	0.21	3.27	0.07	2.76
	Pooled	0.13	1.90	0.07	2.67
Panicle Weight gm	Kunaram	0.06	1.03	0.06	2.90
	Warangal	0.03	0.28	0.12	2.08
	Kampasagar	0.09	0.83	0.11	2.16
	Pooled	0.03	0.31	0.97	2.21
Flag Leaf Length cm	Kunaram	2.20	15.54	0.14	1.88
	Warangal	5.10	20.20	0.25	1.41
	Kampasagar	0.94	12.16	0.08	2.54
	Pooled	1.41	9.52	0.15	1.84
Flag Leaf Width cm	Kunaram	0.01	0.06	0.24	1.45
	Warangal	0.01	0.04	0.16	1.75
	Kampasagar	0.01	0.06	0.16	1.79
	Pooled	0.01	0.04	0.25	1.76
Filled Grains/ Panicle	Kunaram	313.16	2673.55	0.12	2.07
	Warangal	438.95	3300.34	0.13	1.94
	Kampasagar	387.90	3683.41	0.11	2.18
	Pooled	197.50	1565.10	0.13	1.99
Spikelet Fertility %	Kunaram	18.38	194.08	0.09	2.30
	Warangal	30.35	107.70	0.28	1.33
	Kampasagar	10.92	114.24	0.10	2.29
	Pooled	11.21	74.59	0.15	1.82
1000 Grain Weight gm	Kunaram	0.34	0.55	0.61	0.91
	Warangal	0.56	3.03	0.19	1.64
	Kampasagar	2.79	11.88	0.23	1.46
	Pooled	0.69	2.90	0.24	1.45
Yield/ Plant gm	Kunaram	1.66	8.63	0.19	1.61
	Warangal	1.94	9.07	0.21	1.53
	Kampasagar	1.56	8.68	0.18	1.67
	Pooled	1.69	8.50	0.20	1.59
Productivity/ Day (kg / ha)	Kunaram	13.54	50.61	0.27	1.37
	Warangal	26.58	127.59	0.21	1.55
	Kampasagar	18.80	83.77	0.22	1.49
	Pooled	17.66	74.72	0.24	1.45

Table 4.17. Proportional contribution of lines, testers and their interactions to total variance

S. No.	Character	Contribution		
		Line %	Tester %	Line x Tester %
1	Days to 50% flowering	32.37	2.64	64.98
2	Plant height	49.45	0.68	49.87
3	Flag leaf width	26.38	5.99	67.62
4	Flag leaf length	33.85	3.58	62.57
5	Number of productive tillers/plant	32.53	4.99	62.47
6	Panicle length	18.56	2.37	79.07
7	Panicle weight	21.63	4.2	74.17
8	Number of filled grains per panicle	20.69	6.79	72.51
9	Spikelet fertility %	27.34	5.9	66.76
10	1000-grain weight	41.29	5.01	53.7
11	Single plant yield	45.69	0.71	53.61
12	Productivity/day	48.59	1.38	50.04
13	GM Damaged plants% at KRM	9.42	11.43	79.15
14	GM Silver shoots% at KRM	9.42	11.43	79.15
15	GM Damaged plants% at WGL	2.16	9.65	88.19
16	GM Silver shoots% at WGL	2.34	8.04	89.61
17	GM Damaged plants% at KSR	21.96	7.06	70.99
18	GM Silver shoots% at KSR	18.92	8.1	72.97

4.2.6 General and specific combining ability effects

The estimates of general combining ability and specific combining ability for different characters at three locations and pooled analysis are presented character wise below.

4.2.6.1 Gallmidge infested plants (%):(a) gca effects Among the testers, all the testers shown zero reaction to gallmidge at Kunaram, nonsignificant gca effect at Warangal, while 2 testers viz., IR 68897A and APMS 6A at Kampasagar were recorded significant negetive gca effects. Among the lines two at Warangal (JGL 17211 and JGL 8292) and seven lines (JGL 11110-1, JGL 17211, JGL16284, JGL11118, JGL 8605, JGL 8292 and JGL 1798) at Kampasagar recorded significant negative gca effects.

(b) sca effects: Among 65 hybrids, 8 hybrids at Warangal, 29 hybrids at Kampasagar, recorded significant negative sca effects while zero reaction was noticed at Kunaram.

4.2.6.2 Silver shoots (%):(a) gca effects Among the testers, all the testers were shown zero reaction to silver shoots % at Kunaram, one tester APMS 6A shown significant negative gca effects at Warangal, while 2 testers recorded significant negative gca effects (IR 68897A, APMS 6A) at Kampasagar (Table 4.18). Among the lines one at

Table 4.18 Estimates of general and specific combining ability effects for Gall midge damaged Plant (%) (ASIN) and Silver Shoots (%) (ASIN) at Kunaram, Warangal and Kampasagar

Parent/Cross			Gall midge damaged Plant %(ASIN)			Silver Shoots % (ASIN)		
TESTERS			KNM	WGL	KSR	KNM	WGL	KSR
IR 58025A			0	0.58	0.60**	0	0.01	0.17*
IR 68897A			0	1.33	-5.55**	0	0.35	-1.25**
APMS 6A			0	-1.92	-5.55**	0	-0.62*	-1.25**
APMS 8A			0	1.50	8.08**	0	0.33	1.72**
CMS 16A			0	-1.49	2.43**	0	-0.07	0.61**
SE			0.03	0.99	0.10	0.02	0.23	0.06
Gi-Gj			0.04	1.40	0.14	0.02	0.33	0.08
LINES								
JGL 11110-2			0	-1.51	2.87**	0	-0.10	0.85**
JGL 11110-1			0	-1.15	-0.94**	0	-0.40	-0.23
JGL 17211			0	-3.71*	-1.14**	0	-0.77	-0.24*
JGL 16284			0	-0.62	-0.96**	0	0.08	-0.21
JGL 13515			0	0.85	2.08**	0	0.00	0.34**
JGL 11160			0	1.79	0.34	0	0.03	-0.25*
JGL 11118			0	1.53	-2.54**	0	0.30	-0.73**
JGL 11111			0	6.15**	1.99**	0	1.45**	0.67**
JGL 8605			0	2.39	-2.68**	0	0.33	-0.78**
JGL 8292			0	-5.42**	-0.58**	0	-1.27**	-0.10
JGL 3855			0	3.39	0.28	0	0.68	0.18
JGL 3844			0	-0.45	6.83**	0	0.26	1.74**
JGL 1798			0	-3.23	-5.55**	0	-0.60	-1.25**
SE			0.04	1.59	0.16	0.03	0.37	0.09
Gi-Gj			0.06	2.25	0.23	0.04	0.53	0.13
Crosses								
IR 68897A	**X**	**JGL11110-2**	0	-8.88	-9.02**	0	-1.91	-2.28**
IR 68897A	**X**	**JGL11110-1**	0	-9.24	-5.21**	0	-1.61	-1.20**
IR 68897A	**X**	**JGL17211**	0	3.70	-5.01**	0	0.72	-1.19**
IR 68897A	**X**	**JGL16284**	0	-9.77*	-5.19**	0	-2.09	-1.22**
IR 68897A	**X**	**JGL13515**	0	-2.45	7.44**	0	-0.63	1.12**
IR 68897A	**X**	**JGL11160**	0	-4.01	-6.49**	0	-1.13	-1.18**
IR 68897A	**X**	**JGL11118**	0	-3.14	-3.61**	0	-0.93	-0.70**
IR 68897A	**X**	**JGL11111**	0	2.77	-8.14**	0	0.50	-2.10**
IR 68897A	**X**	**JGL8605**	0	6.54	-3.47**	0	1.62	-0.65*
IR 68897A	**X**	**JGL8292**	0	8.83	19.30**	0	2.01	4.46**
IR 68897A	**X**	**JGL3855**	0	-5.61	-6.43**	0	-1.50	-1.61**
IR 68897A	**X**	**JGL3844**	0	13.43**	26.43**	0	3.82**	6.72**
IR 68897A	**X**	**JGL1798**	0	7.84	-0.60	0	1.14	-0.17
APMS 8A	**X**	**JGL11110-2**	0	0.76	-2.87**	0	-0.28	-0.85**
APMS 8A	**X**	**JGL11110-1**	0	5.00	0.94	0	0.61	0.23
APMS 8A	**X**	**JGL17211**	0	-7.44	1.14**	0	-1.58	0.24
APMS 8A	**X**	**JGL16284**	0	2.38	0.96*	0	0.40	0.21
APMS 8A	**X**	**JGL13515**	0	0.92	-2.08**	0	0.14	-0.34
APMS 8A	**X**	**JGL11160**	0	-12.93**	-0.34	0	-2.38*	0.25
APMS 8A	**X**	**JGL11118**	0	17.70**	2.54**	0	4.71**	0.73**
APMS 8A	**X**	**JGL11111**	0	-9.13	-1.99**	0	-2.89**	-0.67*
APMS 8A	**X**	**JGL8605**	0	4.37	2.68**	0	1.35	0.78**
APMS 8A	**X**	**JGL8292**	0	-5.72	0.58	0	-1.08	0.10
APMS 8A	**X**	**JGL3855**	0	4.78	-0.28	0	0.92	-0.18
APMS 8A	**X**	**JGL3844**	0	-10.69*	-6.83**	0	-2.61*	-1.74**
APMS 8A	**X**	**JGL1798**	0	9.99*	5.55**	0	2.70*	1.25**

Table 4.18 (cont.)						
Cross	**Gall midge damaged Plant %(ASIN)**			**Silver Shoots % (ASIN)**		
	KNM	WGL	KSR	KNM	WGL	KSR
CMS 16A X JGL11110-2	0	-6.38	-2.87**	0	-1.27	-0.85**
CMS 16A X JGL11110-1	0	1.43	0.94	0	0.21	0.23
CMS 16A X JGL17211	0	-4.19	1.14*	0	-0.61	0.24
CMS 16A X JGL16284	0	12.88**	0.96*	0	3.63**	0.21
CMS 16A X JGL13515	0	-0.57	-2.08**	0	-0.47	-0.34
CMS 16A X JGL11160	0	9.63*	-0.34	0	2.55*	0.25
CMS 16A X JGL11118	0	-0.64	2.54**	0	-0.30	0.73**
CMS 16A X JGL11111	0	-1.14	-1.99**	0	-0.34	-0.67*
CMS 16A X JGL8605	0	-1.49	2.68**	0	-0.60	0.78**
CMS 16A X JGL8292	0	5.69	0.58	0	0.79	0.10
CMS 16A X JGL3855	0	-3.12	-0.28	0	-1.16	-0.18
CMS 16A X JGL3844	0	-7.44	-6.83**	0	-1.64	-1.74**
CMS 16A X JGL1798	0	-4.66	5.55**	0	-0.78	1.25**
APMS 6A X JGL11110-2	0	21.31**	25.63**	0	5.28**	6.69**
APMS 6A X JGL11110-1	0	9.99*	10.36**	0	2.32*	2.38**
APMS 6A X JGL17211	0	12.54**	9.56**	0	2.63*	2.35**
APMS 6A X JGL16284	0	2.22	10.31**	0	0.07	2.44**
APMS 6A X JGL13515	0	-12.16**	-15.72**	0	-2.33*	-3.32**
APMS 6A X JGL11160	0	2.44	1.09*	0	0.36	-0.09
APMS 6A X JGL11118	0	-4.06	3.97**	0	-1.25	0.39
APMS 6A X JGL11111	0	-17.46**	-15.63**	0	-3.78**	-3.65**
APMS 6A X JGL8605	0	1.29	3.42**	0	-0.10	0.20
APMS 6A X JGL8292	0	-5.89	-13.05**	0	-1.06	-2.88**
APMS 6A X JGL3855	0	-14.70**	-13.91**	0	-3.01**	-3.16**
APMS 6A X JGL3844	0	12.57**	2.05**	0	2.61**	0.37
APMS 6A X JGL1798	0	-8.08	-8.08**	0	-1.73	-1.72**
IR 58025A X JGL11110-2	0	-6.81	-10.86**	0	-1.82	-2.71**
IR 58025A X JGL11110-1	0	-7.17	-7.04**	0	-1.53	-1.64**
IR 58025A X JGL17211	0	-4.62	-6.84**	0	-1.16	-1.63**
IR 58025A X JGL16284	0	-7.71	-7.03**	0	-2.01	-1.65**
IR 58025A X JGL13515	0	14.26**	12.44**	0	3.28**	2.88**
IR 58025A X JGL11160	0	4.88	6.06**	0	0.61	0.78**
IR 58025A X JGL11118	0	-9.86*	-5.44**	0	-2.22*	-1.14**
IR 58025A X JGL11111	0	24.96**	27.75**	0	6.51**	7.08**
IR 58025A X JGL8605	0	-10.71*	-5.31**	0	-2.25*	-1.09**
IR 58025A X JGL8292	0	-2.91	-7.40**	0	-0.66	-1.77**
IR 58025A X JGL3855	0	18.66**	20.90**	0	4.75**	5.12**
IR 58025A X JGL3844	0	-7.87	-14.81**	0	-2.18*	-3.61**
IR 58025A X JGL1798	0	-5.09	-2.43**	0	-1.33	-0.61*
SE	0.10	3.56	0.36	0.06	0.83	0.20
Sij-Skl	0.14	5.04	0.51	0.09	1.18	0.28
Sij-Sik	0.09	3.42	0.35	0.06	0.80	0.19

* Significant at 5% level; ** Significant at 1% level

Warangal (JGL 8292) and 4 at Kampasagar (JGL 17211, JGL 11160, JGL 11118 and JGL 8605), recorded negative gca effects for silver shoots (%).

(b) sca effects: Among 65 hybrids, 8 hybrid at Warangal, 30 hybrids at Kampasagar, recorded significant negative sca effects while zero reaction was noticed at Kunaram (Table 4.18).

Rao.*et al.* (1998) screened 20,000 accessions of rice germplasm both has identified more than 250 sources of resistance. After the detection of gall midge biotypes within the country, resistant germplasm accessions were screened against characterized biotypes to note the range in resistance. Multilocation testing of primary donors against all known biotypes revealed that none of the donors displayed resistance against all six biotypes. Oudhia *et al.* (1999) studied reaction of hybrid rice varieties to gall midge (*Orseolia oryzae*). Nine rice hybrids and the resistant control cv. Mahamaya, growing at Raipur, were observed for infestation by gall midge. Mahamaya was free from infestation, and in the hybrids percentage of infested tillers ranged from 5.23 (%) to 12.32(%). Naikebawane *et al.* (2008) studied genetics of gall midge *Orseolia oryzae* (Wood Mason) resistance in some new donors of rice (*Oryza sativa L.*) at Chattisgarh,India. Results revealed the presence of a single dominant gene for gall midge resistance in 5 new donors, i.e. INRC 202, Tellarigarikasunjavari, ARC 15831, JGL 384 and Bhumansan. The studies indicate that the range in resistance, reaction of hybrid rice varieties to gall midge was different due to various biotypes existing in India, genetics of gall midge *Orseolia oryzae* resistance and host plant resistance.

4.2.6.3 Days to 50% flowering :(a) gca effects Among the testers IR 68897A at Kunaram, IR 68897A and APMS 6A at Warangal and IR 68897A in pooled analysis had significant negative gca effect. The tester IR 68897A had a significant negative gca effect at Kunaram and Warangal locations and also in pooled analysis.

Among the 13 lines, five lines at Kunaram, 6 lines at Warangal, 2 at Kampasagar and 5 lines in pooled analysis had significant negative gca effects. The lines JGL 11110-2 and JGL 11110-1 recorded significant negative gca effects at all the three locations and also in pooled analysis. The line JGL 3844 recorded significant negative gca effect at Kunaram and Warangal locations and also in pooled analysis (Table 4.19).

(b) sca effects Out of the 65 hybrids studied 11 hybrids at Kunaram, 27 hybrids at Warangal, 12 hybrids at Kampasagar and 20 hybrids in pooled analysis had significant negative sca effect.Six hybrids (IR 68897A x JGL 11110-1, IR 68897A x JGL11118, IR 68897A x JGL11160, IR 68897A x JGL3855, CMS 16A x JGL 3855,IR 58025A x

Table 4.19.Estimates of general and specific combining ability effects for days to 50 % flowering and plant height at Kunaram, Warangal and Kampasagar and over locations in present investigation.

Parent/Cross	Days to 50 % flowering				Plant height			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
Testers								
IR 58025A	0.07	2.69**	1.46*	1.41**	1.81**	-2.16**	0.69	0.11
IR 68897A	-1.52**	-1.67**	-1.40	-1.53**	0.09	-0.85**	-0.61	-0.46
APMS 6A	0.82*	-1.67**	0.38	-0.16	-0.81**	0.72**	1.92*	0.61*
APMS 8A	0.10	0.79**	-0.90	-0.00	-2.32**	1.95**	-2.51**	-0.96**
CMS 16A	0.53	-0.15	0.46	0.28	1.24**	0.34	0.51	0.700**
SE(Lines)	0.60	0.25	1.15	0.49	0.47	0.43	1.25	0.43
Gi-Gj	0.86	0.35	1.63	0.30	0.67	0.60	1.76	0.61
Lines								
JGL 11110-2	-2.34**	-4.16**	-4.68**	-3.73**	-0.59	-16.31**	-4.34**	-7.08**
JGL 11110-1	-10.14**	-3.23**	-6.71**	-6.70**	2.01**	-8.61**	-2.03	-2.88**
JGL 17211	-3.68**	2.70**	-0.06	-0.34	3.81**	-7.01**	3.35**	0.05
JGL 16284	3.5**	8.17**	3.58**	5.09**	-6.32**	-10.51**	3.33**	-4.50**
JGL 13515	1.86**	-6.96**	-0.26	-1.79**	2.01**	-9.41**	-0.85	-2.75**
JGL 11160	4.46**	5.57**	5.24**	5.08**	-1.86**	-8.91**	1.65	-3.04**
JGL 11118	3.46**	-5.43**	-0.43	-0.80	-2.79**	-14.11**	-2.15	-6.35**
JGL 11111	-3.01**	4.30**	-0.50	0.26	3.14**	-9.11**	2.58*	-1.13**
JGL 8605	-0.21	6.24**	0.72	2.258**	3.48**	-9.71**	-0.87	-2.37**
JGL 8292	1.39*	1.97**	0.50	1.29**	0.81	27.19**	1.91	9.97**
JGL 3855	3.72**	3.57**	2.77*	3.35**	-0.92	22.69**	1.58	7.78**
JGL 3844	-2.28**	-3.63**	-1.22	-2.37**	-0.86	20.89**	-1.54	6.16**
JGL 1798	3.26**	-9.10**	1.04	-1.60**	-1.92**	22.89**	-2.62*	6.12**
SE(Testers)	0.38	0.15	0.71	0.70	0.29	0.26	0.78	0.27
Gi-Gj	0.53	0.22	1.01	0.43	0.41	0.37	1.09	0.38
Crosses								
IR 68897A X JGL 11110-2	-0.61	10.57**	6.71*	5.56**	12.46**	6.96**	9.55**	9.66**
IR 68897A X JGL11110-1	-4.35**	-8.73**	-5.89*	-6.32**	-13.82**	2.15*	-10.95**	-7.54**
IR 68897A X JGL17211	6.65**	-6.07**	-0.48	0.04	-2.26*	-8.42**	-3.28	-4.65**
IR 68897A X JGL16284	-1.30	11.81**	4.01	4.84**	6.59**	-0.15	7.02*	4.45**
IR 68897A X JGL13515	-0.40	-7.58**	-4.35	-4.11**	-2.97**	-0.54	-2.34	-1.95*
IR 68897A X JGL11160	-4.14**	-5.03**	-4.33	-4.50**	-7.14**	-8.74**	-7.49**	-7.79**
IR 68897A X JGL11118	-3.22*	-7.67**	-6.46*	-5.78**	-3.42**	0.95	-7.19*	-3.22**
IR 68897A X JGL11111	6.45**	7.33**	6.48*	6.76**	2.81**	2.88**	11.35**	5.68**
IR 68897A X JGL8605	-2.50	-0.46	-1.57	-1.51	4.32**	-2.85**	1.45	0.97
IR 68897A X JGL8292	3.40*	5.82**	5.87*	5.03**	3.43**	7.76**	1.89	4.36**
IR 68897A X JGL3855	-5.94**	-9.29**	-9.05**	-8.09**	-2.27*	1.66	-6.94*	-2.52**
IR 68897A X JGL3844	-5.35**	-3.60**	0.35	-2.87**	10.45**	-6.65**	3.55	2.45*
IR 68897A X JGL1798	-3.35*	-1.60**	-5.04	-3.33**	-5.99**	-3.22**	-11.24**	-6.82**
APMS 8A X JGL 11110-2	7.70**	7.94**	8.25**	7.96**	1.19	5.05**	7.53 **	4.59**
APMS 8A X JGL11110-1	6.93**	6.55**	5.49*	6.32**	-3.37**	3.16**	7.10	2.30*
APMS 8A X JGL17211	-1.47	0.57	0.25	-0.22	3.53**	0.16	1.02	1.57
APMS 8A X JGL16284	-0.88	-10.07**	-10.76**	-7.24**	-29.09**	-10.65**	-19.22**	-19.65**
APMS 8A X JGL13515	0.12	4.60**	3.79	2.84**	13.81**	3.78**	6.92**	8.17**
APMS 8A X JGL11160	1.17	3.47**	4.27	2.97**	0.32	3.05**	5.22	2.86**
APMS 8A X JGL11118	1.07	1.42*	2.45	1.65	11.43**	3.66**	6.06*	7.05**
APMS 8A X JGL11111	0.53	-7.29**	5.42*	-0.45	1.19	8.06**	6.19*	5.15**
APMS 8A X JGL8605	2.12	11.73**	2.68	5.51**	0.25	0.25	-0.45	0.02

Table 4.19 (cont.)								
Crosses	**Days to 50 % flowering**				**Plant height**			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
APMS 8A X JGL8292	0.12	-4.27**	-5.37*	-3.17**	-8.19**	0.18	-6.91*	-4.98**
APMS 8A X JGL3855	-1.83	-6.39**	-4.35	-4.19**	0.32	-9.05**	-1.41	-3.38**
APMS 8A X JGL3844	-0.93	6.22**	1.62	2.30*	6.43**	0.56	2.57	3.19**
APMS 8A X JGL1798	1.59	1.17*	2.53	1.76	-1.94	-5.94**	-1.04	-2.97**
CMS 16A X JGL 11110-2	0.85	7.20**	2.79	3.61**	2.11*	0.25	-0.67	0.57
CMS 16A X JGL11110-1	0.85	-17.47**	-7.00**	-7.87**	-1.66	-2.82**	-2.20	-2.23*
CMS 16A X JGL17211	-2.10	4.07**	0.89	0.95	4.52**	2.95**	0.83	2.77**
CMS 16A X JGL16284	-1.20	5.02**	0.79	1.54	-3.04**	5.56**	3.08	1.87
CMS 16A X JGL13515	1.93	-10.83**	-7.21**	-5.37**	1.33	1.76	1.36	1.48
CMS 16A X JGL11160	-0.48	15.20**	6.72*	7.127**	4.05**	7.95**	4.06	5.35**
CMS 16A X JGL11118	0.18	11.53**	4.80	5.51**	5.94**	-1.62	4.07	2.80**
CMS 16A X JGL11111	-1.43	-7.93**	-6.91**	-5.42**	-8.54**	-2.35*	-8.17**	-6.35**
CMS 16A X JGL8605	-0.20	-7.98**	2.59	-1.86	-2.77**	-5.74**	-1.32	-3.28**
CMS 16A X JGL8292	3.73**	1.44*	5.73*	3.63**	10.73**	5.76**	6.50*	7.66**
CMS 16A X JGL3855	-7.35**	-17.20**	-11.54**	-2.03**	-8.89**	-10.05**	-1.67	-6.87**
CMS 16A X JGL3844	-0.02	4.47**	0.14	1.53	2.01	2.38*	-2.73	0.55
CMS 16A X JGL1798	5.37**	8.01**	4.62	6.00**	-3.48**	-0.35	-2.77	-2.20*
APMS 6A X JGL 11110-2	-1.73	3.29**	1.06	0.87	-0.37	2.26*	0.68	0.85
APMS 6A X JGL11110-1	-0.07	-0.83	3.05	0.72	2.06	3.86**	3.48	3.14**
APMS 6A X JGL17211	2.18	1.53**	5.71*	3.14**	-0.55	0.55	1.58	0.53
APMS 6A X JGL16284	3.18*	3.87**	3.12	3.39**	0.68	2.48*	-0.08	1.02
APMS 6A X JGL13515	-0.10	-4.59**	-2.33	-2.34*	-0.48	-0.75	0.29	-0.31
APMS 6A X JGL11160	-5.20**	0.02	-9.55**	-4.91**	-1.71	-6.14**	-5.27	-4.37**
APMS 6A X JGL11118	-2.34	1.77**	-3.87	-1.48	4.06**	-25.04**	-1.77	-7.58**
APMS 6A X JGL11111	2.58	-10.20**	3.32	-1.43	12.11**	6.15**	3.86	7.38**
APMS 6A X JGL8605	-0.08	5.80**	1.20	2.31	-11.99**	6.08**	7.00*	0.36
APMS 6A X JGL8292	-0.03	-3.66**	0.22	-1.16	1.19	3.85**	-2.50	0.84
APMS 6A X JGL3855	-0.13	6.29**	-0.87	1.76	-5.37**	8.96**	-6.59*	-1.00
APMS 6A X JGL3844	-1.01	-5.83**	-1.54	-2.79*	-4.54**	12.46**	-4.50	1.14
APMS 6A X JGL1798	0.92	7.20**	0.46	2.86**	-4.49**	-2.85**	3.93	-1.14
IR 58025A X JGL 11110-2	0.25	5.20**	0.67	2.04	3.74**	-0.42	2.40	1.90*
IR 58025A X JGL11110-1	0.64	1.74**	2.15	1.41	8.26**	0.35	3.03	3.88**
IR 58025A X JGL17211	-0.80	-8.31**	-1.74	-3.62**	-2.97**	-9.54**	-4.86	-5.79**
IR 58025A X JGL16284	4.66**	8.04**	0.65	4.45**	-3.94**	-3.74**	-1.18	-2.95**
IR 58025A X JGL13515	8.25**	14.40**	5.98*	9.54**	-3.55**	8.95**	3.91	3.10**
IR 58025A X JGL11160	-14.75**	-7.60**	-4.08	-8.81**	-0.66	7.38**	-5.21	0.50
IR 58025A X JGL11118	-2.70*	-8.73**	-5.59*	-5.67**	-0.81	2.15	-2.58	-0.41
IR 58025A X JGL11111	4.53**	-6.11**	3.05	0.49	8.96**	-14.74**	5.06	-0.24
IR 58025A X JGL8605	3.13*	15.51**	1.66	6.76**	-15.54**	2.76**	-5.17	-5.98**
IR 58025A X JGL8292	4.72**	0.20	6.66*	3.86**	34.85**	2.95**	19.26**	19.02**
IR 58025A X JGL3855	0.38	-5.80**	1.74	-1.23	1.74	-8.62**	-0.07	-2.32*
IR 58025A X JGL3844	-2.90*	-5.26**	-3.65	-3.93**	-13.41**	-1.85	-7.97**	-7.74**
IR 58025A X JGL1798	-5.33**	-4.65**	-6.41*	-5.46**	-7.64**	4.76**	-6.06*	-2.98**
SE	1.35	0.56	2.58	1.09	1.06	0.95	2.80	0.96
Sij-Skl	1.91	0.80	3.65	1.54	1.49	1.34	3.96	1.36
Sij-Sik	3.20	1.33	6.11	2.58	2.50	2.25	6.62	2.27

*** Significant at 5% level; ** Significant at 1% level**

JGL 11160 had significant negative sca effect at all the three locations as well as in pooled analysis (Table 4.19).

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).

4.2.6.4 Plant height:(a) gca effects Among the testers 2 at Kunaram, 2 at Warangal,1 at Kampasagar had significant negative gca effect.Based on the pooled analysisAPMS 8A recorded significant negative gca effects.

Among the lines, 3 at Kunaram, 9 at Warangal, 2 at Kampasagar and 8 in pooled analysis had significant negative gca effects.The lines JGL11110-2, JGL11110-1, JGL 16284, JGL 13515, JGL 11160, JGL 11111, JGL 11118 and JGL 8605 had significant negative gca effects on pooled analysis (Table 4.25).

(b) sca effects Out of 65 hybrids tested 25 hybrids at Kunaram, 18 hybrids at Warangal, 10 hybrids at Kampasagar and 23 hybrids in pooled analysis shown significant negative sca effects (Table 4.21). Four hybrids (IR 68897A x JGL 11160, IR 68897A x JGL 1798, APMS 8Ax JGL 16284, and CMS 16Ax JGL 11111) recorded negative significant sca effects at three locations and in pooled analysis.

Out of 65 hybrids tested 23 hybrids in pooled analysis shown significant negative sca effects for plant height.The hybrids IR 68897A x JGL 11160 (-7.79), IR 58025A x JGL 3844(-7.74), APMS 6A x JGL 11118 (-7.58), IR 68897A x JGL 11110-1 (-7.54) and CMS 16A x JGL 3855 (-6.87) , recorded high negative sca effects, resulted in short statured hybrids.

Among the top five hybrids, two hybrids with parents IR 68897A x JGL 11160 (-7.79) and APMS 6A x JGL 11118 (-7.58) had high x low gca effects, IR 58025A x JGL 3844(-7.74) and CMS 16A x JGL 3855 (-6.87) had low x low gca effects, and one hybrid with parents IR 68897A x JGL 11110-1 (-7.54) had high x high negative gca effects, indicating that there was no correlation between gca effects of parents and sca effects of that respective hybrids. The mean performance of top 5 hybrids ranged from 79 to 96 cm (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 (Table 4.20).

(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 (Table 4.20).

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).

4.2.6.6 Flag leaf length

(a) gca effects: Among the testers IR 58025A at Kunaram and in pooled analysis had significant positive gca effect, while in lines, 4 at Kunaram, 4 at Warangal, 3 at Kampasagar and 4 in pooled analysis had significant positive gca effects.The line JGL 11160 had significant positive gca effect in two locations *i.e*., Kunaram, Warangal and in pooled analysis (Table 4.20).

(b) sca effects Out of 65 hybrids 14 at Kunaram, 16 at Warangal, 15 at Kampasagar and 17 in pooled analysis had significant positive sca effects (Table 4.17).The hybrids APMS 8A x JGL11110-1, CMS 16A x JGL 8292 and IR 58025A x JGL 3855 recorded positive significant sca effect at three locations and in pooled analysis.The mean performance of these hybrids ranged from 3.25 to 35.79 cms.

Among the five, hybrids three hybrids are with parents APMS 8A x JGL11110-1, CMS 16A x JGL 8292 and CMS 16A x JGL 17211having low x low gca effects, resulting hybrids with high sca effects, while other two hybrids IR 58025A x JGL 3855 and APMS 6A x JGL 11111 having one of the parents with low or high gca effect, resulting, high sca effect in hybrids, indicating no correlation between gca and sca effects of parents and hybrids (Table 4.25).

4.2.6.7 Flag leaf width

(a) gca effects

Among the lines IR 68897A at Kunaram, Warangal and in pooled analysis had significant positive gca effect, while CMS 16A had significant positive gca effect at only Warangal location.

Table 4.20. Estimates of general and specific combining ability effects for number of productive tillers/plant and flag leaf length at Kunaram, Warangal and Kampasagar and over locations in rice

Parent/Cross	No. of productive tillers/plant				Flag leaf length			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
Testers								
IR 58025A	-0.29	0.86**	1.58**s	0.71**	1.92**	0.32	0.91*	1.05**
IR 68897A	0.43	-1.48**	-1.18**	-0.74**	0.07	-0.14	-0.15	-0.07
APMS 6A	-0.62*	0.73**	0.51	0.20	-1.32**	1.48**	-0.80	-0.21
APMS 8A	0.30	-1.61**	-0.92**	-0.73**	-1.14**	-2.22**	-0.69	-1.35**
CMS 16A	0.17	1.50**	0.01	0.56**	0.47	0.55	0.72	0.58**
SE(Lines)	0.40	0.31	0.42	0.21	0.43	0.82	0.67	0.35
Gi-Gj	0.56	0.43	0.59	0.31	0 .61	1.16	0.95	0.49
Lines								
JGL 11110-2	-1.19**	-3.86**	-4.42**	-3.15**	-4.18**	0.38	-3.00**	-2.27**
JGL 11110-1	1.01*	1.61**	5.48**	2.69**	-0.06	2.28**	1.10	1.11**
JGL 17211	-0.19	3.28**	4.78**	2.62**	-1.89**	3.58**	1.75*	1.14**
JGL 16284	-1.39**	0.21	-0.22	-0.46*	0.81	7.88**	2.40**	3.69**
JGL 13515	-0.92*	2.34**	0.88*	0.79**	0.30	-0.92	-2.70**	-1.10**
JGL 11160	-0.32	0.81**	-2.82**	-0.77**	2.50**	3.48**	1.40*	2.46**
JGL 11118	-0.72	1.14**	-2.32**	-0.63**	-0.75	0.28	0.15	-0.11
JGL 11111	0.28	-0.06	0.98*	0.39	2.13**	-0.82	0.30	0.53
JGL 8605	1.28**	2.28**	1.88**	1.81**	-1.97**	1.68*	-0.09	-0.12
JGL 8292	2.28**	-1.46**	-1.62**	-0.26	2.18**	-3.82**	0.40	-0.41
JGL 3855	1.01*	-3.26**	-1.42**	-0.22**	1.34**	-5.72**	-0.30	-1.56**
JGL 3844	-0.32	-1.92**	1.58**	-0.22	0.58	-4.12**	0.40	-1.05**
JGL 1798	-0.79	-1.12**	-2.72**	-1.54**	-0.98*	-4.12**	-1.80**	-2.30**
SE(Testers)	0.25	0.19	0.26	0.13	0.27	0.51	0.42	0.21
Gi-Gj	0.35	0.27	0.37	0.19	0.38	0.72	0.59	0.30
Crosses								
IR 68897A X JGL 11110-2	-0.58	4.34**	3.12**	2.29**	-3.49**	3.28	1.29	0.36
IR 68897A X JGL11110-1	0.04	0.01	-1.62	-0.52	-1.59	-3.76*	-1.15	-2.17**
IR 68897A X JGL17211	-0.58	-5.19**	-3.81**	-3.19**	-2.03*	-4.88**	-4.50**	-3.80**
IR 68897A X JGL16284	-0.17	4.81**	-0.38	1.41**	5.19**	0.32	4.89**	3.46**
IR 68897A X JGL13515	1.29	-3.96**	2.69**	0.00	1.93*	5.05**	-0.52	2.15**
IR 68897A X JGL11160	-1.11	-3.79**	2.22*	-0.89	8.67**	1.38	5.19**	5.08**
IR 68897A X JGL11118	-1.16	1.21	-5.02**	-1.65**	-4.88**	-0.16	-0.25	-1.77 *
IR 68897A X JGL11111	1.22	-4.66**	-2.21*	-1.88**	-0.82	2.22	-3.60*	-0.73
IR 68897A X JGL8605	0.96	4.67**	4.72**	3.45**	0.87	-2.08	-0.21	-0.48
IR 68897A X JGL8292	0.09	2.57**	0.29	0.98*	-3.83**	-1.35	-1.12	-2.10*
IR 68897A X JGL3855	-0.58	2.21**	0.42	0.68	-3.73**	-4.92**	-2.46	-3.70**
IR 68897A X JGL3844	0.04	3.54**	0.18	1.25*	-2.55**	1.04	-3.40*	-1.64*
IR 68897A X JGL1798	0.75	2.67**	4.99**	2.80**	-2.14*	-3.08	-0.25	-1.82*
APMS 8A X JGL 11110-2	-2.17	-4.33**	-2.58**	-3.02**	1.23	3.12	2.14	2.16**
APMS 8A X JGL11110-1	1.96	-4.10**	-3.01**	-1.71**	7.19**	3.85*	3.98**	5.00**
APMS 8A X JGL17211	0.29	-3.72**	-6.08**	-3.17**	-1.33	4.28*	-0.61	0.78
APMS 8A X JGL16284	-0.76	-3.39**	-5.32**	-3.15**	-0.27	4.74*	-4.55**	-0.03
APMS 8A X JGL13515	1.29	-0.59	1.99*	0.89	0.14	-7.38**	2.60	-1.55*
APMS 8A X JGL11160	-1.97	-0.26	3.92**	0.56	0.91	1.32	-1.01	0.40
APMS 8A X JGL11118	1.16	7.97**	5.49**	4.87**	0.55	-2.95	3.58*	0.39
APMS 8A X JGL11111	2.15*	6.48**	4.32**	4.31**	6.69**	-2.92	2.49	2.08**
APMS 8A X JGL8605	0.77	-0.19	-1.42	-0.27	1.69	2.54	-2.95	0.42

Table 4.20 (cont.)								
Crosses	**No. of productive tillers/plant**				**Flag leaf length**			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
APMS 8A X JGL8292	-1.85*	-6.73**	-5.61**	-4.72**	-1.67	-3.08	-1.30	2.02**
APMS 8A X JGL3855	-1.10	-5.39**	2.82**	-1.22*	-1.10	-1.88	0.59	-0.80
APMS 8A X JGL3844	0.03	5.84**	-0.11	1.91**	-5.61**	5.35**	1.18	0.31
APMS 8A X JGL1798	0.22	-4.32**	-3.48**	-2.52**	-3.96**	2.18	-3.61*	-1.80 *
CMS 16A X JGL 11110-2	-1.50	6.34**	3.28**	2.71**	-1.08	-1.86	-0.55	-1.16
CMS 16A X JGL11110-1	-0.78	-8.19**	3.09**	-1.96**	1.07	-3.98*	-2.90	-1.94*
CMS 16A X JGL17211	0.96	0.14	-0.98	0.03	4.41**	3.72*	4.49**	4.20**
CMS 16A X JGL16284	1.09	6.04**	-1.91*	1.74**	-0.44	-0.05	2.58	0.70
CMS 16A X JGL13515	0.62	-4.66**	0.02	-1.34**	-1.59	-1.12	-1.61	-0.44
CMS 16A X JGL11160	-0.10	5.68**	5.78**	3.78**	3.12**	0.84	5.70**	3.22**
CMS 16A X JGL11118	0.95	2.47**	-1.91*	0.50	0.83	-2.28	3.85*	0.80
CMS 16A X JGL11111	0.03	-2.19**	-0.48	-0.88	-2.76**	-1.58	-4.76**	-3.04**
CMS 16A X JGL8605	-1.51	-1.30	-3.41**	-2.07**	0.41	4.15*	-3.17*	0.46
CMS 16A X JGL8292	-0.05	0.88	-5.28**	-1.48**	6.20**	3.98*	4.49**	4.89**
CMS 16A X JGL3855	-1.10	-7.12**	-1.02	-3.07**	-2.61**	-3.56	-3.95**	-3.37**
CMS 16A X JGL3844	0.62	4.01**	-1.21	1.13*	1.19	3.32	3.20*	2.57**
CMS 16A X JGL1798	-0.97	4.34**	5.22**	2.86**	-0.64	-5.48**	0.09	-2.01**
APMS 6A X JGL 11110-2	1.49	-2.10**	2.29*	0.56	-4.13**	1.75	-3.82*	-2.07**
APMS 6A X JGL11110-1	1.95*	6.21**	3.32**	3.82**	3.03**	0.98	1.38	1.79*
APMS 6A X JGL17211	-0.43	-3.12**	5.08**	0.51	0.56	-0.06	4.94**	1.81*
APMS 6A X JGL16284	0.29	-1.33	6.39**	1.78**	2.32*	2.82	4.09**	3.08**
APMS 6A X JGL13515	0.03	-6.33**	-6.68**	-4.32**	-5.35**	4.52*	-5.52**	-2.12**
APMS 6A X JGL11160	-1.84*	4.57**	-8.11**	-1.79**	-0.56	-8.25**	-4.88**	-4.57**
APMS 6A X JGL11118	-0.71	-1.06	2.32*	0.80	-1.19	-0.02	0.39	-0.27
APMS 6A X JGL11111	4.24**	-3.39**	-1.92*	-0.35	5.07**	5.44**	1.95	4.15**
APMS 6A X JGL8605	-3.05**	0.07	-0.61	-1.19*	-1.07	4.32*	0.10	1.11
APMS 6A X JGL8292	1.03	8.74**	-0.18	3.19**	3.04**	-0.48	2.49	1.68*
APMS 6A X JGL3855	-1.51	-4.36**	0.39	-1.82**	-5.85**	-9.25**	-4.92**	-6.67**
APMS 6A X JGL3844	1.55	-1.26	-5.88**	-1.86**	-2.23*	-5.62**	-2.41	-3.42**
APMS 6A X JGL1798	0.50	4.41**	4.38**	3.09**	0.15	-2.66	2.65	0.04
IR 58025A X JGL 11110-2	-0.45	1.21	-0.81	-0.01	-2.46*	9.22**	-5.70**	0.35
IR 58025A X JGL11110-1	0.63	-1.46*	-4.88**	-1.90**	-0.07	0.42	2.19	0.84
IR 58025A X JGL17211	-2.24*	-2.90**	7.19**	0.68	4.62**	-1.35	3.28*	2.18**
IR 58025A X JGL16284	-1.11	-4.26**	5.62**	0.08	-2.24*	-5.72**	-1.61	-3.19**
IR 58025A X JGL13515	-0.83	1.08	0.38	0.21	-3.29**	5.74**	-1.55	0.29
IR 58025A X JGL11160	-0.11	9.54**	-1.31	2.70**	-0.01	-5.38**	0.10	-1.76*
IR 58025A X JGL11118	0.96	-2.13**	1.62	0.15	-2.99**	-2.18	-4.01**	-3.06**
IR 58025A X JGL11111	1.09	-4.23**	-6.31**	-3.14**	8.53**	7.55**	7.08**	7.71**
IR 58025A X JGL8605	-2.65**	2.94**	-0.58	-0.09	-4.81**	4.28*	-2.91	-1.14
IR 58025A X JGL8292	0.30	-5.06**	-2.82**	2.52**	5.70**	-8.26**	3.15*	0.19
IR 58025A X JGL3855	1.69	6.74**	0.99	3.13**	4.68**	8.12**	4.30**	5.70**
IR 58025A X JGL3844	1.76	-0.59	-2.08*	-0.30	-2.75**	0.32	-1.31	-1.24
IR 58025A X JGL1798	-1.11	-4.03**	4.49**	-0.21	-2.81**	-4.45*	-3.22*	-3.49**
SE	0.89	0.69	0.93	0.49	0.96	1.84	1.50	0.78
Sij-Skl	1.26	0.97	1.32	0.69	1.35	2.60	2.12	1.20
Sij-Sik	2.11	1.63	2.21	1.16	2.27	4.36	3.55	1.83

* Significant at 5% level; **, Significant at 1% level

Table 4.21.Estimates of general and specific combining ability effects for flag leaf length and flag leaf width at Kunaram, Warangal and Kampasagar and over locations in rice

Parent/Cross	Flag leaf width				Panicle length			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
Testers								
IR 58025A	0.01	-0.04**	-0.03	-0.01	-0.36**	1.03**	-0.36*	0.10
IR 68897A	0.10**	0.06**	0.06	0.07**	-0.62 **	0.17	-0.40*	-0.28**
APMS 6A	-0.07**	-0.01	-0.01	-0.03*	0.17	-0.98**	0.14	-0.22*
APMS 8A	0.04	-0.07**	0.07*	0.01	0.35**	-0.24	0.48**	0.19*
CMS 16A	-0.08**	0.06**	-0.10**	-0.04**	0.47**	0.02	0.14	0.20*
SE(Lines)	0.04	0.02	0.05	0.02	0.20	0.30	0.27	0.15
Gi-Gj	0.05	0.02	0.08	0.03	0.29	0.43	0.38	0.21
Lines								
JGL 11110-2	-0.17**	-0.10**	-0.27**	-0.18**	1.62**	0.31	1.18**	1.03**
JGL 11110-1	-0.06	-0.08**	-0.15**	-0.09**	0.77**	1.82**	0.68*	1.08**
JGL 17211	-0.12**	-0.04*	-0.11*	-0.09**	0.37	0.11	0.48	0.31*
JGL 16284	0.14**	-0.03	0.22**	0.11**	0.39	0.11	0.48	0.32*
JGL 13515	-0.03	0.00	-0.11*	-0.04*	0.53**	-1.89**	-0.02	0.46**
JGL 11160	0.17**	0.08**	0.18**	0.14**	0.68**	-0.17	0.48	0.32*
JGL 11118	0.09*	-0.13**	0.12*	0.02	-0.06	0.11	0.38	0.14
JGL 11111	0.34**	0.00	0.15**	0.16**	-0.43*	-0.77	-1.02**	0.74**
JGL 8605	0.18**	-0.03	0.11*	0.08**	0.16	-0.59*	0.28	0.05
JGL 8292	0.00	-0.11**	0.03	-0.02	-1.33**	-0.39	-0.32	0.68**
JGL 3855	0.07*	0.21**	0.15**	0.14**	-0.61**	0.21	-0.92	-0.44**
JGL 3844	-0.13**	0.24**	-0.04	0.02	-1.33**	0.54	-1.32**	-0.70**
JGL 1798	-0.48**	0.04*	-0.27**	0.23**	-0.77**	0.61*	-0.32	-0.16
SE(Testers)	0.27	0.51	0.42	0.21	0.13	0.19	0.17	0.09
Gi-Gj	0.38	0.72	0.59	0.30	0.18	0.27	0.24	0.13
Crosses								
IR 68897A X JGL 11110-2	-0.09	0.09*	-0.08	-0.02	2.96**	1.37*	2.36**	2.23**
IR 68897A X JGL11110-1	-0.41**	-0.11**	-0.35**	-0.29**	-0.98*	0.23	-1.10	-0.61
IR 68897A X JGL17211	-0.03	0.06	-0.06	-0.00	-2.30**	-0.12	-2.14**	-1.52**
IR 68897A X JGL16284	0.40**	0.07	0.36**	0.27**	0.85	0.64	1.02	0.83*
IR 68897A X JGL13515	0.13	-0.11**	0.13	0.05	-0.54	-2.12**	-0.14	-0.93**
IR 68897A X JGL11160	0.05	0.07	0.10	0.07	0.22	-0.14	0.36	0.14
IR 68897A X JGL11118	-0.28**	-0.28**	-0.24*	-0.26**	-3.59**	0.22	-2.10**	-1.82**
IR 68897A X JGL11111	0.22**	0.14**	0.22	0.19**	2.82**	-0.12	1.86**	1.52**
IR 68897A X JGL8605	-0.09	0.00	-0.13	-0.07	-0.46	-2.33**	-0.48	-1.09**
IR 68897A X JGL8292	0.11	0.07	0.05	0.07	1.02	2.37**	0.36	1.25**
IR 68897A X JGL3855	-0.09	0.03	-0.24*	-0.10*	-0.32	2.07**	-0.44	0.43
IR 68897A X JGL3844	-0.25**	-0.07	-0.28*	-0.19**	1.34**	0.43	1.10	0.95**
IR 68897A X JGL1798	0.01	0.10*	-0.21	-03	-1.21**	-4.42**	-1.94**	-2.52**
APMS 8A X JGL 11110-2	0.08	0.06	0.21	0.11**	-1.13*	2.34**	0.22	0.47
APMS 8A X JGL11110-1	0.25**	-0.12**	0.53**	0.21**	1.32**	-0.42	1.06	0.65
APMS 8A X JGL17211	0.26**	0.12**	0.27*	0.21**	0.59	-0.43	0.06	0.07
APMS 8A X JGL16284	-0.21*	-0.23**	-0.39**	-0.27**	3.65**	-2.07**	2.10**	1.22**
APMS 8A X JGL13515	0.18*	-0.06	0.10	0.07	-0.31	-0.42	-0.44	-0.38
APMS 8A X JGL11160	-0.07	0.15**	-0.10	-0.00	-1.52**	1.84**	-0.78	-0.15
APMS 8A X JGL11118	-0.16	0.02	0.12	-0.00	-2.41**	1.08	-0.94	-0.75*
APMS 8A X JGL11111	-0.04	-0.01	0.00	-0.01	-0.18	0.07	-0.94	-0.35
APMS 8A X JGL8605	0.63**	-0.16	0.47**	0.31**	1.51**	-2.57**	2.10**	0.34

Table 4.21 (cont.)								
Crosses	**Flag leaf width**				**Panicle length**			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
APMS 8A X JGL8292	-0.37*s*	0.06	-0.37**	-0.22**	-1.51**	2.58**	-1.44*	-0.12
APMS 8A X JGL3855	0.05	-0.08*	0.03*	-0.00	-0.29	0.34	-0.28	-0.07
APMS 8A X JGL3844	-0.26**	0.19**	-0.13	-0.06	0.48	-0.42	0.56	0.20
APMS 8A X JGL1798	0.19*	-0.09*	0.22	0.10*	-2.76**	-1.15	-2.94**	-2.28**
CMS 16A X JGL 11110-2	-0.27**	-0.04	-0.37**	-0.22**	2.16**	1.21	2.10**	1.82**
CMS 16A X JGL11110-1	0.11	-0.02	0.10	0.06	1.44**	-1.11	1.06	0.46
CMS 16A X JGL17211	-0.17*	0.04	-0.18	-0.10*	1.53**	0.66	1.22*	1.13**
CMS 16A X JGL16284	0.14	0.11**	0.24	0.16**	-2.36**	0.39	-1.44*	-1.13**
CMS 16A X JGL13515	0.18*	0.02	0.35**	0.18**	0.11	1.07	-0.34	0.28
CMS 16A X JGL11160	0.52**	0.02	0.49**	0.34**	2.43**	-0.07	0.70	1.02**
CMS 16A X JGL11118	-0.02	0.04	-0.07	-0.01	-2.79**	-3.42**	0.66	-1.84**
CMS 16A X JGL11111	-0.10	0.05	-0.17	-0.07	-0.27	3.34**	-1.68**	0.46
CMS 16A X JGL8605	-0.58**	-0.13**	-0.60**	-0.43**	0.51	-0.92	0.66	0.08
CMS 16A X JGL8292	-0.44**	-0.01	-0.35**	-0.26**	0.64	-0.55	1.06	0.38
CMS 16A X JGL3855	0.27**	-0.11**	0.34**	-0.16**	0.23	-0.19	1.60**	0.54
CMS 16A X JGL3844	-0.14	0.01	-0.12	-0.08	0.18	3.49**	-1.44*	0.74*
CMS 16A X JGL1798	0.14	0.12**	0.20	0.15**	-1.53**	-3.24**	-1.28*	-2.01**
APMS 6A X JGL 11110-2	0.17*	-0.01	-0.06	0.03	0.48	0.48	0.06	0.34
APMS 6A X JGL11110-1	0.18*	0.02	0.24	0.14**	1.86**	0.77	1.76**	1.46**
APMS 6A X JGL17211	-0.20*	-0.08*	-0.18	-0.15**	-0.85	-0.86	-1.70**	-1.13**
APMS 6A X JGL16284	0.08	-0.01	-0.06	0.00	-0.34	2.27**	-0.24	0.56
APMS 6A X JGL13515	0.20*	0.15**	0.25*	0.19**	-0.39	-1.96	0.42	-0.64
APMS 6A X JGL11160	-0.26**	-0.08*	-0.25*	-0.19**	-0.28	-0.22	-0.24	-0.24
APMS 6A X JGL11118	-0.07	-0.10*	-0.11	-0.09*	0.48	-0.93	-0.14	-0.19
APMS 6A X JGL11111	0.05	0.00	0.13	0.05	1.03*	1.93	-0.10	0.95**
APMS 6A X JGL8605	0.10	0.02	0.14	0.08	-2.59**	-0.92	1.86**	-0.54
APMS 6A X JGL8292	0.02	-0.02	-0.09	-0.02	1.30**	0.34	-0.48	0.38
APMS 6A X JGL3855	-0.11	0.10**	-0.07	-0.02	-0.22	-0.42	-1.14	-0.59
APMS 6A X JGL3844	0.03	-0.22**	-0.15	-0.11*	-2.14**	-2.53**	-1.04	-1.90**
APMS 6A X JGL1798	0.14	0.58**	0.28*	0.33**	0.11	1.33	2.00**	1.14**
IR 58025A X JGL 11110-2	-0.09	0.15**	-0.04	0.00	1.79**	1.98**	-0.54	1.07**
IR 58025A X JGL11110-1	-0.02	-0.19**	0.15	-0.02	1.68**	-0.76	1.12	0.68*
IR 58025A X JGL17211	-0.06	-0.32**	-0.24	-0.20**	-1.44**	-0.02	-1.54*	-1.00**
IR 58025A X JGL16284	0.07	-0.25**	-0.04	-0.07	1.44**	-0.70	2.36**	1.03**
IR 58025A X JGL13515	0.12	0.60**	-0.02	0.23**	-7.80**	1.49*	-7.60**	-4.63**
IR 58025A X JGL11160	-0.27**	-0.28**	0.32**	-0.07	2.15**	-0.36	0.86	0.88**
IR 58025A X JGL11118	-0.19	-0.22**	-0.31*	-0.24**	0.73	-0.59	1.52*	0.55
IR 58025A X JGL11111	0.27**	0.15**	0.06	0.16**	3.48**	0.15	2.86**	2.16**
IR 58025A X JGL8605	-0.23**	0.35**	-0.20	-0.02	-2.91**	1.07	-2.14**	-1.32**
IR 58025A X JGL8292	-0.11	-0.15**	0.13	-0.04	0.78	-1.07	0.90	0.20
IR 58025A X JGL3855	0.22**	-0.18**	0.05	0.02	2.66**	0.58	1.86**	1.70**
IR 58025A X JGL3844	-0.24**	-0.12**	-0.21	-0.18**	-0.49	-0.66	-0.48	-0.54
IR 58025A X JGL1798	0.37**	0.10**	0.23	0.23**	-0.04	0.08	-0.14	-0.03
SE	0.96	1.84	1.50	0.78	0.45	0.69	0.60	0.34
Sij-Skl	1.35	2.60	2.12	1.20	0.64	0.97	0.85	0.47
Sij-Sik	2.27	4.36	3.55	1.83	109	1.62	1.42	0.79

* Significant at 5% level; **, Significant at 1% level

Five lines at Kunaram, 5 at Warangal, 6 at Kampasagar and 6 in pooled analysis had significant positive gca effects. The line JGL 11160 had and JGL3855 significant positive gca effects at three locations and in pooled analysis (Table 4.21).

(b) sca effects

For flag leaf width out of 65 hybrids tested, 16 hybrids at Kunaram, 17 hybrids at Warangal, 10 hybrids at Kampasagar and 16 hybrids in pooled analysis had positive sca effects.The hybrid APMS 8A x JGL 17211 and APMS 6A x JGL 13515 had positive significant sca effect at three locations and in pooled analysis.

Regarding the flag leaf width among the 65 hybrids tested, 16 hybrids in pooled analysis had positive sca effects. The top five hybrids with high sca effect for flag leaf width are, CMS 16A x JGL 11160 (0.34), APMS 6A x JGL 1798 (0.33), APMS 8A x JGL 8605 (0.31), IR 68897A x JGL 16284 (0.27) and IR 58025A x JGL 13515 (0.23).

Among the five hybrids three hybrids with parents CMS 16A x JGL 11160, APMS 6A x JGL 1798 and APMS 8A x JGL 8605 having low x low gca effects, resulting hybrids with high sca effects, due to accumulation and interaction of favourable alleles, while other two hybrids IR 68897A x JGL 16284 and IR 58025A x JGL 13515 having one of the parents with low or high gca effect, resulting, high sca effect in hybrids, due to high frequency of dominant alleles, indicating no correlation between gca and sca effects of parents and hybrids (Table 4.27). The range of mean performance of flag leaf width among these five hybrids ranged between 1.31 cm to1.97 cm (Table 4.25).

4.2.6.8 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 (Table 4.23). 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 (Table 4.18). 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).

4.2.6.9 Panicle weight

(a) gca effects

Among the testers CMS 16A recorded positive significant gca effect at three locations and in pooled analysis, while IR 58025A and IR68897 A recorded significant positive gca effect at two locations and in pooled analysis (4.22).

Among the lines, JGL 8605 recorded significant positive gca effect for panicle weight at all the three locations as well as in pooled analysis.The lines JGL 11110-1, JGL 16284, and JGL11160 recorded positive gca effect at two locations and in pooled analysis.

(b) sca effects

In hybrids out of 65, 21 at Kunaram, 20 at Warangal, 28 at Kampasagar and 27 in pooled analysis had significant positive sca effects for panicle weight. The hybrids APMS 8A x JGL 11110-2, APMS 8A x JGL 11110-1, CMS 16A x JGL 11110-2, CMS 16A x JGL 11160, CMS 16A x JGL 11118, APMS 6A x JGL 11118, IR 58025A x JGL 16284 and IR 58025A x JGL 11111 have shown significant sca effects for panicle weight at two locations and in pooled analysis. The hybrid APMS 6A x JGL 17211 had significant positive sca effects for panicle weight at all the three locations and in pooled analysis (Table 4.22).

Table 4.22. Estimates of general and specific combining ability effects for panicle weight and no. of filled grains per panicle at Kunaram, Warangal and Kampasagar and over locations in rice

Parent/Cross	Panicle weight				No. of filled grains per panicle			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
Testers								
IR 58025A	0.04	0.12**	0.06**	0.07**	11.82**	12.76**	5.22**	9.93**
IR 68897A	0.16**	-0.09**	-0.07**	-0.02	10.73**	-10.50**	18.10**	6.11**
APMS 6A	-0.14**	-0.02	-0.17**	-0.11**	2.83	-21.70**	-23.32**	-14.06**
APMS 8A	-0.22**	-0.21**	0.04	0.13**	-22.83**	-8.63**	-2.75	-11.40**
CMS 16A	0.17**	0.19**	0.15**	0.17**	-2.55	28.07**	2.75	9.42**
SE(Lines)	0.05	0.05	0.03	0.02	6.79	3.09	2.51	2.53
Gi-Gj	0.07	0.06	0.05	0.03	9.60	4.37	3.56	3.58
Lines								
JGL 11110-2	-0.03	-0.15**	0.04	0.04*	-23.46**	-20.09**	-17.42**	-20.32**
JGL 11110-1	0.08	0.21**	0.48**	0.25**	-33.70**	-20.79**	-6.82**	-20.43**
JGL 17211	0.11*	-0.29**	-0.18**	-0.12**	-6.37	-11.59**	-36.72**	- 18.22**
JGL 16284	0.88**	0.32**	0.04	0.14**	26.48**	18.61**	-22.02**	7.69**
JGL 13515	-0.45**	-0.05	-0.43**	-0.31**	31.67**	3.01	-0.12	11.52**
JGL 11160	-0.36**	0.14**	0.58**	0.12**	2.41	41.91**	-0.62	14.56**
JGL 11118	0.19**	-0.26**	0.14**	0.02	-1.76	10.21**	79.98**	29.48**
JGL 11111	-0.07	0.22**	-0.12**	0.01	-3.47	20.21**	-21.52**	-1.59
JGL 8605	0.34**	0.27**	0.65**	0.42**	51.71**	29.21**	16.48**	32.46**
JGL 8292	0.28**	-0.13**	-0.78**	0.20**	23.48**	-27.69**	3.98	-0.07
JGL 3855	-0.19**	-0.33**	0.10**	-0.14**	-35.72**	-32.89**	-8.32**	25.64**
JGL 3844	-0.46**	0.13**	0.59**	0.08**	-11.87	7.51*	18.68**	4.77
JGL 1798	-0.34**	-0.09	-1.08**	-0.50**	-19.38**	-17.65**	-5.62*	-0.42**
SE(Testers)	0.03	0.03	0.02	0.01	4.21	1.92	1.56	1.57
Gi-Gj	0.04	0.04	0.03	0.02	5.96	2.71	2.21	2.22
Crosses								
IR 68897A X JGL 11110-2	-0.23*	-0.02	0.94**	0.22**	-25.67	-11.76	11.18*	-8.74
IR 68897A X JGL11110-1	-1.05**	0.39**	-0.16*	-0.27**	-41.54**	9.00	-16.20**	-16.24**
IR 68897A X JGL17211	-0.85**	0.15	-0.76**	-0.48**	-14.22	9.20	-22.28**	-9.09
IR 68897A X JGL16284	2.09**	0.34**	0.76**	1.06**	101.02**	60.13**	23.15**	61.43**
IR 68897A X JGL13515	0.04	-0.86**	-0.78**	-0.53**	-19.59	-66.57**	4.15	-27.33**
IR 68897A X JGL11160	0.19	-0.08	1.30**	0.47**	-3.26	-22.06**	45.58**	6.75
IR 68897A X JGL11118	-1.70**	-0.56**	-0.30**	-0.85**	-64.17**	-26.80**	-63.30**	-51.42**
IR 68897A X JGL11111	0.80	-0.20	0.70**	0.43**	56.39**	12.90	93.12**	54.14**
IR 68897A X JGL8605	0.18	0.86**	-0.78**	0.08	35.85*	41.33**	-10.45	22.24**
IR 68897A X JGL8292	0.52	-0.01	-0.92**	-0.13**	-24.81	-5.37	-64.95**	-31.71**
IR 68897A X JGL3855	-1.30**	-0.08	-0.84**	-0.74**	-72.63**	-57.26**	-23.52**	-51.13**
IR 68897A X JGL3844	-0.39**	0.14	0.19*	-0.02	-17.99	-17.50*	-34.40**	-23.29**
IR 68897 A X JGL1798	0.01	-0.20	-0.74**	-0.31**	-53.31**	-4.30	-74.48**	-44.0**
APMS 8A X JGL 11110-2	0.35**	-0.11	0.55**	0.26**	56.73**	42.13**	47.45**	48.76**
APMS 8A X JGL11110-1	1.33**	0.25*	0.84**	0.80**	87.20**	36.93**	84.95**	69.69**
APMS 8A X JGL17211	-0.11	0.14	1.84**	0.62**	32.19*	69.04**	79.78**	60.33**
APMS 8A X JGL16284	-0.43**	-0.14	0.87**	0.09*	-4.55	-8.20	7.90	-1.61
APMS 8A X JGL13515	0.04	0.35**	-1.46**	-0.35**	-10.07	61.50**	-62.18**	-3.58
APMS 8A X JGL11160	1.45**	-0.02	-0.57**	0.28**	42.96**	-28.57**	10.75	8.37
APMS 8A X JGL11118	-0.94**	-0.33**	-0.68**	-0.65**	-60.53**	-93.77**	-36.25**	-63.51**
APMS 8A X JGL11111	0.46**	0.22*	0.20**	0.29**	-3.30	52.64**	-5.12	14.74**
APMS 8A X JGL8605	0.20	-0.30**	0.21**	0.03	25.80	-32.60**	-8.00	-4.93s

Table 4.22 (cont.)								
Crosses	**Panicle weight**				**No. of filled grains per panicle**			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
APMS 8A X JGL8292	0.30**	-0.08	-0.49**	-0.08	8.40	-16.90**	24.92**	5.47
APMS 8A X JGL3855	0.01	0.02	-0.40**	-0.12**	-25.77	7.53	-48.65**	-22.29**
APMS 8A X JGL3844	-0.98**	0.15	0.49**	-0.11*	-5.14	-10.67	36.85**	7.01
APMS 8A X JGL1798	-0.97**	-0.41**	-1.74**	-1.03**	-53.20**	-67.26	-81.12**	-67.19**
CMS 16A X JGL 11110-2	1.41**	0.44**	-0.10	0.58**	45.35**	60.50**	-4.00	33.94**
CMS 16A X JGL11110-1	0.84**	-0.47**	0.40**	0.25**	73.49**	-21.30**	43.92**	32.04**
CMS 16A X JGL17211	-0.35**	0.12	1.32**	0.36**	-14.30	36.13**	40.35**	20.72**
CMS 16A X JGL16284	-0.94**	0.32**	0.11	-0.16**	-51.34**	-8.07	0.85	-19.51**
CMS 16A X JGL13515	0.48**	-0.31**	0.33**	0.16**	12.30	113.44**	-6.22	39.84**
CMS 16A X JGL11160	-0.54**	0.50**	0.87**	0.27**	-28.07	-5.30	53.90**	6.84
CMS 16A X JGL11118	1.36**	0.66**	-0.13	0.63**	57.20**	2.90	-8.18	17.31**
CMS 16A X JGL11111	-0.66**	-0.28**	-0.08	-0.33**	-0.05	-42.67**	-37.75**	-26.82**
CMS 16A X JGL8605	-0.65**	-0.58**	-0.99**	-0.74**	-41.38**	-68.37**	-1.75	-37.16**
CMS 16A X JGL8292	0.34**	-0.16	-1.04**	-0.28**	64.42**	-50.06**	17.78**	10.71
CMS 16A X JGL3855	0.99**	-0.98**	-0.21**	-0.06	19.60	-30.80**	-7.60	-6.26
CMS 16A X JGL3844	-0.18	-0.15	0.09	-0.07	-77.71**	-43.10**	-0.68	-40.49**
CMS 16A X JGL1798	-1.17**	-0.46**	0.78**	-0.27**	-59.14**	-68.67**	-5.25	-44.38**
APMS 6A X JGL 11110-2	0.01	1.74**	0.37**	0.70**	52.83**	192.63**-	-4.25	-80.40**
APMS 6A X JGL11110-1	-0.04	0.60**	0.09	0.21**	-11.38	40.44**	-66.72**	-12.55*
APMS 6A X JGL17211	1.11**	0.58**	0.93**	0.87**	32.96*	-18.80**	38.40**	17.52**
APMS 6A X JGL16284	0.11	-0.30**	0.33**	0.04	20.78	-72.10**	52.82**	0.50
APMS 6A X JGL13515	-1.41**	-0.70**	-1.48**	-1.19**	-63.52**	-36.17**	-65.75**	-55.14**
APMS 6A X JGL11160	0.23*	-0.17	0.14	0.06	21.16	86.63**	41.25**	49.67**
APMS 6A X JGL11118	1.69**	-0.64**	0.56**	0.53**	47.31**	-52.66**	119.28**	37.98**
APMS 6A X JGL11111	0.07	0.27**	0.26**	0.19**	31.03*	61.10**	31.40**	41.17**
APMS 6A X JGL8605	-1.53**	-0.40**	-0.71**	-0.87**	-78.78**	-23.70**	-18.68**	-40.38**
APMS 6A X JGL8292	-0.42**	0.49**	-0.35	-0.09*	-13.45	35.73**	-70.25**	-15.99**
APMS 6A X JGL3855	0.19	0.29**	0.24	0.23**	13.89	-20.47**	-61.75**	-22.77**
APMS 6A X JGL3844	0.30**	0.39**	-1.12**	-0.14**	28.43	-14.96*	-32.42**	-6.31
APMS 6A X JGL1798	-0.56**	0.27**	-1.29**	-0.52**	-13.89	46.30**	-86.30**	-17.96**
IR 58025A X JGL 11110-2	-0.56**	0.00	0.48**	-0.02	-12.54	0.50	45.12**	11.02
IR 58025A X JGL11110-1	0.62**	-0.18	0.67*	0.37**	-0.71	-15.07*	31.05**	5.08
IR 58025A X JGL17211	0.20	-0.48**	1.26**	0.32**	-1.29	-16.77*	42.55**	8.16
IR 58025A X JGL16284	0.37**	-0.27**	0.15**	0.08	56.58**	-6.86	-20.92**	9.60
IR 58025A X JGL13515	-0.98**	0.04	-1.31**	-0.75**	-70.45**	16.40*	-76.30**	-43.45**
IR 58025A X JGL11160	-0.68**	0.94**	1.42**	0.55**	-36.01*	76.60**	-47.38**	-2.26
IR 58025A X JGL11118	-0.61**	-0.17	-0.52**	-0.43**	-28.06	-20.47**	112.55**	21.33**
IR 58025A X JGL11111	1.90**	-0.54**	0.27**	0.54**	77.95**	-65.67**	32.05**	14.77**
IR 58025A X JGL8605	-1.18**	0.62**	-0.65**	-0.40**	-71.79	7.30	-37.62**	-34.03**
IR 58025A X JGL8292	1.86**	-0.64**	0.05	0.42**	85.92**	-53.24**	164.50**	65.72**
IR 58025A X JGL3855	0.33**	-0.31**	0.85**	0.29**	66.37**	17.76*	-26.08**	19.35**
IR 58025A X JGL3844	-0.09	0.08	0.08	0.02	-31.55*	-11.31	-27.15**	-23.34**
IR 58025A X JGL1798	-0.92**	0.25	-0.33	-0.33**	-48.96**	39.49**	-73.65**	27.70**
SE	0.10	0.10	0.07	0.05	15.18	6.91	5.62	5.65
Sij-Skl	0.15	0.15	0.10	0.07	21.47	9.77	7.95	8.00
Sij-Sik	0.25	0.24	0.18	0.11	35.93	16.34	13.31	13.38

* Significant at 5% level; ** Significant at 1% level

Among the 65 hybrids studied for sca effects for panicle weight, 27 hybrids in pooled analysis had significant positive sca effects. The top 5 hybrids, which recorded highest positive sca effects are, IR 68897A x JGL 16284 (1.06), APMS 6A x JGL 17211 (0.87), APMS 8A x JGL 11110-1 (0.80), APMS 6A x JGL 11110-2 (0.70) and CMS 16A x JGL 11118 (0.63). The mean performance of these five top hybrids ranged between 3.64 to 3.99 gm.

Among the top five hybrids, 3 hybrids with parents IR 68897A x JGL 16284, APMS 8A x JGL 11110-1, APMS 6A x JGL 11110-2, CMS 16A x JGL 11118 with one of the parent having low gca effect, resulted in a hybrid with high sca effect. The one hybrid APMS 6A x JGL 17211 with low x low sca effects, resulted high sca effect in hybrid, indicating no correlation between gca and sca effects of parents and hybrids.(Table 4.25)

4.2.6.10 Number of filled grains per panicle

(a) gca effects

Among the testers IR 58025 A had significant gca effects at all the three locations and in pooled analysis. IR 68897A had significant gca effect at Kunaram, Kampasagar and pooled analysis, while in lines, 4 at Kunaram, 6 at Warangal, 3 at Kampasagar and 6 in pooled analysis had significant gca effects. The line JGL 8605 recorded significant positive gca effect all the three locations as well as in pooled analysis for number of filled grains per panicle (Table 4.22)

(b) sca effects

Out of 65 hybrids tested, 19 at Kunaram, 20 hybrids at Warangal, 23 hybrids at Kampasagar and 20 hybrids in pooled analysis recorded the significant sca effects for number of filled grains per panicle. The hybrids IR 68897A x JGL 16284, APMS 8A x JGL 11110-1 and IR 58025A x JGL 8292 recorded the significant positive sca effects at all the three locations i.e., Kunaram, Warangal, Kampasagar and also in pooled analysis for the character number of filled grains per panicle (Table 4.22).

For trait of number of filled grains per panicle which is one of the important components of the yield, among the hybrids, out of 65 tested, the hybrids, APMS 8A x JGL 11110-1 (69.69), IR 58025A x JGL 8292 (65.72), APMS 8A x JGL 17211 (60.33), IR 68897A x JGL 16284 (61.43) and IR 68897A x JGL 11111 (54.14) recorded high sca effects. The range of mean performance among these hybrids is between 179 grains/panicle to 353 grains/panicle.

Out of the five hybrids, the three hybrids IR 58025A x JGL 8292, IR 68897A x JGL 16284 and IR 68897A x JGL 11111 have one of the parent with high gca and another parent with low gca, resulted in hybrid with high sca effect, while in other two hybrids APMS 8A x JGL 17211 and APMS 8A x JGL 11110-1 the parents recorded low gca effects, lead to a hybrid with high sca effect for the character filled grains per panicle. There was no correlation to predict that, parents with significant positive gca effects combine to give rise to hybrids of significant positive sca effects. Involvement of at least one parent with high gca effects, indicating that a high general combiner in the cross combination might result in good specific combinations (Table 4.25). Peng and Virmani (1990) also reported the possibility of interaction between positive alleles from good combiner and negative alleles from poor combiner in high x low combiner crosses and suggested for exploitation of heterosis in F_1 generation.

4.2.6.11 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 (Table 4.23) 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

Table 4.23. Estimates of general and specific combining ability effects for spikelet fertility % and 1000-grain weight at Kunaram, Warangal and Kampasagar and over locations in rice

Parent/Cross	Spikelet fertility %				1000-grain weight			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
Testers								
IR 58025A	1.94**	-4.36**	-4.45**	-2.29**	0.57	0.95**	-0.18	0.44**
IR 68897A	1.64**	5.24**	3.05**	3.30**	0.06	-0.01	0.66**	0.23*
APMS 6A	-1.97**	-3.66**	-0.11	-1.91**	-0.61*	-0.78**	-1.07**	-0.81**
APMS 8A	-1.50**	-1.59**	0.05	-1.01**	-0.09	0.15	0.85**	0.30**
CMS 16A	-0.11	4.37**	1.47**	1.91**	0.06	-0.32**	-0.26	-0.17
SE(Lines)	0.71	0.46	0.61	0.36	0.48	0.15	0.25	0.16
Gi-Gj	2.00	0.66	0.86	0.50	0.68	0.32	0.36	0.23
Lines								
JGL 11110-2	3.93**	7.92**	0.81	4.21**	1.72**	0.35*	2.66**	-1.57**
JGL 11110-1	3.48**	-4.38**	-0.29	-0.39	1.79**	1.85**	6.36**	3.33**
JGL 17211	-2.27**	-7.28**	-7.89**	-5.81**	0.66	-0.05	2.16**	0.92**
JGL 16284	10.30**	-1.38**	4.01**	4.30**	-0.94	-0.45**	2.46**	0.35*
JGL 13515	0.82	7.52**	0.21	2.84**	-2.14**	-1.65**	-1.04**	-1.60**
JGL 11160	0.82	-7.28**	-5.69**	-4.05**	-0.81	-1.65**	1.06**	-0.46**
JGL 11118	3.94**	5.92**	6.51**	5.45**	-1.01*	-0.85**	-2.74**	-1.53**
JGL 11111	-13.88**	-9.38**	-3.59**	-8.95**	-0.08	0.15	0.96**	0.34*
JGL 8605	6.62**	3.22**	6.51**	5.45**	0.66	0.65**	-0.74**	0.19
JGL 8292	3.04**	-13.55**	-3.39**	-4.63**	0.06	0.75**	-2.94**	-0.70**
JGL 3855	-11.41**	5.45**	-1.19	-2.38**	0.46	1.05**	-3.94**	-0.80**
JGL 3844	6.29**	6.72**	3.81**	5.60**	0.06	-0.35*	-2.64**	-0.97**
JGL 1798	-11.68**	6.52**	0.21	-1.65**	-0.41	0.15	-1.64**	-0.63**
SE(Testers)	0.44	0.29	0.38	0.22	0.30	0.10	0.16	0.10
Gi-Gj	0.62	0.41	0.54	0.31	0.42	0.14	0.22	0.14
Crosses								
IR 68897A X JGL 11110-2	1.95	-1.34	-9.85**	-3.07**	1.23	3.15**	4.68**	3.0**
IR 68897A X JGL11110-1	-8.58**	-1.94	4.65**	-1.95*	-1.93	-2.39**	-2.16**	-2.16**
IR 68897A X JGL17211	6.87**	7.96**	3.81**	6.21**	-1.59	-2.12**	-1.43*	-1.71**
IR 68897A X JGL16284	7.25**	-1.11	-6.85**	-0.23	1.89	2.95**	2.65**	2.49**
IR 68897A X JGL13515	-7.50**	-3.57**	8.23**	-0.94	0.41	-1.58**	-3.74**	-1.63**
IR 68897A X JGL11160	0.90	5.96**	17.75**	8.20**	-0.17	1.15**	2.48**	1.15**
IR 68897A X JGL11118	-5.80**	-2.14*	-0.25	-2.7**	-0.33	0.11	1.14*	0.30
IR 68897A X JGL11111	-9.61**	-3.74**	5.41**	-2.64**	-1.33	-2.62**	-7.13**	-3.69**
IR 68897A X JGL8605	8.56**	2.69*	-21.25**	-3.33**	-0.51	-0.55	1.45*	0.13
IR 68897A X JGL8292	5.95**	-2.77**	-1.67	0.50	2.34*	1.92**	2.06**	2.10**
IR 68897A X JGL3855	9.52**	-1.14	1.35	3.24**	0.96	0.55	-3.82**	-0.77*
IR 68897A X JGL3844	1.45	-11.24**	12.85**	1.02	0.47	1.51**	1.34*	1.10**
IR 68897A X JGL1798	-33.37**	-5.84**	-33.49**	-24.23**	3.14**	1.78**	5.57**	3.49**
APMS 8A X JGL 11110-2	7.59**	11.59**	17.85**	12.34**	-2.37*	-1.65**	-0.35	-1.45**
APMS 8A X JGL11110-1	14.81**	6.63**	1.43	7.62**	-2.19*	-2.18**	-2.74**	-2.37**
APMS 8A X JGL17211	0.11	-14.04**	-1.55	-5.16**	-1.44	-1.55**	3.88**	0.29
APMS 8A X JGL16284	-0.32	8.86**	-6.55**	0.66	1.07	-1.09**	-2.96**	-0.99**
APMS 8A X JGL13515	2.02	10.76**	6.61**	6.46**	1.41	2.18**	4.77**	2.78**
APMS 8A X JGL11160	-2.02	5.19**	8.95**	4.04**	0.23	-0.25	-7.15**	-2.39**
APMS 8A X JGL11118	0.22	-10.77**	-7.47**	-6.00**	-1.26	0.72*	1.46*	0.30
APMS 8A X JGL11111	-24.82**	9.06**	4.75**	-3.66**	-0.57	-1.35**	1.38*	-0.18
APMS 8A X JGL8605	9.59**	-7.04**	3.25*	1.93*	-0.06	0.11	0.04	0.02

Table 4.23(cont.)								
Crosses	**Spikelet fertility %**				**1000-grain weight**			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
APMS 8A X JGL8292	14.02**	8.36**	8.91**	10.42**	-0.39	-0.62	-4.23**	-1.75**
APMS 8A X JGL3855	-3.88*	-4.71**	-8.75**	-5.77**	-0.24	-0.55	0.35	-0.14
APMS 8A X JGL3844	5.09**	-5.67**	-8.17**	-2.91**	1.27	2.42**	2.46**	2.05**
APMS 8A X JGL1798	-12.94**	-11.64**	-23.35**	-15.97**	-0.91	-0.85*	-3.72**	-1.82**
CMS 16A X JGL 11110-2	2.86	-5.24**	3.15*	0.25	-0.06	0.11	0.94	0.32
CMS 16A X JGL11110-1	-3.53*	17.66**	11.81**	8.64**	-0.06	-0.62	-0.83	-0.50
CMS 16A X JGL17211	8.00**	-12.41**	10.15**	1.91*	2.09	1.95**	4.25**	2.76**
CMS 16A X JGL16284	5.61**	11.63**	-1.77	5.15**	-1.06	-0.58	-0.64	-0.76*
CMS 16A X JGL13515	-11.57**	3.66**	0.95	-2.31**	-1.37	-0.15	2.08**	0.18
CMS 16A X JGL11160	0.45	1.06	-2.05	-0.17	1.14	1.31**	-3.26**	-0.27
CMS 16A X JGL11118	1.84	-9.04**	-5.89**	-4.36**	0.81	1.58**	-2.03**	0.11
CMS 16A X JGL11111	0.77	3.39**	2.45	2.20**	-0.37	-1.85**	0.05	-0.72*
CMS 16A X JGL8605	8.50**	0.93	4.53**	4.65**	-0.19	-0.88*	3.16**	0.69
CMS 16A X JGL8292	9.08**	5.46**	-0.45	4.69**	1.03	0.85*	-5.62**	-1.24**
CMS 16A X JGL3855	12.28**	17.36**	9.55**	13.06**	-0.13	-2.69**	3.54**	0.23
CMS 16A X JGL3844	-21.93**	-8.74**	-0.79	-10.48**	0.21	3.58**	2.27**	2.01**
CMS 16A X JGL1798	-17.24**	-28.81**	-11.45**	19.16**	-0.64	-0.35	4.35**	1.12**
APMS 6A X JGL 11110-2	17.81**	14.73**	3.13*	11.89**	-0.46	-1.38**	-4.54**	-2.12**
APMS 6A X JGL11110-1	0.75	-5.64**	5.95**	0.35	1.96	-2.15**	-1.92**	-0.70
APMS 6A X JGL17211	-5.46**	-5.74**	-5.05**	-5.41**	0.81	2.31**	6.24**	3.11**
APMS 6A X JGL16284	-3.33*	0.66	0.11	-0.85	-1.19	-1.42**	1.97**	-0.21
APMS 6A X JGL13515	4.73**	10.09**	-0.55	4.75**	-1.04	0.65	-1.95**	-0.78*
APMS 6A X JGL11160	3.30*	0.63	-0.47	1.15	-0.53	0.62	-4.34**	-1.41**
APMS 6A X JGL11118	-5.16**	2.12*	8.35**	1.77*	0.56	-0.75*	-2.72*	-0.97**
APMS 6A X JGL11111	4.57**	16.30**	-1.15	6.57**	-0.59	0.71*	1.44**	0.51
APMS 6A X JGL8605	0.09	-21.54**	-12.99**	-11.42**	-1.26	-0.52	-2.33**	-1.37**
APMS 6A X JGL8292	0.82	1.35	-5.15**	-0.99	0.56	-0.95**	0.25	-0.04
APMS 6A X JGL3855	-0.31	1.76	10.93**	4.12**	0.74	1.52**	3.36**	1.87**
APMS 6A X JGL3844	18.16**	3.13**	1.15	7.48**	-0.51	1.95**	1.28*	0.90*
APMS 6A X JGL1798	-28.83**	1.53	-16.85**	14.71**	-0.33	-0.09	-2.56**	-0.99**
IR 58025A X JGL 11110-2	20.70**	-9.56**	2.31	4.48**	1.67	0.68	3.17**	1.83**
IR 58025A X JGL11110-1	9.89**	2.86**	9.15**	7.30**	-0.17	-1.75**	-2.75**	-1.55**
IR 58025A X JGL17211	-19.92**	2.04	4.23**	-4.55**	-0.66	-0.78*	0.86	-0.19
IR 58025A X JGL16284	2.43	10.36**	7.15**	6.64**	-1.11	-1.65**	0.98	-0.59
IR 58025A X JGL13515	-4.70**	-9.74**	-0.85	-5.09**	0.74	0.81*	-2.86**	-0.43
IR 58025A X JGL11160	7.91**	7.16**	3.81//	6.29**	-0.26	-0.92**	-0.13	-0.43
IR 58025A X JGL11118	-2.96	6.59**	-3.35*	0.09	-0.44	0.15	-0.05	-0.11
IR 58025A X JGL11111	-2.68	-14.37**	-6.77**	-7.94**	1.07	1.62**	2.06**	1.58**
IR 58025A X JGL8605	11.58**	-5.94**	-12.25**	-2.20**	0.36	0.85*	0.98	0.73*
IR 58025A X JGL8292	22.49**	-2.04	-0.75	6.56**	-0.79	-0.69*	-0.86	-0.78*
IR 58025A X JGL3855	18.33**	5.86**	10.41**	11.53**	-1.13	-0.92**	0.37	-0.56
IR 58025A X JGL3844	-21.51**	3.29**	8.75**	-3.15**	1.03	2.15**	-1.05	0.70
IR 58025A X JGL1798	-30.89**	-1.17	-6.17**	-12.74**	0.54	-1.38**	0.56	-0.09
SE	1.58	1.04	1.37	0.79	1.08	0.35	0.57	0.36
Sij-Skl	2.23	1.47	1.93	1.12	1.52	0.49	0.80	0.51
Sij-Sik	3.73	2.46	3.23	1.88	2.55	0.82	1.34	0.86

* Significant at 5% level; ** Significant at 1% level

sca effects at three locations and in pooled analysis for spikelet fertility percentage (Table 4.23)

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 (Table 4.26). 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

Table 4.24. Estimates of general and specific combining ability effects for single plant yield and Productivity/ Day (kg / ha) at Kunaram, Warangal and Kampasagar and over locations in rice

Parent/Cross	Single plant yield				Productivity/ Day (kg / ha)			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
Testers								
IR 58025A	-0.11	-0.04	-0.16*	-0.10	-0.28	-2.16**	-1.48*	-1.30**
IR 68897A	-0.06	0.08	-0.11	-0.03	0.48	1.91**	0.53	0.97**
APMS 6A	0.60**	0.46**	0.55**	0.53**	1.19**	2.72**	1.80**	1.90**
APMS 8A	-0.30*	-0.61**	-0.10	-0.33**	-0.82*	-2.68**	0.18	-1.10**
CMS 16A	-0.13	0.11	-0.19**	-0.06	-0.57	0.21	-1.04	-0.46
SE(Lines)	0.19	0.25	0.10	0.12	0.56	0.85	0.97	0.52
Gi-Gj	0.26	0.35	0.15	0.17	0.79	1.21	1.37	0.74
Lines								
JGL 11110-2	-0.57**	-0.28	-0.62**	-0.48**	-0.34	2.78**	1.30	1.24*
JGL 11110-1	-0.52**	-0.23	-0.57**	-0.44**	3.61**	1.03	2.36*	2.33**
JGL 17211	2.07**	2.36**	2.02**	2.14**	6.62**	4.52**	5.76**	5.63**
JGL 16284	-0.37*	-0.08	-0.42**	-0.29*	-2.66**	-6.74**	-3.81**	-4.40**
JGL 13515	1.35**	1.64**	1.29**	1.42**	2.36**	12.06**	4.41**	6.27**
JGL 11160	-3.41**	-5.04**	-2.80**	-3.75**	-10.56**	-20.45**	-11.26**	14.08**
JGL 11118	-1.71**	-2.17**	-1.77**	-1.88**	-6.02**	-3.36**	-5.43**	-4.94**
JGL 11111	0.26	1.17**	0.20	0.54**	2.31**	0.94	1.44	1.56**
JGL 8605	3.34**	3.26**	3.29**	3.29**	8.56**	5.23**	10.10**	7.96**
JGL 8292	4.09**	3.41**	4.03**	3.84**	9.49**	10.35**	12.69**	10.84**
JGL 3855	-1.99**	-2.09**	-2.04**	-2.04**	-6.79**	-10.15**	-8.82**	-8.58**
JGL 3844	1.23**	1.52**	1.20**	1.32**	4.37**	8.66**	4.85**	5.96**
JGL 1798	-3.76**	-3.47**	-3.81**	-3.67**.	-10.95**	-4.87**	-13.59**	-9.80**
SE(Testers)	0.12	0.15	0.06	0.07	0.35	0.53	0.60	0.32
Gi-Gj								
Crosses								
IR 68897A X JGL 11110-2	0.08	0.00	0.12	0.06	0.33	-8.93**	-4.52*	-4.37**
IR 68897A X JGL11110-1	-0.81	-0.95	-0.74**	-0.83**	0.03	4.00*	1.68	1.90
IR 68897A X JGL17211	-2.76**	-2.62**	-2.72**	-2.17**	-10.02**	-4.48*	-9.16**	-7.88**
IR 68897A X JGL16284	2.23**	2.54**	2.02**	2.26**	6.34**	-1.77	3.70	2.75*
IR 68897A X JGL13515	1.27**	1.03	1.32**	1.20**	3.32**	11.18**	8.29**	7.59**
IR 68897A X JGL11160	0.71	0.63	0.74**	0.69*	4.39**	6.66**	6.15**	5.73**
IR 68897A X JGL11118	-5.10**	-5.24**	-5.04**	-5.12**	-12.50**	-13.29**	-13.83**	-13.20**
IR 68897A X JGL11111	0.35	0.50	0.41	0.41	-2.42	-3.87*	-3.29	-3.19**
IR 68897A X JGL8605	0.73	1.04	0.52*	0.76**	3.47**	4.30*	3.61	3.79**
IR 68897A X JGL8292	3.31**	3.08**	3.37**	3.25**	7.05**	6.19**	7.36**	6.87**
IR 68897A X JGL3855	-4.96**	-5.04**	-4.93**	-4.97**	-9.81**	-9.40**	-10.01**	-9.74**
IR 68897A X JGL3844	-2.82**	-2.97**	-2.79**	-2.85**	-4.02**	-6.79**	-8.66**	-6.48**
IR 68897A X JGL1798	-4.73**	-4.59**	-4.68**	-4.66**	-10.36**	-13.65**	-11.88**	-11.96**
APMS 8A X JGL 11110-2	6.97**	7.28**	6.80**	7.01**	13.67**	17.18**	16.10**	15.64**
APMS 8A X JGL11110-1	5.55**	5.31**	5.60**	5.48**	10.52**	12.66**	14.46**	12.54**
APMS 8A X JGL17211	0.85*	0.77	0.91**	0.84**	2.74*	1.93	2.47	2.37*
APMS 8A X JGL16284	0.30	0.16	0.35	0.27	1.18	7.88**	9.03**	6.02**
APMS 8A X JGL13515	3.94**	4.09**	4.00**	4.01**	9.53**	9.35**	9.45**	9.44**
APMS 8A X JGL11160	-1.42**	-1.10	-1.63**	-1.38**	-3.97**	-5.75**	-7.96**	-5.89**
APMS 8A X JGL11118	-3.68**	-3.92**	-3.63**	-3.74**	-9.48**	-13.41**	-12.98**	-11.95**
APMS 8A X JGL11111	1.48**	1.40*	1.53**	1.46**	3.38**	12.06**	0.76	5.40**
APMS 8A X JGL8605	3.96**	3.82**	4.00**	3.93**	8.94**	1.71	11.09**	7.24**

Table 4.24(cont.)								
Crosses	**Single plant yield**				**Productivity/ Day (kg / ha)**			
	KNM	WGL	KSR	POOLED	KNM	WGL	KSR	POOLED
APMS 8A X JGL8292	-2.74**	-2.60**	-2.70**	-2.68**	-6.96**	-5.04**	-5.10*	-5.70**
APMS 8A X JGL3855	0.71	1.02	0.51*	0.74**	2.73*	9.98**	5.56*	6.09**
APMS 8A X JGL3844	-3.40**	-3.64**	-3.35**	-3.46**	-8.09**	-18.71**	-12.31**	-13.03**
APMS 8A X JGL1798	-2.62**	-0.78	-3.24**	-2.20**	-7.00**	-3.62	-12.36**	-7.65**
CMS 16A X JGL 11110-2	0.47	2.24**	-0.15	0.85**	0.73	1.44	-3.50	-0.44
CMS 16A X JGL11110-1	0.81	1.90**	0.18	0.96**	1.56	19.16**	9.32**	10.01**
CMS 16A X JGL17211	-1.77**	-7.18**	0.70**	-2.75**	-3.45**	-25.40**	0.32	-9.51**
CMS 16A X JGL16284	3.11**	3.82**	2.50**	3.14**	8.15**	8.42**	6.22**	7.59**
CMS 16A X JGL13515	2.93**	2.64**	2.99**	2.85**	6.35**	19.64**	15.73**	13.90**
CMS 16A X JGL11160	0.16	-0.20	0.21	0.05	0.64	-12.55**	-4.03**	-5.31**
CMS 16A X JGL11118	1.91**	1.84**	1.97**	1.90**	4.60**	-3.04	2.49	1.35
CMS 16A X JGL11111	-1.24**	-1.88**	-1.45**	-1.52**	-2.44	-1.40	-0.08	-1.30
CMS 16A X JGL8605	-3.76**	-2.40**	-3.72**	-3.29**	-9.15**	-2.65	-14.12**	-8.63**
CMS 16A X JGL8292	-3.19**	-2.27**	-3.11**	-2.85**	-10.23**	-9.37**	-14.18**	-11.26**
CMS 16A X JGL3855	1.63**	0.40	1.66**	1.23**	8.41**	17.43**	15.32**	13.72**
CMS 16A X JGL3844	-0.40	-2.03**	-0.35	-0.92**	-1.38	-10.98**	-2.19	-4.84**
CMS 16A X JGL1798	-2.93**	-0.58	-3.15**	-2.22**	-10.21**	-8.22**	-13.98**	-10.80**
APMS 6A X JGL 11110-2	4.90**	4.47**	4.94**	4.77**	13.41**	11.13**	15.03**	13.18**
APMS 6A X JGL11110-1	3.10**	1.91**	3.14**	2.71**	7.86**	6.77**	7.46**	7.36**
APMS 6A X JGL17211	-1.42**	0.26	-1.36**	-0.84**	-4.69**	-0.58	-8.56**	-4.6**
APMS 6A X JGL16284	2.27**	1.18*	2.32**	1.92**	4.34**	0.69	4.65*	3.22**
APMS 6A X JGL13515	-1.64**	-1.13*	-1.86**	-1.54**	-4.21**	0.06	-4.15	-2.76*
APMS 6A X JGL11160	-2.31**	-2.22**	-2.24**	-2.25**	-3.30**	-6.95**	0.60	-3.21**
APMS 6A X JGL11118	0.55	0.47	0.60*	0.54*	2.68*	-1.20	5.03*	2.17
APMS 6A X JGL11111	2.47**	2.33**	2.53**	2.44**	4.93**	18.94**	5.85**	9.90**
APMS 6A X JGL8605	1.59**	1.74**	1.64**	1.65**	3.91**	0.09	4.22	2.74*
APMS 6A X JGL8292	0.39	0.70	0.17	0.41	1.01	4.87*	0.69	2.19
APMS 6A X JGL3855	-5.00**	-5.24**	-4.95**	-5.06**	-12.54**	-22.70**	-15.80**	-17.01**
APMS 6A X JGL3844	-0.73	-1.39*	-0.68**	-0.93**	-1.42	-0.85	-1.18	-1.15
APMS 6A X JGL1798	-0.41	-1.14*	-0.36	-0.63*	-1.42	-9.10**	-1.59	-4.03**
IR 58025A X JGL 11110-2	0.08	0.61	0.13	0.27	0.03	-1.80	-0.27	-0.67
IR 58025A X JGL11110-1	0.53	1.23*	0.32	0.69*	1.09	2.83	-0.16	1.25
IR 58025A X JGL17211	0.53	0.68	0.59*	0.60*	1.72	8.92**	3.21	4.61**
IR 58025A X JGL16284	2.23**	2.15**	2.28**	2.22**	2.97*	-0.66	6.63**	2.98*
IR 58025A X JGL13515	0.27	0.12	0.33	0.23	-3.54**	-12.41**	-3.41	-6.45**
IR 58025A X JGL11160	-0.88*	-0.74	-0.82**	-0.81**	5.94**	5.36**	0.99	4.09**
IR 58025A X JGL11118	-1.30**	-0.99	-1.50**	-1.25**	-2.08	3.85*	-0.85	0.30
IR 58025A X JGL11111	-0.32	-0.55	-0.29	-0.38	-3.29**	3.86*	-3.35	-0.92
IR 58025A X JGL8605	-0.42	-0.50	-0.37	-0.43	-2.24	-13.02**	-1.98	-5.74**
IR 58025A X JGL8292	1.31**	1.17*	1.36**	1.37**	1.30	3.30	0.61	1.73
IR 58025A X JGL3855	0.57	0.71	0.61**	0.63*	1.20	8.20**	0.77	3.39**
IR 58025A X JGL3844	-1.26**	-0.95	-1.47**	-1.22**	-1.95	-0.53	-2.79	-1.75
IR 58025A X JGL1798	-0.20	-0.43	-0.14	-0.25	1.68	2.06	3.38	2.37*
SE	0.42	0.55	0.23	0.27	1.25	1.91	2.17	1.17
Sij-Skl	0.59	0.78	0.33	0.38	1.77	2.70	3.06	1.65
Sij-Sik	0.98	1.31	0.55	0.64	2.96	4.52	5.13	2.77

* Significant at 5% level; ** Significant at 1% level

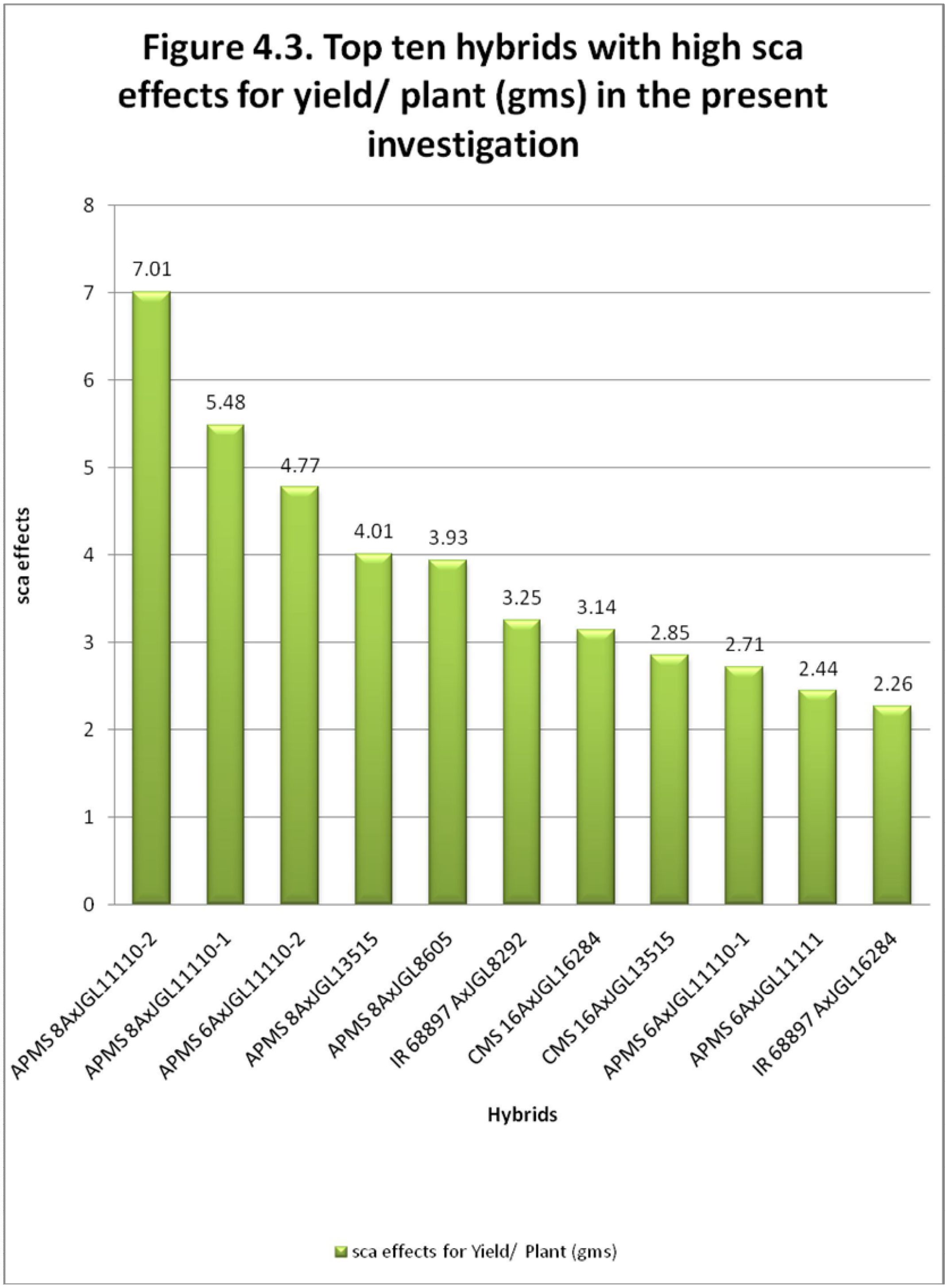


Figure 4.3. Top ten hybrids with high sca effects for yield/ plant (gms) in the present investigation
sca effects
0
1
2
3
4
5
6
7
8
7.01
5.48
4.77
4.01
3.93
3.25
3.14
2.85
2.71
2.44
2.26
APMS 8AxJGL11110-2
APMS 8AxJGL11110-1
APMS 6AxJGL11110-2
APMS 8AxJGL13515
APMS 8AxJGL8605
IR 68897 AxJGL8292
CMS 16AxJGL16284
CMS 16AxJGL13515
APMS 6AxJGL11110-1
APMS 6AxJGL11111
IR 68897 AxJGL16284
Hybrids
sca effects for Yield/ Plant (gms)

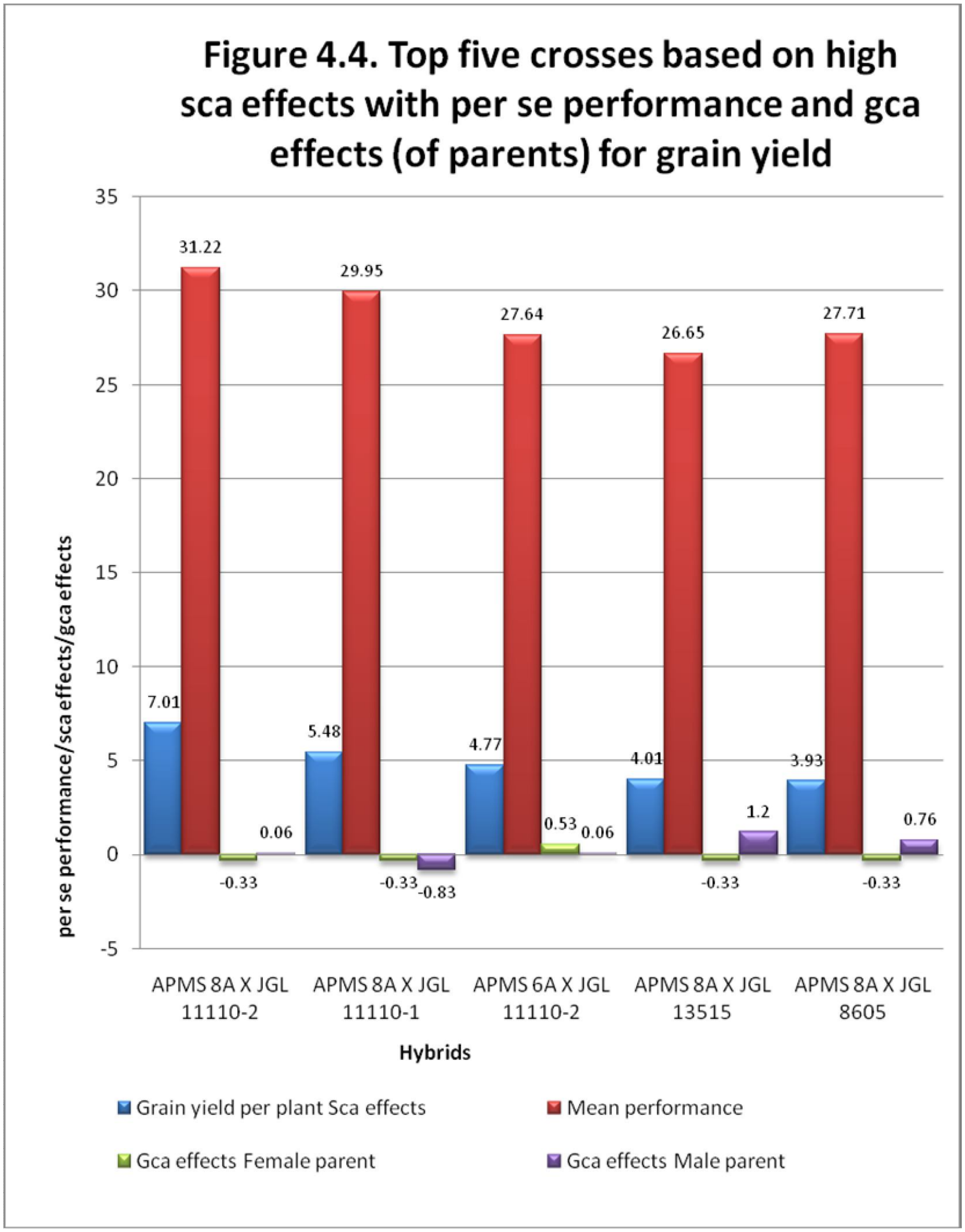


Figure 4.4. Top five crosses based on high sca effects with per se performance and gca effects (of parents) for grain yield
35
30
25
20
15
10
5
0
-5
per se performance/sca effects/gca effects
31.22
29.95
27.64
26.65
27.71
7.01
5.48
4.77
4.01
3.93
0.06
0.53
0.06
1.2
0.76
-0.33
-0.33
-0.83
-0.33
-0.33
APMS 8A X JGL 11110-2
APMS 8A X JGL 11110-1
APMS 6A X JGL 11110-2
APMS 8A X JGL 13515
APMS 8A X JGL 8605
Hybrids
Grain yield per plant Sca effects
Mean performance
Gca effects Female parent
Gca effects Male parent

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.

4.2.6.14 Productivity/day (kg/ha)

(a) gca effects

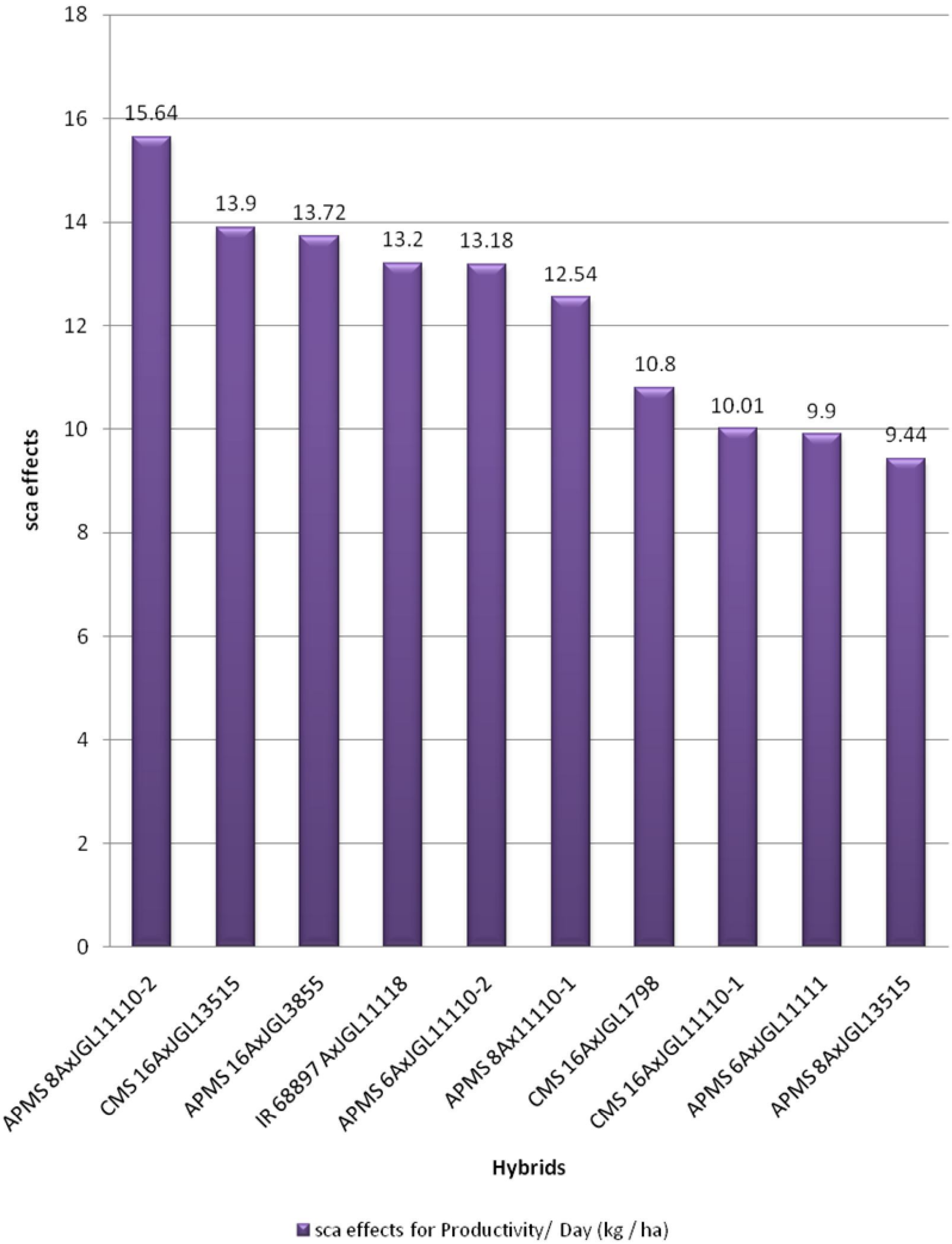
Among the testers APMS 6A recorded significant positive gca effects at Kunaram, Warangal and in pooled analysis. IR 68897A had significant positive gca effect at Warangal and in pooled analysis.

Among the lines, 7 at Kunaram, 6 at Warangal, 6 at Kampasagar and 9 in pooled analysis had significant positive gca effect. The lines JGL 17211, JGL 13515, JGL 8605, JGL 8292 and JGL 3844 recorded significant positive gca effects at all the three locations as well as in pooled analysis.

(b) sca effects

Out of 65 hybrids tested 24 at Kunaram, 23 at Warangal, 18 at Kampasagar and 29 in pooled analysis recorded significant positive sca effects. The hybrids APMS 8A x JGL 11110-2, APMS 8A x JGL 11110-1, APMS 8A x JGL 13515, CMS 16A x JGL 3855, APMS 6A x JGL 11110-2, APMS 6A x JGL 111109-1, IR 68897A x JGL 13515, x JGL 11160, x JGL 8292, APMS 8A x JGL 3855, CMS 16A x JGL16284, CMS 16A x JGL13595 and APMS 6A x JGL 11111 had significant sca effects at all the three locations and in pooled analysis for productivity/day (Table 4.24).

Figure 4.5.Top ten hybrids with high sca effects for productivity/ day (kg / ha) in the present investigation



The productivity/day indicates the economic yield per unit time which determines the worthiness of a short duration hybrid. Out of 65 hybrids tested 29 hybrids recorded significant positive sca effects, in pooled analysis for the character, among these top five hybrids with high sca effects are, APMS 8A x JGL 11110-2 (15.64), CMS 16A x JGL 13515 (13.90), CMS 16A x JGL 3855 (13.72), IR 68897A x JGL 11118 (13.20) and APMS 6A x JGL 11110-2 (13.18), with a mean performance ranged from 69.75 kg/ha to 99.82 kg/ha(Table 4.25). Out of 5 top hybrids, one hybrid, the parents recorded high gca, resulted in hybrid with high sca effect, which may be due to additive x additive gene action. In the two hybrids, the parents recorded with high or low gca effects, resulted in hybrids with high sca, which may be due to predominance of dominant alleles, while in other two hybrids, the parents recorded low gca effects resulting in hybrids with high sca, which may be due to accumulation and interaction of favourable alleles and due to non-additive gene action. Similar results of high x low or low x low or high x high gca combinations were reported by Raju *et al.* 2006 and 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.

It is not necessary that the parents involved in the cross combinations should have high gca effects to get significant sca effects. The reason ascribed is due to positive interaction between nuclear and cytoplasmic genes appear to be important that the interaction between nuclear genes alone.

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 (Table 4.26).

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

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 Female parent	Male parent	Gca status
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

Table 4.25(cont.)

Character/ cross			***Sca* effects**	**Mean performance**	***Gca* effects Female parent**	**Male parent**	**Gca status**
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

* Significant at 5% level; ** Significant at 1% level

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

Table 4.26. Promising general and specific combiners for yield and yield contributing traits in rice

General combiners		
S.NO	**PARENTS**	**CHARACTERS**
1	JGL 8292	Plant height, Productivity per day, Panicle length, Panicle weight, Spikelet fertility, Grain yield per plant, 1000-grain weight.
2	JGL 8605	Plant height, Flag leaf width, Productive tillers per plant, Panicle weight, Filled grains per panicle, Spikelet fertility, Grain yield per plant, Productivity per day.
3	JGL 17211	Flag leaf width, Productive tillers per plant,1000-grain weight, Panicle weight, Spikelet fertility, Filled grains per panicle, Grain yield per plant, Productivity per day.
4	JGL 13515	Days to 50% flowering, Plant height, 1000-grain weight, Panicle weight, Spikelet fertility, Grain yield per plant, Productivity per day.
5	JGL 3844	Plant height, Panicle length, Panicle weight, Filled grains per panicle, Productivity per day, Grain yield per plant, Spikelet fertility.
6	APMS 6A	1000-grain weight, Panicle weight, Filled grains per panicle, Spikelet fertility, Grain yield per plant, Productivity per day.

Specific combiners				
S.NO	**CROSS COMBINATION**			**CHARACTERS**
1	APMS 8A	X	JGL 11110-2	Panicle weight, Spikelet fertility, Filled grains per panicle, Grain yield per plant, Productivity per day.
2	APMS 8A	X	JGL 11110-1	Panicle weight, Flag leaf length, Flag leaf width, Filled grains per panicle, Spikelet fertility, Grain yield per plant, Productivity per day.
3	APMS 6A	x	JGL 11110-2	Panicle weight, Spikelet fertility, Grain yield per plant, Productivity per day
4	APMS 8A	x	JGL 13515	Spikelet fertility, 1000-grain weight, Grain yield per plant, Productivity per day.
5	APMS 8A	x	JGL 8605	Flag leaf width, Grain yield per plant
6	IR 68897A	x	JGL 8292	Panicle length,1000-grain weight, Productivity per day Grain yield per plant,
7	CMS 16A	x	JGL16284	Productive tillers per plant, Flag leaf width, Spikelet fertility, Productivity per day, Grain yield per plant.
8	CMS 16A	x	JGL13515	Days to 50% flowering, Panicle weight, Flag leaf width, Filled grains per panicle, Grain yield per plant Productivity per day.
9	APMS 6A	x	JGL11110-1	Panicle length, Productive tillers per plant, Panicle weight, Flag leaf width, Productivity per day.
10	APMS 6A	x	JGL11111	Panicle weight, Flag leaf length, Filled grains per panicle, Spikelet fertility, Grain yield per plant, Productivity per day.

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 (Table 4.26)..

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.

4.2.7 Heterosis

Heterosis is an universal phenomena and exploitation of heterosis is a quick and convenient way of combining desirable characters and hence assumes greater significance in the development of hybrids. It is often exploited to increase the yield potential of crop plants where there is a availability of cytoplasmic male sterility and fertility restoration systems. Hybrids have become an integral part of agricultural to boost productivity as they would respond very well to higher fertilizer levels.

High heterosis for grain yield in rice is due to simultaneous heterosis for more than one trait. Hence, in the present study an attempt was made to measure the magnitude of heterosis in rice due to emphasis laid on contributions of different morphological traits.

The commercial exploitation of heterosis in rice has been a recent development. It is obviously important that the crosses are compared with released hybrids rather than merely comparing with their mid/better parent. So in the present study the performance of the experimental crosses were compared with that of the most popular released hybrids *viz.*, KRH-2 and PA 6201 in order to estimate the magnitude of standard heterosis. The crosses with high heterotic potential could be isolated for further evaluation at different locations and seasons.

In present investigation, efforts were made to know the nature and magnitude of heterosis and in the form of average heterosis, heterobeltiosis and standard heterosis for single plant yield and its components in 65 rice hybrids at three locations and in pooled analysis. Heterosis is estimated in 65 hybrids for 12 characters *viz.*, days to 50% flowering, plant height, productive tillers/plant, flag leaf length, flag leaf width, panicle length, panicle weight, filled grains/panicle, spikelet fertility percentage, 1000 grain weight, yield per plant and productivity/day in three locations and expressed as a average heterosis, Heterobeltiosis and standard heterosis over check PA 6201. The negative heterotic values for days to 50% flowering and plant height indicates earliness and short stature which are desirable. For other characters positive estimates were considered as desirable. The character wise performance of hybrid is presented in table 4.27 to 4.39.

4.2.7.1 Days to 50% flowering: At Kunaram 32 hybrids (Table 4.28) recorded significant negative average heterosis ranging from -3.12 (APMS 6A x JGL 16284) to -18.51 (IT 58025A x JGL 11160). Significant negative heterobeltiosis was observed in 41 hybrids, ranged from -3.71 (APMS 8A x JGL 11110-2) to -22.29 (IR 58025A x JGL 11160). The significant negative standard heterosis was recorded in 8 hybrids ranged from -5.50 (IR 68897A x JGL 11110-1) to -13.75 (IR 58025A x JGL 11160). At Warangal, 39 hybrids recorded significant negative average heterosis, ranged from -22.95 (IR 58025A x JGL 3855) to- 2.57 (APMS 6A x JGL 11160). Significant negative heterobeltiosis was observed in 45 hybrid ranging from -24.92 (IR 58025A x JGL 3855) to -1.59 (IR 68897A XJGL16284). The significant negative standard heterosis, ranged from -15.16 (IR 58025A x JGL 3855) to -2.53 (IR 58025A x JGL 17211) i.e. in 22 hybrids, when compared with check PA 6201.

At Kampasagar, 14 hybrids recorded significant negative average heterosis, ranged from -13.19 (APMS 6A x JGL 11160) to -8.84 (IR 68897A x JGL 17211). Significant negative heterobeltiosis was observed in 19 hybrids ranging from -16.31 (CMS 16A x JGL 3855) to -9.48 (IR 58025A x JGL 3844). The significant negative standard heterosis is recorded in 3 hybrids, which ranged from -12.69 (IR 68897A x JGL 11118) to -10.00 (IR 68897A x JGL 11110-1) when compared with best check PA 6201.

In pooled analysis for days to 50% flowering 38 hybrids recorded significant average negative heterosis, ranging from -16.42 (IR 58025A x JGL 11160) to -2.50 (APMS 58025A x JGL 11110-1). The significant negative heterobeltiosis was recorded in 41 hybrids which, ranged from -18.24 (IR 58025A x JGL 11160) to -3.18 (APMS 58025Ax JGL 11110-1). The negative standard heterosis was observed in 11 hybrids which ranged from -11.98 (IR 68897A x JGL 11118) to -3.57 (APMS 8A x JGL 3855), when compared with check PA 6201 (Table 4.27).

Early maturing hybrids are desirable as they produce more yields per day and fit well in multiple cropping systems.Majority of the hybrids exhibited significant negative values of heterosis and heterobeltiosis imply early flowering in hybrids. Significant positive and negative heterosis and heterobeltiosis for this trait was reported by Deoraj *et al*. (2007) and Roy *et al.* (2009). Out of 65 hybrids, the significant negative standard heterosis was observed in 11 hybrids over check PA 6201. Highest significant negative standard heterosis (-11.98), heterobeltiosis (-17.50) and average heterosis (-15.55) was observed in IR 68897Ax JGL 11118. The other hybrids IR 68897A x JGL 11110-1 (-9.44), IR 58025A x JGL 11160 (-9-18), IR68897A x JGL 11160 (-7.55) and IR 68897A x JGL 8605 (-5.9) also reported negative standard heterosis over check PA 6201 (Table 4.39 and Figure 4.7). Presence of both negative and positive standard heterosis of similar magnitude was observed in their studies by Mishra and Pandey (1998), Singh *et al*. (2006), Deoraj *et al.*(2007), Rosamma and Vijay Kumar (2007) and Akarsh Parihar and Palhak (2008).

Table 4.27. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA-6201) for days to 50% flowering at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-7.03**	-8.78**	0.00	2.13**	0.65	12.64**
IR 68897A	X	JGL11110-1	-6.46**	-10.42**	-5.50**	-22.88**	-23.49**	-13.00**
IR 68897A	X	JGL17211	0.00	-2.48	8.25**	-20.06**	-20.45**	-10.11**
IR 68897A	X	JGL16284	-8.40**	-10.80**	-0.69	-0.80	-1.59*	11.91**
IR 68897A	X	JGL13515	-6.69**	-8.72**	0.69	-19.68**	-19.68**	-10.11**
IR 68897A	X	JGL11160	-17.36**	-19.44**	-11.68**	-12.99**	-14.92**	-3.25**
IR 68897A	X	JGL11118	-12.67**	-15.84**	-12.37**	-21.59**	-21.59**	-10.83**
IR 68897A	X	JGL11111	-7.03**	-9.91**	0.00	-7.01**	-7.30**	5.42**
IR 68897A	X	JGL8605	-16.43**	-19.14**	-9.97**	-12.38**	-12.38**	-0.36
IR 68897A	X	JGL8292	-9.94**	-12.46**	-3.44	-6.56**	-7.30**	5.42**
IR 68897A	X	JGL3855	-13.56**	-15.05**	-6.87**	-10.64**	-11.94**	-1.44
IR 68897A	X	JGL3844	-9.00**	-12.99**	-7.90**	-11.36**	-12.06**	0.00
IR 68897A	X	JGL1798	-10.94**	-13.00**	-3.44	-9.15**	-9.58**	2.17*
APMS 8A	X	JGL11110-2	-1.27	-3.70*	7.22**	2.08**	1.27	15.16**
APMS 8A	X	JGL11110-1	-1.11	-3.12	6.87**	0.65	0.65	12.64**
APMS 8A	X	JGL17211	-3.32*	-4.08*	5.15*	5.98**	5.98**	15.16**
APMS 8A	X	JGL16284	1.85	-3.50	4.12*	-11.04**	-13.02**	-1.08
APMS 8A	X	JGL13515	-1.73	-3.10	7.56**	3.58**	1.60*	14.80**
APMS 8A	X	JGL11160	-1.57	-3.09	7.90**	4.55**	2.22**	16.25**
APMS 8A	X	JGL11118	-0.79	-1.87	8.25**	2.45**	0.97	13.00**
APMS 8A	X	JGL11111	-3.76*	-3.76*	5.50**	-20.00**	-22.84**	-9.75**
APMS 8A	X	JGL8605	2.33	-3.76*	5.50**	-7.98**	-9.26**	6.14**
APMS 8A	X	JGL8292	-4.05*	-4.64*	5.84**	-22.76**	-24.07**	-11.19**
APMS 8A	X	JGL3855	-6.69**	-7.41**	3.09	-22.69**	-23.77**	-10.83**
APMS 8A	X	JGL3844	-5.00**	-5.30**	4.47*	-11.04**	-12.96**	1.81*
APMS 8A	X	JGL1798	2.25	-0.31	9.28**	1.46*	-0.95	13.00**
CMS 16A	X	JGL11110-2	6.51**	2.64	6.87**	0.79	0.63	14.80**
CMS 16A	X	JGL11110-1	1.60	-1.55	9.28**	-22.42**	-22.78**	-11.91**
CMS 16A	X	JGL17211	-2.07	-5.25**	5.50**	0.16	0.00	14.08**
CMS 16A	X	JGL16284	-0.32	-3.12	6.87**	0.96	0.00	14.08**
CMS 16A	X	JGL13515	6.76**	-0.94	8.59**	-16.72**	-18.94**	-11.91**
CMS 16A	X	JGL11160	9.75**	8.19**	4.47*	3.00**	-1.90*	11.55**
CMS 16A	X	JGL11118	5.03**	-3.10	7.56**	-0.33	-4.79**	7.58**
CMS 16A	X	JGL11111	2.51	-5.56**	5.15*	-17.67**	-21.59**	-10.83**
CMS 16A	X	JGL8605	4.71**	-3.12	6.87**	-17.98**	-21.29**	-11.91**
CMS 16A	X	JGL8292	-4.13*	-5.33**	3.78	8.01**	2.99**	11.91**
CMS 16A	X	JGL3855	-10.81**	-15.11**	-9.28**	-18.03**	-23.49**	-13.00**
CMS 16A	X	JGL3844	-7.57**	-9.29**	0.69	4.44**	-2.24**	10.47**
CMS 16A	X	JGL1798	-3.31*	-5.25**	5.50**	10.20**	2.86**	16.97**
APMS 6A	X	JGL11110-2	-9.18**	-10.59**	-1.37	5.32**	-0.97	10.83**
APMS 6A	X	JGL11110-1	-6.27**	-6.27**	2.75	0.82	-0.96	11.55**
APMS 6A	X	JGL17211	0.33	-5.64**	3.44	-3.35**	-3.81**	9.39**
APMS 6A	X	JGL16284	-3.12*	-3.72*	6.87**	-0.80	-0.96	11.91**

Table 4.27 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-7.00**	-7.72**	2.75	-6.86**	-7.30**	5.42**
APMS 6A	X	JGL11160	-10.94**	-11.21**	-2.06	-2.57**	-2.88**	9.39**
APMS 6A	X	JGL11118	-4.81**	-6.90**	2.06	-0.49	-1.94*	9.75**
APMS 6A	X	JGL11111	4.78**	0.66	5.50**	-18.40**	-19.05**	-7.94**
APMS 6A	X	JGL8605	-2.55	-5.26**	5.15*	-2.73**	-3.19**	9.39**
APMS 6A	X	JGL8292	-3.34*	-6.17**	4.47*	-9.76**	-10.48**	1.81*
APMS 6A	X	JGL3855	-2.56	-4.98**	4.81*	-0.32	-0.32	11.55**
APMS 6A	X	JGL3844	-3.30*	-3.45	5.84**	-7.29**	-9.49**	3.25**
APMS 6A	X	JGL1798	3.17	-2.83	6.19**	-1.11	-1.27	12.64**
IR 58025A	X	JGL11110-2	-2.03	-2.79	7.90**	-2.70**	-3.16**	10.47**
IR 58025A	X	JGL11110-1	-2.49	-3.40	7.56**	-3.96**	-4.11**	9.39**
IR 58025A	X	JGL17211	-2.97	-3.43	6.53**	-13.74**	-14.56**	-2.53**
IR 58025A	X	JGL16284	0.33	-3.76*	5.50**	-0.16	-1.92*	10.47**
IR 58025A	X	JGL13515	9.06**	6.83**	7.56**	-0.48	-0.95	12.64**
IR 58025A	X	JGL11160	-18.51**	-22.29**	-13.75**	-21.28**	-21.41**	-11.19**
IR 58025A	X	JGL11118	-7.62**	-12.04**	-2.06	-20.26**	-20.63**	-9.75**
IR 58025A	X	JGL11111	0.33	-4.05*	5.84**	-18.01**	-18.27**	-7.94**
IR 58025A	X	JGL8605	4.25*	0.00	9.62**	4.35**	3.65**	12.64**
IR 58025A	X	JGL8292	11.15**	8.87**	9.62**	-17.32**	-19.68**	-8.66**
IR 58025A	X	JGL3855	1.62	-3.10	7.56**	-22.95**	-24.92**	-15.16**
IR 58025A	X	JGL3844	-2.43	-7.10**	3.44	-20.26**	-22.54**	-11.91**
IR 58025A	X	JGL1798	-3.91*	-8.10**	1.37	-19.93**	-21.61**	-12.27**
Hybrid			**Kampasagar**			**Pooled**		
			Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
IR 68897A	X	JGL11110-2	0.16	-1.09	6.00	-1.62	-2.19	6.11**
IR 68897A	X	JGL11110-1	-10.03 **	-13.86 **	-10.00 **	-13.34**	-15.54**	-9.44**
IR 68897A	X	JGL17211	-8.84 **	-10.85 **	-2.55	-9.60**	-11.16**	-1.33
IR 68897A	X	JGL16284	-5.65	-7.65 *	0.76	-4.96**	-6.72**	3.87*
IR 68897A	X	JGL13515	-12.18 **	-13.80 **	-6.48	-12.82**	-14.00**	-5.22**
IR 68897A	X	JGL11160	-11.81 **	-13.71 **	-7.52 *	-14.07**	-14.78**	-7.55**
IR 68897A	X	JGL11118	-11.87 **	-14.86 **	-12.69 **	-15.55**	-17.50**	-11.98**
IR 68897A	X	JGL11111	-3.19	-6.18	2.55	-5.76**	-7.62**	2.61
IR 68897A	X	JGL8605	-12.22 **	-14.85 **	-7.10	-13.66**	-15.49**	-5.90**
IR 68897A	X	JGL8292	-3.33	-5.98	2.00	-6.63**	-8.2**	1.26
IR 68897A	X	JGL3855	-11.15 **	-11.84 **	-5.52	-11.80**	-12.12**	-4.66**
IR 68897A	X	JGL3844	0.69	-4.05	1.24	-6.68**	-9.24**	-2.26
IR 68897A	X	JGL1798	-9.21 **	-10.79 **	-2.48	-9.77**	-1.14**	-1.31
APMS 8A	X	JGL11110-2	2.44	0.76	9.93 **	1.07	-0.59	10.70**
APMS 8A	X	JGL11110-1	1.39	0.00	8.48 *	0.30	-0.85	9.28**
APMS 8A	X	JGL17211	0.48	0.32	7.86 *	0.97	0.75	9.30**
APMS 8A	X	JGL16284	-7.91 *	-13.02 **	-6.48	-5.76**	-8.48**	-1.14
APMS 8A	X	JGL13515	1.84	1.01	10.41 **	1.20	-0.19	10.86**
APMS 8A	X	JGL11160	1.18	0.44	9.59 *	1.35	-0.17	11.17**
APMS 8A	X	JGL11118	1.02	0.57	9.10 *	.88	-0.13	10.07**
APMS 8A	X	JGL11111	1.41	0.89	9.24 *	-7.43**	-8.69**	1.84
APMS 8A	X	JGL8605	1.49	-4.46	3.45	-1.54	-5.85**	5.01**

Table 4.27 (cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-10.87 **	-11.29 **	-3.03	-12.54**	-12.43**	-2.66
APMS 8A	X	JGL3855	-11.04 **	-11.38 **	-3.31	-13.47**	-13. 54* *	-3.57*
APMS 8A	X	JGL3844	-3.79	-3.88	4.28	-6.61**	-7.17**	3.54*
APMS 8A	X	JGL1798	6.22 *	4.44	11.93 **	3.30*	2.66	11.38**
CMS 16A	X	JGL11110-2	9.70 **	5.46	9.24 *	5.52**	2.87	10.23**
CMS 16A	X	JGL11110-1	-5.15	-7.63 *	0.97	-8.69**	-10.30**	-0.37
CMS 16A	X	JGL17211	1.36	-1.20	7.79 *	-0.19	-2.07	9.04**
CMS 16A	X	JGL16284	2.89	0.57	9.10 *	1.17	-0.23	9.95**
CMS 16A	X	JGL13515	-5.02	-10.42 **	-4.00	-4.95**	-9.93**	-2.28
CMS 16A	X	JGL11160	12.78 **	12.41 **	7.45	8.36**	5.89**	7.76**
CMS 16A	X	JGL11118	5.06	-1.83	7.31	3.25*	-3.23*	7.48**
CMS 16A	X	JGL11111	-8.01 *	-13.97 **	-6.14	-7.74**	-13.63**	-3.82*
CMS 16A	X	JGL8605	3.32	-3.12	5.10	-3.34*	-9.07**	0.21
CMS 16A	X	JGL8292	2.69	1.99	9.31 *	2.012	-0.19	8.28**
CMS 16A	X	JGL3855	-12.09 **	-16.31 **	-11.52 **	-13.64**	-14.48**	11.24**
CMS 16A	X	JGL3844	-4.75	-6.31	2.41	-2.80	-5.98**	4.43**
CMS 16A	X	JGL1798	-1.57	-3.10	5.72	1.58	-1.86	9.28**
APMS 6A	X	JGL11110-2	-3.41	-4.64	3.45	-2.62*	-5.46**	4.20**
APMS 6A	X	JGL11110-1	0.45	0.32	7.79 *	-1.72	-2.33	7.30**
APMS 6A	X	JGL17211	5.98	0.13	7.59 *	0.89	-2.82	6.76**
APMS 6A	X	JGL16284	-1.50	-2.33	6.76	-1.81	-2.35	8.46**
APMS 6A	X	JGL13515	-7.83 *	-8.53 *	-0.21	-7.23**	-7.85**	2.61
APMS 6A	X	JGL11160	-13.19 **	-13.60 **	-6.28	-8.93**	-9.07**	0.21
APMS 6A	X	JGL11118	-5.12	-6.31	0.41	-3.48**	-4.15**	3.99*
APMS 6A	X	JGL11111	4.86	0.40	4.90	-3.28*	-5.64**	0.96
APMS 6A	X	JGL8605	-2.19	-4.35	4.55	-2.49	-4.28**	6.32**
APMS 6A	X	JGL8292	-4.29	-6.32	2.21	-5.80**	-7.64**	2.84
APMS 6A	X	JGL3855	-3.76	-5.53	2.48	-2.21	-3.64**	6.20**
APMS 6A	X	JGL3844	-1.42	-1.87	5.17	-3.99**	-4.56**	4.78**
APMS 6A	X	JGL1798	3.35	-1.82	4.28	1.74	-1.97	7.62**
IR 58025A	X	JGL11110-2	-1.31	-2.71	6.34	-2.02	-2.58	8.21**
IR 58025A	X	JGL11110-1	-1.02	-2.34	6.55	-2.50*	-3.18*	7.81**
IR 58025A	X	JGL17211	-3.18	-4.20	3.93	-6.61**	-6.79**	2.73
IR 58025A	X	JGL16284	-2.95	-3.60	3.31	-0.93	-1.96	6.36**
IR 58025A	X	JGL13515	5.17	0.13	5.86	4.44**	2.24	8.62**
IR 58025A	X	JGL11160	-9.49 **	-10.98 **	-2.69	-16.42**	-18.24**	-9.18**
IR 58025A	X	JGL11118	-12.10 **	-13.46 **	-5.59	-13.36**	-15.34**	-5.73**
IR 58025A	X	JGL11111	-2.19	-3.43	4.76	-6.66**	-8.33**	1.03
IR 58025A	X	JGL8605	3.20	-0.45	6.69	3.93**	1.03	9.60**
IR 58025A	X	JGL8292	11.59 **	9.35 *	8.90 *	1.35	1.02	3.47*
IR 58025A	X	JGL3855	1.16	-3.34	5.66	-6.71**	-1035**	-0.42
IR 58025A	X	JGL3844	-5.35	-9.48 **	-1.24	-9.34**	-12.98**	-3.10
IR 58025A	X	JGL1798	-6.46 *	-10.30 **	-2.69	-10.09**	-13.26	-4.41**

* Significant at 5% level; ** Significant at 1% level

Table 4.28. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA-6201) for plant height at Kunaram , Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	26.43 **	3.01 *	5.88 **	-24.11 **	-28.55 **	-31.44 **
IR 68897A	X	JGL11110-1	-21.70 **	-22.29 **	-20.12 **	-29.17 **	-31.83 **	-34.58 **
IR 68897A	X	JGL17211	-7.79 **	-12.65 **	-10.22 **	-36.54 **	-40.25 **	-42.66 **
IR 68897A	X	JGL16284	0.16	-6.02 **	-3.41 *	-34.13 **	-36.69 **	-34.13 **
IR 68897A	X	JGL13515	-7.98 **	-11.45 **	-8.98 **	-37.61 **	-41.45 **	-35.93 **
IR 68897A	X	JGL11160	7.98 **	-11.82 **	-9.91 **	-36.48 **	-43.45 **	-38.62 **
IR 68897A	X	JGL11118	-9.59 **	-10.00 **	-8.05 **	-27.77 **	-34.34 **	-28.74 **
IR 68897A	X	JGL11111	-0.16	-5.15 **	-3.10 *	-23.01 **	-31.45 **	-25.60 **
IR 68897A	X	JGL8605	0.81	-5.15 **	-3.10 *	-33.80 **	-35.17 **	-29.64 **
IR 68897A	X	JGL8292	0.78	-2.73 *	-0.62	-28.02 **	-28.32 **	-21.56 **
IR 68897A	X	JGL3855	19.39 **	-0.32	-3.72 **	-25.50 **	-33.79 **	-27.84 **
IR 68897A	X	JGL3844	7.67 **	5.20 **	6.50 **	-33.38 **	-39.56 **	-34.13 **
IR 68897A	X	JGL1798	-4.11 **	-6.41 **	-9.60 **	-27.36 **	-35.44 **	-29.64 **
APMS 8A	X	JGL11110-2	2.49	-0.96	-4.33 **	-25.93 **	-27.61 **	-21.11 **
APMS 8A	X	JGL11110-1	-1.13	-1.92	-5.26 **	-30.64 **	-30.78 **	-24.25 **
APMS 8A	X	JGL17211	17.32 **	-0.33	-7.74 **	-20.14 **	-20.14 **	-32.34 **
APMS 8A	X	JGL16284	-37.70 **	-40.37 **	-39.63 **	-31.84 **	-33.39 **	-40.87 **
APMS 8A	X	JGL13515	7.72 **	7.36 **	-0.62	-13.25 **	-13.25 **	-26.50 **
APMS 8A	X	JGL11160	-6.44 **	-7.69 **	-14.55 **	-21.65 **	-28.92 **	-26.05 **
APMS 8A	X	JGL11118	5.61 **	4.23 **	-0.93	-24.75 **	-33.24 **	-26.95 **
APMS 8A	X	JGL11111	18.57 **	-2.47	-2.17	-15.74 **	-20.31 **	-24.25 **
APMS 8A	X	JGL8605	-5.38 **	-5.81 **	-4.64 **	-23.94 **	-26.46 **	-30.09 **
APMS 8A	X	JGL8292	-9.82 **	-13.58 **	-13.31 **	-20.73 **	-25.04 **	-28.74 **
APMS 8A	X	JGL3855	-2.11	-7.10 **	-6.81 **	-35.64 **	-38.42 **	-35.93 **
APMS 8A	X	JGL3844	4.60 **	1.85	2.17	-30.31 **	-34.88 **	-28.74 **
APMS 8A	X	JGL1798	21.15 **	6.12 **	-8.67 **	-35.65 **	-43.71 **	-36.38 **
CMS 16A	X	JGL11110-2	-0.17	-7.65 **	-6.50 **	-30.27 **	-37.75 **	-29.64 **
CMS 16A	X	JGL11110-1	0.17	-3.03 *	-10.84 **	-30.20 **	-38.94 **	-30.99 **
CMS 16A	X	JGL17211	6.15 **	3.78 *	-6.50 **	-30.62 **	-33.38 **	-24.70 **
CMS 16A	X	JGL16284	-0.85	-5.54 **	-10.22 **	-31.49 **	-32.58 **	-23.80 **
CMS 16A	X	JGL13515	21.77 **	5.23 **	-6.50 **	-30.87 **	-37.77 **	-34.13 **
CMS 16A	X	JGL11160	-0.65	-6.73 **	-5.57 **	-25.38 **	-31.40 **	-27.40 **
CMS 16A	X	JGL11118	5.48 **	3.70 *	-4.64 **	-31.34 **	-38.19 **	-34.58 **
CMS 16A	X	JGL11111	-10.03 **	-10.65 **	-19.50 **	-37.23 **	-37.77 **	-34.13 **
CMS 16A	X	JGL8605	-3.03 *	-6.19 **	-10.84 **	-42.98 **	-43.91 **	-38.62 **
CMS 16A	X	JGL8292	31.07 **	8.07 **	7.74 **	-20.51 **	-27.03 **	-26.05 **
CMS 16A	X	JGL3855	-12.48 **	-13.15 **	-12.07 **	-35.91 **	-39.88 **	-39.07 **
CMS 16A	X	JGL3844	1.45	-2.48	-2.79 *	-21.00 **	-27.47 **	-26.50 **
CMS 16A	X	JGL1798	-4.40 **	-9.01 **	-9.29 **	-29.74 **	-30.65 **	-27.84 **
APMS 6A	X	JGL11110-2	-0.48	-2.80 *	-3.10 *	-30.68 **	-33.24 **	-26.95 **
APMS 6A	X	JGL11110-1	27.42 **	8.39 **	0.00	-27.97 **	-37.30 **	-28.29 **
APMS 6A	X	JGL17211	-0.80	-5.20 **	-4.02 **	-31.17 **	-38.87 **	-30.09 **
APMS 6A	X	JGL16284	4.54 **	4.36 **	-3.72 **	-26.62 **	-36.13 **	-26.95 **

Table 4.28 (cont.)

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A X JGL13515	2.89 *	1.68	-6.19 **	-34.75 **	-37.70 **	-28.74 **
APMS 6A X JGL11160	2.48	0.98	-4.02 **	-41.94 **	-43.19 **	-35.03 **
APMS 6A X JGL11118	22.99 **	2.56	-0.62	-11.58 **	-15.81 **	-21.11 **
APMS 6A X JGL11111	6.25 **	3.98 **	5.26 **	18.46 **	15.34 **	8.08 **
APMS 6A X JGL8605	-13.11 **	-15.34 **	-17.96 **	22.65 **	16.77 **	9.43 **
APMS 6A X JGL8292	-0.66	-4.15 **	-7.12 **	9.77 **	4.32 **	8.53 **
APMS 6A X JGL3855	-6.13 **	-7.03 **	-9.91 **	9.95 **	2.05	11.68 **
APMS 6A X JGL3844	15.77 **	-0.68	-10.22 **	9.27 **	-4.73 **	8.53 **
APMS 6A X JGL1798	-7.92 **	-12.84 **	-11.76 **	-5.32 **	-15.77 **	-4.04 **
IR 58025A X JGL11110-2	4.24 **	3.37 *	-4.95 **	0.23	-12.61 **	-0.45
IR 58025A X JGL11110-1	8.40 **	8.22 **	-2.17	-7.01 **	-11.04 **	1.35
IR 58025A X JGL17211	-2.17	-4.56 **	-9.29 **	-18.50 **	-20.11 **	-8.98 **
IR 58025A X JGL16284	20.66 **	6.18 **	-9.60 **	-5.51 **	-16.62 **	-7.63 **
IR 58025A X JGL13515	-4.32 **	-11.93 **	-10.84 **	5.18 **	-5.27 **	4.94 **
IR 58025A X JGL11160	2.80 *	-1.01	-8.98 **	7.35 **	-5.27 **	4.94 **
IR 58025A X JGL11118	2.12	-0.69	-10.53 **	-5.64 **	-8.51 **	1.35
IR 58025A X JGL11111	13.06 **	7.17 **	1.86	-23.05 **	-23.51 **	-15.27 **
IR 58025A X JGL8605	-0.59	-15.89 **	-21.36 **	16.48 **	14.97 **	0.00
IR 58025A X JGL8292	27.19 **	22.32 **	23.84 **	15.33 **	14.17 **	1.35
IR 58025A X JGL3855	-0.50	-1.32	-7.74 **	7.59 **	6.20 **	-7.63 **
IR 58025A X JGL3844	-16.36 **	-17.88 **	-23.22 **	4.23 **	-4.32 **	-0.45
IR 58025A X JGL1798	-9.36 **	-10.10 **	-14.55 **	5.95 **	-4.92 **	4.04 **

Hybrid	Kampasagar			Pooled		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A X JGL11110-2	-1.49	-11.45 **	6.57	-0.66	-12.14**	-7.21**
IR 68897A X JGL11110-1	-23.76 **	-30.86 **	-16.79 **	-24.81**	-28.30**	-24.28**
IR 68897A X JGL17211	-14.97 **	-21.78 **	-5.86	-19.56**	-24.70**	-20.48**
IR 68897A X JGL16284	-8.46 *	-16.56 **	0.43	-14.64**	-17.82**	-13.21**
IR 68897A X JGL13515	-15.23 **	-22.20 **	-6.36	-20.75**	-22.16**	-17.80**
IR 68897A X JGL11160	-11.92 **	-17.57 **	-9.21 *	-14.83**	-25.05**	-19.94**
IR 68897A X JGL11118	-13.77 **	-18.55 **	-10.29 *	-17.18**	-21.45**	-16.09**
IR 68897A X JGL11111	6.32	1.95	12.29 **	-6.01**	-12.49**	-6.52**
IR 68897A X JGL8605	-7.34 *	-12.00 **	-3.07	-14.50**	-18.13**	-12.55**
IR 68897A X JGL8292	-4.47	-8.63 *	0.64	-11.53**	-13.60**	-7.71**
IR 68897A X JGL3855	-2.12	-5.23	-2.86	-4.40**	-14.43**	-1.06**
IR 68897A X JGL3844	6.77	4.39	7.00	-7.17**	-10.32**	-7.83**
IR 68897A X JGL1798	-7.79 *	-8.43 *	-6.14	-13.49**	-17.99**	-5.71**
APMS 8A X JGL11110-2	8.36 *	6.55	9.21 *	-6.51**	-8.80**	-6.26**
APMS 8A X JGL11110-1	10.31 **	9.27 *	12.00 **	-8.97**	-9.39**	-6.87**
APMS 8A X JGL17211	4.05	-1.33	5.64	-0.18	-7.03**	-12.51**
APMS 8A X JGL16284	-19.44 **	-22.88 **	-17.43 **	-29.19**	-30.52**	-33.44**
APMS 8A X JGL13515	8.85 *	5.80	13.29 **	1.30	0.22	-5.69**
APMS 8A X JGL11160	3.53	-0.33	6.71	-8.57**	-10.27**	-12.29**
APMS 8A X JGL11118	6.78	3.54	10.86 *	-4.74**	-8.35**	-6.68**
APMS 8A X JGL11111	8.30 *	5.58	6.71	2.98*	-6.13**	-7.39**
APMS 8A X JGL8605	-1.29	-2.83	-1.79	-10.38**	-11.68**	-12.86**

Table 4.28 (cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-7.00	-7.00	-6.00	-12.59**	-15.50**	-16.63**
APMS 8A	X	JGL3855	-4.93	-5.87	-4.86	15.08**	-15.48**	-16.61**
APMS 8A	X	JGL3844	1.81	1.55	2.64	-8.93**	-10.34**	-8.71**
APMS 8A	X	JGL1798	5.96	5.88	1.64	-5.97**	-14.27**	-15.46**
CMS 16A	X	JGL11110-2	3.87	2.77	0.64	-10.10**	-11.38**	-12.61**
CMS 16A	X	JGL11110-1	3.30	0.64	1.71	10.09**	-13.05**	-14.27**
CMS 16A	X	JGL17211	2.82	1.15	0.21	-9.33**	-9.72**	-10.98**
CMS 16A	X	JGL16284	7.78 *	5.26	5.86	-8.98**	-11.86**	-10.26**
CMS 16A	X	JGL13515	5.57	4.32	0.14	-11.13**	5.47**	-14.36**
CMS 16A	X	JGL11160	6.08	3.79	1.64	-7.84**	-7.31**	-11.20**
CMS 16A	X	JGL11118	7.15	3.25	4.36	-9.33**	-5.13**	-12.63**
CMS 16A	X	JGL11111	-10.26 **	-12.69 **	-13.50 **	-20.01**	-21.15**	-22.92**
CMS 16A	X	JGL8605	-0.07	-3.48	-2.93	-15.30**	-19.84**	-18.38**
CMS 16A	X	JGL8292	11.63 **	8.16	10.71 *	-4.45**	18.95**	-3.42.**
CMS 16A	X	JGL3855	0.43	-1.74	0.57	-18.79**	-14.33**	-17.92**
CMS 16A	X	JGL3844	0.42	-0.21	2.14	-10.73**	-2.03	-9.77**
CMS 16A	X	JGL1798	-3.33	-4.88	-2.64	-14.83**	-11.93**	-13.92**
APMS 6A	X	JGL11110-2	2.78	1.88	4.29	-10.36**	-11.02**	-9.39**
APMS 6A	X	JGL11110-1	1.36	-4.60	3.79	-13.36**	12.13**	-8.95**
APMS 6A	X	JGL17211	-2.90	-7.75 *	0.36	-16.26**	-8.15**	-12.01**
APMS 6A	X	JGL16284	-3.47	-6.89	1.29	-14.83**	-2.83*	-10.50**
APMS 6A	X	JGL13515	-6.74	-10.90 **	-3.07	17.49**	-11.30**	-13.30**
APMS 6A	X	JGL11160	-10.00 **	-13.39 **	-5.79	-19.68**	-17.12**	-15.60**
APMS 6A	X	JGL11118	4.73	4.12	1.14	-3.37*	14.05**	-7.40**
APMS 6A	X	JGL11111	8.46 *	8.02	5.79	11.05**	11.08**	6.42**
APMS 6A	X	JGL8605	12.86 **	10.67 *	11.86 **	5.09**	9.35**	0.72
APMS 6A	X	JGL8292	-1.20	-2.16	-3.07	4.00**	1.97	-0.33
APMS 6A	X	JGL3855	-3.11	-4.76	-4.21	3.81**	-2.30	-0.51
APMS 6A	X	JGL3844	2.09	1.93	-2.14	-1.49	21.78**	-1.12
APMS 6A	X	JGL1798	8.96 *	7.73	5.50	-4.21**	0.36	-3.85
IR 58025A	X	JGL11110-2	8.31 *	5.44	6.57	-0.28	8.68**	0.10
IR 58025A	X	JGL11110-1	5.24	3.46	2.50	0.11	2.80*	0.48
IR 58025A	X	JGL17211	-0.87	-3.27	-2.71	-7.56**	-8.88**	-7.21**
IR 58025A	X	JGL16284	3.74	2.16	-1.93	-3.37*	15.02**	-6.61**
IR 58025A	X	JGL13515	6.96	4.30	2.14	2.09	2.99*	-1.33
IR 58025A	X	JGL11160	-2.06	-5.94	-4.93	0.56	5.53**	-2.81*
IR 58025A	X	JGL11118	-3.05	-5.98	-6.86	-1.91	-3.01*	-5.20**
IR 58025A	X	JGL11111	8.00 *	3.98	4.57	-0.09	-5.17**	-3.44**
IR 58025A	X	JGL8605	-3.68	-3.85	-7.36	-1.73	1.38**	-9.56**
IR 58025A	X	JGL8292	20.88 **	19.91 **	17.43 **	23.77**	18.89**	13.91**
IR 58025A	X	JGL3855	0.72	-1.63	-0.57	2.62	2.54	-5.56**
IR 58025A	X	JGL3844	-11.77 **	-12.98 **	-13.79 **	-4.69**	10.26**	-12.28**
IR 58025A	X	JGL1798	-7.07	-9.02 *	-8.50 *	2.02	-7.80**	-6.12**

* Significant at 5% level; ** Significant at 1% level

4.2.7.2 Plant height (cm)

At Kunaram 19 hybrids recorded significant average heterosis for plant height ranging from -37.70 (APMS 8A x JGL 3844) to -3.03 (CMS 16A x JGL 11111). The significant negative heterobeltiosis was recorded in 34 hybrids for plane height, the ranging from -40.37 (APMS 8A x JGL 16284) to -2.73 (IR68897A x JGL 8292). The negative standard heterosis was observed in 51 hybrids over PA 6201 and it ranged between -39.63 (APMS 8A x JGL 16284) to -2.79 (CMS 16A x JGL 3844).

At Warangal, 52 hybrids recorded significant average negative heterosis ranging from -42.98 (CMS 16A x JGL 8605) to -5.32 (APMS 6A x JGL 1798) for plant height. The significant negative heterobeltiosis was recorded in 58 hybrids, with a range of -43.91 (CMS 16A x JGL 8605) to -4.32 (IR 58025A x JGL 3844). The significant negative standard heterosis was observed in 51 hybrids, with a range from -42.66 (IR 68897A x JGL 17211) to -4.04 (APMS 6A x JGL 1798), when compared with highest yielding check PA 6201.

At Kampasagar the average negative heterosis was observed in 12 hybrids with a range from -23.76 (IR 68897A x JGL 11110-1) to -7.34 (IR68897A x JGL 8605). The average negative heterobeltiosis was observed in 17 hybrids ranged from -30.86 (IR 68897A x JGL 11110-1) to -7.75 (APMS 6A x JGL 17211. The significant negative standard heterosis was recorded in 7 hybrids and it ranged from -17.43 (APMS 8A x JGL 16284) to -8.50 (IR 58025A x JGL 1798).

In pooled analysis for plant height, the average significant negative heterosis was observed in 43 hybrids and it ranged from -29.19 (APMS 8A x JGL 16284) to -3.37 (APMS 6A x JGL 16284). The average significant negative heterobeltiosis was recorded in 44 hybrids, with a range of -30.52 (APMS 8A x JGL 16284) to -2.83 (APMS 6A x JGL 16284). The significant negative standard heterosis was recorded in 57 hybrids, with a range of -33.44 (PMS 8A x JGL 16284) to -1.06 (IR68897A x JGL 3855), when compared with check PA 6201 (Table 4.28).

Short plant type is an important trait of hybrid to withstand lodging. Hence, heterosis in negative direction which implies short stature is desirable for this trait.The hybrid APMS 8A x JGL 16284 recorded, highest standard heterosis (33.44) over the check PA 6201, with relative high standard heterosis over check KRH-2 (35.81), heterobeltiosis (-30.52) and average heterosis (-29.19), out of 65 hybrids, 57 hybrids, recorded significant standard heterosis over the check PA 6201. The other hybrids IR 68897A x JGL 11110-1 (-24.28), CMS 16A x JGL 11111 (-22.92), IR 68897A x

JGL 17211 (-20.48) and IR 68897A x JGL 11160 (-19.94) also recorded high standard heterosis over check PA 6201(Table 4.39 and Figure 4.7). Both positive and negative heterosis was expressed over standard checks, mid parent and better parent by several rice researchers *viz.*, Ghosh (2002), Doeraj *et al*. (2007), Hariramakrishnan *et al*. (2009) and Roy *et al*. (2009).Standard heterosis of similar nature was reported by Singh *et al*. (2006a & 2006b), Anju Choudhary *et al*. (2007), Doeraj *et al.* (2007), Rosamma and Vijaykumar (2007) and Akarsh Parihar and Pathak (2008).

4.2.7.3 Productive tillers/plant

At Kunaram, the positive significant average heterosis was recorded in 13 hybrids, with a range from 113.95 (APMS 6A x JGL 11111) to 30.23 (IR 58025A x JGL 11118). The significant positive heterobeltiosis was recorded in 6 hybrids, with a range of 91.67 (APMS 6A x JGL 11111) to 40.91 (APMS 6A x JGL 11110-1). The significant positive standard heterosis was observed in only one hybrid APMS 6A x JGL 11111 (39.39) when compared to check PA 6201(Table 4.29).

At Warangal, the positive significant average heterosis was recorded in 36 hybrids with range of 158.62 (IR 58025A x JGL 11160) to 16.52 (IR 68897A x JGL 8292). The significant heterobeltiosis was recorded in 30 hybrids with a range of 141.94 (IR 58025A x JGL 11160) to 9.84 (IR68897A x JGL 8292). Positive significant standard heterosis was recorded in 37 hybrids with a range of 102.58 (APMS 8A x JGL 11118) to 15.38 (APMS 6A x JGL 11118), when compared with check PA 6201.

At Kampasagar the significant average heterosis recorded in 38 hybrids with a range of 141.32 (IR 58025A x JGL 16284) to 22.50 (APMS 8A x JGL 3844). The significant heterobeltiosis recorded in 28 hybrids with a range of 135.48 (IR 58025A x JGL 16284) to 23.76 (APMS 8A x JGL11118). The significant standard heterosis is recorded in 32 hybrids and it ranged from 138.46 (IR 68897A x JGL 1798) to 28.38 (CMS 16A x JGL 3844), when compared to the check PA 6201.

In pooled analysis, 49 hybrids recorded positive significant average heterosis and it ranged from 90.68 (APMS 8A x JGL 11111) to 9.09 (APMS 8A x JGL 11110-1). The significant heterobeltiosis was recorded in 41 hybrids, with a range of 90.68 (APMS 8A x JGL 11111) to 9.09 (APMS 8A x JGL 11110-1). The significant standard heterosis was recorded in 29 hybrids and it ranged from 59.33 (APMS 8A x JGL 11118) to 13.40 (CMS 16A x JGL 8292) when compared to check PA 6201 (Table 4.29).

Number of productive tillers per plant is known to directly contribute towards grain yield and can be exploited. More the number of productive tillers more will be the yield and vice versa. Hence, heterosis over better parent and standard checks in positive direction is desirable for this trait. Among the 65 hybrids studied, 29 hybrids recorded significant standard heterosis over the best check PA 6201 in pooled analysis. The hybrid APMS 8A x JGL 11118 (59.33) recorded the highest standard heterosis over the best check PA 6201, with relative high standard heterosis when compared with check KRH-2 (57.08), heterobeltiosis (54.52) and average heterosis (54.52). The hybrid IR 68897A x JGL 8292 (53.11), IR 68897A x JGL 3855 (51.20), APMS 6A x JGL 16284 (49.28) and APMS 8A x JGL 3844 (44.50) also recorded high standard heterosis over best check PA 6201(Table 4.39 and Figure 4.7). In the present investigation majority of the hybrids recorded significant positive heterosis and heterobeltiosis. Mid parental heterosis both positive and negative directions were reported by Reddy and Nerkar (1995), Joshi *et al.* (2004), Shantala *et al.* (2006), Doeraj *et al.* (2007) and Hariramakrishnan *et al.* (2009). Heterobeltiosis of positive nature was observed by Pandey *et al.* (1995), Jayamani et al. (1997), Verma *et al.* (2004), whereas Mishra and Pandey (1998), Singh *et al.* (2006 a), Doeraj *et al.* (2007), Akarsh Parihar and Pathak (2008) and Roy *et al.* (2009) reported both heterobeltiosis and standard heterosis in both positive and negative directions

4.2.7.4 Flag leaf length (cms)

At Kunaram the significant positive average heterosis was recorded in 35 hybrids, with a range from 71.48 (APMS 8A x JGL 11111) to 8.75 (APMS 8A x JGL 11160). The positive significant heterobeltiosis was recorded in only 18 hybrids, which ranged from 65.98 (APMS 8A x JGL 11111) to 10.11 (APMS 6A x JGL 11110-2). The significant standard heterosis was observed in 23 hybrids, ranging from 43.77 (IR 6897A x JGL 11160) to 9.96 (APMS 6A x JGL 3844), when compared with check PA 6201.

At Warangal, positive significant average heterosis was observed in 30 hybrids, ranging from 80.43 (APMS 8A x JGL 16284) to15.70 (IR 68897A x JGL 11111). The significant heterobeltiosis was observed in 17 hybrids with a range from 69.39 (APMS 8A x JGL 16284) to 21.43 (CMS 16A x JGL 8605). The significant positive standard heterosis was observed in 4 hybrids, with a range from 72.92 (APMS 8A x JGL 17211) to 18.03 (APMS 8A x JGL 111160) when compared with check PA 6201.

At Kampasagar, the positive significant average heterosis was recorded in 25 hybrids ranging from 50.52 (IR 58025A x JGL 11111) to 15.79 (CMS 16A x JGL

Table 4.29. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for productive tillers/plant at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-22.45	-38.71 **	-42.42 **	52.11 **	35.00 **	38.46 **
IR 68897A	X	JGL11110-1	-8.00	-25.81 *	-30.30 **	1.49	-15.00 *	-12.82
IR 68897A	X	JGL17211	-32.08 *	-41.94 **	-45.45 **	-29.58 **	-37.50 **	-35.90 **
IR 68897A	X	JGL16284	-16.98	-29.03 *	-33.33 **	-9.43 *	-27.27 **	23.08 **
IR 68897A	X	JGL13515	-10.34	-16.13	-21.21	-34.04 **	-42.59 **	-20.51 **
IR 68897A	X	JGL11160	6.67	-11.11	-27.27 *	0.00	-24.59 **	17.95 *
IR 68897A	X	JGL11118	13.04	-3.70	-21.21	22.73 **	-11.48 *	38.46 **
IR 68897A	X	JGL11111	22.45	11.11	-9.09	-6.52	-29.51 **	10.26
IR 68897A	X	JGL8605	30.61 *	18.52	-3.03	0.79	-3.03	64.10 **
IR 68897A	X	JGL8292	7.41	7.41	-12.12	16.52 **	9.84 *	71.79 **
IR 68897A	X	JGL3855	-2.22	-18.52	-33.33 **	86.49 **	60.47 **	76.92 **
IR 68897A	X	JGL3844	13.04	-3.70	-21.21	88.57 **	53.49 **	69.23 **
IR 68897A	X	JGL1798	2.04	-7.41	-24.24 *	89.19 **	62.79 **	79.49 **
APMS 8A	X	JGL11110-2	-22.45	-29.63 *	-42.42 **	-22.94 **	-36.36 **	7.69
APMS 8A	X	JGL11110-1	14.81	14.81	-6.06	7.22	-3.70	33.33 **
APMS 8A	X	JGL17211	-4.55	-19.23	-36.36 **	52.73 **	35.48 **	7.69
APMS 8A	X	JGL16284	-11.11	-23.08	-39.39 **	41.18 **	33.33 **	-7.69
APMS 8A	X	JGL13515	-4.17	-11.54	-30.30 **	85.45 **	64.52 **	30.77 **
APMS 8A	X	JGL11160	-33.33 *	-38.46 **	-51.52 **	0.00	-31.82 **	15.38 *
APMS 8A	X	JGL11118	-5.66	-7.41	-24.24 *	102.56 **	46.30 **	102.56 **
APMS 8A	X	JGL11111	30.23 *	12.00	-15.15	100.00 **	64.58 **	102.56 **
APMS 8A	X	JGL8605	18.18	4.00	-21.21	38.67 **	8.33	33.33 **
APMS 8A	X	JGL8292	-36.17 *	-40.00 **	-54.55 **	-1.27	-18.75 **	0.00
APMS 8A	X	JGL3855	-14.89	-20.00	-39.39 **	-36.84 **	-45.45 **	-7.69
APMS 8A	X	JGL3844	-11.54	-14.81	-30.30 **	54.90 **	46.30 **	102.56 **
APMS 8A	X	JGL1798	26.32	20.00	-27.27 *	6.33	-12.50 *	7.69
CMS 16A	X	JGL11110-2	7.69	5.00	-36.36 **	78.67 **	39.58 **	71.79 **
CMS 16A	X	JGL11110-1	-4.76	-9.09	-39.39 **	-24.05 **	-37.50 **	-23.08 **
CMS 16A	X	JGL17211	33.33 *	27.27	-15.15	-15.79 **	-27.27 **	23.08 **
CMS 16A	X	JGL16284	19.15	3.70	-15.15	47.06 **	38.89 **	92.31 **
CMS 16A	X	JGL13515	29.73	26.32	-27.27 *	6.33	-12.50 *	7.69
CMS 16A	X	JGL11160	26.32	26.32	-27.27 *	76.00 **	37.50 **	69.23 **
CMS 16A	X	JGL11118	17.07	9.09	-27.27 *	59.49 **	31.25 **	61.54 **
CMS 16A	X	JGL11111	17.07	9.09	-27.27 *	-26.32 **	-36.36 **	7.69
CMS 16A	X	JGL8605	-17.39	-29.63 *	-42.42 **	5.88	0.00	38.46 **
CMS 16A	X	JGL8292	19.05	4.17	-24.24 *	96.43 **	77.42 **	41.03 **
CMS 16A	X	JGL3855	11.63	0.00	-27.27 *	-7.69	-11.11	-38.46 **
CMS 16A	X	JGL3844	13.04	8.33	-21.21	128.57 **	106.45 **	64.10 **
CMS 16A	X	JGL1798	4.35	0.00	-27.27 *	27.47 **	-12.12 **	48.72 **
APMS 6A	X	JGL11110-2	21.57	14.81	-6.06	21.52 **	-11.11 *	23.08 **
APMS 6A	X	JGL11110-1	65.85 **	47.83 **	3.03	122.86 **	100.00 **	100.00 **
APMS 6A	X	JGL17211	38.10 *	26.09	-12.12	30.30 **	10.26	10.26
APMS 6A	X	JGL16284	24.44	21.74	-15.15	57.14 **	41.03 **	41.03 **

Table 4.29 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	33.33 *	30.43	-9.09	-37.14 **	-50.00 **	-15.38 *
APMS 6A	X	JGL11160	-4.00	-11.11	-27.27 *	61.29 **	38.89 **	92.31 **
APMS 6A	X	JGL11118	38.10 *	20.83	-12.12	34.33 **	25.00 **	15.38 *
APMS 6A	X	JGL11111	113.95 **	91.67 **	39.39 **	-1.59	-13.89	-20.51 **
APMS 6A	X	JGL8605	-8.70	-12.50	-36.36 **	43.28 **	33.33 **	23.08 **
APMS 6A	X	JGL8292	56.52 **	50.00 **	9.09	31.37 **	1.52	71.79 **
APMS 6A	X	JGL3855	9.80	3.70	-15.15	-17.78 **	-31.48 **	-5.13
APMS 6A	X	JGL3844	72.97 **	68.42 **	-3.03	41.82 **	25.81 **	0.00
APMS 6A	X	JGL1798	63.16 **	63.16 **	-6.06	92.16 **	81.48 **	25.64 **
IR 58025A	X	JGL11110-2	21.95	13.64	-24.24 *	67.27 **	48.39 **	17.95 *
IR 58025A	X	JGL11110-1	51.22 **	40.91 *	-6.06	-31.11 **	-53.03 **	-20.51 **
IR 58025A	X	JGL17211	-4.35	-18.52	-33.33 **	-7.69	-33.33 **	-7.69
IR 58025A	X	JGL16284	2.56	-4.76	-39.39 **	17.24 *	9.68	-12.82
IR 58025A	X	JGL13515	15.00	9.52	-30.30 **	59.26 **	59.26 **	10.26
IR 58025A	X	JGL11160	2.33	0.00	-33.33 **	158.62 **	141.94 **	92.31 **
IR 58025A	X	JGL11118	30.23 *	27.27	-15.15	-29.03 **	-50.00 **	-15.38 *
IR 58025A	X	JGL11111	16.67	3.70	-15.15	-11.11	-33.33 **	-7.69
IR 58025A	X	JGL8605	-37.78 *	-48.15 **	-57.58 **	87.10 **	87.10 **	48.72 **
IR 58025A	X	JGL8292	8.70	-7.41	-24.24 *	-6.90	-12.90	-30.77 **
IR 58025A	X	JGL3855	6.12	-3.70	-21.21	122.58 **	122.58 **	76.92 **
IR 58025A	X	JGL3844	18.37	7.41	-12.12	-17.53 **	-39.39 **	2.56
IR 58025A	X	JGL1798	-25.93 *	-25.93	-39.39 **	-8.24	-27.78 **	0.00
Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	57.02 **	53.23 **	46.15 **	33.52**	33.52**	15.31*
IR 68897A	X	JGL11110-1	-19.35	-23.08	-23.08	-8.38	-8.38	-21.53**
IR 68897A	X	JGL17211	-33.80 **	-43.37 **	-27.69 *	-31.79**	-31.79**	-36.36**
IR 68897A	X	JGL16284	-24.84 **	-39.80 **	-9.23	-16.21**	-16.21**	-4.78
IR 68897A	X	JGL13515	3.75	-17.82 *	27.69 *	-15.09**	-15.09**	-5.74
IR 68897A	X	JGL11160	134.65 **	129.23 **	129.23 **	44.14**	44.14**	38.28**
IR 68897A	X	JGL11118	36.92 **	36.92 **	36.92 **	25.13**	25.13**	19.14**
IR 68897A	X	JGL11111	56.76 **	39.76 **	78.46 **	21.86**	21.86**	25.36**
IR 68897A	X	JGL8605	82.82 **	52.04 **	129.23 **	32.43**	32.43**	63.16**
IR 68897A	X	JGL8292	54.22 **	26.73 **	96.92 **	26.98**	26.98**	53.11**
IR 68897A	X	JGL3855	74.03 **	45.65 **	106.15 **	61.22**	61.2**	51.20**
IR 68897A	X	JGL3844	47.77 **	26.09 **	78.46 **	54.24**	54.24**	43.54**
IR 68897A	X	JGL1798	77.14 **	68.48 **	138.46 **	63.90**	63.90**	65.07**
APMS 8A	X	JGL11110-2	6.32	3.06	55.38 **	-11.86**	-11.86**	6.70
APMS 8A	X	JGL11110-1	7.77	2.97	60.00 **	9.09*	9.09*	29.19**
APMS 8A	X	JGL17211	0.00	-4.41	0.00	16.46*	16.46*	-8.61
APMS 8A	X	JGL16284	-20.30	-22.06	-18.46	1.54	1.54	-21.05**
APMS 8A	X	JGL13515	41.72 **	28.92 **	64.62 **	42.86**	42.86**	22.01**
APMS 8A	X	JGL11160	32.53 **	12.24	69.23 **	4.98	4.98	11.00
APMS 8A	X	JGL11118	47.93 **	23.76 **	92.31 **	54.52**	54.52**	59.33**
APMS 8A	X	JGL11111	121.49 **	116.13 **	106.15 **	90.68**	90.68**	66.51**
APMS 8A	X	JGL8605	33.87 **	27.69 *	27.69 *	32.04**	32.04**	14.35*

Table 4.29(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-4.23	-18.07	4.62	-10.66	-10.66	-15.79**
APMS 8A	X	JGL3855	40.13 **	12.24	69.23 **	-7.31	-7.31	6.22
APMS 8A	X	JGL3844	22.50 **	-2.97	50.77 **	29.06**	29.06**	44.50**
APMS 8A	X	JGL1798	13.04	4.84	0.00	12.89*	12.89*	-5.74
CMS 16A	X	JGL11110-2	50.85 **	36.92 **	36.92 **	53.18**	53.18**	26.79**
CMS 16A	X	JGL11110-1	44.12 **	18.07	50.77 **	4.76	4.76	-5.26
CMS 16A	X	JGL17211	-13.91	-33.67 **	0.00	-6.26	-6.26	3.83
CMS 16A	X	JGL16284	-15.58	-35.64 **	0.00	19.91**	19.91**	29.67**
CMS 16A	X	JGL13515	33.83 **	25.35 *	36.92 **	21.10**	2.1.10**	5.74
CMS 16A	X	JGL11160	57.35 **	50.70 **	64.62 **	58.56**	58.56**	37.32**
CMS 16A	X	JGL11118	-7.79	-14.46	9.23	24.37**	24.37**	17.22**
CMS 16A	X	JGL11111	-15.98	-27.55 **	9.23	-15.24**	-15.24**	-2.87
CMS 16A	X	JGL8605	-31.40 **	-41.58 **	-9.23	-12.39**	-12.39**	-7.91
CMS 16A	X	JGL8292	27.27 *	24.19	18.46	49.53**	49.53**	13.40*
CMS 16A	X	JGL3855	38.71 **	32.31 **	32.31 **	15.92*	15.92*	-12.92.*
CMS 16A	X	JGL3844	33.80 **	14.46	46.15 **	58.96**	58.96**	31.58**
CMS 16A	X	JGL1798	59.24 **	27.55 **	92.31 **	34.11**	34.11**	38.28**
APMS 6A	X	JGL11110-2	41.25 **	11.88	73.85 **	29.05**	29.05**	29.67**
APMS 6A	X	JGL11110-1	70.70 **	41.05 **	106.15 **	88.92**	88.92**	71.29**
APMS 6A	X	JGL17211	60.00 **	34.74 **	96.92 **	44.68**	44.68**	30.14**
APMS 6A	X	JGL16284	64.04 **	53.68 **	124.62 **	52.94**	52.94**	49.28**
APMS 6A	X	JGL13515	-38.86 **	-39.80 **	-9.23	-24.95**	-74.95**	-7.48
APMS 6A	X	JGL11160	-42.86 **	-44.55 **	-13.85	5.39	5..39	21.53**
APMS 6A	X	JGL11118	72.58 **	72.58 **	64.62 **	49.12**	49.12**	22.01**
APMS 6A	X	JGL11111	2.36	0.00	0.00	20.33**	39.49**	4.78
APMS 6A	X	JGL8605	14.48	0.00	27.69 *	21.43**	16.93*	5.74
APMS 6A	X	JGL8292	-3.75	-21.43 **	18.46	55.49**	3.28	35.41**
APMS 6A	X	JGL3855	5.52	-14.85	32.31 **	18.68**	-17.87**	3.35
APMS 6A	X	JGL3844	-4.84	-4.84	-9.23	35.81**	25.63**	-3.83
APMS 6A	X	JGL1798	63.78 **	60.00 **	60.00 **	78.38**	68.15**	26.32**
IR 58025A	X	JGL11110-2	14.48	0.00	27.69 *	52.03**	19.05**	7.66
IR 58025A	X	JGL11110-1	-37.50 **	-48.98 **	-23.08	17.57*	-36.50**	-16.75**
IR 58025A	X	JGL17211	57.06 **	26.73 **	96.92 **	64.86**	-7.22	16.75**
IR 58025A	X	JGL16284	141.32 **	135.48 **	124.62 **	63.87**	58.75**	21.53**
IR 58025A	X	JGL13515	58.06 **	50.77 **	50.77 **	48.39**	46.50**	10.05
IR 58025A	X	JGL11160	38.03 **	18.07	50.77 **	88.39**	54.50**	59.71**
IR 58025A	X	JGL11118	36.31 **	9.18	64.62 **	47.74**	-16.42**	9.57
IR 58025A	X	JGL11111	-18.75 *	-35.64 **	0.00	24.52**	-26.62**	-7.66
IR 58025A	X	JGL8605	44.35 **	33.87 **	27.69 *	34.32**	41.88**	8.61
IR 58025A	X	JGL8292	-10.17	-18.46	-18.46	-7.10	0.00	-24.88**
IR 58025A	X	JGL3855	26.47 **	3.61	32.31 **	63.31**	46.03**	32.06**
IR 58025A	X	JGL3844	-21.85 *	-39.80 **	-9.23	16.57*	-28.10**	-5.74
IR 58025A	X	JGL1798	35.06 **	2.97	60.00 **	31.36**	-15.59**	6.22

* Significant at 5% level; ** Significant at 1% level

Table 4.30. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for flag leaf length at Kunaram , Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-8.13	-21.27 **	-14.18 **	24.53 **	17.86	37.50 **
IR 68897A	X	JGL11110-1	-19.96 **	-21.11 **	-14.00 **	-2.86	-8.93	6.25
IR 68897A	X	JGL17211	-14.89 **	-27.09 **	-20.52 **	-0.95	-7.14	8.33
IR 68897A	X	JGL16284	8.91 *	-2.94	5.81	-9.84	-16.67 *	14.58
IR 68897A	X	JGL13515	-3.60	-8.32	-0.06	25.00 **	25.00 **	45.83 **
IR 68897A	X	JGL11160	41.01 **	14.02 **	43.77 **	8.20	-8.33	37.50 **
IR 68897A	X	JGL11118	-23.29 **	-29.44 **	-11.03 *	2.48	-13.89	29.17 **
IR 68897A	X	JGL11111	-3.40	-21.92 **	-1.54	15.70 *	-2.78	45.83 **
IR 68897A	X	JGL8605	-0.56	-16.65 **	5.10	-21.74 **	-25.00 **	12.50
IR 68897A	X	JGL8292	-16.12 **	-25.35 **	-5.87	-4.69	-15.28 *	27.08 *
IR 68897A	X	JGL3855	-0.44	-14.77 **	-6.88	3.70	-3.45	16.67
IR 68897A	X	JGL3844	-15.63 **	-16.94 **	-9.25	25.23 **	15.52	39.58 **
IR 68897A	X	JGL1798	-6.69	-20.14 **	-12.75 **	15.89	6.90	29.17 **
APMS 8A	X	JGL11110-2	2.68	-8.58	-0.12	8.06	1.52	39.58 **
APMS 8A	X	JGL11110-1	22.17 **	16.07 **	26.81 **	29.82 **	27.59 **	54.17 **
APMS 8A	X	JGL17211	16.02 **	-2.39	11.27 *	78.49 **	66.00 **	72.92 **
APMS 8A	X	JGL16284	-1.32	-4.84	8.48	80.43 **	69.39 **	72.92 **
APMS 8A	X	JGL13515	9.50 *	-7.91	4.98	34.78 **	26.53 *	29.17 **
APMS 8A	X	JGL11160	8.75 *	-4.94	8.36	32.11 **	9.09	50.00 **
APMS 8A	X	JGL11118	6.26	-1.04	12.81 **	39.39 **	23.21 *	43.75 **
APMS 8A	X	JGL11111	71.48 **	65.98 **	38.02 **	-3.77	-8.93	6.25
APMS 8A	X	JGL8605	20.24 **	7.34	13.64 **	16.19	8.93	27.08 *
APMS 8A	X	JGL8292	20.24 **	16.33 **	-3.26	0.95	-5.36	10.42
APMS 8A	X	JGL3855	18.03 **	16.55 **	-0.59	-21.31 **	-27.27 **	0.00
APMS 8A	X	JGL3844	-1.83	-9.41	-10.91 *	21.43 **	21.43 *	41.67 **
APMS 8A	X	JGL1798	9.64 *	-9.36 *	7.95	25.00 **	12.90	45.83 **
CMS 16A	X	JGL11110-2	-0.76	-6.27	11.63 *	9.91	-1.61	27.08 *
CMS 16A	X	JGL11110-1	16.12 **	-4.03	14.29 **	8.11	-3.23	25.00 *
CMS 16A	X	JGL17211	24.09 **	6.47	26.81 **	6.25	3.03	41.67 **
CMS 16A	X	JGL16284	6.06	-3.19	15.30 **	11.86	6.45	37.50 **
CMS 16A	X	JGL13515	23.44 **	13.93 **	4.80	12.87	11.76	18.75
CMS 16A	X	JGL11160	16.25 **	8.63	15.01 **	20.00 *	17.65	25.00 *
CMS 16A	X	JGL11118	20.06 **	10.77 *	1.90	14.00	11.76	18.75
CMS 16A	X	JGL11111	1.24	-2.45	-10.26 *	-12.82	-22.73 **	6.25
CMS 16A	X	JGL8605	12.18 **	8.56	6.76	27.10 **	21.43 *	41.67 **
CMS 16A	X	JGL8292	35.00 **	6.79	42.76 **	38.30 **	30.00 **	35.42 **
CMS 16A	X	JGL3855	-12.45 **	-21.56 **	4.86	5.38	0.00	2.08
CMS 16A	X	JGL3844	7.27	-15.17 **	13.40 **	41.94 **	34.69 **	37.50 **
CMS 16A	X	JGL1798	-1.79	-19.57 **	7.53	-25.45 **	-37.88 **	-14.58
APMS 6A	X	JGL11110-2	-13.09 **	-24.58 **	0.83	22.00 *	8.93	27.08 *
APMS 6A	X	JGL11110-1	27.08 **	10.11 *	16.90 **	34.74 **	28.00 **	33.33 **
APMS 6A	X	JGL17211	-4.22	-4.36	1.54	29.79 **	24.49 *	27.08 *
APMS 6A	X	JGL16284	11.83 *	-3.13	2.85	48.94 **	42.86 **	45.83 **

Table 4.30(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-20.45 **	-28.27 **	-23.84 **	18.92 *	0.00	37.50 **
APMS 6A	X	JGL11160	-3.25	-6.82	-1.07	-8.91	-17.86	-4.17
APMS 6A	X	JGL11118	20.82 **	1.18	16.67 **	3.03	2.00	6.25
APMS 6A	X	JGL11111	19.71 **	14.81 **	32.38 **	24.49 **	24.49 *	27.08 *
APMS 6A	X	JGL8605	9.37 *	-8.44 *	5.58	26.53 **	26.53 *	29.17 **
APMS 6A	X	JGL8292	20.46 **	4.78	20.82 **	-21.74 **	-31.82 **	-6.25
APMS 6A	X	JGL3855	-11.16 **	-17.70 **	-5.10	-37.14 **	-41.07 **	-31.25 **
APMS 6A	X	JGL3844	37.54 **	33.96 **	9.96 *	-34.55 **	-40.00 **	-25.00 *
APMS 6A	X	JGL1798	19.03 **	5.66	11.86 *	-24.77 **	-31.67 **	-14.58
IR 58025A	X	JGL11110-2	22.15 **	18.93 **	-2.37	24.77 **	13.33	41.67 **
IR 58025A	X	JGL11110-1	27.57 **	25.17 **	6.76	-31.75 **	-34.85 **	-10.42
IR 58025A	X	JGL17211	43.20 **	31.36 **	29.18 **	-22.41 **	-25.00 **	-6.25
IR 58025A	X	JGL16284	37.13 **	36.45 **	7.24	-13.33	-22.00 *	-18.75
IR 58025A	X	JGL13515	5.08	-8.46	-3.08	37.08 **	24.49 *	27.08 *
IR 58025A	X	JGL11160	32.55 **	31.85 **	3.62	-5.62	-14.29	-12.50
IR 58025A	X	JGL11118	14.30 **	9.81	-6.35	-22.64 **	-37.88 **	-14.58
IR 58025A	X	JGL11111	58.70 **	42.76 **	40.39 **	37.50 **	17.86	37.50 **
IR 58025A	X	JGL8605	7.73	-1.52	-7.47	18.00 *	18.00	22.92 *
IR 58025A	X	JGL8292	23.48 **	16.53 **	23.37 **	-33.33 **	-34.00 **	-31.25 **
IR 58025A	X	JGL3855	33.68 **	22.16 **	14.77 **	39.39 **	38.00 **	43.75 **
IR 58025A	X	JGL3844	-0.73	-5.30	-11.03 *	-20.69 **	-30.30 **	-4.17
IR 58025A	X	JGL1798	-1.73	-3.92	-5.52	-20.75 *	-25.00 **	-12.50
Hybrid			**Kampasagar**			**Pooled**		
			Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
IR 68897A	X	JGL11110-2	8.91	3.77	27.91 **	8.48*	-0.61	14.97**
IR 68897A	X	JGL11110-1	-5.88	-9.43	11.63	-10.10**	-13.47**	0.09
IR 68897A	X	JGL17211	-16.67 *	-24.53 **	-6.98	-10.67**	-19.73**	-7.16
IR 68897A	X	JGL16284	20.41 **	11.32	37.21 **	5.39	1.88	17.84**
IR 68897A	X	JGL13515	-6.42	-8.93	18.60	4.98	4.05	20.36**
IR 68897A	X	JGL11160	32.71 **	20.34 **	65.12 **	26.78**	7.89*	47.96**
IR 68897A	X	JGL11118	7.41	-1.69	34.88 **	-5.39	-15.79**	15.49**
IR 68897A	X	JGL11111	-1.96	-15.25 *	16.28	3.88	-13.14**	19.11**
IR 68897A	X	JGL8605	9.62	-3.39	32.56 **	-5.73	-15.75**	15.53**
IR 68897A	X	JGL8292	0.87	-1.69	34.88 **	-6.86*	-14.84**	16.78**
IR 68897A	X	JGL3855	6.54	-3.39	32.56 **	3.29	-7.32*	12.32**
IR 68897A	X	JGL3844	-1.85	-10.17	23.26 *	1.82	-4.15	6.17**
IR 68897A	X	JGL1798	13.73	-1.69	34.88 **	7.63*	-5.25	14.83**
APMS 8A	X	JGL11110-2	21.15 **	6.78	46.51 **	10.36**	4.33	26.45**
APMS 8A	X	JGL11110-1	20.87 **	17.80 *	61.63 **	24.26**	20.38**	45.90**
APMS 8A	X	JGL17211	12.73	0.00	44.19 **	33.55**	22.75**	40.99**
APMS 8A	X	JGL16284	-6.31	-16.13 *	20.93 *	20.02**	15.91**	33.13**
APMS 8A	X	JGL13515	23.81 **	4.84	51.16 **	22.06**	10.02*	26.36**
APMS 8A	X	JGL11160	8.41	-6.45	34.88 **	16.40**	1.91**	29.69**
APMS 8A	X	JGL11118	18.64 **	12.90	62.79 **	20.36**	19.72**	37.50**
APMS 8A	X	JGL11111	24.73 **	20.83 *	34.88 **	28.90**	26.29**	26.74**
APMS 8A	X	JGL8605	-4.26	-8.16	4.65	11.30**	7.85	15.40**

Table 4.30(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	6.82	4.44	9.30	8.93*	4.49	4.87
APMS 8A	X	JGL3855	13.33	13.33	18.60	1.00	-2.56	5.21
APMS 8A	X	JGL3844	8.91	-1.79	27.91 **	9.88**	3.47	17.57**
APMS 8A	X	JGL1798	1.89	-6.90	25.58 *	12.37**	-1.21	25.45**
CMS 16A	X	JGL11110-2	8.41	0.00	34.88 **	5.53	-2.78	23.46**
CMS 16A	X	JGL11110-1	8.91	3.77	27.91 **	9.25**	-5.72	19.72**
CMS 16A	X	JGL17211	-5.88	-9.43	11.63	19.28**	10.34**	40.13**
CMS 16A	X	JGL16284	-16.67 *	-24.53 **	-6.98	11.12**	5.28	33.70**
CMS 16A	X	JGL13515	20.41 **	11.32	37.21 **	14.87**	9.38*	16.44**
CMS 16A	X	JGL11160	-6.42	-8.93	18.60	22.62**	22.31**	30.87**
CMS 16A	X	JGL11118	2.97	-10.34	20.93 *	21.25**	13.12**	20.43**
CMS 16A	X	JGL11111	30.10 **	15.52 *	55.81 **	-6.58	-7.24	0.16
CMS 16A	X	JGL8605	15.79 *	13.79	53.49 **	11.12**	7.61	22.28**
CMS 16A	X	JGL8292	8.82	2.78	29.07 **	29.68**	13.95**	44.86**
CMS 16A	X	JGL3855	32.04 **	25.93 **	58.14 **	-8.93**	-16.14**	6.61
CMS 16A	X	JGL3844	29.90 **	16.67 *	46.51 **	18.78**	2.46	30.25**
CMS 16A	X	JGL1798	-7.07	-14.81	6.98	-9.02**	-15.87**	6.95
APMS 6A	X	JGL11110-2	-5.45	-7.14	20.93 *	-4.82	-9.87**	14.58**
APMS 6A	X	JGL11110-1	17.24 **	0.00	58.14 **	23.67**	14.42**	29.55**
APMS 6A	X	JGL17211	-16.24 *	-27.94 **	13.95	13.56**	10.44**	25.05**
APMS 6A	X	JGL16284	11.71	-8.82	44.19 **	26.20**	14.49**	29.62**
APMS 6A	X	JGL13515	-0.88	-17.65 **	30.23 **	-6.14	-8.32*	3.80
APMS 6A	X	JGL11160	-17.74 **	-25.00 **	18.60	-10.34**	-10.50**	1.70
APMS 6A	X	JGL11118	10.91	-1.61	41.86 **	11.92**	1.59	19.95**
APMS 6A	X	JGL11111	18.92 **	6.45	53.49 **	18.56**	13.00**	33.42**
APMS 6A	X	JGL8605	20.00 **	1.61	46.51 **	14.59**	2.03	20.47**
APMS 6A	X	JGL8292	-17.76 *	-29.03 **	2.33	4.53	0.06	18.14**
APMS 6A	X	JGL3855	-18.47 **	-22.42 **	11.86	-20.64**	-22.13**	-8.06
APMS 6A	X	JGL3844	11.11	0.00	39.53 **	3.69	1.12	2.45
APMS 6A	X	JGL1798	11.93	1.67	41.86 **	7.53*	4.68	12.00**
IR 58025A	X	JGL11110-2	8.74	-6.67	30.23 **	16.47**	11.22*	12.68**
IR 58025A	X	JGL11110-1	16.19 *	1.67	41.86 **	5.17	1.93	10.05*
IR 58025A	X	JGL17211	-15.52 *	-18.33 *	13.95	14.79**	8.57*	23.37**
IR 58025A	X	JGL16284	16.48 *	10.42	23.26 *	16.35**	9.55*	5.48
IR 58025A	X	JGL13515	32.61 **	24.49 **	41.86 **	19.91**	7.60	15.13**
IR 58025A	X	JGL11160	0.00	0.00	0.00	19.78**	15.13**	6.14
IR 58025A	X	JGL11118	34.09 **	31.11 **	37.21 **	-0.29	-10.89**	-3.78
IR 58025A	X	JGL11111	29.29 **	14.29	48.84 **	49.03**	30.27**	48.03**
IR 58025A	X	JGL8605	25.84 **	16.67	30.23 **	7.91	3.36	8.70
IR 58025A	X	JGL8292	20.00 *	10.20	25.58 *	3.32	2.43	9.60*
IR 58025A	X	JGL3855	33.33 **	30.23 **	30.23 **	33.22**	25.00**	31.45**
IR 58025A	X	JGL3844	11.63	6.67	11.63	-7.56*	-8.77*	-1.49
IR 58025A	X	JGL1798	50.52 **	30.36 **	69.77 **	-11.14**	-14.45**	-2.79

* Significant at 5% level; ** Significant at 1% level

16284). The significant positive heterobeltiosis was recorded in 11 hybrids and it ranged from 31.11 (IR 58025A x JGL 11110-1) to 15.52 (CMS 16A x JGL 8605). The significant standard heterosis was recorded in 47 hybrids ranging from 69.77 (IR 58025A x JGL 11111) to 20.93 (CMS16A x JGL 8605), when compared check PA 6201.

In pooled analysis, positive significant average heterosis recorded was in 39 hybrids, and it ranged from 40.03 (IR 58025A x JGL 11111) to 7.53 (APMS 6A x JGL 1798). The significant heterobeltiosis was observed in 22 hybrids, with a range from 30.27 (IR 58025A x JGL 11111) to 7.89 (IR68897A x JGL 11160). Positive significant standard heterosis was observed in 47 hybrids, ranging from 48.03 (IR 58025A x JGL 11111) to 9.60 (IR58025A x JGL 8292), when compared with check PA 6201 (Table 4.30).

Higher flag leaf length is a desirable feature of hybrid rice for efficient photosynthesis at and after flowering. Significant standard heterosis for flag leaf length was observed in 47 hybrids, in pooled analysis over the best check PA 6201. The hybrid IR 58025A x JGL 11111 (48.03) recorded highest standard heterosis over the best check PA 6201, with relative high standard heterosis (36.67) over check KRH-2, heterobeltiosis (30.27) and average heterosis (49.03). The hybrids IR 68897A x JGL 11160 (47.96), APMS 8A x JGL 11110-1 (45.90), CMS 16A x JGL 8292 (44.89) and APMS 8A x JGL 17211 (40.99) also recorded high standard heterosis over best check PA 6201. The heterobeltiosis both on positive and negative directions were reported by Mishra and Pandey (1998)

4.2.7.5 Flag leaf width

The positive significant average heterosis was recorded in 15 hybrids,(Table 4.32) ranging from 88.51 (CMS 16A x JGL 11160) to 15.07 (APMS 6A x JGL 13515). The significant heterobeltiosis in positive direction was observed in 8 hybrids, with a range from 85.78 (CMS 16A x JGL 11160) to 28.56 (APMS 8A x JGL 1798). The significant positive standard heterosis was recorded in 11 hybrids, with a range from 50.78 (CMS 16A x JGL 11160) to 18.20 (CMS16 A x JGL 13515) when compared with check PA 6201 for the character flag leaf width at Kunaram.

The positive significant average heterosis was observed in 4 hybrids, with a range from 114.95 (IR 58025A x JGL 13515) to 11.54 (CMS 16A x JGL 3855). Only two hybrids, IR 58025A x JGL 13515 (98.29) and APMS 6A x JGL 1798 recorded positive significant heterobeltiosis and standard heterosis over high yielding check PA 6201, at Warangal.

Table 4.31. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for flag leaf width at Kunaram , Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-8.06	-16.78	-22.30 *	-18.88 **	-31.76 **	-29.27 **
IR 68897A	X	JGL11110-1	-30.72 **	-36.12 **	-40.35 **	-2.80	-10.34	-36.59 **
IR 68897A	X	JGL17211	-22.15 **	-25.35 **	-24.05 **	-20.55 **	-34.09 **	-29.27 **
IR 68897A	X	JGL16284	21.01 **	16.91	17.09	-29.03 **	-43.30 **	-32.93 **
IR 68897A	X	JGL13515	-4.64	-5.61	-11.87	-45.55 **	-60.90 **	-36.59 **
IR 68897A	X	JGL11160	5.24	-10.65	-3.16	-41.12 **	-48.21 **	-29.27 **
IR 68897A	X	JGL11118	-16.47 *	-27.87 **	-21.82 *	-46.58 **	-61.61 **	-47.56 **
IR 68897A	X	JGL11111	-1.66	-4.67	3.32	-36.00 **	-42.86 **	-21.95 **
IR 68897A	X	JGL8605	-15.02 *	-18.24 *	-11.39	-50.24 **	-53.57 **	-36.59 **
IR 68897A	X	JGL8292	-5.30	-12.68	-5.37	-47.76 **	-51.88 **	-21.95 **
IR 68897A	X	JGL3855	-12.62	-26.30 **	-18.84 *	-41.12 **	-48.21 **	-29.27 **
IR 68897A	X	JGL3844	-19.60 *	-31.03 **	-24.05 **	-27.95 **	-48.21 **	-29.27 **
IR 68897A	X	JGL1798	-22.19 **	-25.15 **	-17.57	-36.00 **	-42.86 **	-21.95 **
APMS 8A	X	JGL11110-2	-7.90	-12.07	-3.16	-44.50 **	-48.21 **	-29.27 **
APMS 8A	X	JGL11110-1	-0.46	-8.90	0.33	-55.10 **	-58.65 **	-32.93 **
APMS 8A	X	JGL17211	37.23 **	15.61	27.70 **	-26.01 **	-27.27 **	-21.95 **
APMS 8A	X	JGL16284	4.68	-10.31	-0.94	-28.47 **	-44.32 **	-40.24 **
APMS 8A	X	JGL13515	8.71	4.42	15.34	-37.50 **	-37.50 **	-32.93 **
APMS 8A	X	JGL11160	-0.23	-4.88	5.06	-30.81 **	-34.02 **	-21.95 **
APMS 8A	X	JGL11118	-11.46	-19.07 *	-10.61	-42.08 **	-51.88 **	-21.95 **
APMS 8A	X	JGL11111	2.29	-11.47	-8.38	-31.76 **	-31.76 **	-29.27 **
APMS 8A	X	JGL8605	63.53 **	44.03 **	49.06 **	-17.91 **	-35.29 **	-32.93 **
APMS 8A	X	JGL8292	-41.26 **	-41.76 **	-39.72 **	-26.01 **	-27.27 **	-21.95 **
APMS 8A	X	JGL3855	-1.02	-2.62	0.78	-42.86 **	-46.39 **	-36.59 **
APMS 8A	X	JGL3844	-29.72 **	-33.81 **	-31.49 **	-30.28 **	-42.86 **	-7.32
APMS 8A	X	JGL1798	44.45 **	28.56 **	24.68 **	-29.27 **	-31.76 **	-29.27 **
CMS 16A	X	JGL11110-2	9.62	-0.65	-3.65	4.69	-15.19 **	-18.29 **
CMS 16A	X	JGL11110-1	12.74	10.10	12.03	-23.35 **	-27.27 **	-21.95 **
CMS 16A	X	JGL17211	1.30	-0.30	-0.15	-27.27 **	-34.02 **	-21.95 **
CMS 16A	X	JGL16284	20.74 *	17.31	13.77	-28.30 **	-42.86 **	-7.32
CMS 16A	X	JGL13515	50.76 **	45.63 **	18.20 *	-27.27 **	-38.82 **	-36.59 **
CMS 16A	X	JGL11160	88.51 **	85.78 **	50.78 **	8.41	0.00	-29.27 **
CMS 16A	X	JGL11118	5.88	-4.83	-3.16	-24.66 **	-37.50 **	-32.93 **
CMS 16A	X	JGL11111	9.27	-1.09	-0.94	-32.90 **	-46.39 **	-36.59 **
CMS 16A	X	JGL8605	-37.67 **	-41.18 **	-46.20 **	-48.69 **	-63.16 **	-40.24 **
CMS 16A	X	JGL8292	2.14	-10.42	-10.13	-17.14 **	-31.76 **	-29.27 **
CMS 16A	X	JGL3855	68.34 **	50.29 **	50.78 **	11.54 *	5.45	-29.27 **
CMS 16A	X	JGL3844	5.09	4.35	6.18	-14.69 **	-30.68 **	-25.61 **
CMS 16A	X	JGL1798	36.08 **	35.96 **	36.41 **	-15.79 **	-34.02 **	-21.95 **
APMS 6A	X	JGL11110-2	34.98 **	29.02 **	29.44 **	-31.91 **	-51.88 **	-21.95 **
APMS 6A	X	JGL11110-1	25.77 **	1.67	24.68 **	-31.76 **	-31.76 **	-29.27 **
APMS 6A	X	JGL17211	1.32	-16.78 *	2.05	-13.43 **	-31.76 **	-29.27 **
APMS 6A	X	JGL16284	-1.27	-9.68	10.76	-32.95 **	-34.09 **	-29.27 **

Table 4.31 (cont.)

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A X JGL13515	15.07 *	4.52	28.18 **	-29.67 **	-34.02 **	-21.95 **
APMS 6A X JGL11160	-20.92 **	-30.97 **	-15.34	-46.79 **	-56.39 **	-29.27 **
APMS 6A X JGL11118	-3.72	-20.38 **	-7.90	-49.45 **	-52.58 **	-43.90 **
APMS 6A X JGL11111	10.34	-7.24	7.29	-20.55 **	-40.21 **	-29.27 **
APMS 6A X JGL8605	-9.32	-14.77	-1.42	-40.54 **	-43.30 **	-32.93 **
APMS 6A X JGL8292	-6.02	-12.32	1.42	-49.48 **	-49.48 **	-40.24 **
APMS 6A X JGL3855	-20.41 **	-28.74 **	-17.57	-44.35 **	-51.88 **	-21.95 **
APMS 6A X JGL3844	19.00 *	3.73	5.54	-31.76 **	-31.76 **	-29.27 **
APMS 6A X JGL1798	33.57 **	18.51 *	20.58 *	67.16 **	31.76 **	36.59 **
IR 58025A X JGL11110-2	-11.97	-11.97	-10.43	-5.20	-6.82	0.00
IR 58025A X JGL11110-1	2.82	2.02	3.80	-36.26 **	-40.21 **	-29.27 **
IR 58025A X JGL17211	-5.16	-9.95	-8.38	-46.79 **	-56.39 **	-29.27 **
IR 58025A X JGL16284	12.82	3.89	-6.63	-18.88 **	-31.76 **	-29.27 **
IR 58025A X JGL13515	22.32 *	14.79	3.16	114.95 **	98.28 **	40.24 **
IR 58025A X JGL11160	-36.42 **	-40.13 **	-39.09 **	-20.55 **	-34.09 **	-29.27 **
IR 58025A X JGL11118	-20.06 *	-24.17 **	-24.05 **	-25.16 **	-40.21 **	-29.27 **
IR 58025A X JGL11111	12.22	11.24	1.75	-7.85 *	-33.83 **	7.32
IR 58025A X JGL8605	-43.50 **	-44.25 **	-56.68 **	14.69 **	-3.53	0.00
IR 58025A X JGL8292	-24.36 *	-24.90 *	-40.81 **	8.41	0.00	-29.27 **
IR 58025A X JGL3855	-20.63 *	-30.01 **	-28.78 **	-28.77 **	-40.91 **	-36.59 **
IR 58025A X JGL3844	-48.75 **	-54.50 **	-54.43 **	-32.90 **	-46.39 **	-36.59 **
IR 58025A X JGL1798	-2.72	-10.05	-17.72 *	-23.56 **	-45.11 **	-10.98 **

Hybrid	Kampasagar			Pooled		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A X JGL11110-2	-31.03 **	-38.55 **	-14.06	-20.01**	-21.19**	-22.50**
IR 68897A X JGL11110-1	-40.86 **	-50.28 **	-30.47	-27.01**	-35.09**	-36.17**
IR 68897A X JGL17211	-29.91 **	-35.20 **	-9.38	-24.41**	-37.98**	-21.78**
IR 68897A X JGL16284	5.98	-2.01	37.03 *	-0.63	-6.71	4.53
IR 68897A X JGL13515	-27.07 **	-28.49 *	0.00	-27.57**	-36.27**	-17.50**
IR 68897A X JGL11160	-9.99	-20.82	14.06	-17.75**	-28.40**	-7.78
IR 68897A X JGL11118	-24.28 *	-37.09 **	-9.38	-29.55**	-43.84**	-27.66**
IR 68897A X JGL11111	-2.50	-11.06	28.13	-14.78**	-21.46**	1.16
IR 68897A X JGL8605	-21.76 *	-28.63 *	2.81	-30.69**	-35.20**	-16.53**
IR 68897A X JGL8292	-25.48 *	-27.98 *	3.75	29.39**	-29.56**	-8.82
IR 68897A X JGL3855	-32.93 **	-41.49 **	-14.06	-30.23**	-39.55**	-21.28**
IR 68897A X JGL3844	-25.16 *	-38.30 **	-9.38	-24.34**	-39.93**	-21.78**
IR 68897A X JGL1798	-31.76 **	-38.30 **	-9.38	-30.36--	-36.14**	-16.84**
APMS 8A X JGL11110-2	3.53	-6.38	37.50 *	-18.37**	-24.06**	-1.11
APMS 8A X JGL11110-1	7.78	3.19	51.56 **	-20.84**	-21.07**	2.78
APMS 8A X JGL17211	22.54 *	2.91	65.63 **	9.89*	-2.65	20.39**
APMS 8A X JGL16284	-12.80	-30.58 **	11.72	-11.76**	28.57**	-11.66*
APMS 8A X JGL13515	8.38	-5.83	51.56 **	-6.96	-12.63**	8.05
APMS 8A X JGL11160	0.00	-13.11	39.84 *	-10.82**	-15.01**	5.11
APMS 8A X JGL11118	-2.12	-10.19	44.53 **	-20.24**	-22.02**	0.94
APMS 8A X JGL11111	-16.47	-28.28 **	9.38	-16.35**	-24.20**	-10.94*
APMS 8A X JGL8605	29.89 **	5.53	60.94 **	26.32**	4.31	22.56**

Table 4.31(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-43.55 **	-49.80 **	-23.44	-36.86**	-39.24**	28.61**
APMS 8A	X	JGL3855	-10.71	-20.59	21.09	-19.02**	-20.90**	-7.06
APMS 8A	X	JGL3844	-36.82 **	-40.57 **	-9.38	-32.28**	-35.41**	-16.39**
APMS 8A	X	JGL1798	21.95 *	6.38	56.25 **	10.47*	2.76	14.00**
CMS 16A	X	JGL11110-2	-9.68	-25.53 *	9.38	1.03.	-14.62**	-5.28
CMS 16A	X	JGL11110-1	10.59	0.00	46.88 **	-0.20	-1.25	9.56
CMS 16A	X	JGL17211	-3.53	-12.77	28.13	-10.36**	-10.80*	-0.05
CMS 16A	X	JGL16284	7.78	3.19	51.56 **	-2.80	-9.74*	16.84**
CMS 16A	X	JGL13515	32.28 **	18.75	63.28 **	17.62**	16.35**	11.06*
CMS 16A	X	JGL11160	58.39 **	34.09 **	84.38 **	54.36**	40.45**	31.16**
CMS 16A	X	JGL11118	-1.83	-8.52	25.78	-6.71	-13.25**	-5.78
CMS 16A	X	JGL11111	-3.66	-10.23	23.44	-9.46*	-17.00**	-7.00
CMS 16A	X	JGL8605	-50.57 **	-51.14 **	-32.81 *	-46.35**	-53.82**	-40.22**
CMS 16A	X	JGL8292	-13.40	-17.74	0.00	-9.56*	-10.13	-14.22**
CMS 16A	X	JGL3855	59.22 **	42.03 **	72.66 **	49.68**	35.63**	27.83**
CMS 16A	X	JGL3844	2.73	1.54	23.44	-1.90	-8.39	-0.50
CMS 16A	X	JGL1798	33.94 **	32.39 *	60.94 **	18.39**	8.98*	22.12**
APMS 6A	X	JGL11110-2	-5.37	-9.88	21.09	-3.14	-16.31**	8.34
APMS 6A	X	JGL11110-1	14.12	-3.00	51.56 **	2.09	-10.07*	12.67*
APMS 6A	X	JGL17211	-3.73	-22.50 *	21.09	-4.82	-23.33**	-3.95
APMS 6A	X	JGL16284	-8.52	-19.50	25.78	-14.11**	-19.82**	0.44
APMS 6A	X	JGL13515	18.07	3.90	62.34 **	0.81	-4.51	19.63**
APMS 6A	X	JGL11160	-31.18 **	-36.00 **	0.00	-34.09**	-35.15**	-16.05**
APMS 6A	X	JGL11118	-9.49	-18.75	11.72	-22.52**	-31.16**	-15.44**
APMS 6A	X	JGL11111	22.15	3.41	42.19 **	4.21	-15..42**	3.89
APMS 6A	X	JGL8605	7.32	0.00	37.50 *	-15.17**	-20.08**	-1.83
APMS 6A	X	JGL8292	-3.66	-10.23	23.44	-21.24**	-24.70**	-7.50
APMS 6A	X	JGL3855	-19.54	-20.45	9.38	-29.84**	-31.63**	-11.50*
APMS 6A	X	JGL3844	-3.80	-13.64	18.75	-7.13	-14.21**	-3.39
APMS 6A	X	JGL1798	44.30 **	22.16	67.97 **	47.90**	24.22**	39.89**
IR 58025A	X	JGL11110-2	2.56	-4.43	31.41	-4.83	-6.52	5.27
IR 58025A	X	JGL11110-1	21.95 *	13.64	56.25 **	-5.04	-5.28	6.67
IR 58025A	X	JGL17211	-22.99 *	-23.86 *	4.69	-27.52**	-32.23**	-12.28*
IR 58025A	X	JGL16284	-0.84	-2.88	10.78	-2.74	-5.63	-9.93
IR 58025A	X	JGL13515	15.67	6.16	21.09	46.42**	35.64**	21.78**
IR 58025A	X	JGL11160	26.17 *	23.68	46.88 **	-10.34*	-18.11**	-7.06*
IR 58025A	X	JGL11118	-18.12	-19.74	-4.69	-21.17**	-29.00**	-20.44**
IR 58025A	X	JGL11111	-8.18	-15.12	14.06	-2.13	-17.13**	7.28
IR 58025A	X	JGL8605	-25.31	-31.71 *	-25.31	-16.35**	23.63**	-27.10**
IR 58025A	X	JGL8292	22.69	19.67	14.06	1.68	0.21	-21.00**
IR 58025A	X	JGL3855	-4.48	-15.79	0.00	-18.31**	-29.51**	-23.44**
IR 58025A	X	JGL3844	-20.15	-29.61 *	-16.41	-34.11**	-43.88**	-37.11**
IR 58025A	X	JGL1798	-2.78	-18.60	9.38	-11.23**	-28.59**	-7.56

* Significant at 5% level; ** Significant at 1% level

Table 4.32 Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for panicle length at Kunaram , Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	44.07 **	20.91 **	18.06 **	39.00 **	34.95 **	24.11 **
IR 68897A	X	JGL11110-1	3.65	2.99	0.56	25.12 **	23.30 **	13.39 *
IR 68897A	X	JGL17211	-0.35	-1.39	-1.67	5.36	-2.48	5.36
IR 68897A	X	JGL16284	18.82 **	14.94 **	12.22 **	9.01 *	-2.31	13.39 *
IR 68897A	X	JGL13515	10.87 **	9.53 **	6.94 *	13.71 **	8.74	0.00
IR 68897A	X	JGL11160	15.13 **	-8.62 **	3.06	4.51	-17.75 **	24.11 **
IR 68897A	X	JGL11118	-17.66 **	-23.65 **	-13.89 **	1.12	-19.53 **	21.43 **
IR 68897A	X	JGL11111	9.28 **	2.96	16.11 **	-12.34 **	-24.79 **	13.48 *
IR 68897A	X	JGL8605	1.16	-8.50 **	3.19	-20.94 **	-30.06 **	5.54
IR 68897A	X	JGL8292	5.61 *	-2.59	9.86 **	12.55 **	-12.43 **	32.14 **
IR 68897A	X	JGL3855	18.02 **	-2.59	-0.83	21.89 **	4.41	26.79 **
IR 68897A	X	JGL3844	5.96 *	3.14	5.00	7.63	-6.62	13.39 *
IR 68897A	X	JGL1798	-3.10	-4.09	-2.36	-29.18 **	-33.09 **	-18.75 **
APMS 8A	X	JGL11110-2	2.30	-3.00	-1.25	2.26	0.00	21.43 **
APMS 8A	X	JGL11110-1	11.06 **	7.50 **	9.44 **	5.22	-11.03 *	8.04
APMS 8A	X	JGL17211	26.84 **	7.07 *	3.06	11.89 **	-2.31	13.39 *
APMS 8A	X	JGL16284	19.11 **	19.02 **	14.72 **	-2.61	-13.85 **	0.00
APMS 8A	X	JGL13515	3.61	1.81	1.53	-8.37 *	-11.54 *	2.68
APMS 8A	X	JGL11160	3.70	1.01	-2.78	2.31	2.31	18.75 **
APMS 8A	X	JGL11118	-1.81	-2.31	-5.97 *	16.07 **	0.00	16.07 **
APMS 8A	X	JGL11111	21.21 **	0.98	0.42	-7.09	-24.84 **	5.36
APMS 8A	X	JGL8605	8.65 **	6.98 *	6.39 *	-24.51 **	-38.22 **	-13.39 *
APMS 8A	X	JGL8292	-2.51	-2.65	-2.92	-12.95 **	-22.93 **	8.04
APMS 8A	X	JGL3855	7.94 **	3.49	2.92	-21.95 **	-28.66 **	0.00
APMS 8A	X	JGL3844	9.56 **	7.26 **	6.67 *	-13.15 **	-30.57 **	-2.68
APMS 8A	X	JGL1798	12.46 **	-4.27	-9.72 **	6.61	-6.92	8.04
CMS 16A	X	JGL11110-2	15.08 **	13.83 **	9.72 **	13.04 **	0.00	16.07 **
CMS 16A	X	JGL11110-1	13.39 **	10.31 **	10.00 **	-12.99 **	-16.00 **	-2.50
CMS 16A	X	JGL17211	19.76 **	17.82 **	11.11 **	-4.46	-4.46	10.89 *
CMS 16A	X	JGL16284	0.66	0.15	-4.58	10.89 *	-4.46	10.89 *
CMS 16A	X	JGL13515	24.93 **	7.21 *	-0.83	15.25 **	-2.16	21.43 **
CMS 16A	X	JGL11160	14.12 **	11.82 **	7.78 **	3.77	-10.79 *	10.71 *
CMS 16A	X	JGL11118	-7.08 **	-10.45 **	-10.69 **	-25.38 **	-30.22 **	-13.39 *
CMS 16A	X	JGL11111	9.45 **	8.71 **	0.56	5.58	2.16	26.79 **
CMS 16A	X	JGL8605	11.09 **	9.48 **	4.31	1.29	-15.11 **	5.36
CMS 16A	X	JGL8292	20.94 **	0.98	-0.14	17.48 **	11.01 *	8.04
CMS 16A	X	JGL3855	-0.57	-1.83	-2.92	12.92 **	8.26	5.36
CMS 16A	X	JGL3844	0.84	0.42	0.14	15.83 **	10.08 *	18.93 **
CMS 16A	X	JGL1798	-1.39	-5.20	-6.25 *	-18.66 **	-25.23 **	-13.21 *
APMS 6A	X	JGL11110-2	5.72 *	3.79	2.64	19.31 **	11.10 *	8.12
APMS 6A	X	JGL11110-1	36.69 **	18.20 **	7.36 **	14.54 **	0.00	16.07 **
APMS 6A	X	JGL17211	1.48	-1.44	-5.00	0.09	-11.46 *	2.77
APMS 6A	X	JGL16284	5.39 *	0.70	0.42	1.20	-2.31	13.39 *

Table 4.32 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	10.91 **	10.65 **	0.97	-18.46 **	-18.46 **	-5.36
APMS 6A	X	JGL11160	9.55 **	7.00 *	1.94	5.36	-9.23 *	5.36
APMS 6A	X	JGL11118	7.85 **	-13.80 **	-4.58	9.50 *	-2.42	8.04
APMS 6A	X	JGL11111	-6.64 **	-12.67 **	-3.33	18.75 **	7.26	18.75 **
APMS 6A	X	JGL8605	-19.34 **	-23.34 **	-15.14 **	-11.02 **	-12.10 *	-2.68
APMS 6A	X	JGL8292	0.83	-8.03 **	1.81	-4.72	-6.92	8.04
APMS 6A	X	JGL3855	-6.81 **	-13.30 **	-4.03	8.26	-4.84	5.36
APMS 6A	X	JGL3844	11.50 **	-3.52	-12.50 **	-6.12	-22.30 **	2.68
APMS 6A	X	JGL1798	2.45	-0.58	-4.17	7.26	-10.14 *	18.75 **
IR 58025A	X	JGL11110-2	11.45 **	6.41 *	6.11 *	-3.35	-12.16 **	16.07 **
IR 58025A	X	JGL11110-1	16.95 **	16.59 **	6.39 *	-15.11 **	-20.27 **	5.36
IR 58025A	X	JGL17211	0.97	-1.46	-6.11 *	2.48	-16.22 **	10.71 *
IR 58025A	X	JGL16284	31.98 **	17.76 **	-0.56	26.11 **	20.75 **	14.29 **
IR 58025A	X	JGL13515	-33.79 **	-37.90 **	-40.14 **	32.04 **	28.30 **	21.43 **
IR 58025A	X	JGL11160	13.57 **	4.87	4.58	3.96	-2.48	5.36
IR 58025A	X	JGL11118	13.20 **	8.98 **	-0.56	2.54	-6.92	8.04
IR 58025A	X	JGL11111	23.96 **	16.91 **	11.39 **	27.00 **	19.81 **	13.39 *
IR 58025A	X	JGL8605	6.93 *	-7.24 *	-16.39 **	20.87 **	4.51	24.11 **
IR 58025A	X	JGL8292	4.99 *	1.59	-2.08	3.86	-9.02 *	8.04
IR 58025A	X	JGL3855	14.85 **	9.33 **	9.03 **	-2.36	-6.77	10.71 *
IR 58025A	X	JGL3844	6.58 *	5.94 *	-3.33	-7.98 *	-9.02 *	8.04
IR 58025A	X	JGL1798	6.82 **	3.94	-0.97	11.89 **	-4.51	13.39 *

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	19.54 **	8.33 *	15.56 **	33.43**	19.97**	18.93**
IR 68897A	X	JGL11110-1	-3.23	-6.25	0.00	6.86**	4.44*	4.04
IR 68897A	X	JGL17211	-3.30	-8.33 *	-2.22	0.26	-0.51	0.15
IR 68897A	X	JGL16284	14.61 **	6.25	13.33 **	14.40**	13.93**	12.94**
IR 68897A	X	JGL13515	3.23	0.00	6.67	8.78**	5.78**	4.86*
IR 68897A	X	JGL11160	5.62	-6.00	4.44	8.35**	-11.01**	9.57**
IR 68897A	X	JGL11118	-11.58 **	-16.00 **	-6.67	-9.73**	-19.82**	-1.28
IR 68897A	X	JGL11111	9.68 **	2.00	13.33 **	2.24	-7.08**	14.40**
IR 68897A	X	JGL8605	3.30	-6.00	4.44	-5.80**	-15.29**	4.30
IR 68897A	X	JGL8292	1.05	-4.00	6.67	6.23**	-6.48**	15.14**
IR 68897A	X	JGL3855	5.88	-2.17	0.00	15.01**	-0.19	7.37**
IR 68897A	X	JGL3844	5.49	4.35	6.67	6.29**	0.38	7.98**
IR 68897A	X	JGL1798	-3.37	-6.52	-4.44	-11.42**	-14.27**	-7.77**
APMS 8A	X	JGL11110-2	10.34 **	4.35	6.67	4.89**	0.38	7.98**
APMS 8A	X	JGL11110-1	7.69 *	6.52	8.89 *	8.19**	1.19	8.85**
APMS 8A	X	JGL17211	10.84 **	4.55	2.22	16.45**	3.20	5.73**
APMS 8A	X	JGL16284	12.36 **	11.11 **	11.11 **	10.33**	6.64**	9.26**
APMS 8A	X	JGL13515	5.75	4.55	2.22	0.53	-0.35	2.10
APMS 8A	X	JGL11160	8.24 *	4.55	2.22	4.71*	2.60	5.12*
APMS 8A	X	JGL11118	1.12	0.00	0.00	4.43*	-0.05	2.40
APMS 8A	X	JGL11111	3.61	-2.27	-4.44	5.61**	-9.39**	0.15
APMS 8A	X	JGL8605	10.11 **	8.89 *	8.89 *	-1.44	-8.10**	1.59

Table 4.32(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-1.15	-2.27	-4.44	-5.59**	-9.81**	-0.31
APMS 8A	X	JGL3855	8.24 *	4.55	2.22	-2.47	-7.87**	1.84
APMS 8A	X	JGL3844	5.62	4.44	4.44	1.10	-6.62**	3.22
APMS 8A	X	JGL1798	-1.23	-4.76	-11.11 **	5.82**	-5.31*	-5.12*
CMS 16A	X	JGL11110-2	14.94 **	11.11 **	11.11 **	14.42**	11.79**	12.02**
CMS 16A	X	JGL11110-1	15.29 **	13.95 **	8.89 *	5.58**	5.34*	6.04**
CMS 16A	X	JGL17211	20.48 **	19.05 **	11.11 **	11.88*	10.82**	11.05**
CMS 16A	X	JGL16284	1.15	-2.22	-2.22	3.85**	0.46	0.66
CMS 16A	X	JGL13515	8.43 *	2.27	0.00	15.98**	2.38	5.83**
CMS 16A	X	JGL11160	5.62	4.44	4.44	8.02**	3.96	7.47**
CMS 16A	X	JGL11118	10.34 **	9.09 *	6.67	-7.35**	-8.56**	-5.47*
CMS 16A	X	JGL11111	3.53	0.00	-2.22	6.21**	3.61	7.11**
CMS 16A	X	JGL8605	7.87 *	6.67	6.67	7.01**	1.98	5.42*
CMS 16A	X	JGL8292	5.88	-2.17	0.00	14.42	2.67	2.25
CMS 16A	X	JGL3855	1.10	0.00	2.22	3.72	1.64	1.23
CMS 16A	X	JGL3844	-7.87 *	-10.87 **	-8.89 *	2.27**	1.73	2.40
CMS 16A	X	JGL1798	-3.45	-8.70 *	-6.67	-7.42**	-8.01**	-8.39**
APMS 6A	X	JGL11110-2	-3.30	-4.35	-2.22	6.11**	2.95	2.53
APMS 6A	X	JGL11110-1	18.07 **	11.36 **	8.89 *	22.93	9.88**	10.38**
APMS 6A	X	JGL17211	-5.62	-6.67	-6.67	-1.41*	-3.79	-3.35
APMS 6A	X	JGL16284	5.75	4.55	2.22	4.17	4.07	4.76*
APMS 6A	X	JGL13515	12.94 **	9.09 *	6.67	1.75**	0.66	1.13
APMS 6A	X	JGL11160	3.37	2.22	2.22	6.14**	2.55	3.02
APMS 6A	X	JGL11118	0.00	-10.20 **	-2.22	5.54**	-9.29**	-0.15
APMS 6A	X	JGL11111	-6.38 *	-10.20 **	-2.22	-6.09**	8.13**	3.38
APMS 6A	X	JGL8605	6.52 *	0.00	8.89 *	-12.13**	-3.31	-3.27
APMS 6A	X	JGL8292	0.00	-8.16 *	0.00	-6.46**	4.73*	2.97
APMS 6A	X	JGL3855	-8.51 **	-12.24 **	-4.44	-10.50**	5.19*	-1.48
APMS 6A	X	JGL3844	-2.38	-8.89 *	-8.89 *	-11.99	17.65**	-6.91**
APMS 6A	X	JGL1798	4.44	4.44	4.44	-0.39	10.22**	5.37*
IR 58025A	X	JGL11110-2	-2.27	-4.44	-4.44	0.44	4.62*	5.32*
IR 58025A	X	JGL11110-1	9.30 **	4.44	4.44	-0.34**	7.23**	5.42*
IR 58025A	X	JGL17211	-8.89 **	-8.89 *	-8.89 *	-7.59**	4.37	-2.25
IR 58025A	X	JGL16284	17.50 **	14.63 **	4.44	17.57**	33.23**	5.42*
IR 58025A	X	JGL13515	-37.21 **	-40.00 **	-40.00 **	-13.52**	-18.89**	-22.46**
IR 58025A	X	JGL11160	7.14 *	4.65	0.00	15.12**	2.54	3.22
IR 58025A	X	JGL11118	14.63 **	14.63 **	4.44	15.57**	5.41*	3.63
IR 58025A	X	JGL11111	13.95 **	8.89 *	8.89 *	23.90	18.62**	11.10**
IR 58025A	X	JGL8605	-3.61	-9.09 *	-11.11 **	-3.90	22.62**	-2.97
IR 58025A	X	JGL8292	3.37	2.22	2.22	1.32**	7.01**	2.30
IR 58025A	X	JGL3855	12.64 **	11.36 **	8.89 *	8.41	8.74**	9.46**
IR 58025A	X	JGL3844	5.88	2.27	0.00	0.10	2.81	1.07
IR 58025A	X	JGL1798	1.12	0.00	0.00	2.48	10.49**	3.48

* Significant at 5% level; ** Significant at 1% level

At Kampasagar, positive significant average heterosis was recorded in 12 hybrids, which ranged from 59.22 (CMS 16A x JGL 3855) to 21.95 (IR58025A x JGL 11110-1). The significant heterobeltiosis was recorded in only 3 hybrids, 42.03(CMS 16A x JGL 3855) to 32.39 (CMS 16A x JGL 1798). The significant standard heterosis was observed in 22 hybrids which ranged from 84.38 (CMS 16A x JGL 11160) to 37.03 (IR68897A x JGL 16284), when compared with check PA 6201, for the character flag leaf width.

In Pooled analysis, positive significant average heterosis was recorded in 10 hybrids, which ranged from 54.36 (CMS 16A x JGL 11160) to 9.89 (APMS 8A x JGL 17211). The significant heterobeltiosis was recorded in 8 hybrids, with a range from 40.45 (CMS 16A x JGL 11160) to 8.98 (CMS 16A x JGL 1798). The significant standard positive heterosis was recorded in 13 hybrids, which ranged from 39.89 (APMS 6A x JGL 1798) to 11.06 (CMS 16A x JGL 13515), when compared with check PA 6201 (Table 4.31).

Higher flag leaf width is a desirable feature of hybrid rice for efficient photosynthesis at and after flowering. Significant standard heterosis for flag leaf length was observed in 13 hybrids, over the best check PA 6201. The hybrid APMS 6A x JGL 1798 (39.89) recorded highest standard heterosis over the best check PA 6201. The significant heterobeltiosis was recorded in 8 hybrids, with a range from 40.45 (CMS 16A x JGL 11160) to 8.98 (CMS 16A x JGL 1798). The heterobeltiosis both on positive and negative directions were reported by Mishra and Pandey (1998)

4.2.7.6 Panicle length (cms)

At Kunaram, positive the significant average heterosis was recorded in 42 hybrids (Table 4.32), with a range from 44.07 (IR 68897A x JGL 11110-2) to 4.99 (IR58025A x JGL 8292). The significant positive heterobeltiosis was observed in 25 hybrids with a range from 20.91 (IR 68897A x JGL 11110-2) to 5.94 (IR58025A x JGL 3844). The significant standard heterosis was recorded in 18 hybrids and it ranged from 18.06 (IR 68897A x JGL 11110-2) to 6.11 (IR 58025A x JGL 11110-2) compared to check PA 6201.

At Warangal, the positive significant average heterosis was recorded in 23 hybrids with a range from 39.00 (IR 68897A x JGL 11110-2) to 9.01 (IR 68897A x JGL 16284). The significant heterobeltiosis was recorded in 8 hybrids and it ranged between 34.95 (IR68897AxJGL1110-2) to 10.08 (CMS 16A x JGL 3844). The significant standard heterosis was observed in 32 hybrids, with range from 32.14 (IR 68897A x JGL 8292) to 10.71 (IR 58025A x JGL 3855), when compared with check PA 6201.

At Kampasagar, positive significant average heterosis was observed in 25 hybrids with range from 20.48 (CMS 16A x JGL 17211) to 6.52 (IR 68897A x JGL 8605). The significant heterobeltiosis was recorded in 13 hybrids with range from 8.33 (IR 68897A x JGL 11110-2) to 11.11 (CMS 16A x JGL 11110-2). The positive significant standard heterosis was recorded in 13 hybrids with a range from 15.56 (IR 68897A x JGL 11110-2) to 8.89 (IR58025A x JGL 3855) when compared to check PA 6201.

In Pooled analysis positive significant average heterosis was recorded in 41 hybrids with range from 33.43 (IR 68897A x JGL 11110-2) to 1.32 (IR58025A x JGL 8292). The significant heterobeltiosis was recorded in 23 hybrids, which ranged from 33.23 (IR 58025A x JGL 16284) to 4.44 (IR 68897A x JGL 11110-2). The positive standard heterosis was observed in 28 hybrids with a range from 18.93 (IR 68897A x JGL 11110-2) to 4.76 (APMS 6A x JGL 16284) when compared with PA 6201 (Table 4.32).

Hybrids are generally characterized by having longer panicles, indicating their efficiency in partitioning assimilates into reproductive parts. This is one of the important attribute for higher yields in hybrids. The significant standard heterosis for panicle length was recorded in 23 hybrids when compared with best check PA 6201. The hybrid IR 68897A x JGL 11110-2 (18.93) recorded highest standard heterosis, over best check PA6201, with relatively high standard heterosis (6.75) over check KRH-2, heterobeltiosis (19.97) and average heterosis (33.43). The other hybrids, IR 68897A x JGL 8292 (15.14), IR 68897A x JGL 11111 (14.40), IR 68897A x JGL 16284 (12.94) and CMS 16A x JGL 11110-2 (12.02) also recorded high heterosis over the best check PA 6201(Table 4.41 and Figure 4.9). Significant positive and negative heterosis was exhibited over mid parent and better parent in hybrids. The results are in accordance with Jayamani *et al.* (1997), Vanaja and Babu (2004), Deoraj *et al.* (2007), Hariramakrishnan *et al.* (2009) and Roy *et al.* (2009). Standard heterosis of both positive and negative nature was observed by Singh *et al.* (2006 a), Doeraj *et al.* (2007), Singh *et al.* (2007) and Akarsh Parihar and Pathak (2008).

4.2.7.7 Panicle weight

At Kunaram, the positive significant average heterosis was recorded in 41 hybrids with a range from 143.28 (IR 68897A x JGL 16284) to 16.84 (APMS 6A x JGL 11110-2). The significant heterobeltiosis was recorded in 28 hybrids for panicle weight which ranged from 120.27 (IR 68897A x JGL 16284) to 13.27 (APMS 6A x JGL 11110-2). The positive significant standard heterosis was observed in 19 hybrids

Table 4.33. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for panicle weight at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	46.38 **	36.49 **	-8.18 *	32.11 **	24.14 **	-20.00 **
IR 68897A	X	JGL11110-1	-9.60 *	-22.33 **	-27.27 **	20.00 **	8.33	-13.33 **
IR 68897A	X	JGL17211	19.38 **	4.05	-30.00 **	11.45 *	0.00	-18.89 **
IR 68897A	X	JGL16284	143.28 **	120.27 **	48.18 **	0.00	-17.05 **	-18.89 **
IR 68897A	X	JGL13515	36.14 **	22.83 **	2.73	-30.99 **	-41.67 **	-45.56 **
IR 68897A	X	JGL11160	34.48 **	6.36	6.36	-11.96 **	-39.10 **	-10.00 *
IR 68897A	X	JGL11118	-39.91 **	-41.82 **	-41.82 **	-41.46 **	-54.89 **	-33.33 **
IR 68897A	X	JGL11111	57.58 **	18.18 **	18.18 **	-29.13 **	-45.11 **	-18.89 **
IR 68897A	X	JGL8605	28.24 **	-0.91	-0.91	-10.41 **	-25.56 **	10.00 *
IR 68897A	X	JGL8292	29.70 **	19.09 **	19.09 **	-21.66 **	-36.09 **	-5.56
IR 68897A	X	JGL3855	-20.22 **	-38.66 **	-33.64 **	-23.26 **	-45.45 **	-26.67 **
IR 68897A	X	JGL3844	-6.31	-12.61 **	-5.45	-31.61 **	-45.45 **	-26.67 **
IR 68897A	X	JGL1798	22.99 **	-10.08 **	-2.73	-40.21 **	-52.07 **	-35.56 **
APMS 8A	X	JGL11110-2	28.49 **	-3.36	4.55	-47.37 **	-54.55 **	-38.89 **
APMS 8A	X	JGL11110-1	47.87 **	31.09 **	41.82 **	-23.90 **	-35.54 **	-13.33 **
APMS 8A	X	JGL17211	78.38 **	57.14 **	20.00 **	-7.14	-37.24 **	1.11
APMS 8A	X	JGL16284	34.76 **	22.33 **	14.55 **	-29.95 **	-47.59 **	-15.56 **
APMS 8A	X	JGL13515	88.49 **	55.95 **	19.09 **	-14.68 **	-35.86 **	3.33
APMS 8A	X	JGL11160	137.50 **	103.57 **	55.45 **	-34.76 **	-47.59 **	-15.56 **
APMS 8A	X	JGL11118	26.14 **	20.65 **	0.91	-31.00 **	-45.52 **	-12.22 *
APMS 8A	X	JGL11111	25.29 **	-0.91	-0.91	65.66 **	60.78 **	-8.89
APMS 8A	X	JGL8605	-1.41	-4.55	-4.55	0.00	-16.67 **	-33.33 **
APMS 8A	X	JGL8292	20.00 **	-10.00 *	-10.00 *	14.05 *	-5.48	-23.33 **
APMS 8A	X	JGL3855	3.53	-20.00 **	-20.00 **	-2.94	-25.00 **	-26.67 **
APMS 8A	X	JGL3844	-30.69 **	-36.36 **	-36.36 **	24.24 **	-2.38	-8.89
APMS 8A	X	JGL1798	-27.37 **	-45.24 **	-37.27 **	-20.69 **	-43.90 **	-23.33 **
CMS 16A	X	JGL11110-2	25.76 **	14.29 **	30.91 **	-9.74 *	-28.46 **	-2.22
CMS 16A	X	JGL11110-1	30.39 **	-6.35	7.27	-35.71 **	-48.78 **	-30.00 **
CMS 16A	X	JGL17211	-13.98 **	-36.51 **	-27.27 **	-28.91 **	-39.02 **	-16.67 **
CMS 16A	X	JGL16284	-32.11 **	-41.27 **	-32.73 **	-10.14 **	-24.39 **	3.33
CMS 16A	X	JGL13515	52.66 **	22.86 **	17.27 **	-34.78 **	-54.89 **	-33.33 **
CMS 16A	X	JGL11160	-1.92	-2.86	-7.27	-23.90 **	-41.35 **	-13.33 **
CMS 16A	X	JGL11118	87.50 **	42.86 **	36.36 **	-17.48 **	-36.09 **	-5.56
CMS 16A	X	JGL11111	5.45	-17.14 **	-20.91 **	-53.85 **	-61.65 **	-43.33 **
CMS 16A	X	JGL8605	0.51	-5.71	-10.00 *	-50.23 **	-59.40 **	-40.00 **
CMS 16A	X	JGL8292	44.44 **	19.39 **	6.36	24.41 **	3.95	-12.22 *
CMS 16A	X	JGL3855	39.30 **	35.92 **	27.27 **	-35.14 **	-36.84 **	-46.67 **
CMS 16A	X	JGL3844	25.49 **	-2.04	-12.73 **	0.67	-1.32	-16.67 **
CMS 16A	X	JGL1798	-18.99 **	-34.69 **	-41.82 **	-26.83 **	-31.82 **	-33.33 **
APMS 6A	X	JGL11110-2	16.84 **	13.27 **	0.91	72.50 **	64.29 **	53.33 **
APMS 6A	X	JGL11110-1	43.90 **	18.00 **	7.27	12.57 **	-21.97 **	14.44 **
APMS 6A	X	JGL17211	53.69 **	51.46 **	41.82 **	-5.88	-27.27 **	6.67
APMS 6A	X	JGL16284	50.97 **	17.00 **	6.36	-29.76 **	-45.45 **	-20.00 **

Table 4.33(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-13.75 **	-31.00 **	-37.27 **	-50.91 **	-59.09 **	-40.00 **
APMS 6A	X	JGL11160	35.42 **	30.00 **	18.18 **	-24.07 **	-37.88 **	-8.89
APMS 6A	X	JGL11118	104.88 **	68.00 **	52.73 **	-7.69	-18.18 **	-40.00 **
APMS 6A	X	JGL11111	21.18 **	19.42 **	11.82 **	8.70	4.17	-16.67 **
APMS 6A	X	JGL8605	-14.84 **	-34.00 **	-40.00 **	-17.99 **	-21.92 **	-36.67 **
APMS 6A	X	JGL8292	21.25 **	-3.00	-11.82 **	1.30	-11.36 *	-13.33 **
APMS 6A	X	JGL3855	32.29 **	27.00 **	15.45 **	12.00 *	0.00	-6.67
APMS 6A	X	JGL3844	17.28 **	-11.81 **	1.82	11.27 *	-13.19 **	-12.22 *
APMS 6A	X	JGL1798	-21.74 **	-29.13 **	-18.18 **	-15.34 **	-24.18 **	-23.33 **
IR 58025A	X	JGL11110-2	-10.99 *	-36.22 **	-26.36 **	-23.17 **	-30.77 **	-30.00 **
IR 58025A	X	JGL11110-1	21.93 **	-10.24 **	3.64	-41.90 **	-42.86 **	-42.22 **
IR 58025A	X	JGL17211	3.20	-11.02 **	2.73	-37.14 **	-39.56 **	-38.89 **
IR 58025A	X	JGL16284	76.67 **	65.62 **	-3.64	15.87 **	-2.67	-18.89 **
IR 58025A	X	JGL13515	-13.21 **	-33.01 **	-37.27 **	3.40	1.33	-15.56 **
IR 58025A	X	JGL11160	24.32 **	23.21 **	-37.27 **	41.89 **	40.00 **	16.67 **
IR 58025A	X	JGL11118	18.97 **	15.00 *	-37.27 **	-19.02 **	-25.00 **	-26.67 **
IR 58025A	X	JGL11111	110.81 **	69.57 **	41.82 **	-15.72 **	-20.24 **	-25.56 **
IR 58025A	X	JGL8605	-43.75 **	-60.63 **	-42.73 **	50.00 **	27.40 **	3.33
IR 58025A	X	JGL8292	20.15 **	-1.25	43.64 **	-32.41 **	-32.88 **	-45.56 **
IR 58025A	X	JGL3855	-4.19	-35.63 **	-6.36	-16.44 **	-16.44 **	-32.22 **
IR 58025A	X	JGL3844	-20.00 **	-45.00 **	-20.00 **	-16.77 **	-23.86 **	-25.56 **
IR 58025A	X	JGL1798	-40.48 **	-53.13 **	-31.82 **	7.01	0.00	-6.67

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	85.61 **	74.32 **	40.22 **	56.48**	53.30**	3.42
IR 68897A	X	JGL11110-1	17.20 **	0.00	0.00	7.76**	-6.37**	-14.38**
IR 68897A	X	JGL17211	-12.88 **	-27.55 **	-22.83 **	4.49	-2.21	-2.32**
IR 68897A	X	JGL16284	56.69 **	33.70 **	33.70 **	64.30**	49.58**	22.95**
IR 68897A	X	JGL13515	-14.44 **	-34.43 **	-13.04 **	-2.22	-18.79**	-17.12**
IR 68897A	X	JGL11160	120.14 **	106.76 **	66.30 **	41.25**	13.96**	20.21**
IR 68897A	X	JGL11118	28.66 **	9.78 **	9.78 **	-21.74**	-26.95**	-22.95**
IR 68897A	X	JGL11111	57.06 **	30.61 **	39.13 **	23.97**	7.47**	13.36**
IR 68897A	X	JGL8605	14.65 **	-2.17	-2.17	8.76**	-3.25	2.05
IR 68897A	X	JGL8292	-4.81	-27.05 **	-3.26	0.66	-0.97	4.45
IR 68897A	X	JGL3855	-18.82 **	-28.13 **	-25.00 **	-20.76**	-38.10**	-28.77**
IR 68897A	X	JGL3844	2.13	0.00	4.35	-11.77**	-20.83**	-8.90**
IR 68897A	X	JGL1798	-32.99 **	-33.67 **	-29.35 **	-18.15**	-31.55**	-21.23**
APMS 8A	X	JGL11110-2	17.02 **	14.58 **	19.57 **	-2.78	-16.67**	-4.11*
APMS 8A	X	JGL11110-1	11.93 **	0.00	32.61 **	12.30**	5.95**	21.92**
APMS 8A	X	JGL17211	127.74 **	110.81 **	69.57 **	57.59**	29.79**	29.79**
APMS 8A	X	JGL16284	58.71 **	33.70 **	33.70 **	16.28**	11.30**	11.30**
APMS 8A	X	JGL13515	-37.89 **	-48.98 **	-45.65 **	5.79**	-6.16**	-6.16**
APMS 8A	X	JGL11160	7.10 *	-9.78 **	-9.78 **	24.06**	13.01**	13.01**
APMS 8A	X	JGL11118	-10.27 **	-31.97 **	-9.78 **	-7.46**	-8.39**	-6.51**
APMS 8A	X	JGL11111	38.81 **	25.68 **	1.09	39.56**	30.28**	-2.74
APMS 8A	X	JGL8605	17.11 **	-3.26	-3.26	4.74*	-4.87*	-13.01**

Table 4.33 (cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-17.72 **	-33.67 **	-29.35 **	4.95*	3.10	-20.21**
APMS 8A	X	JGL3855	-2.63	-19.57 **	-19.57 **	-0.44	-5.00*	-21.92**
APMS 8A	X	JGL3844	14.29 **	-14.75 **	13.04 **	-0.78	-14.09**	-12.33**
APMS 8A	X	JGL1798	-2.26	-12.16 **	-29.35 **	-18.31**	-34.09**	-30.48**
CMS 16A	X	JGL11110-2	45.70 **	19.57 **	19.57 **	18.96*/*	11.04**	17.12**
CMS 16A	X	JGL11110-1	55.41 **	24.49 **	32.61 **	13.48**	-1.62	3.77*
CMS 16A	X	JGL17211	106.62 **	69.57 **	69.57 **	13.50**	0.97	6.51**
CMS 16A	X	JGL16284	35.91 **	0.82	33.70 **	-4.29*	-5.84**	-0.68
CMS 16A	X	JGL13515	28.09 **	9.62 **	23.91 **	14.12**	-11.40**	3.77
CMS 16A	X	JGL11160	28.57 **	21.15 **	36.96 **	0.49	-10.53**	4.79*
CMS 16A	X	JGL11118	-7.92 **	-10.58 **	1.09	15.49**	-4.09*	12.33**
CMS 16A	X	JGL11111	3.06	-2.88	9.78 **	-17.87**	-30.12**	-18.15**
CMS 16A	X	JGL8605	-31.86 **	-36.89 **	-16.30 **	-28.12**	-32.75**	-21.23**
CMS 16A	X	JGL8292	-10.34 **	-12.16 **	-29.35 **	20.28**	6.53**	-10.62**
CMS 16A	X	JGL3855	5.52	-6.52	-6.52	7.03**	2.62	-6.16**
CMS 16A	X	JGL3844	8.88 **	-6.12	0.00	11.68**	7.35**	-9.93**
CMS 16A	X	JGL1798	46.01 **	29.35 **	29.35 **	0.21	-0.82	16.78**
APMS 6A	X	JGL11110-2	13.99 **	-9.84 **	19.57 **	32.23**	20.47**	22.95**
APMS 6A	X	JGL11110-1	70.63 **	64.86 **	32.61 **	40.00**	13.95**	17.47**
APMS 6A	X	JGL17211	77.64 **	55.43 **	55.43 **	39.08**	31.23**	35.27**
APMS 6A	X	JGL16284	46.11 **	24.49 **	32.61 **	18.03**	3.32	6.51**
APMS 6A	X	JGL13515	-8.07 *	-19.57 **	-19.57 **	-27.17**	-34.55**	-32.53**
APMS 6A	X	JGL11160	31.94 **	3.28	36.96 **	12.85**	12.29**	15.75**
APMS 6A	X	JGL11118	32.86 **	25.68 **	1.09	49.64**	35.78**	7.88**
APMS 6A	X	JGL11111	1.27	-13.04 **	-13.04 **	11.42**	4.12	-4.79*
APMS 6A	X	JGL8605	-41.46 **	-51.02 **	-47.83 **	-25.33**	26.29**	-41.44**
APMS 6A	X	JGL8292	-17.72 **	-29.35 **	-29.35 **	1.69	0.00	-17.81**
APMS 6A	X	JGL3855	-8.51 **	-29.51 **	-6.52	12.08**	-0.34	1.71
APMS 6A	X	JGL3844	11.29 *	-6.76	-25.00 **	13.79**	-2.99	-10.96**
APMS 6A	X	JGL1798	-15.49 **	-34.78 **	-34.78 **	18.13**	-18.28**	-25.00**
IR 58025A	X	JGL11110-2	48.65 **	12.24 **	19.57 **	2.83	-5.22*	-13.01**
IR 58025A	X	JGL11110-1	71.83 **	32.61 **	32.61 **	13.39**	7.46**	-1.37
IR 58025A	X	JGL17211	66.28 **	17.21 **	55.43 **	9.89**	4.36*	6.51**
IR 58025A	X	JGL16284	64.86 **	64.86 **	32.61 **	52.79**	46.83**	3.08
IR 58025A	X	JGL13515	-10.84 **	-19.57 **	-19.57 **	-7.20**	-17.98**	-25.00**
IR 58025A	X	JGL11160	77.91 **	56.12 **	66.30 **	51.74**	44.69**	11.99**
IR 58025A	X	JGL11118	21.69 **	9.78 **	9.78 **	6.07**	-1.67	-19.18**
IR 58025A	X	JGL11111	30.61 **	4.92	39.13 **	39.56**	17.79**	20.21**
IR 58025A	X	JGL8605	-35.57 **	-36.00 **	-47.83 **	-17.91**	-33.77**	-30.14**
IR 58025A	X	JGL8292	-22.16 **	-29.35 **	-29.35 **	-5.39**	-11.69**	-6.85**
IR 58025A	X	JGL3855	-0.58	-12.24 **	-6.52	-6.37**	-18.83**	-14.38**
IR 58025A	X	JGL3844	-17.37 **	-25.00 **	-25.00 **	-18.25**	-27.27**	-23.29**
IR 58025A	X	JGL1798	-39.09 **	-50.82 **	-34.78 **	-27.72**	-28.90**	-25.00**

* Significant at 5% level; ** Significant at 1% level

which ranged from 55.45 (APMS 8A x JGL 11160) to 11.82 (APMS 6A x JGL 11111) when compared with check PA 6201, for the character panicle weight.

At Warangal, the positive significant average heterosis was recorded in 14 hybrids, with a range from 72.50 (APMS 6A x JGL 11110-2) to 11.27 (APMS 6A x JGL 3844). The significant heterobeltiosis was observed in 5 hybrids ranging from 64.29 (APMS 6A x JGL 11110-2) to 24.14 (IR 58025A x JGL 11110-2). The positive significant standard heterosis was observed in 4 hybrids which ranged from 53.33 (APMS 6A x JGL 11110-2) to 10.00 (IR68897A x JGL 8605), when compared with check PA 6201.

At Kampasagar, the positive significant average heterosis was recorded in 37 hybrids, with a range from 127.74 (APMS 8A x JGL 17211) to 7.10 (APMS 8A x JGL 11118). The significant heterobeltiosis was observed in 25 hybrids, which ranged from 110.81 (APMS 8A x JGL 17211) to 9.62 (CMS 16A x JGL 13515). The positive significant standard heterosis was recorded in 30 hybrids for panicle weight, which ranged from 69.57 (APMS 8A x JGL 17211) to 9.78 (IR 58025A x JGL 11118) when compared with check PA 6201 (Table 4.33).

In pooled analysis, positive significant average heterosis was recorded in 38 hybrids, with a range from 64.30 (IR 68897A x JGL 16284) to 4.74 (APMS 8A x JGL 8605). The significant heterobeltiosis was observed in 23 hybrids, which ranged from 53.30 (IR68897 A x JGL 11110.2) to 4.36 (IR58025A x JGL 17211). The positive significant standard heterosis was recorded in 30 hybrids out of 23 hybrids tested for panicle weight and it ranged from 35.27 (APMS 6A x JGL 17211) to 3.77 (CMS 16A A x JGL 11160) when compared with check PA 6201 (Table 4.33).

Panicle weight is positively associated with grain yield and is known to contribute grain yield via more number of filled grains. The hybrid APMS 6A x JGL 17211 (35.27) recorded the highest standard heterosis over best check PA 6201 with relative high standard heterosis over check KRH-2 (24.21), heterobeltiosis (31.23) and average heterosis (39.08). The other hybrids APMS 8A x JGL 17211 (29.79), IR 68897A x JGL 16284 (22.95), APMS 6A x JGL 11110-2 (22.95) and APMS 8A x JGL 11110-1 (21.92) recorded high standard heterosis over the best check PA 6201. Most of the hybrids expressed significant positive heterosis and heterobeltiosis for this trait. In contrary to this heterosis and heterobeltiosis for both positive and negative nature in their studies were reported by Lokaprakash *et al.* (1992) and Ghosh (2002), while Lingaraju (1997) observed standard heterosis of similar nature in his experiment (Table 4.39 and Figure 4.7).

Table 4.34 Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for filled grains per panicle panicle at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A X JGL11110-2	10.49	-12.08	3.98	-12.92 *	-32.68 **	36.92 **
IR 68897A X JGL11110-1	-9.66	-21.93	-7.67	-14.51 **	-33.81 **	34.62 **
IR 68897A X JGL17211	5.88	-10.65	5.67	-26.35 **	-38.80 **	24.46 **
IR 68897A X JGL16284	56.66 **	41.38 **	67.20 **	-6.36	-9.76 *	83.54 **
IR 68897A X JGL13515	-21.86 *	-26.26 *	-1.72	-63.24 **	-70.73 **	0.46
IR 68897A X JGL11160	-3.72	-31.25 **	12.34	-35.70 **	-55.24 **	26.77 **
IR 68897A X JGL11118	-44.10 **	-57.31 **	-30.25 *	-48.87 **	-64.37 **	0.92
IR 68897A X JGL11111	20.24	-9.95	47.14 **	-39.10 **	-55.08 **	27.23 **
IR 68897A X JGL8605	-10.75	-29.37 **	15.40	-29.83 **	-41.55 **	65.54 **
IR 68897A X JGL8292	-40.90 **	-46.35 **	-12.34	-50.10 **	-54.46 **	56.31 **
IR 68897A X JGL3855	-28.40 *	-48.85 **	-16.54	-47.75 **	-63.60 **	2.77
IR 68897A X JGL3844	-3.55	-26.31 **	20.23	-40.08 **	-58.20 **	18.00 *
IR 68897A X JGL1798	-25.93 *	-44.50 **	-9.44	-42.51 **	-57.55 **	19.85 *
APMS 8A X JGL11110-2	14.97	-8.98	48.51 **	-25.78 **	-38.09 **	74.77 **
APMS 8A X JGL11110-1	23.71 **	12.38	83.37 **	-34.83 **	-40.61 **	103.85 **
APMS 8A X JGL17211	32.85 **	-10.12	78.02 **	19.39 **	-18.43 **	147.23 **
APMS 8A X JGL16284	6.99	-23.24 **	52.03 **	-25.49 **	-49.04 **	54.46 **
APMS 8A X JGL13515	2.23	-27.89 **	42.82 **	-4.75	-31.22 **	108.46 **
APMS 8A X JGL11160	10.23	-18.40 *	61.62 **	-44.12 **	-54.67 **	37.38 **
APMS 8A X JGL11118	-36.94 **	-47.25 **	4.46	-65.63 **	-67.64 **	11.08
APMS 8A X JGL11111	49.45 **	11.94	57.21 **	91.22 **	86.68 **	117.69 **
APMS 8A X JGL8605	55.74 **	25.64 *	76.45 **	3.03	0.79	17.54
APMS 8A X JGL8292	43.45 **	13.27	59.07 **	-3.12	-9.60	21.69 *
APMS 8A X JGL3855	0.13	-16.00	17.97	2.42	-17.13 **	56.31 **
APMS 8A X JGL3844	6.73	4.01	46.08 **	-24.59 **	-49.48 **	73.38 **
APMS 8A X JGL1798	-16.66	-41.84 **	2.83	-13.06 **	-34.35 **	42.92 **
CMS 16A X JGL11110-2	29.12 **	-3.98	69.78 **	45.42 **	9.96 *	139.38 **
CMS 16A X JGL11110-1	42.31 **	3.88	83.69 **	-12.84 **	-29.47 **	53.54 **
CMS 16A X JGL17211	-22.24 *	-40.19 **	5.75	7.61 *	0.42	118.62 **
CMS 16A X JGL16284	-39.22 **	-46.70 **	-5.75	-24.52 **	-38.32 **	111.69 **
CMS 16A X JGL13515	41.86 **	7.83	44.96 **	29.94 **	-12.52 **	180.46 **
CMS 16A X JGL11160	5.62	-13.35	16.49	-30.87 **	-53.41 **	49.38 **
CMS 16A X JGL11118	57.24 **	26.19 *	69.63 **	-35.59 **	-54.27 **	46.62 **
CMS 16A X JGL11111	-1.86	-16.18	12.68	-54.20 **	-63.63 **	16.62
CMS 16A X JGL8605	-26.62 **	-26.93 *	-1.77	-61.81 **	-63.07 **	26.77 **
CMS 16A X JGL8292	80.29 **	38.92 **	79.59 **	19.00 **	13.60	38.77 **
CMS 16A X JGL3855	37.45 **	14.52	48.05 **	15.60 *	10.58	35.08 **
CMS 16A X JGL3844	-28.03 *	-41.38 **	-24.21	-11.68	-15.77 *	13.38
CMS 16A X JGL1798	-36.81 **	-45.14 **	-29.08	-34.46 **	-46.00 **	1.85
APMS 6A X JGL11110-2	23.22 *	21.37	61.76 **	61.98 **	9.82 **	276.92 **
APMS 6A X JGL11110-1	32.81 **	-7.67	65.43 **	16.97 **	-18.58 **	130.62 **
APMS 6A X JGL17211	47.10 **	8.91	95.13 **	-21.75 **	-45.46 **	54.46 **
APMS 6A X JGL16284	39.22 **	1.21	81.34 **	-54.57 **	-66.49 **	-5.08

Table 4.34 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-22.87 *	-40.94 **	5.81	-40.59 **	-50.52 **	40.15 **
APMS 6A	X	JGL11160	13.88	-0.70	77.90 **	-8.25 **	-16.27 **	187.38 **
APMS 6A	X	JGL11118	42.50 **	-2.73	86.35 **	-35.31 **	-46.99 **	-7.85
APMS 6A	X	JGL11111	25.60 **	-8.96	74.41 **	23.13 **	1.06	75.69 **
APMS 6A	X	JGL8605	-31.44 **	-51.17 **	-6.44	-43.54 **	-49.91 **	-12.92
APMS 6A	X	JGL8292	-15.75	-36.94 **	20.81	-15.03 **	-18.35 **	54.00 **
APMS 6A	X	JGL3855	-5.49	-19.87 *	53.52 **	-47.40 **	-60.38 **	36.00 **
APMS 6A	X	JGL3844	0.34	-31.80 **	32.71 *	-33.53 **	-52.37 **	22.15 *
APMS 6A	X	JGL1798	-26.70 **	-47.12 **	2.89	-14.55 **	-38.69 **	57.23 **
IR 58025A	X	JGL11110-2	-28.68 **	-49.43 **	-1.60	-46.50 **	-59.21 **	4.62
IR 58025A	X	JGL11110-1	-38.65 **	-54.32 **	-11.10	-54.03 **	-60.11 **	2.31
IR 58025A	X	JGL17211	-37.52 **	-47.36 **	2.43	-55.11 **	-60.78 **	34.62 **
IR 58025A	X	JGL16284	139.18 **	137.59 **	68.43 **	60.98 **	50.28 **	66.92 **
IR 58025A	X	JGL13515	2.42	-6.64	-19.58	60.62 **	49.66 **	66.92 **
IR 58025A	X	JGL11160	29.61	21.29	-1.35	83.74 **	57.60 **	112.15 **
IR 58025A	X	JGL11118	4.15	-9.14	-13.51	-5.51	-28.63 **	34.62 **
IR 58025A	X	JGL11111	69.69 **	29.98 **	73.24 **	-42.32 **	-63.07 **	26.77 **
IR 58025A	X	JGL8605	-32.54 **	-50.82 **	-24.90	9.69	-10.30 *	56.77 **
IR 58025A	X	JGL8292	52.95 **	19.62 *	82.68 **	-44.52 **	-54.56 **	-20.58 *
IR 58025A	X	JGL3855	39.99 **	7.27	63.82 **	-12.98 *	-22.98 **	34.62 **
IR 58025A	X	JGL3844	-36.32 **	-48.31 **	-21.06	-34.04 **	-36.46 **	19.85 *
IR 58025A	X	JGL1798	-43.42 **	-47.02 **	-19.09	-22.54 **	-41.55 **	100.62 **

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	3.41	-7.67	21.18 **	-0.39	-18.45**	19.17**
IR 68897A	X	JGL11110-1	-15.01 **	-15.34 **	11.11 *	-13.27**	24.29**	10.64
IR 68897A	X	JGL17211	-39.60 **	-40.48 **	-21.88 **	-22.05**	-21.01**	0.82
IR 68897A	X	JGL16284	-7.15 *	-8.70 *	23.96 **	10.86**	6.75	56.00**
IR 68897A	X	JGL13515	-18.22 **	-23.08 **	14.58 **	-38.77**	-46.57**	4.77
IR 68897A	X	JGL11160	-7.87 **	-33.08 **	52.43 **	-16.30**	-40.37**	30.77**
IR 68897A	X	JGL11118	-52.09 **	-62.35 **	-14.24 *	-48.81**	-61.69**	-15.97**
IR 68897A	X	JGL11111	-6.74 *	-27.29 **	65.63 **	-10.56**	-32.33**	48.41**
IR 68897A	X	JGL8605	-40.59 **	-52.59 **	7.99	-28.73**	-42.38**	26.37**
IR 68897A	X	JGL8292	-60.74 **	-67.53 **	-26.04 **	-51.19**	-53.77**	1.39
IR 68897A	X	JGL3855	-30.25 **	-38.83 **	-16.32 **	-36.40**	-52.28**	-11.20
IR 68897A	X	JGL3844	-36.28 **	-37.82 **	-14.93 **	-27.54**	-42.55**	6.90
IR 68897A	X	JGL1798	-78.45 **	-79.19 **	-71.53 **	-49.05**	-59.12**	-23.94**
APMS 8A	X	JGL11110-2	-6.50	-6.85	27.43 **	-7.88*	-20.44**	48.03**
APMS 8A	X	JGL11110-1	10.09 **	5.59	57.29 **	-6.06*	-8.47**	79.51**
APMS 8A	X	JGL17211	0.32	-27.06 **	65.63 **	16.48**	-18.88**	92.38**
APMS 8A	X	JGL16284	-30.22 **	-45.11 **	24.65 **	-17.50**	-39.79**	42.79**
APMS 8A	X	JGL13515	-73.36 **	-79.20 **	-52.78 **	-27.88**	-46.83**	26.09**
APMS 8A	X	JGL11160	-38.18 **	-50.61 **	12.15 *	-26.37**	-42.18**	37.12**
APMS 8A	X	JGL11118	-55.68 **	-63.30 **	-16.67 **	-54.48**	-58.42**	-1.38
APMS 8A	X	JGL11111	16.23 **	14.33 **	21.88 **	49.76**	32.19**	60.89**
APMS 8A	X	JGL8605	8.80 *	-1.07	28.82 **	24.11**	17.64**	43.17**

Table 4.34(cont.)

Hybrid	Kampasagar			Pooled		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A X JGL8292	5.04	-3.54	22.92 **	15.96**	11.59*	35.81**
APMS 8A X JGL3855	-28.94 **	-36.57 **	-13.89 *	-9.05*	-13.62**	16.88**
APMS 8A X JGL3844	16.85 **	0.23	49.31 **	-2.66	-21.13**	54.68**
APMS 8A X JGL1798	-23.40 **	-33.33 **	-31.25 **	-17.13**	-33.11**	1.41
CMS 16A X JGL11110-2	27.06 **	0.80	31.25 **	34.14**	15.29**	74.79**
CMS 16A X JGL11110-1	33.22 **	6.54	35.76 **	19.74**	4.31	58.14**
CMS 16A X JGL17211	39.12 **	8.70 *	47.57 **	5.69	0.01	51.61**
CMS 16A X JGL16284	10.02 *	-16.78 **	23.96 **	-21.22**	-30.16**	39.97**
CMS 16A X JGL13515	37.38 **	14.64 **	76.74 **	35.49**	0.57	93.35**
CMS 16A X JGL11160	59.95 **	47.52 **	127.43 **	9.93**	-13.87**	65.59**
CMS 16A X JGL11118	10.48 **	0.90	55.56 **	3.86	-17.68**	58.27**
CMS 16A X JGL11111	2.99	-3.15	49.31 **	-22.4**	-33.94**	27.01**
CMS 16A X JGL8605	17.53 **	15.54 **	78.13 **	-30.53**	-31.21**	34.91**
CMS 16A X JGL8292	2.91	-9.46 *	22.92 **	32.80**	14.10**	47.97**
CMS 16A X JGL3855	-14.10 **	-15.86 **	14.24 *	10.84*	2.00	32.28**
CMS 16A X JGL3844	-31.40 **	-33.50 **	-9.72	-24.64**	-29.62**	-8.73
CMS 16A X JGL1798	-25.32 **	-25.32 **	1.39	-31.80**	-33.21**	-9.63
APMS 6A X JGL11110-2	-25.61 **	-28.90 **	5.90	22.85**	2.04	100.13**
APMS 6A X JGL11110-1	-25.85 **	-35.87 **	-9.38	8.80*	-19.45**	56.10**
APMS 6A X JGL17211	27.11 **	22.11 **	72.57 **	16.18**	-9.24**	75.90**
APMS 6A X JGL16284	14.47 **	8.85 *	53.82 **	-3.47	-23.71**	47.85**
APMS 6A X JGL13515	-38.10 **	-39.31 **	-14.24 *	-34.43**	-44.32**	7.91
APMS 6A X JGL11160	12.92 **	10.02 **	63.89 **	3.94	3.33	102.64**
APMS 6A X JGL11118	45.45 **	12.80 **	111.11 **	21.93**	-8.36*	69.66**
APMS 6A X JGL11111	0.22	-15.03 **	59.03 **	15.04**	-8.62**	69.19**
APMS 6A X JGL8605	-39.29 **	-48.98 **	-4.51	-37.86**	-50.05**	-7.51
APMS 6A X JGL8292	-54.19 **	-60.48 **	-26.04 **	-29.55**	-39.03**	12.89*
APMS 6A X JGL3855	-50.21 **	-55.29 **	-16.32 **	-35.23**	-37.04**	23.48**
APMS 6A X JGL3844	5.66	-5.72	-2.78	-7.18**	-31.30**	16.29**
APMS 6A X JGL1798	-34.87 **	-47.20 **	-31.25 **	-24.58**	-38.15**	5.33
IR 58025A X JGL11110-2	26.00 **	3.00	31.25 **	-20.81**	-34.24**	11.98*
IR 58025A X JGL11110-1	25.32 **	0.00	35.76 **	-28.33**	-35.69**	9.51
IR 58025A X JGL17211	28.40 **	-0.93	47.57 **	-30.39**	-34.97**	27.53**
IR 58025A X JGL16284	-1.24	-16.20 **	23.96 **	52.81**	43.75**	51.93*-*
IR 58025A X JGL13515	-32.08 **	-36.15 **	-5.56	1.59	0.04	9.05
IR 58025A X JGL11160	-37.70 **	-42.02 **	-14.24 *	14.47**	10.99*	24.89**
IR 58025A X JGL11118	48.84 **	42.72 **	111.11 **	20.08**	6.93	44.69**
IR 58025A X JGL11111	7.13 *	6.76	59.03 **	3.01	-20.74**	55.45**
IR 58025A X JGL8605	-4.84	-7.41	-4.51	-9.70*	-24.54**	4.71
IR 58025A X JGL8292	114.94 **	88.00 **	144.79 **	42.91**	27.59**	77.04**
IR 58025A X JGL3855	-25.62 **	-34.33 **	-16.32 **	0.98	-8.57*	26.87**
IR 58025A X JGL3844	-16.67 **	-28.39 **	-2.78	-29.44**	-30.32**	-3.31
IR 58025A X JGL1798	-44.23 **	-53.85 **	-31.25 **	-34.84**	-44.37**	9.10

* Significant at 5% level; ** Significant at 1% level

Table 4.35. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for spikelet fertility percentage at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	7.80 **	2.99	-6.13 *	-3.36 *	-10.98 **	2.82
IR 68897A	X	JGL11110-1	-3.09	-5.25	-17.69 **	7.72 **	-1.57	13.68 **
IR 68897A	X	JGL17211	17.93 **	14.37 **	-5.07 *	4.89 **	-0.52	14.89 **
IR 68897A	X	JGL16284	3.92	-5.54 *	-4.14	-5.64 **	-7.84 **	6.44 **
IR 68897A	X	JGL13515	-9.04 **	-15.36 **	-18.40 **	-0.81	-4.18 **	10.66 **
IR 68897A	X	JGL11160	-2.02	-5.08 *	-7.73 **	-7.68 **	-13.88 **	-3.22
IR 68897A	X	JGL11118	-7.86 **	-12.76 **	-15.20 **	-5.18 **	-12.27 **	-1.41
IR 68897A	X	JGL11111	-12.24 **	-20.91 **	-23.12 **	-20.44 **	-23.55 **	-14.08 **
IR 68897A	X	JGL8605	-2.59	-4.64 *	-3.23	-13.54 **	-14.42 **	-3.82 *
IR 68897A	X	JGL8292	-1.38	-1.79	-4.53	-12.03 **	-13.88 **	-3.22
IR 68897A	X	JGL3855	8.24 **	4.60	-4.66	-15.97 **	-18.80 **	-15.29 **
IR 68897A	X	JGL3844	0.54	-0.54	-13.60 **	-15.85 **	-19.38 **	-15.90 **
IR 68897A	X	JGL1798	-44.30 **	-46.59 **	-54.60 **	-23.16 **	-23.43 **	-20.12 **
APMS 8A	X	JGL11110-2	-3.91	-11.71 **	-10.40 **	-3.54 *	-6.07 **	3.42
APMS 8A	X	JGL11110-1	8.90 **	2.47	-1.21	-1.28	-2.80	4.63 *
APMS 8A	X	JGL17211	5.50 *	2.85	-1.30	-26.47 **	-30.77 **	-23.74 **
APMS 8A	X	JGL16284	7.11 **	2.04	-2.08	12.28 **	4.86 **	15.49 **
APMS 8A	X	JGL13515	11.01 **	0.62	-3.44	0.17	-2.82	7.04 **
APMS 8A	X	JGL11160	-6.04 **	-8.59 **	-7.24 **	-6.63 **	-6.65 **	2.82
APMS 8A	X	JGL11118	0.46	0.23	-3.37	-16.67 **	-17.61 **	-9.26 **
APMS 8A	X	JGL11111	-33.93 **	-35.78 **	-38.00 **	9.48 **	2.03	14.89 **
APMS 8A	X	JGL8605	7.27 **	1.90	-1.63	2.84	-4.94 **	7.04 **
APMS 8A	X	JGL8292	13.72 **	2.81	-0.76	6.29 **	2.03	14.89 **
APMS 8A	X	JGL3855	-18.52 **	-20.51 **	-19.33 **	-8.75 **	-9.76 **	1.61
APMS 8A	X	JGL3844	-4.93 *	-4.99 *	-8.29 **	-2.25	-4.40 **	7.65 **
APMS 8A	X	JGL1798	-23.53 **	-28.31 **	-25.33 **	-30.95 **	-35.32 **	-27.97 **
CMS 16A	X	JGL11110-2	-4.51 *	-12.43 **	-8.80 **	-11.71 **	-17.97 **	-8.65 **
CMS 16A	X	JGL11110-1	-11.57 **	-22.67 **	-19.47 **	0.72	-2.79	8.25 **
CMS 16A	X	JGL17211	-9.22 **	-10.38 **	-6.67 **	-32.77 **	-33.15 **	-25.55 **
CMS 16A	X	JGL16284	-7.99 **	-11.41 **	-7.73 **	1.06	-0.63	10.66 **
CMS 16A	X	JGL13515	-13.60 **	-14.37 **	-20.53 **	-0.52	-8.79 **	6.44 **
CMS 16A	X	JGL11160	2.36	-0.91	-8.04 **	8.25 **	-1.55	14.89 **
CMS 16A	X	JGL11118	-8.42 **	-12.34 **	-11.04 **	-3.48 *	-6.21 **	9.46 **
CMS 16A	X	JGL11111	4.31 *	2.36	-1.32	1.35	-2.59	13.68 **
CMS 16A	X	JGL8605	-13.34 **	-16.86 **	-17.52 **	-12.54 **	-17.19 **	-9.86 **
CMS 16A	X	JGL8292	-8.03 **	-13.75 **	-14.44 **	13.58 **	6.65 **	16.10 **
CMS 16A	X	JGL3855	-48.97 **	-54.42 **	-54.78 **	-30.48 **	-32.16 **	-26.16 **
CMS 16A	X	JGL3844	-49.45 **	-50.01 **	-49.27 **	-52.40 **	-52.67 **	-47.89 **
CMS 16A	X	JGL1798	-8.39 **	-9.68 **	-10.40 **	3.35 *	2.77	11.87 **
APMS 6A	X	JGL11110-2	0.59	-3.24	-4.53	-9.73 **	-13.61 **	-8.05 **
APMS 6A	X	JGL11110-1	-4.59 *	-10.29 **	-11.49 **	2.39	-2.84	3.42
APMS 6A	X	JGL17211	-1.58	-11.89 **	-13.07 **	-4.39 **	-5.67 **	0.40
APMS 6A	X	JGL16284	-4.03	-5.36 *	-3.96	5.56 **	3.80 *	14.29 **

Table 4.35 (cont.)

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A X JGL13515	-1.58	-2.70	-4.00	2.82	2.24	10.06 **
APMS 6A X JGL11160	-11.74 **	-16.53 **	-14.67 **	-20.39 **	-23.82 **	-18.91 **
APMS 6A X JGL11118	0.88	-6.70 **	-4.61	8.70 **	3.15	9.79 **
APMS 6A X JGL11111	-3.73	-15.14 **	-13.25 **	-49.19 **	-49.87 **	-46.64 **
APMS 6A X JGL8605	-13.56 **	-13.88 **	-11.96 **	-22.88 **	-24.16 **	-16.50 **
APMS 6A X JGL8292	-11.07 **	-13.61 **	-11.68 **	-14.81 **	-15.28 **	-8.81 **
APMS 6A X JGL3855	-0.77	-5.12 *	-5.21 *	5.35 **	2.66	5.23 **
APMS 6A X JGL3844	-52.51 **	-55.61 **	-55.65 **	16.01 **	12.09 **	14.89 **
APMS 6A X JGL1798	4.92 *	-6.58 **	-6.67 **	-11.93 **	-12.39 **	-9.26 **
IR 58025A X JGL11110-2	-18.26 **	-18.89 **	-17.69 **	1.83	-1.68	8.25 **
IR 58025A X JGL11110-1	-47.03 **	-47.96 **	-48.01 **	8.92 **	6.32 **	14.45 **
IR 58025A X JGL17211	10.92 **	6.33 *	-3.09	15.09 **	11.67 **	15.49 **
IR 58025A X JGL16284	4.39	2.42	-11.03 **	3.34 *	-0.58	2.82
IR 58025A X JGL13515	22.00 **	17.92 **	-1.43	8.67 **	8.58 **	12.47 **
IR 58025A X JGL11160	-5.46 *	-13.79 **	-12.52 **	7.05 **	3.80 *	14.29 **
IR 58025A X JGL11118	-0.81	-7.41 **	-10.73 **	-8.87 **	-10.65 **	-3.82 *
IR 58025A X JGL11111	-9.26 **	-13.97 **	-12.51 **	-9.91 **	-16.81 **	-4.43 *
IR 58025A X JGL8605	4.79 *	-2.85	-1.19	6.31 **	-2.63	11.87 **
IR 58025A X JGL8292	0.73	-11.01 **	-9.49 **	1.31	-3.68 *	10.66 **
IR 58025A X JGL3855	-52.23 **	-52.28 **	-51.47 **	-2.16	-4.20 **	10.06 **
IR 58025A X JGL3844	-59.62 **	-60.67 **	-60.00 **	0.54	-2.63	11.87 **
IR 58025A X JGL1798	-8.42 **	-12.34 **	-11.04 **	-3.48 *	-6.21 **	9.46 **
Hybrid	**Kampasagar**			**Pooled**		
	Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
IR 68897A X JGL11110-2	-15.95 **	-28.65 **	-25.95 **	-3.82**	-7.77**	-10.19**
IR 68897A X JGL11110-1	12.77 **	-3.21	-2.16	5.88**	3.04*	-2.69*
IR 68897A X JGL17211	11.25 **	-2.26	-6.49 **	10.95**	9.39**	0.59
IR 68897A X JGL16284	-3.49	-16.02 **	-17.84 **	-1.79	-8.24**	-5.59**
IR 68897A X JGL13515	18.59 **	3.93	0.00	2.42*	-2..94*	-3.3*
IR 68897A X JGL11160	6.15 **	-1.04	2.70	-1.12	-0.14	-2.76*
IR 68897A X JGL11118	-4.25 *	-9.63 **	-8.65 **	-5.75**	-3.32*	-8.70**
IR 68897A X JGL11111	1.46	-1.69	-5.95 **	-10.52**	-6.95**	-14.44**
IR 68897A X JGL8605	-30.26 **	-33.15 **	-34.59 **	-15.12**	-16.60**	-14.19**
IR 68897A X JGL8292	-5.23 **	-8.43 **	-11.89 **	-6.24**	-6.47**	-6.66**
IR 68897A X JGL3855	-23.86 **	-26.04 **	-23.24 **	-11.10**	-12.02**	-14.32**
IR 68897A X JGL3844	-2.17	-3.74	-2.70	-5.75**	-5.29**	-10.56**
IR 68897A X JGL1798	-54.75 **	-55.25 **	-56.22 **	-40.79**	-39.69**	-44.54**
APMS 8A X JGL11110-2	1.66	1.66	-0.54	-1.90	-5.48**	-2.76*
APMS 8A X JGL11110-1	-14.21 **	-14.92 **	-16.76 **	-2.40*	-4.57**	-4.76**
APMS 8A X JGL17211	-12.81 **	-16.67 **	-13.51 **	-11.18**	-10.05**	-12.41**
APMS 8A X JGL16284	-8.84 **	-11.76 **	-10.81 **	3.28**	6.24**	0.33
APMS 8A X JGL13515	5.11 **	4.52 *	0.00	5.28**	9.81**	0.97
APMS 8A X JGL11160	6.74 **	4.97 *	2.70	-2.07	-3.51**	-0.73
APMS 8A X JGL11118	-9.35 **	-10.11 **	-13.51 **	-8.51**	-8.49**	-8.67**
APMS 8A X JGL11111	-12.47 **	-14.06 **	-10.81 **	-12.39**	-10.01**	-12.37**
APMS 8A X JGL8605	-4.84 **	-5.35 *	-4.32 *	1.58	6.01**	0.11

Table 4.35 (cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	0.55	-1.62	-1.62	6.63**	12.84**	3.76**
APMS 8A	X	JGL3855	-19.67 **	-20.54 **	-20.54 **	-15.64**	-15.73**	-13.30**
APMS 8A	X	JGL3844	-16.80 **	-18.38 **	-18.38 **	-7.99**	-6.67**	-6.85**
APMS 8A	X	JGL1798	-47.28 **	-49.48 **	-47.57 **	-34.00**	-32.00**	-33.79**
CMS 16A	X	JGL11110-2	-9.09 **	-11.76 **	-10.81 **	-8.39**	-4.11**	-9.45**
CMS 16A	X	JGL11110-1	-0.28	-0.56	-4.86 *	-3.61**	2.32	-5.92**
CMS 16A	X	JGL17211	-3.08	-4.42 *	-6.49 **	-15.03**	-14.87**	-12.42**
CMS 16A	X	JGL16284	-14.12 **	-14.61 **	-17.84 **	-6.97**	-8.53**	-5.54**
CMS 16A	X	JGL13515	-9.81 **	-11.46 **	-8.11 **	-7.96**	-10.32**	-7.96**
CMS 16A	X	JGL11160	-3.76 *	-4.28 *	-3.24	2.16*	-1.92	0.67
CMS 16A	X	JGL11118	-8.84 **	-10.81 **	-10.81 **	-7.31**	-12.13**	-9.82**
CMS 16A	X	JGL11111	-0.55	-1.62	-1.62	-4.14**	-4.25**	-1.49
CMS 16A	X	JGL8605	4.13 *	2.16	2.16	3.24**	1.82	4.50**
CMS 16A	X	JGL8292	-22.02 **	-23.44 **	-20.54 **	-16..13**	-8.20**	-16.20**
CMS 16A	X	JGL3855	-2.15	-2.67	-1.62	0.94	-3.01*	-0.63
CMS 16A	X	JGL3844	-14.36 **	-16.22 **	-16.22 **	-30.77**	-34.32**	-32.71**
CMS 16A	X	JGL1798	-26.78 **	-27.57 **	-27.57 **	-42.91**	-43.03**	-41.39**
APMS 6A	X	JGL11110-2	-8.54 **	-10.27 **	-10.27 **	-4.57**	-5.80**	-3.50**
APMS 6A	X	JGL11110-1	-2.70	-6.25 **	-2.70	-3.83**	-5.19**	-4.99**
APMS 6A	X	JGL17211	-5.21 **	-7.49 **	-6.49 **	-2..57*	-5.38**	-5.18**
APMS 6A	X	JGL16284	-0.28	-0.56	-4.32 *	-2.08	-6.12**	-5.92**
APMS 6A	X	JGL13515	-1.95	-2.76	-4.86 *	-0.20	-1.49	1.35
APMS 6A	X	JGL11160	0.56	0.56	-3.24	0.58	0.37	0.59
APMS 6A	X	JGL11118	-11.29 **	-14.06 **	-10.81 **	-14.31**	-16.18**	-14.65**
APMS 6A	X	JGL11111	-12.26 **	-13.90 **	-12.97 **	-1.21	-4.80**	-3.05*
APMS 6A	X	JGL8605	-26.61 **	-27.22 **	-29.19 **	-26.73**	-30.28**	-29.01**
APMS 6A	X	JGL8292	-18.56 **	-18.78 **	-20.54 **	-18.23**	-18.65**	-16.31**
APMS 6A	X	JGL3855	1.68	1.11	-1.62	-8.09**	-9.00**	-7.34**
APMS 6A	X	JGL3844	-16.89 **	-19.27 **	-16.22 **	-4.52**	-5.77**	-5.78**
APMS 6A	X	JGL1798	-27.17 **	-28.34 **	-27.57 **	-22.11**	-24.28**	-24.28**
IR 58025A	X	JGL11110-2	-7.26 **	-8.29 **	-10.27 **	-4.87**	-8.70**	-8.70**
IR 58025A	X	JGL11110-1	-0.55	-0.55	-2.70	-5.91**	-7.23**	-4.56**
IR 58025A	X	JGL17211	-3.62	-4.42 *	-6.49 **	-14.42**	-14.50**	-14.51**
IR 58025A	X	JGL16284	-6.10 **	-7.81 **	-4.32 *	6.07**	4.96**	2.20
IR 58025A	X	JGL13515	-5.38 **	-5.88 **	-4.86 *	0.49	0.02	-4.65**
IR 58025A	X	JGL11160	-1.10	-3.24	-3.24	9.17**	7.23**	2.23
IR 58025A	X	JGL11118	-9.84 **	-10.81 **	-10.81 **	-2.81*	-6.38**	-3.68**
IR 58025A	X	JGL11111	-11.29 **	-12.97 **	-12.97 **	-7.12**	-9.20**	-9.38**
IR 58025A	X	JGL8605	-29.76 **	-31.77 **	-29.19 **	-16.51**	-19.33**	-15.75**
IR 58025A	X	JGL8292	-8.15 **	-9.63 **	-8.65 **	0.84	-3.99**	0.27
IR 58025A	X	JGL3855	3.35	2.21	0.00	1.82	-4.27**	-0.02
IR 58025A	X	JGL3844	0.55	0.55	-1.62	-18.38**	-18.98**	-15.39**
IR 58025A	X	JGL1798	-13.65 **	-14.36 **	-16.22 **	-24.43**	-26.10**	-22.82**

* Significant at 5% level; ** Significant at 1% level

4.2.7.8 Filled grains per panicle

The significant positive average heterosis was recorded in 23 hybrids, ranging from 139.18 (IR 58025A X JGL 16284) to 23.22 (APMS 6A x JGL 11110-2) at Kunaram (Table 4.36). The significant positive heterobeltiosis was observed in only 9 hybrids, which ranged from 137.59 (IR 58025A x JGL 16284) to 19.62 (IR 58025A x JGL 8292). The significant positive standard heterosis was recorded in 27 hybrids, with a range from 95.13 (APMS 6A x JGL 17211) to 32.71 (APMS 6A x JGL 3844), when compared with check PA 6201.

At Warangal, the significant positive average heterosis was recorded in 14 hybrids, and it ranged from 91.22 (APMS 8A x JGL 11111) to 7.61(CMS16 A x JGL 17211). The significant heterobeltiosis was recorded in 8 hybrids, which ranged from 86.68 (APMS 8A x JGL 11111) to 9.82 (APMS 6A x JGL 11110-2). The significant positive standard heterosis was recorded in 51 hybrids, which ranged from 276.92 (APMS 6A x JGL 11110-2) to 18.00 (IR 68897A x JGL 3844) when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was recorded in 22 hybrids, ranged from 114.94 (IR 58025A x JGL 8292) to 7.13 (IR58025A x JGL 11111). The significant positive heterobeltiosis was observed in 11 hybrids with range from 88.00 (IR 58025A x JGL 8292) to 8.70 (CMS16 A x JGL 17211). The significant positive standard heterosis was recorded in 38 hybrids, ranging between 144.79 (IR 58025A x JGL 8292) to 11.11 (IR 68897A x JGL 11110-1) when compared with check PA 6201.

In Pooled analysis, the significant positive average heterosis was recorded in 20 hybrids, which ranged between 52.81 (IR 58025A x JGL 16284) to 8.80 (APMS 6A x JGL 11110-1. The significant heterobeltiosis was recorded in 9 hybrids with a range from 43.75 (IR 58025A x JGL 16284) to 10.99 (IR 58025A x JGL 11160). The significant positive standard heterosis was recorded in 45 hybrids with a range from 102.64 (APMS 6A x JGL 11160) to 11.98 (IR58025A x JGL 11110-2) when compared with check PA 6201, for the character number of filled grains per panicle (Table 4.34).

The number of filled grains per panicle is the most important yield contributing character in the hybrids. Out of 65 hybrids, significant standard heterosis was recorded in 45 hybrids over the best check PA 6201. The hybrid APMS 6A x JGL 11160 (102.64) recorded the highest positive standard heterosis over the best check PA 6201. The heterobeltiosis recorded was 3.33 while average heterosis was 3.94 only. The other better hybrids with positive significant standard heterosis are APMS 6A x JGL

Table 4.36 Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for 1000 grain weight at Kunaram, Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	12.50	8.62	-11.27	28.52 **	17.36 **	-18.16 **
IR 68897A	X	JGL11110-1	-12.61	-20.00 **	-26.76 **	-22.50 **	-24.62 **	-44.39 **
IR 68897A	X	JGL17211	-7.27	-8.93	-28.17 **	-28.34 **	-32.87 **	-46.41 **
IR 68897A	X	JGL16284	23.53 **	16.67	-11.27	14.90 **	11.58 **	-22.20 **
IR 68897A	X	JGL13515	11.32	9.26	-16.90 **	-14.90 **	-17.36 **	-42.38 **
IR 68897A	X	JGL11160	8.26	1.72	-16.90 **	38.52 **	38.52 **	-20.18 **
IR 68897A	X	JGL11118	-1.72	-12.31	-19.72 **	9.22 **	-2.74	-28.25 **
IR 68897A	X	JGL11111	-2.80	-7.14	-26.76 **	-16.15 **	-27.81 **	-42.38 **
IR 68897A	X	JGL8605	13.13	9.80	-21.13 **	13.09 **	6.14 *	-30.27 **
IR 68897A	X	JGL8292	26.21 **	25.00 **	-8.45	26.18 **	18.43 **	-22.20 **
IR 68897A	X	JGL3855	10.28	1.72	-16.90 **	13.09 **	6.14 *	-30.27 **
IR 68897A	X	JGL3844	-1.75	-13.85	-21.13 **	0.00	-5.47 *	-30.27 **
IR 68897A	X	JGL1798	18.10 *	10.71	-12.68	-6.93 **	-15.17 **	-32.29 **
APMS 8A	X	JGL11110-2	-3.09	-4.08	-33.80 **	-12.29 **	-12.29 **	-42.38 **
APMS 8A	X	JGL11110-1	-4.95	-7.69	-32.39 **	-18.43 **	-18.43 **	-46.41 **
APMS 8A	X	JGL17211	-15.32 *	-18.97 *	-33.80 **	0.00	-3.27	-40.36 **
APMS 8A	X	JGL16284	-10.17	-18.46 **	-25.35 **	-14.90 **	-21.88 **	-42.38 **
APMS 8A	X	JGL13515	-4.59	-7.14	-26.76 **	-4.28	-15.17 **	-32.29 **
APMS 8A	X	JGL11160	-0.99	-5.66	-29.58 **	-3.17	-6.14 *	-38.34 **
APMS 8A	X	JGL11118	-12.38	-13.21	-35.21 **	0.00	-3.07	-36.32 **
APMS 8A	X	JGL11111	-14.81 *	-20.69 **	-35.21 **	-3.50	-3.50	-44.39 **
APMS 8A	X	JGL8605	-20.00 **	-29.23 **	-35.21 **	-12.29 **	-21.88 **	-42.38 **
APMS 8A	X	JGL8292	-18.87 *	-23.21 **	-39.44 **	-24.96 **	-35.39 **	-48.43 **
APMS 8A	X	JGL3855	-8.16	-10.00	-36.62 **	-9.82 **	-15.36 **	-44.39 **
APMS 8A	X	JGL3844	-1.96	-3.85	-29.58 **	6.55 *	0.00	-34.31 **
APMS 8A	X	JGL1798	-9.26	-15.52	-30.99 **	-1.72	-3.38	-42.38 **
CMS 16A	X	JGL11110-2	-13.04	-23.08 **	-29.58 **	-13.61 **	-21.88 **	-42.38 **
CMS 16A	X	JGL11110-1	-9.43	-14.29	-32.39 **	-26.05 **	-35.39 **	-48.43 **
CMS 16A	X	JGL17211	14.29	12.00	-21.13 **	4.83	0.00	-34.31 **
CMS 16A	X	JGL16284	-7.84	-9.62	-33.80 **	-14.49 **	-18.43 **	-46.41 **
CMS 16A	X	JGL13515	-15.32 *	-18.97 *	-33.80 **	10.51 **	10.51 **	-36.32 **
CMS 16A	X	JGL11160	-10.17	-18.46 **	-25.35 **	0.00	-10.94 **	-34.31 **
CMS 16A	X	JGL11118	-8.26	-10.71	-29.58 **	-7.34 **	-20.22 **	-36.32 **
CMS 16A	X	JGL11111	-4.95	-9.43	-32.39 **	-13.09 **	-18.43 **	-46.41 **
CMS 16A	X	JGL8605	-6.67	-7.55	-30.99 **	-9.82 **	-15.36 **	-44.39 **
CMS 16A	X	JGL8292	0.88	-1.72	-19.72 **	18.30 **	12.68 **	-28.25 **
CMS 16A	X	JGL3855	-13.33 *	-20.00 **	-26.76 **	-22.02 **	-27.36 **	-46.41 **
CMS 16A	X	JGL3844	-8.11	-8.93	-28.17 **	5.63 *	-5.06 *	-24.22 **
CMS 16A	X	JGL1798	-2.91	-9.09	-29.58 **	-1.56	-3.07	-36.32 **
APMS 6A	X	JGL11110-2	-4.67	-7.27	-28.17 **	-10.92 **	-12.29 **	-42.38 **
APMS 6A	X	JGL11110-1	11.71	6.90	-12.68	5.16	3.38	-38.34 **
APMS 6A	X	JGL17211	-3.39	-12.31	-19.72 **	13.61 **	2.74	-24.22 **
APMS 6A	X	JGL16284	-10.09	-12.50	-30.99 **	-17.36 **	-27.81 **	-42.38 **

Table 4.36 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	0.99	-3.77	-28.17 **	11.27 **	6.14 *	-30.27 **
APMS 6A	X	JGL11160	0.95	0.00	-25.35 **	8.05 **	3.07	-32.29 **
APMS 6A	X	JGL11118	-4.27	-5.08	-21.13 **	19.60 **	17.51 **	-32.29 **
APMS 6A	X	JGL11111	-17.74 **	-21.54 **	-28.17 **	7.80 **	-5.47 *	-30.27 **
APMS 6A	X	JGL8605	-18.26 **	-20.34 **	-33.80 **	-8.94 **	-22.75 **	-38.34 **
APMS 6A	X	JGL8292	0.93	-8.47	-23.94 **	4.99	-3.07	-36.32 **
APMS 6A	X	JGL3855	-0.90	-6.78	-22.54 **	18.30 **	9.22 **	-28.25 **
APMS 6A	X	JGL3844	-6.09	-6.90	-23.94 **	17.88 **	2.59	-20.18 **
APMS 6A	X	JGL1798	-13.11 *	-18.46 **	-25.35 **	-10.65 **	-12.97 **	-32.29 **
IR 58025A	X	JGL11110-2	0.88	0.00	-19.72 **	-14.08 **	-15.17 **	-32.29 **
IR 58025A	X	JGL11110-1	0.95	-7.02	-25.35 **	-14.06 **	-20.75 **	-38.34 **
IR 58025A	X	JGL17211	-4.59	-8.77	-26.76 **	-11.25 **	-18.16 **	-36.32 **
IR 58025A	X	JGL16284	-7.27	-12.07	-28.17 **	0.00	-3.27	-40.36 **
IR 58025A	X	JGL13515	-5.98	-15.38 *	-22.54 **	-2.98	-10.94 **	-34.31 **
IR 58025A	X	JGL11160	-7.41	-10.71	-29.58 **	-21.39 **	-30.34 **	-44.39 **
IR 58025A	X	JGL11118	2.00	-1.92	-28.17 **	0.00	-3.07	-36.32 **
IR 58025A	X	JGL11111	7.69	7.69	-21.13 **	6.34 *	3.07	-32.29 **
IR 58025A	X	JGL8605	-11.48	-15.63 *	-23.94 **	24.51 **	24.51 **	-28.25 **
IR 58025A	X	JGL8292	-24.03 **	-24.62 **	-30.99 **	-6.14 *	-16.41 **	-38.34 **
IR 58025A	X	JGL3855	-23.33 **	-28.13 **	-35.21 **	-16.15 **	-27.81 **	-42.38 **
IR 58025A	X	JGL3844	-3.57	-15.63 *	-23.94 **	19.64 **	12.29 **	-26.23 **
IR 58025A	X	JGL1798	-8.26	-10.71	-29.58 **	-6.55 *	-12.29 **	-42.38 **

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	38.79 **	25.78 **	17.52 **	26.65**	-23.96**	-4.44*
IR 68897A	X	JGL11110-1	5.04	-6.72	-8.76 *	-9.57**	-16.59**	-27.12**
IR 68897A	X	JGL17211	17.82 **	14.42 **	-13.14 **	-6.67**	-8.52**	-29.70**
IR 68897A	X	JGL16284	60.62 **	49.04 **	13.14 **	32.59**	25.66**	-7.25**
IR 68897A	X	JGL13515	7.32	5.77	-19.71 **	1.46	-0.63	-26.66**
IR 68897A	X	JGL11160	46.55 **	32.81 **	24.09 **	30.90**	23.36**	-4.91*
IR 68897A	X	JGL11118	40.34 **	24.63 **	21.90 **	16.53**	3.75	-9.35**
IR 68897A	X	JGL11111	5.94	2.88	-21.90 **	-4.35	-9.74**	-30.63**
IR 68897A	X	JGL8605	76.17 **	63.46 **	24.09 **	34.30**	32.23**	-9.82**
IR 68897A	X	JGL8292	62.93 **	60.58 **	21.90 **	38.87**	36.34**	-3.51
IR 68897A	X	JGL3855	-4.04	-16.41 **	-21.90 **	5.96*	-0.30	-23.15**
IR 68897A	X	JGL3844	24.89 **	6.72	4.38	7.98**	-4.01	-16.13**
IR 68897A	X	JGL1798	63.73 **	61.22 **	15.33 **	23.57**	16.43**	-10.52**
APMS 8A	X	JGL11110-2	45.65 **	41.05 **	-2.19	9.42**	7.91*	-26.66**
APMS 8A	X	JGL11110-1	15.31 **	11.88 *	-17.52 **	-2.70	-4.63	-32.50**
APMS 8A	X	JGL17211	30.25 **	21.09 **	13.14 **	5.96*	2.43	-21.04**
APMS 8A	X	JGL16284	-2.46	-11.19 **	-13.14 **	-8.81**	-16.86**	27.36**
APMS 8A	X	JGL13515	49.04 **	40.91 **	13.14 **	13.04**	9.43**	-15.90**
APMS 8A	X	JGL11160	-4.52	-13.64 **	-30.66 **	-2.88	-6.83*	-32.97**
APMS 8A	X	JGL11118	32.70 **	27.27 **	2.19	7.05**	6.18*	-23.62**
APMS 8A	X	JGL11111	3.93	-7.03	-13.14 **	-4.71	-10.92**	-31.33**
APMS 8A	X	JGL8605	-1.28	-13.43 **	-15.33 **	-11.06**	-21.41**	-31.33**

Table 4.36(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-19.60 **	-20.79 **	-41.61 **	-21.13**	-26.17**	-43.26**
APMS 8A	X	JGL3855	25.26 **	17.82 **	-13.14 **	2.46	1.74	-31.80**
APMS 8A	X	JGL3844	23.76 **	23.76 **	-8.76 *	9.50**	6.61*	-24.55**
APMS 8A	X	JGL1798	-12.93 **	-21.09 **	-26.28 **	-8.52**	-13.65**	-34.44**
CMS 16A	X	JGL11110-2	12.61 **	0.00	-2.19	-4.05	-14.45 **	-25.25**
CMS 16A	X	JGL11110-1	11.88 **	8.65	-17.52 **	-8.05**	-13.08**	-33.20**
CMS 16A	X	JGL17211	60.62 **	49.04 **	13.14 **	26.77**	24.60**	-14.73**
CMS 16A	X	JGL16284	16.10 **	14.42 **	-13.14 **	-1.68	-3.30	-31.57**
CMS 16A	X	JGL13515	-6.22	-11.72 **	-17.52 **	-4.89	-8.49**	-29.46**
CMS 16A	X	JGL11160	-30.36 **	-35.82 **	-37.23 **	-14.59**	22.48**	-32.27**
CMS 16A	X	JGL11118	-21.33 **	-26.55 **	-39.42 **	-2.32**	15.52**	-35.07**
CMS 16A	X	JGL11111	5.94	-5.31	-21.90 **	-3.75	-7.22*	-33.90**
CMS 16A	X	JGL8605	11.21 **	5.31	-13.14 **	-1.32	-1.64	29.93**
CMS 16A	X	JGL8292	-26.14 **	-30.47 **	-35.04 **	-4.33	-6.07*	-27.59**
CMS 16A	X	JGL3855	20.65 **	11.19 **	8.76 *	-3.76	-10.97**	-22.21**
CMS 16A	X	JGL3844	24.17 **	15.93 **	-4.38	6.96**	5.17	-19.17**
CMS 16A	X	JGL1798	53.47 **	37.17 **	13.14 **	16.49**	10.07**	-18.24**
APMS 6A	X	JGL11110-2	-11.21 **	-15.93 **	-30.66 **	-8.87**	-11.02**	-33.90**
APMS 6A	X	JGL11110-1	-15.13 **	-21.09 **	-26.28 **	-0.16	-3.94	-25.95**
APMS 6A	X	JGL17211	27.05 **	15.67 **	13.14 **	12.53**	2.14	-10.76**
APMS 6A	X	JGL16284	14.42 **	8.18	-13.14 **	-4.42	-7.91**	-29.23**
APMS 6A	X	JGL13515	7.54	-2.73	-21.90 **	6.47*	2.63	-26.89**
APMS 6A	X	JGL11160	-18.48 **	-21.82 **	-37.23 **	-3.62	-3.94	-31.57**
APMS 6A	X	JGL11118	-35.91 **	-36.64 **	-39.42 **	-10.58**	-10.85**	-30.87**
APMS 6A	X	JGL11111	-14.72 **	-15.67 **	-17.52 **	-9.64**	-14.72**	-25.49**
APMS 6A	X	JGL8605	-30.13 **	-38.93 **	-41.61 **	-19.54**	-19.90**	-37.88**
APMS 6A	X	JGL8292	-2.73	-18.32 **	-21.90 **	0.81	-6.63*	-27.59**
APMS 6A	X	JGL3855	2.59	-9.16 *	-13.14 **	5.83*	1.21	-21.51**
APMS 6A	X	JGL3844	-15.13 **	-21.09 **	-26.28 **	-2.09	-3.53	-23.38**
APMS 6A	X	JGL1798	-31.97 **	-38.06 **	-39.42 **	-18.79**	-22.48**	32.27**
IR 58025A	X	JGL11110-2	2.88	-2.73	-21.90 **	-3.74	-5.30	-24.79**
IR 58025A	X	JGL11110-1	-16.58 **	-24.55 **	-39.42 **	-9.80**	-17.37**	-34.37**
IR 58025A	X	JGL17211	-7.11	-10.91 *	-28.47 **	-7.63**	-12.66	-30.63**
IR 58025A	X	JGL16284	-7.76 *	-16.41 **	-21.90 **	-5.40*	-9.71**	-30.40**
IR 58025A	X	JGL13515	-25.21 **	-33.58 **	-35.04 **	-11.88**	-20.61**	-30.63**
IR 58025A	X	JGL11160	-5.94	-8.65	-30.66 **	-11.62**	-15.52**	-35.07**
IR 58025A	X	JGL11118	10.88 *	2.88	-21.90 **	4.29	1.33	-28.99**
IR 58025A	X	JGL11111	10.24 *	8.65	-17.52 **	8.14**	7.60*	-23.85**
IR 58025A	X	JGL8605	-17.52 **	-22.60 **	-17.52 **	-4.93*	-8.90**	-23.38**
IR 58025A	X	JGL8292	-23.57 **	-26.71 **	-21.90 **	-19.09**	-20.61**	-30.63**
IR 58025A	X	JGL3855	-14.75 **	-28.77 **	-24.09 **	-18.16**	-21.69**	-34.14**
IR 58025A	X	JGL3844	-8.94 *	-26.71 **	-21.90 **	1.09	-9.73**	-24.08**
IR 58025A	X	JGL1798	-10.93 **	-24.66 **	-19.71 **	-8.91**	-16.13**	-29.46**

* Significant at 5% level; ** Significant at 1% level

11110-2 (100.13), CMS 16A x JGL 13515 (93.35), APMS 8A x JGL 17211 (92.38) and APMS 8A x JGL 11110-1 (79.51), over the best check PA 6201 (Table 4.39 and Figure 4.7). Relative heterosis and heterobeltiosis of both positive and negative nature was reported by Hariramakrishna *et al*. (2009) and Roy *et al*. (2009). Earlier rice workers viz., Singh *et al.* (2006 a), Rosamma and Vijaykumar (2007) and Akarsh Parihar and Pathak (2008) reported both positive and negative heterobeltiosis and standard heterosis values for this trait.

4.2.7.9 Spikelet fertility percentage

At Kunaram, the significant positive average heterosis was recorded in 16 hybrids, (Table 4.37) ranging from 22.00 (IR 58025A x JGL 11160) to 4.31 (CMS16A x JGL 8605). The significant positive heterobeltiosis was recorded in only 3 hybrids viz., IR 68897A x JGL17211, IR 58025A x JGL 17211 (17.92) and IR 58025A x JGL 13515 (6.33). None of the hybrid recorded significant positive standard heterosis, when compared with check PA 6201, for the character spikelet fertility percentage.

At Warangal, the significant positive average heterosis was recorded in 18 hybrids, which ranged from 16.01 (APMS 6A x JGL 1798) to 3.34 (IR 58025A x JGL 13515). The Significant heterobeltiosis was recorded in 8 hybrids which ranged between 12.09 (APMS 6A x JGL 1798) to 3.80 (IR 58025A x JGL 11118). The significant standard heterosis was recorded in 33 hybrids, which ranged from 16.10 (CMS 16A x JGL 3855) to 4.63 (APMS 8A x JGL 11110-1) when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was recorded in 7 hybrids, which ranged between 18.59 (IR 68897A x JGL 13515) to 4.13 (CMS16A x JGL 8605).The significant heterobeltiosis was recorded in 2 hybrids viz; APMS 8A x JGL l1160 (4.97) and APMS 8A x JGL 13515(4.52). None of the hybrid recorded significant standard heterosis over PA 6201, for the character spikelet fertility percentage.

In pooled analysis, for the character spikelet fertility percentage, the significant positive average heterosis was recorded in 10 hybrids which ranged between 10.95 (IR 68897A x JGL 17211) to 2.16 (CMS 16A x JGL 11160). The significant heterobeltiosis was recorded in 8 hybrids, ranged between 12.84 (APMS 8A x JGL 8292) to 3.04 (IR 68897A x JGL 11110-1). The significant standard positive heterosis was recorded in two hybrids viz., CMS 16A x JGL 8605 (4.5) and APMS 8A x JGL 8292 (3.76), when compared with check PA 6201 (Table 4.35).

Table 4.37. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for single plant yield at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A X JGL11110-2	1.89	-13.81 **	-20.10 **	2.06	-14.83 **	-21.46 **
IR 68897A X JGL11110-1	-2.54	-16.84 **	-22.90 **	-2.76	-18.08 **	-24.46 **
IR 68897A X JGL17211	-8.18 **	-21.48 **	-27.20 **	-8.90 **	-23.06 **	-29.05 **
IR 68897A X JGL16284	7.93 **	-6.71 **	-13.51 **	8.61 **	-7.20 *	-14.42 **
IR 68897A X JGL13515	8.30 **	-9.58 **	-16.17 **	9.04 **	-10.29 **	-17.27 **
IR 68897A X JGL11160	12.96 **	1.03	-17.84 **	14.21 **	1.12	-19.05 **
IR 68897A X JGL11118	-14.31 **	-22.65 **	-37.10 **	-15.67 **	-24.57 **	-39.62 **
IR 68897A X JGL11111	13.28 **	2.51	-16.64 **	14.53 **	2.72	-17.77 **
IR 68897A X JGL8605	9.62 **	0.35	-18.39 **	10.52 **	0.39	-19.64 **
IR 68897A X JGL8292	26.65 **	11.68 **	-9.18 **	29.24 **	12.67 **	-9.81 **
IR 68897A X JGL3855	-5.86 **	-18.82 **	-28.15 **	-6.39	-20.27 **	-30.06 **
IR 68897A X JGL3844	2.82	-10.54 **	-20.83 **	3.08	-11.36 **	-22.24 **
IR 68897A X JGL1798	-2.79	-15.23 **	-24.98 **	-3.04	-16.40 **	-26.67 **
APMS 8A X JGL11110-2	42.42 **	25.58 **	11.13 **	46.18 **	27.56 **	11.89 **
APMS 8A X JGL11110-1	42.02 **	20.84 **	6.94 **	45.89 **	22.44 **	7.40 **
APMS 8A X JGL17211	11.24 **	-2.59	-16.85 **	12.29 **	-2.79	-17.99 **
APMS 8A X JGL16284	8.02 **	-4.54	-18.52 **	8.76 **	-4.91	-19.78 **
APMS 8A X JGL13515	26.82 **	12.34 **	-4.11 *	29.28 **	13.33 **	-4.39
APMS 8A X JGL11160	-1.97	-12.18 **	-25.04 **	-2.15	-13.16 **	-26.74 **
APMS 8A X JGL11118	-7.85 **	-20.40 **	-32.06 **	-8.59 *	-22.04 **	-34.24 **
APMS 8A X JGL11111	27.70 **	16.11 **	-9.01 **	30.41 **	17.52 **	-9.63 **
APMS 8A X JGL8605	38.28 **	26.92 **	-0.53	41.99 **	29.30 **	-0.57
APMS 8A X JGL8292	9.92 **	1.15	-20.73 **	10.88 **	1.25	-22.14 **
APMS 8A X JGL3855	20.32 **	12.03 **	-12.20 **	22.26 **	13.09 **	-13.03 **
APMS 8A X JGL3844	6.25 *	-4.78	-25.38 **	6.87	-5.20	-27.10 **
APMS 8A X JGL1798	-11.62 **	-17.89 **	-38.62 **	-12.78 **	-19.55 **	-41.24 **
CMS 16A X JGL11110-2	2.46	-3.89	-28.15 **	2.70	-4.25	-30.06 **
CMS 16A X JGL11110-1	6.99 **	0.63	-24.78 **	2.63	-4.04	-29.91 **
CMS 16A X JGL17211	-10.66 **	-14.95 **	-36.42 **	-51.08 **	-53.65 **	-66.15 **
CMS 16A X JGL16284	17.60 **	7.65 **	-19.53 **	14.20 **	3.63	-24.30 **
CMS 16A X JGL13515	21.53 **	11.55 **	-14.39 **	18.62 **	8.00 *	-18.83 **
CMS 16A X JGL11160	7.56 **	-0.33	-23.51 **	3.31	-4.94	-28.55 **
CMS 16A X JGL11118	18.65 **	10.24 **	-15.40 **	15.50 **	6.57	-19.90 **
CMS 16A X JGL11111	-1.54	-7.43 **	-28.96 **	-10.33 **	-16.17 **	-37.00 **
CMS 16A X JGL8605	-9.01 **	-17.69 **	-36.83 **	-5.38	-15.22 **	-36.28 **
CMS 16A X JGL8292	-4.99 *	-17.43 **	-28.25 **	2.39	-12.08 **	-24.39 **
CMS 16A X JGL3855	15.49 **	1.27	-12.00 **	14.73 **	-0.51	-14.44 **
CMS 16A X JGL3844	9.26 **	-3.96	-16.55 **	4.64	-9.02 **	-21.76 **
CMS 16A X JGL1798	-6.80 **	-17.16 **	-28.02 **	5.17	-7.44 *	-20.40 **
APMS 6A X JGL11110-2	32.53 **	13.62 **	-1.27	37.69 **	16.50 **	0.19
APMS 6A X JGL11110-1	48.21 **	37.52 **	3.08	45.17 **	33.72 **	-2.04
APMS 6A X JGL17211	25.47 **	17.55 **	-11.89 **	35.60 **	26.25 **	-7.52 **
APMS 6A X JGL16284	45.83 **	36.98 **	2.67	42.00 **	32.59 **	-2.87

Table 4.37(cont.)

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A X JGL13515	21.51 **	15.52 **	-13.41 **	22.76 **	16.15 **	-14.91 **
APMS 6A X JGL11160	23.92 **	13.29 **	-15.08 **	26.10 **	14.28 **	-16.28 **
APMS 6A X JGL11118	37.34 **	25.73 **	-2.94	36.01 **	23.47 **	-6.59 *
APMS 6A X JGL11111	45.27 **	34.26 **	3.64	44.72 **	32.77 **	0.44
APMS 6A X JGL8605	43.92 **	33.35 **	2.94	43.24 **	31.78 **	-0.31
APMS 6A X JGL8292	32.48 **	24.21 **	-4.11 *	30.70 **	21.82 **	-7.84 **
APMS 6A X JGL3855	12.61 **	1.60	-21.57 **	8.78 *	-2.82	-26.48 **
APMS 6A X JGL3844	-4.04	-16.58 **	-27.57 **	-9.09 **	-21.91 **	-32.90 **
APMS 6A X JGL1798	-3.29	-15.17 **	-26.35 **	-8.22 *	-20.39 **	-31.59 **
IR 58025A X JGL11110-2	1.55	-10.71 **	-22.47 **	1.70	-11.55 **	-23.99 **
IR 58025A X JGL11110-1	-1.49	-12.42 **	-23.96 **	-1.64	-13.41 **	-25.59 **
IR 58025A X JGL17211	2.89	-11.77 **	-23.39 **	3.15	-12.70 **	-24.98 **
IR 58025A X JGL16284	25.16 **	9.99 **	-6.89 **	27.51 **	10.80 **	-7.36 **
IR 58025A X JGL13515	15.50 **	2.43	-13.29 **	16.92 **	2.62	-14.20 **
IR 58025A X JGL11160	13.09 **	0.53	-14.90 **	14.28 **	0.57	-15.91 **
IR 58025A X JGL11118	6.04 **	-4.66 *	-19.29 **	6.59 *	-5.04	-20.60 **
IR 58025A X JGL11111	15.23 **	-0.12	-15.45 **	16.68 **	-0.13	-16.50 **
IR 58025A X JGL8605	-6.64 **	-16.18 **	-32.43 **	-7.28 *	-17.56 **	-34.63 **
IR 58025A X JGL8292	0.64	-8.79 **	-26.48 **	0.70	-9.55 **	-28.28 **
IR 58025A X JGL3855	0.05	-9.11 **	-26.73 **	0.04	-9.89 **	-28.55 **
IR 58025A X JGL3844	-13.40 **	-20.41 **	-35.84 **	-14.66 **	-22.15 **	-38.27 **
IR 58025A X JGL1798	-4.32	-15.31 **	-31.73 **	-4.74	-16.62 **	-33.88 **

Hybrid	Kampasagar			Pooled		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A X JGL11110-2	2.26	-16.24 **	-23.46 **	2.06	-14.90**	-21.59**
IR 68897A X JGL11110-1	-2.97 *	-19.72 **	-26.64 **	-2.74	-18.14**	-24.57**
IR 68897A X JGL17211	-9.98 **	-25.32 **	-31.76 **	-8.96**	23.18**	-29.22**
IR 68897A X JGL16284	9.48 **	-7.90 **	-15.84 **	8.62**	-7.24**	-14.53**
IR 68897A X JGL13515	10.02 **	-11.30 **	-18.94 **	9.07**	-10.34**	-17.39**
IR 68897A X JGL11160	15.91 **	1.17	-20.88 **	14.26**	1.10	-19.18**
IR 68897A X JGL11118	-17.68 **	-27.35 **	-43.19 **	-15.77**	-24.71**	-39.82**
IR 68897A X JGL11111	16.40 **	3.03	-19.43 **	14.63**	2.74	-17.87**
IR 68897A X JGL8605	11.70 **	0.38	-21.50 **	10.54**	0.37	-19.76**
IR 68897A X JGL8292	32.96 **	14.06 **	-10.80 **	29.39**	12.73**	-9.89**
IR 68897A X JGL3855	-7.27 **	-22.38 **	-32.86 **	-6.46**	-20.39**	-30.24**
IR 68897A X JGL3844	3.39 *	-12.55 **	-24.36 **	3.08	-11.43**	-22.39**
IR 68897A X JGL1798	-3.40 *	-18.06 **	-29.12 **	-3.06	-16.48**	-26.82**
APMS 8A X JGL11110-2	51.72 **	30.55 **	12.93 **	46.47**	27.75**	11.94**
APMS 8A X JGL11110-1	51.52 **	24.78 **	7.94 **	46.15**	22.57**	7.40**
APMS 8A X JGL17211	13.76 **	-3.13 *	-19.66 **	12.34**	-2.82	-18.10**
APMS 8A X JGL16284	9.74 **	-5.55 **	-21.66 **	8.78**	-4.97**	-19.91**
APMS 8A X JGL13515	32.85 **	14.68 **	-4.89 **	29.45**	13.38**	-4.45**
APMS 8A X JGL11160	-2.66	-14.73 **	-29.28 **	-2.23	-13.28**	-26.92**
APMS 8A X JGL11118	-9.86 **	-24.51 **	-37.39 **	-8.69**	-22.20**	-34.43**
APMS 8A X JGL11111	34.44 **	19.69 **	-10.59 **	30.60**	17.65**	-9.70**
APMS 8A X JGL8605	47.47 **	32.80 **	-0.80	42.25**	29.48**	-0.63

Table 4.37(cont.)

Hybrid	Kampasagar			Pooled		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A X JGL8292	12.29 **	1.42	-24.24 **	10.94**	1.27	-22.28**
APMS 8A X JGL3855	25.08 **	14.75 **	-14.28 **	22.39**	13.20**	-13.12**
APMS 8A X JGL3844	7.68 **	-5.82 **	-29.65 **	6.88**	-5.23**	-27.27**
APMS 8A X JGL1798	-14.61 **	-22.03 **	-44.97 **	-12.89**	-19.68**	-44.23**
CMS 16A X JGL11110-2	3.03	-4.81 **	-32.82 **	2.71	-4.29*	-30.23**
CMS 16A X JGL11110-1	8.65 **	0.70	-28.93 **	6.02**	-0.92	-27.77**
CMS 16A X JGL17211	6.16 **	-0.02	-29.44 **	-19.24**	-23.49**	-44.23**
CMS 16A X JGL16284	22.02 **	9.39 **	-22.80 **	17.76**	6.82**	-22.13**
CMS 16A X JGL13515	26.74 **	14.02 **	-16.82 **	22.09**	11.10**	-16.82**
CMS 16A X JGL11160	9.28 **	-0.55	-27.45 **	6.64**	-1.94	-26.41**
CMS 16A X JGL11118	23.08 **	12.35 **	-18.03 **	18.90**	9.64**	-17.72**
CMS 16A X JGL11111	-2.16	-9.26 **	-33.80 **	-4.67**	-10.91**	-33.14**
CMS 16A X JGL8605	-11.52 **	-21.82 **	-42.97 **	-8.53**	-8.10 **	-38.53**
CMS 16A X JGL8292	-6.08 **	-20.71 **	-32.84 **	-2.84	-6.63**	-28.37**
CMS 16A X JGL3855	18.85 **	1.40	-14.11 **	16.24**	0.71	-13.47**
CMS 16A X JGL3844	11.31 **	-4.77 **	-19.33 **	8.32**	-5.90**	-19.15**
CMS 16A X JGL1798	-8.52 **	-20.59 **	-32.74 **	-3.30*	-14.95**	-26.92**
APMS 6A X JGL11110-2	39.80 **	16.10 **	-1.66	36.43**	15.34**	-0.90
APMS 6A X JGL11110-1	60.17 **	46.02 **	3.43 **	50.72**	38.78**	1.47
APMS 6A X JGL17211	31.81 **	21.56 **	-13.89 **	30.74**	21.66**	-11.04**
APMS 6A X JGL16284	57.14 **	45.39 **	2.99 *	47.89**	38.02**	0.92
APMS 6A X JGL13515	26.49 **	18.92 **	-15.76 **	23.41**	16.75**	-14.64**
APMS 6A X JGL11160	29.96 **	16.32 **	-17.60 **	26.43**	14.53**	-16.26**
APMS 6A X JGL11118	46.57 **	31.56 **	-3.52 **	39.62**	26.71**	-4.34**
APMS 6A X JGL11111	56.41 **	42.00 **	4.14 **	48.38**	36.08**	2.72*
APMS 6A X JGL8605	54.62 **	40.82 **	3.27 *	46.86**	35.06**	1.95
APMS 6A X JGL8292	40.07 **	29.59 **	-4.97 **	34.14**	5.02**	-5.62**
APMS 6A X JGL3855	15.69 **	1.99	-25.20 **	12.23**	0.24	-24.33**
APMS 6A X JGL3844	-4.97 **	-19.73 **	-32.10 **	-6.01**	-19.32**	-30.75**
APMS 6A X JGL1798	-4.02 **	-18.06 **	-30.70 **	-5.16**	-17.80**	-29.44**
IR 58025A X JGL11110-2	1.90	-12.76 **	-26.21 **	1.71	-7.61**	-24.13**
IR 58025A X JGL11110-1	-1.97	-14.85 **	-27.98 **	-1.68	-13.49**	-25.74**
IR 58025A X JGL17211	3.45 *	-14.05 **	-27.30 **	3.14	-2.77**	-25.13**
IR 58025A X JGL16284	31.05 **	12.06 **	-7.99 **	27.70**	10.89**	-7.38**
IR 58025A X JGL13515	19.18 **	3.01	-15.42 **	17.07**	2.67	-14.25**
IR 58025A X JGL11160	16.21 **	0.73	-17.29 **	14.42**	0.61	-15.97**
IR 58025A X JGL11118	7.39 **	-5.52 **	-22.43 **	6.63**	-5.05**	-20.70**
IR 58025A X JGL11111	18.63 **	-0.25	-18.10 **	16.73**	-0.16	-16.62**
IR 58025A X JGL8605	-8.24 **	-19.53 **	-37.75 **	-7.33**	.17.65**	-34.81**
IR 58025A X JGL8292	0.78	-10.63 **	-30.87 **	0.70	-9.60**	-28.43**
IR 58025A X JGL3855	0.03	-11.03 **	-31.18 **	0.04	-9.95**	-28.71**
IR 58025A X JGL3844	-16.64 **	-24.72 **	-41.77 **	-14.79**	-22.29**	-38.48**
IR 58025A X JGL1798	-5.46 **	-18.53 **	-36.98 **	-4.80**	-16.71**	-34.07**

* Significant at 5% level; ** Significant at 1% level

The spikelet fertility percentage is yet another important character which directly influences the ultimate product. Significant standard heterosis recorded was in only two hybrids in pooled analysis viz., CMS 16A x JGL 8605 (4.5) and APMS 8A x JGL 8292 (3.76), over best check PA 6201.Standard heterosis of both positive and negative nature was observed by Balasundara (2000), Panwar *et al.* (2002) and Banumurthy *et al.* (2003), whereas similar nature of mid parental heterosis and heterobeltiosis was reported by Hariramakrishnan *et al.* (2009) (Table 4.39 and Figure 4.7).

4.2.7.10 1000 grain weight

At Kunaram, the significant positive standard heterosis was recorded in only 3 hybrids viz., IR 68897A x JGL 8292 (26.21), IR 68897A x JGL 16284 (23.53) and IR68897A x JGL 1798(18.10). The significant heterobeltiosis was recorded in only one hybrids IR 6887 A x JGL 8292 (25.00) for the character 1000 grain weight. None of the hybrid recorded significant standard heterosis, when compared with check PA 6201, for the character 1000 grain weight.

At Warangal, the significant positive average heterosis was recorded in 21 hybrids, ranging from 38.52 (IR 68897A x JGL 11160) to 5.63 (CMS16 Ax JGL3844). The significant heterobeltiosis was recorded in 13 hybrids, ranging from 38.52 (IR 68897A x JGL 11160) to 6.14 (APMS 6A x JGL 13515), where as none of the hybrid recorded significant standard heterosis, when compared with check PA 6201, for the character 1000 grain weight (Table 4.37).

1000 grain weight of a genotype serves as an indicator to the end product *i.e.*, grain yield. The significant standard heterosis was recorded only in three hybrids *viz*., APMS 6A x JGL 1798 (32.27), CMS 16A x JGL 8605 (29.93) and APMS 8A x JGL 16284 (27.36), over best check PA 6201(Table 4.39 and Figure 4.7). For this character both significant positive and negative heterobeltiosis and standard heterosis was recorded. Similar results were reported by Singh *et al.* (2006 b), Deoraj *et al.* (2007) and Akarsh Parihar and Pathak (2008), whereas only positive nature of relative heterosis was observed by Verma *et al.* (2004), Hariramakrishnan *et al.* (2009) and Roy *et al.* (2009).

4.2.7.11 Single plant yield (gm)

At Kunaram, the significant positive average heterosis was recorded in 39 hybrids, ranging between 48.21 (AMS 6A x JGL 11110-1) to 6.04 (IR 58025A x JGL 11118). The significant heterobeltiosis was recorded in 21 hybrids ranging from 37.52 (APMS 6A x JGL 11110-1) to 7.65 (CMS 16A x JGL 16284). The significant positive

Table 4.38. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for productivity/day at Kunaram, Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	7.46 **	-10.19 **	-20.10 **	0.27	-11.15 **	-23.18 **
IR 68897A	X	JGL11110-1	3.04	-9.53 **	-19.51 **	18.03 **	3.97	-10.11 **
IR 68897A	X	JGL17211	-8.52 **	-23.03 **	-31.52 **	9.95 **	-2.86	-16.01 **
IR 68897A	X	JGL16284	15.04 **	-2.29	-13.06 **	6.51 **	-5.25 *	-18.08 **
IR 68897A	X	JGL13515	13.80 **	-6.28 *	-16.62 **	25.09 **	8.84 **	-5.90 **
IR 68897A	X	JGL11160	30.19 **	14.42 **	-9.79 **	21.40 **	13.11 **	-12.54 **
IR 68897A	X	JGL11118	-4.92	-11.90 **	-30.54 **	5.12 *	-2.67	-24.75 **
IR 68897A	X	JGL11111	19.42 **	5.72 *	-16.65 **	15.72 **	7.49 **	-16.89 **
IR 68897A	X	JGL8605	25.28 **	12.04 **	-11.67 **	17.84 **	10.25 **	-14.75 **
IR 68897A	X	JGL8292	36.75 **	18.30 **	-6.74 **	25.85 **	15.01 **	-11.08 **
IR 68897A	X	JGL3855	4.97	-10.51 **	-24.19 **	3.63	-6.70 **	-22.21 **
IR 68897A	X	JGL3844	10.87 **	-0.54	-15.74 **	11.14 **	-0.53	-17.07 **
IR 68897A	X	JGL1798	5.88 *	-9.09 **	-22.99 **	4.57	-6.12 *	-21.73 **
APMS 8A	X	JGL11110-2	43.41 **	24.33 **	5.33 *	29.80 **	17.33 **	-2.17
APMS 8A	X	JGL11110-1	42.82 **	19.94 **	1.60	31.06 **	15.83 **	-3.42
APMS 8A	X	JGL17211	14.12 **	-0.59	-19.99 **	4.09	-5.99 *	-22.15 **
APMS 8A	X	JGL16284	6.91 *	-1.86	-21.01 **	15.09 **	3.31	-14.45 **
APMS 8A	X	JGL13515	28.37 **	12.63 **	-9.35 **	17.08 **	5.42 *	-12.70 **
APMS 8A	X	JGL11160	-0.91	-12.18 **	-29.31 **	-4.71	-13.60 **	-28.46 **
APMS 8A	X	JGL11118	-7.40 *	-20.59 **	-36.08 **	-7.52 **	-18.03 **	-32.12 **
APMS 8A	X	JGL11111	31.56 **	19.61 **	-12.69 **	42.49 **	35.76 **	0.09
APMS 8A	X	JGL8605	36.09 **	30.76 **	-4.55 *	36.50 **	29.22 **	-4.73 *
APMS 8A	X	JGL8292	13.49 **	3.97	-24.10 **	29.52 **	23.02 **	-9.31 **
APMS 8A	X	JGL3855	26.92 **	17.51 **	-14.22 **	39.06 **	33.05 **	-1.91
APMS 8A	X	JGL3844	10.55 **	-1.13	-27.83 **	13.64 **	6.15 *	-21.74 **
APMS 8A	X	JGL1798	-13.28 **	-20.90 **	-42.68 **	-9.36 **	-12.85 **	-36.96 **
CMS 16A	X	JGL11110-2	-2.31	-5.81	-31.74 **	1.39	-3.15	-29.94 **
CMS 16A	X	JGL11110-1	5.45	-3.08	-29.76 **	21.60 **	16.54 **	-15.70 **
CMS 16A	X	JGL17211	-9.10 **	-15.56 **	-38.81 **	-34.30 **	-36.56 **	-54.11 **
CMS 16A	X	JGL16284	17.59 **	5.50	-23.54 **	8.73 **	2.47	-25.88 **
CMS 16A	X	JGL13515	14.52 **	-0.27	-19.67 **	28.72 **	18.50 **	-5.95 **
CMS 16A	X	JGL11160	0.09	-8.16 **	-26.02 **	-0.24	-8.73 **	-27.56 **
CMS 16A	X	JGL11118	13.22 **	-0.70	-20.01 **	10.33 **	1.26	-19.63 **
CMS 16A	X	JGL11111	-4.25	-15.17 **	-31.67 **	5.61 *	-2.38	-22.52 **
CMS 16A	X	JGL8605	-13.09 **	-25.49 **	-39.98 **	9.85 **	-0.79	-21.25 **
CMS 16A	X	JGL8292	-2.01	-15.55 **	-30.28 **	-4.42	-16.89 **	-24.93 **
CMS 16A	X	JGL3855	26.42 **	14.72 **	-5.30 *	26.51 **	9.38 **	-1.20
CMS 16A	X	JGL3844	15.86 **	0.56	-16.98 **	-0.95	-14.11 **	-22.42 **
CMS 16A	X	JGL1798	-4.57	-16.35 **	-30.94 **	-4.17	-16.36 **	-24.45 **
APMS 6A	X	JGL11110-2	42.41 **	20.86 **	-0.23	20.07 **	2.57	-7.35 **
APMS 6A	X	JGL11110-1	55.98 **	44.72 **	1.04	29.72 **	24.03 **	-9.23 **
APMS 6A	X	JGL17211	25.28 **	22.99 **	-14.13 **	26.93 **	20.58 **	-11.75 **
APMS 6A	X	JGL16284	50.75 **	40.96 **	-1.58	28.80 **	22.76 **	-10.16 **

Table 4.38(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	28.51 **	21.48 **	-15.19 **	21.26 **	16.44 **	-14.79 **
APMS 6A	X	JGL11160	35.51 **	23.62 **	-13.69 **	19.62 **	12.11 **	-17.95 **
APMS 6A	X	JGL11118	42.45 **	28.37 **	-4.42	24.90 **	17.98 **	-11.42 **
APMS 6A	X	JGL11111	40.35 **	33.58 **	-0.54	52.10 **	42.76 **	7.19 **
APMS 6A	X	JGL8605	46.53 **	33.04 **	-0.94	32.00 **	24.29 **	-6.68 **
APMS 6A	X	JGL8292	35.74 **	24.54 **	-7.27 **	30.36 **	23.66 **	-7.15 **
APMS 6A	X	JGL3855	14.57 **	1.57	-24.37 **	6.23 *	-1.61	-26.13 **
APMS 6A	X	JGL3844	-1.51	-14.47 **	-30.66 **	-1.10	-9.81 **	-26.91 **
APMS 6A	X	JGL1798	-5.18	-13.25 **	-29.67 **	-4.86 *	-13.77 **	-30.12 **
IR 58025A	X	JGL11110-2	3.11	-9.81 **	-26.89 **	3.30	-6.08 *	-23.89 **
IR 58025A	X	JGL11110-1	0.37	-11.33 **	-28.12 **	1.78	-6.81 **	-24.48 **
IR 58025A	X	JGL17211	5.33	-9.94 **	-26.99 **	13.66 **	1.71	-17.58 **
IR 58025A	X	JGL16284	24.16 **	6.12 *	-10.64 **	19.30 **	9.27 **	-12.30 **
IR 58025A	X	JGL13515	8.23 **	-2.65	-18.03 **	11.96 **	1.92	-18.21 **
IR 58025A	X	JGL11160	31.19 **	12.92 **	-4.92 *	31.08 **	19.70 **	-3.93
IR 58025A	X	JGL11118	12.27 **	-2.42	-17.83 **	22.97 **	13.09 **	-9.24 **
IR 58025A	X	JGL11111	14.18 **	-3.88	-19.06 **	28.93 **	15.87 **	-7.01 **
IR 58025A	X	JGL8605	-10.03 **	-21.50 **	-37.06 **	-7.68 **	-15.35 **	-32.22 **
IR 58025A	X	JGL8292	-7.12 **	-14.59 **	-31.52 **	14.39 **	4.23	-16.53 **
IR 58025A	X	JGL3855	-1.70	-13.61 **	-30.73 **	20.01 **	9.70 **	-12.15 **
IR 58025A	X	JGL3844	-12.02 **	-21.90 **	-37.38 **	4.44	-3.86	-23.01 **
IR 58025A	X	JGL1798	-1.83	-15.67 **	-32.38 **	12.72 **	1.40	-18.80 **

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	1.91	-17.38 **	-27.77 **	2.63	-12.75**	-23.74**
IR 68897A	X	JGL11110-1	8.67 *	-6.72	-18.45 **	11.26**	-2.82	-15.06**
IR 68897A	X	JGL17211	-0.76	-19.15 **	-29.32 **	2.02	-13.10**	-24.05**
IR 68897A	X	JGL16284	15.49 **	-4.55	-16.55 **	11.33**	-4.25*	-16.31**
IR 68897A	X	JGL13515	25.60 **	-0.17	-12.72 **	22.26**	2.11	-10.75**
IR 68897A	X	JGL11160	30.95 **	12.08 **	-14.46 **	26.39**	13.16**	-12.39**
IR 68897A	X	JGL11118	-6.26	-14.65 **	-34.86 **	-0.88	-8.65**	-29.28**
IR 68897A	X	JGL11111	19.60 **	2.91	-21.45 **	17.79**	5.67**	-18.19**
IR 68897A	X	JGL8605	26.73 **	10.76 *	-15.46 **	22.32**	10.88**	-14.15**
IR 68897A	X	JGL8292	36.73 **	14.54 **	-12.58 **	31.76**	15.75**	-10.38**
IR 68897A	X	JGL3855	4.29	-13.29 **	-28.94 **	4.17*	-9.64**	-24.73**
IR 68897A	X	JGL3844	3.55	-8.63 *	-25.13 **	8.87**	-2.91	-19.12**
IR 68897A	X	JGL1798	6.08	-11.34 **	-27.35 **	5.34**	-8.45**	-23.73**
APMS 8A	X	JGL11110-2	47.55 **	25.17 **	2.57	38.42**	21.50**	1.21
APMS 8A	X	JGL11110-1	48.82 **	21.22 **	-0.67	39.13**	18.51**	-1.28
APMS 8A	X	JGL17211	13.13 **	-3.60	-25.64 **	9.19**	-3.89	-22.62**
APMS 8A	X	JGL16284	20.31 **	9.02 *	-15.91 **	14.40**	3.58	-16.61**
APMS 8A	X	JGL13515	30.15 **	11.50 *	-14.00 **	23.65**	9.05**	-12.21**
APMS 8A	X	JGL11160	-4.03	-16.50 **	-35.59 **	-3.53	-14.06**	-30.81**
APMS 8A	X	JGL11118	-10.91 *	-25.68 **	-42.67 **	-8.42**	-20.88**	-36.30**
APMS 8A	X	JGL11111	32.65 **	18.60 **	-18.25 **	36.92**	26.58**	-8.73**
APMS 8A	X	JGL8605	45.54 **	38.92 **	-4.24	38.97**	32.39**	-4.54**

Table 4.38(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	27.16 **	14.33 **	-21.18 **	24.66**	15.48**	-16.73**
APMS 8A	X	JGL3855	41.37 **	29.22 **	-10.92 **	36.51**	27.83**	-7.83**
APMS 8A	X	JGL3844	11.92 *	-2.20	-32.58 **	12.36**	1.84	-26.57**
APMS 8A	X	JGL1798	-19.82 **	-27.93 **	-50.92 **	-13.27**	-19.31**	-42.62**
CMS 16A	X	JGL11110-2	-6.06	-9.80	-38.58 **	-1.73	-5.76*	-32.99**
CMS 16A	X	JGL11110-1	25.75 **	13.68 **	-22.59 **	18.49**	10.48**	-21.44**
CMS 16A	X	JGL17211	4.41	-4.03	-34.65 **	-16.89**	-21.66**	-44.30**
CMS 16A	X	JGL16284	18.12 **	3.77	-29.34 **	13.64**	3.65	-26.30**
CMS 16A	X	JGL13515	33.37 **	13.73 **	-12.42 **	26.29**	12.08**	-11.48**
CMS 16A	X	JGL11160	-3.45	-12.45 **	-32.58 **	-1.08	-9.66**	-28.65**
CMS 16A	X	JGL11118	15.52 **	-0.97	-23.74 **	12.54**	0.09	-20.95**
CMS 16A	X	JGL11111	6.65	-7.14	-28.49 **	3.30	-7.19**	-26.70**
CMS 16A	X	JGL8605	-15.69 **	-29.62 **	-45.81 **	-3.30	-15.78**	-33.48**
CMS 16A	X	JGL8292	-8.58	-23.26 **	-38.58 **	-4.94*	-18.33**	-30.40**
CMS 16A	X	JGL3855	36.22 **	21.43 **	-2.81	29.23**	14.11**	-2.75
CMS 16A	X	JGL3844	16.61 **	-1.61	-21.25 **	8.18**	-6.88**	-20.64**
CMS 16A	X	JGL1798	-7.35	-20.63 **	-36.47 **	-5.15**	-17.55**	-29.73**
APMS 6A	X	JGL11110-2	44.51 **	18.79 **	-4.92	32.44**	11.76**	-4.76**
APMS 6A	X	JGL11110-1	59.49 **	45.56 **	-4.18	44.64**	35.46**	-5.03**
APMS 6A	X	JGL17211	24.40 **	21.40 **	-20.08 **	25.78**	31.44**	-14.85**
APMS 6A	X	JGL16284	59.45 **	46.36 **	-3.65	42.90**	34.12**	-5.97**
APMS 6A	X	JGL13515	37.52 **	28.38 **	-15.48 **	27.62**	21.09**	-15.10**
APMS 6A	X	JGL11160	50.85 **	34.49 **	-11.46 **	32.23**	21.38*-*	-4.90**
APMS 6A	X	JGL11118	54.22 **	36.81 **	-4.00	37.56**	26.10**	-7.37**
APMS 6A	X	JGL11111	49.37 **	41.38 **	-0.79	48.17**	39.92**	-2.78
APMS 6A	X	JGL8605	57.83 **	40.79 **	-1.20	42.96**	31.32**	-3.54*
APMS 6A	X	JGL8292	46.09 **	32.47 **	-7.04 *	36.15**	26.40**	-7.15**
APMS 6A	X	JGL3855	19.71 **	3.83	-27.14 **	12.12**	0.78	-25.97**
APMS 6A	X	JGL3844	-3.57	-18.84 **	-35.47 **	-1.90	-13.69**	-30.45**
APMS 6A	X	JGL1798	-6.67	-16.56 **	-33.65 **	-5.47**	-14.45**	-31.06**
IR 58025A	X	JGL11110-2	2.99	-12.87 **	-30.72 **	3.16	-9.06**	-26.71**
IR 58025A	X	JGL11110-1	-1.08	-15.03 **	-32.44 **	0.60	10.42**	-27.80**
IR 58025A	X	JGL17211	6.84	-11.95 **	-29.99 **	9.57**	-5.38*	-23.75*
IR 58025A	X	JGL16284	34.88 **	14.69 **	-11.08 **	24.91**	9.96**	-11.50**
IR 58025A	X	JGL13515	13.85 **	2.93	-20.20 **	11.48**	0.95	-18.75**
IR 58025A	X	JGL11160	30.11 **	11.23 *	-13.77 **	30.84**	15.41**	-7.12**
IR 58025A	X	JGL11118	22.28 **	6.16	-17.69 **	19.91**	6.84**	-14.01**
IR 58025A	X	JGL11111	21.00 **	0.73	-21.91 **	22.79**	6.10**	-14.61**
IR 58025A	X	JGL8605	-11.76 *	-25.00 **	-41.79 **	-9.43**	-19.79**	-36.34**
IR 58025A	X	JGL8292	-9.56 *	-18.27 **	-36.56 **	1.72	-7.32**	-26.43**
IR 58025A	X	JGL3855	-1.90	-16.18 **	-34.94 **	8.16**	-4.02	-23.82**
IR 58025A	X	JGL3844	-12.14 **	-23.76 **	-40.82 **	-4.56*	-14.44**	-32.09**
IR 58025A	X	JGL1798	0.33	-16.52 **	-35.20 **	5.45**	-8.34**	-27.25**

* Significant at 5% level; ** Significant at 1% level

Figure 4.6. Top five hybrids identified based on standard heterosis % over check PA 6201 in the present investigation

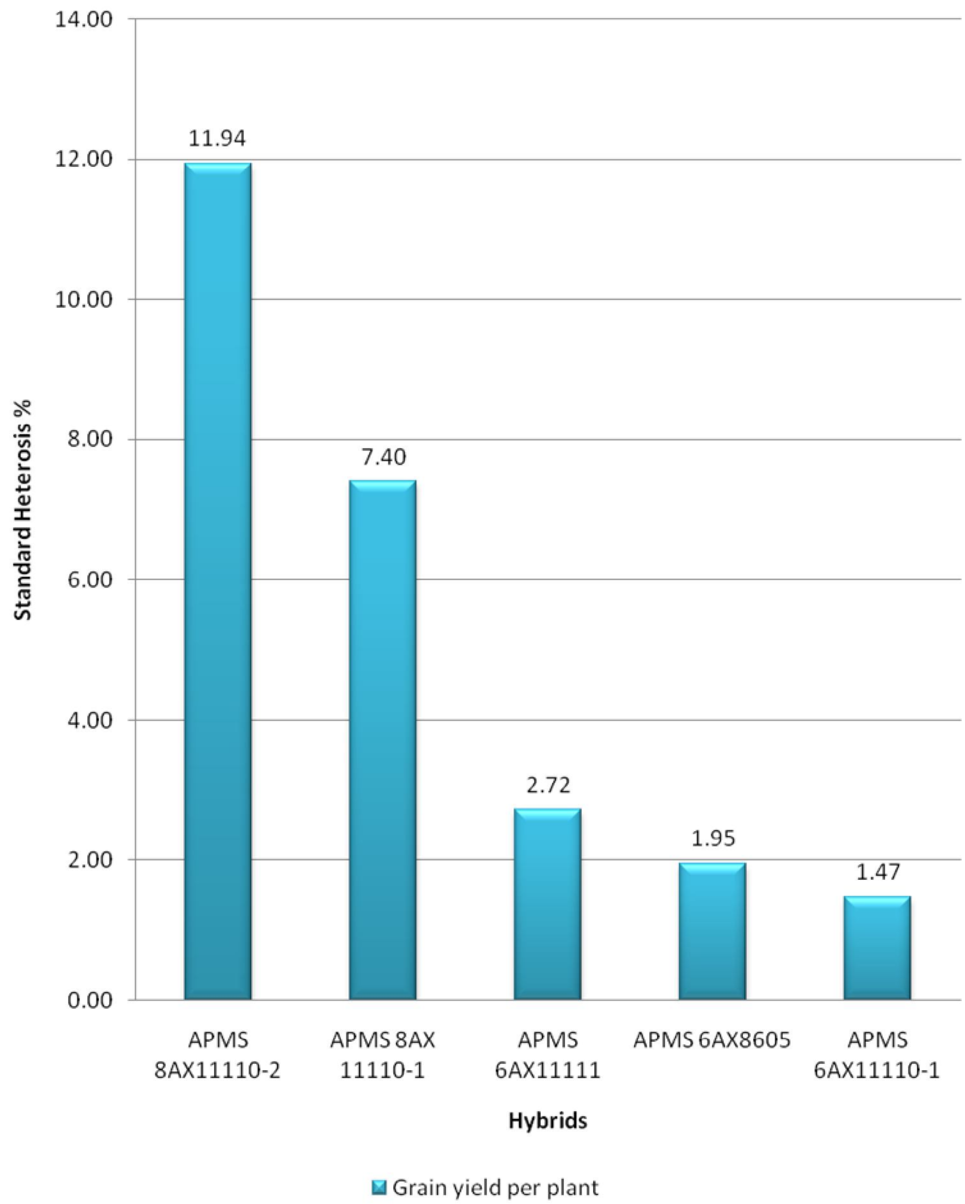


Table 4.39 Standard heterosis, heterobeltiosis and average heterosis for top five crosses for each trait in rice

Character/ cross	Heterosis: Standard Heterosis over PA 6201	Standard Heterosis over KRH-2	Heterobeltiosis	Average Heterosis
Days to 50% flowering				
IR 68897A X JGL11118	-11.98 **	-9.36 **	-17.50 **	-15.55 **
IR 68897A X JGL11110-1	-9.44 **	-6.75 **	-15.54 **	-13.34 **
IR 58025A X JGL11160	-9.18 **	-6.48 **	-18.24 **	-16.42 **
IR 68897A X JGL11160	-7.55 **	-4.80 **	-14.78 **	-14.07 **
IR 68897A X JGL8605	-5.9 **	-3.10	-15.49 **	-13.66 **
Plant height				
APMS 8A X JGL16284	-33.44 **	-35.81 **	-30.52 **	-29.19 **
IR 68897A X JGL11110-1	-24.28 **	-26.88 **	-28.30 **	-24.81 **
CMS 16A X JGL11111	-22.92 **	-21.15 **	-21.45 **	-20.01 **
IR 68897A X JGL17211	-20.48 **	-23.32 **	-24.70 **	-19.56 **
IR 68897A X JGL11160	-19.94 **	-22.80 **	-25.05 **	-14.83 **
Panicle length				
IR 68897A X JGL11110-2	18.93 **	6.75 **	19.97 **	33.43 **
IR 68897A X JGL8292	15.14 **	3.35	-6.48 **	6.23 **
IR 68897A X JGL11111	14.40 **	2.69	-7.08 **	2.24
IR 68897A X JGL16284	12.94 **	1.38	13.93 **	14.40 **
CMS 16A X JGL11110-2	12.02 **	0.55	11.79 **	14.42 **
Panicle weight				
APMS 6A X JGL17211	35.27 **	24.21 **	31.23 **	39.08 **
APMS 8A X JGL17211	29.79 **	19.18 **	29.79 **	57.59 **
IR 68897A X JGL16284	22.95 **	12.89 **	49.58 **	64.30 **
APMS 6A X JGL11110-2	22.95 **	12.89 **	20.47 **	32.23 **
APMS 8A X JGL11110-1	21.92 **	11.95 **	5.95 **	12.30 **
Flag leaf length				
IR 58025A X JGL11111	48.03 **	36.67 **	30.27 **	49.03 **
IR 68897A X JGL11160	47.96 **	36.61 **	7.89 *	26.78 **
APMS 8A X JGL11110-1	45.9 **	34.71 **	20.38 **	24.26 **
CMS 16A X JGL8292	44.86 **	33.74 **	13.95 **	29.68 **
APMS 8A X JGL17211	40.99 **	30.17 **	22.75 **	33.55 **
Flag leaf width				
APMS 6A X JGL1798	39.89 **	14.41 **	24.22 **	47.90 **
CMS 16A X JGL11160	31.16 **	7.27	40.45 **	54.36 **
APMS 8A X JGL8292	28.61 **	-41.62 **	-39.24 **	-36.86 **
CMS 16A X JGL3855	27.83 **	4.54	35.63 **	49.68 **
APMS 8A X JGL8605	22.56 **	0.23	4.31	26.32 **
Productive tillers per plant				
APMS 8A X JGL11118	59.33 **	57.08 **	54.52 **	54.52 **
IR 68897A X JGL8292	53.11 **	50.94 **	49.53 **	26.98 **
IR 68897A X JGL3855	51.20 **	49.06 **	61.20 **	61.22 **
APMS 6A X JGL16284	49.28 **	47.17 **	52.94 **	52.94 **
APMS 8A X JGL3844	44.50 **	42.45 **	29.06 **	29.06 **
1000-grain weight				
APMS 6A X JGL1798	32.27 **	-32.43 **	-22.48 **	18.78 **
CMS 16A X JGL8605	29.93 **	-3.09 **	-1.64	-1.32
APMS 8A X JGL16284	27.36 **	-27.53 **	-16.86 **	-8.81 **
IR 68897A X JGL8292	-3.51	-3.73	36.34 **	38.87 **
IR 68897A X JGL11110-2	-4.44 *	-4.67 *	-23.96 **	26.65 **
Spikelet fertility				
CMS 16A X JGL8605	4.5 **	1.64	1.82	3.24 **
APMS 8A X JGL8292	3.76 **	0.93	12.84 **	6.63 **
IR 58025A X JGL11160	2.23	-0.56	7.23 **	9.17 **
IR 58025A X JGL16284	2.2	0.59	4.96 **	6.07 **

Table 4.39 (cont.)

Character/ cross	Heterosis							
	Standard Heterosis				Heterobeltiosis		Average Heterosis	
	over PA 6201		over KRH-2					
APMS 6A X JGL13515	1.35		-1.42		-1.49		-0.20	
Filled grains per panicle								
APMS 6A X JGL11160	102.64	**	64.42	**	3.33		3.94	
APMS 6A X JGL11110-2	100.13	**	62.38	**	2.04		22.85	**
CMS 16A X JGL13515	93.35	**	58.88	**	0.57		35.49	**
APMS 8A X JGL17211	92.38	**	56.09	**	-18.88	**	16.48	**
APMS 8A X JGL11110-1	79.51	**	45.65	**	-8.47	**	-6.06	*
Grain yield per plant								
APMS 8A X JGL11110-2	11.94	**	23.15	**	27.75	**	46.47	
APMS 8A X JGL11110-1	7.40	**	18.16	**	22.57	**	46.15	**
APMS 6A X JGL11111	2.72	*	13.01	**	36.08	**	48.38	**
APMS 6A X JGL8605	1.95		12.17	**	35.06	**	46.86	**
APMS 6A X JGL11110-1	1.47		11.64	**	38.78	**	50.72	**
Productivity per day								
APMS 8A X JGL11110-2	1.21		8.22	**	21.50	**	38.42	**
APMS 8A X JGL11110-1	-1.28		5.56	**	18.51	**	39.13	**
CMS 16A X JGL3855	-2.75		3.98	*	14.11	**	29.23	**
APMS 6A X JGL11111	-2.78		9.90	**	39.92	**	48.17	**
APMS 6A X JGL8605	-3.54	*	3.14		31.32	**	42.96	**

standard heterosis was observed in only two hybrids *viz.*, APMS 8A x JGL 11110-2 (11.13) and APMS 8A x JGL 11110-1 (6.94), when compared to check PA 6201, for the character single plant yield (Table 4.37)

At Warangal, the significant positive average heterosis was recorded in 36 hybrids, ranging from 46.18 (APMS 8A x JGL 11110-2) to 6.59 (IR 58025A x JGL 3844). The significant heterobeltiosis was recorded in 19 hybrids ranging from 33.72 (APMS 6A x JGL 11110-1) to 8.00 (CMS16A x JGL 13515). The positive significant standard heterosis was recorded in only two hybrids viz., APMS 8A x JGL 11110-2 (11.89) and APMS 8A x JGL 11110-1 (7.40), when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was observed in 42 hybrids out of 65 hybrids tested, ranging from 60.17 (APMS 6A x JGL 11110-1) to 3.39 (IR68897A x JGL 3844). The significant heterobeltiosis was recorded in 21 hybrids ranging from 46.02 (APMS 6A x JGL 11110-1) to 9.39 (CMS 16A x JGL 16284). The significant standard heterosis was recorded in 6 hybrids ranged from 12.93 (APMS 8A x JGL 11110-2) to 2.99 (APMS 6A x JGL 16284), when compared with check PA 6201.

In pooled analysis, the significant positive average heterosis was recorded in 39 hybrids ranging from 50.72 (APMS 6A x JGL 11110-1) to 6.02 (CMS 16A x JGL 11110-1). The significant heterobeltiosis was observed in 23 hybrids ranging from 38.78 (APMS 6A x JGL 11110-1) to 5.02 (APMS 6A x JGL 8292). The significant standard heterosis was observed in 7 hybrids, ranging from 24.57 (IR 68897A x JGL 11110-1) to 1.94 (APMS 8A x JGL 11110-2), when compared with check PA 6201, for the character, single plant yield (Table 4.37).

Heterosis for single plant yield is mainly because of simultaneous manifestation of heterosis for yield component traits. Out of 65 hybrids studied, the significant standard heterosis is observed in 7 hybrids, over best check PA 6201, top hybrids are APMS 8A x JGL11110-2, APMS 8A x JGL11110-1 andAPMS 6A x JGL11111 (Table 4.39 and Figure 4.7).

4.2.7.12 Productivity/day (kg/ha)

At Kunaram, the significant positive average heterosis was recorded in 40 hybrids, ranging from 55.98 (APMS 6A x JGL 11110-1) to 5.88 (IR 68897A x JGL 1798). The significant heterobeltiosis was recorded in 23 hybrids, ranging from 44.72

(APMS 6A x JGL 11110-1) to 5.72 (IR 68897A x JGL 11111).Only one hybrid (APMS 8A x JGL11110-2) recorded significant standard heterosis (5.33) when compared with checks PA 6201, for the character productivity/day.

At Warangal, the significant positive average heterosis was observed in 46 hybrids ranging between 52.10 (APMS 6A x JGL 11111) to 5.12 (IR 68897A x JGL 11118). The significant heterobeltiosis was recorded in 30 hybrids ranging from 42.76 (APMS 6A x JGL 11111) to 5.42 (APMS 8A x JGL 13515). The significant standard heterosis was recorded in only one hybrid viz., APMS 6A x JGL 11111 (7.19), when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was recorded in 39 hybrids ranging from 59.49 (APMS 6A x JGL 11110-1) to 8.67 (IR68897A x JGL 11110-1). The significant heterobeltiosis was recorded in 26 hybrids, ranging between 46.36 (APMS 6A x JGL 16284) to 9.02 (APMS 8A x JGL 16284). None of the hybrids recorded significant standard heterosis when compared with check PA 6201 for the character productivity/day.

In pooled analysis, the significant positive average heterosis was recorded in 45 hybrids out of 65 hybrids tested, ranging between 48.17 (APMS 6A x JGL 11111) to 4.17 (IR 68897A x JGL 3855). The significant heterobeltiosis was recorded in 29 hybrids ranging from 39.92 (APMS 6A x JGL 11111) to 5.67 (IR 68897A x JGL 11111). Whereas no hybrids recorded significant standard heterosis when compared with checks PA 6201, for the character productivity/day (Table 4.38).

Table 4.40. Overall performance of top 20 heterotic hybrids for grain yield per plant in rice

	Hybrid			Average Heterosis (%)	Hetero-beltiosis (%)	Standard Heterosis (%)		Mean perfor-mance	*Sca* effect	Stable/ unstable
						Over PA-6201	Over KRH-2			
1	**APMS 6A**	**X**	**JGL11110-1**	50.72**	38.78**	1.47	11.64**	28.30	2.71**	Stable
2	**APMS 6A**	**X**	**JGL11111**	48.38**	36.08**	2.72*	13.01**	28.65	2.44**	Stable
3	**APMS 6A**	**X**	**JGL16284**	47.89**	30.02**	0.92	11.02**	28.14	1.92**	Stable
4	**APMS 6A**	**X**	**JGL8605**	46.86**	35.06**	1.95*	12.17**	28.43	1.65**	Stable
5	**APMS 8A**	**X**	**JGL11110-2**	46.47**	27.75**	1.94*	23.15**	31.22	7.01**	Stable
6	**APMS 8A**	**X**	**JGL11110-1**	46.15**	22.57**	7.40**	18.16**	29.95	5.48**	Stable
7	**APMS 8A**	**X**	**JGL8605**	42.25**	29.48**	-0.63	9.32**	27.71	3.93**	Stable
8	**APMS 6A**	**X**	**JGL11118**	39.62**	26.71**	-4.34	5.24**	26.68	0.54*	Stable
9	**APMS 6A**	**X**	**JGL11110-2**	36.43**	15.34**	-0.90	9.02**	27.64	4.77**	Stable
10	**APMS 6A**	**X**	**JGL8292**	34.14**	5.02**	-5.62	3.83*	26.32	0.41	Stable
11	**APMS 6A**	**X**	**JGL17211**	30.74**	21.66**	7.04**	-2.13	24.81	-0.84**	Unstable
12	**APMS 8A**	**X**	**JGL11111**	30.6**	17.65**	-9.70**	-0.66	25.18	1.46**	Stable
13	**APMS 8A**	**X**	**JGL13515**	29.45**	13.38**	-4.45**	5.13**	26.65	4.01**	Stable
14	**IR 68897A**	**X**	**JGL8292**	29.39**	12.73**	-9.89**	-0.86	25.13	3.25**	Stable
15	**IR 58025A**	**X**	**JGL16284**	27.7**	10.89**	-7.38**	1.89	25.83	2.22**	Stable
16	**APMS 6A**	**X**	**JGL11160**	26.43**	14.53**	-16.26**	-7.87**	23.35	-2.25**	Stable
17	**APMS 6A**	**X**	**JGL13515**	23.41**	16.75**	-14.64**	-5.66**	23.81	-1.54**	Stable
18	**APMS 8A**	**X**	**JGL3855**	22.39**	13.20**	-13.12**	-4.42**	24.23	1.23**	Stable
19	**CMS 16A**	**X**	**JGL13515**	22.09**	11.10**	16.62**	-8.27**	23.25	2.85**	Stable
20	**CMS 16A**	**X**	**JGL11118**	18.9**	9.64**	-17.72**	-9.47**	22.95	1.9**	Stable
							CD at 5 %	3.76	SE ij 0.81	

The productivity/day indicates the efficiency of hybrid with reference to its duration. Out of 65 hybrids studied, no hybrid recorded significant standard heterosis, over check PA 6201, while 3 hybrids were significant over check KRH-2 *viz.*, APMS 8A x JGL 11110-2 (6.22), APMS 8A x JGL 11110-1 (5.56) and APMS 6A x JGL 11111 (9.90) (Table 4.41 and Figure 4.9).

The top twenty hybrids based on the average heterosis, are APMS 6A x JGL 11110-1, APMS 6A x JGL 11111, APMS 6A X JGL 16284, APMS 6A x JGL 8605, APMS 8A x JGL 11110-2, APMS 8A x JGL 8605, APMS 6A x JGL 11118, APMS 6A x JGL 11110-2, APMS 6A x JGL 8292, APMS 6A x JGL 17211, APMS 8A x JGL 11111, APMS 8A x JGL 11111, APMS 8A x JGL 13515, IR 68897A x JGL 8292, IR 58025A x JGL 16284, APMS 6A x JGL 11160, APMS 6A x JGL 13515, APMS 8A x JGL 3855, CMS 16A x JGL 13515 and CMS 16A x JGL 11118. The average heterosis ranged from APMS 6A x JGL 11110-1 (50.72) to CMS 16A x JGL 11118(18.90). The heterobeltiosis is also significant for all the hybrids ranged between 38.78 (APMS 6A x JGL 11110-1) to 5.02 (APMS 6A x JGL 8292). The standard heterosis for these 20 hybrids is significant for only three hybrids, 7.40 (APMS 8A x JGL 11110-1), 7.04 (APMS 6A x JGL 17211) and 16.62 (CMS 16A x JGL 11118) when compared with check PA 6201(Table 4.42and Figure 4.10).

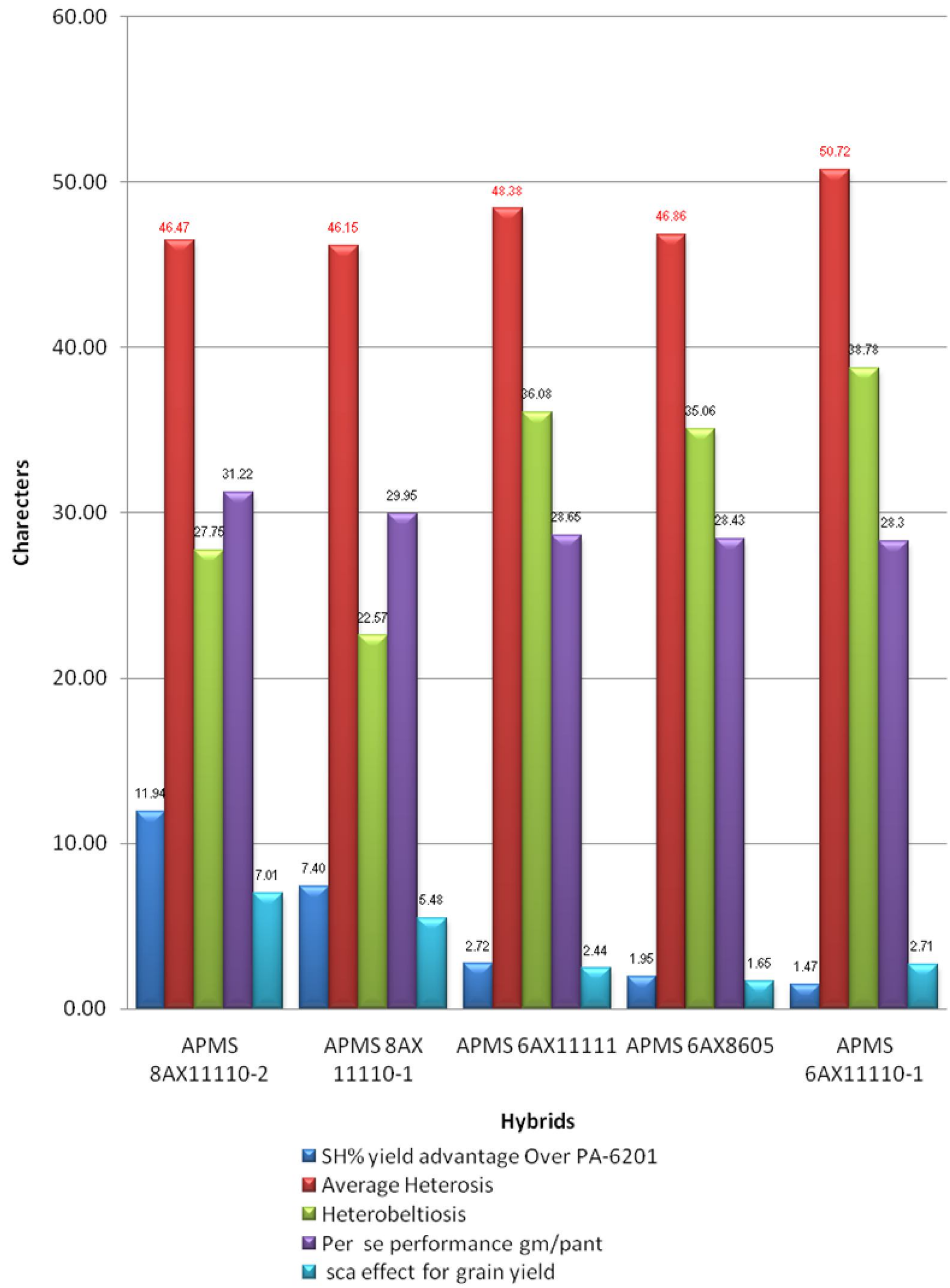
The standard heterosis is significant for only 10 hybrids ranged between 5.13 (APMS 8A x JGL 13515) to 18.16 (APMS 8A x JGL 11110-1). The sca effects are significant for 15 hybrids ranged between 1.23 (APMS 8A x JGL 3855) to 7.01 (APMS

8A x JGL 11110-2), and the mean performance ranged from 22.95 (CMS 16A x JGL 11118) to 31.22 (APMS 8A x JGL 11110-2). Among the twenty hybrids only one hybrid was unstable, while all other 19 hybrids are found to be stable over three environments tested (Table 4.40). Heterosis and heterobeltiosis of both positive and negative nature was reported which was supported by Peng and Virmani (1991), Lokaprakash *et al.* (1992), Pandey *et al.* (1995), Jayamani *et al.* (1997), Ganeshan *et al.* (1997) and Narsimhan *et al.* (2007). Superiority of positive mid parental heterosis was observed by Reddy and Nerkar (1995), Verma *et al.* (2004), Deoraj *et al.* (2007) and Roy *et al.* (2009). Standard heterosis of mixed trend was observed in their studies by Ghosh (2002),Anand Kumar *et al.* (2006), Singh *et al.* (2006 a), Doeraj *et al.* (2007), Eradappa *et al.* (2007), Rosamma and Vijayakumar (2007), Singh *et al.* (2007) and Akarsh Parihar and Pathak (2008).

On the whole, 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 hybrids APMS 6A x JGL11110-1, APMS 8A x JGL11111, APMS 8A x JGL11110-1, APMS 6A x JGL 11111 recorded significant positive standard heterosis over check KRH-2 and APMS 8A x JGL11110-1 recorded significant positive standard heterosis over check PA-6201 for productive tillers/ plant , the hybrids APMS 6A x JGL11111, APMS 6A x JGL 8292 recorded significant positive standard heterosis over check KRH -2 and APMS 6A x JGL11110-1, APMS 8A x JGL11110-1, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check PA- 6201 for panicle length. The hybrids APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL11110-1, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check KRH -2 and APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL11110-1, APMS 8A x JGL11110-2, APMS 6A x JGL8292 recorded significant positive standard heterosis over check PA- 6201 for filled grains/ panicle. The hybrids APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check KRH -2 and APMS 6A x JGL11111, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check PA- 6201 for 1000 grain weight. The hybrids APMS 8A x JGL11110-2A, PMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL8605, APMS 6A x JGL11110-1, APMS 6A x JGL8292 recorded significant positive standard heterosis over check KRH-2 and APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL8605, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check PA- 6201 for single plant yield.

Figure 4.7. Top five hybrids identified based on standard heterosis (%) over check PA 6201 along with average heterosis and heterobeltiosis in the present investigation



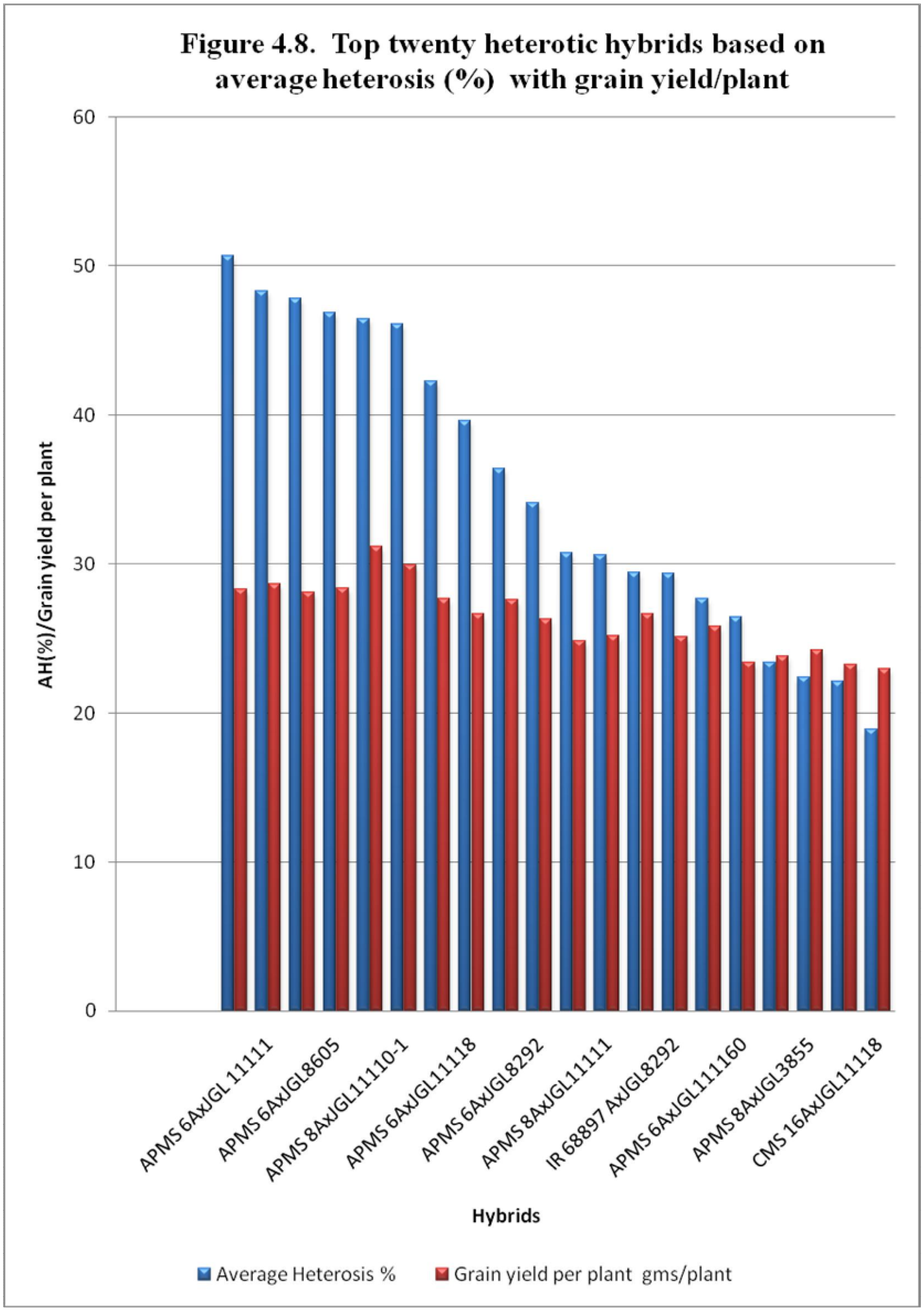


Figure 4.8. Top twenty heterotic hybrids based on average heterosis (%) with grain yield/plant
60
50
40
30
20
10
0
AH(%)/Grain yield per plant
APMS 6AxJGL 11111
APMS 6AxJGL8605
APMS 8AxJGL11110-1
APMS 6AxJGL11118
APMS 6AxJGL8292
APMS 8AxJGL11111
IR 68897 AxJGL8292
APMS 6AxJGL111160
APMS 8AxJGL3855
CMS 16AxJGL11118
Hybrids
Average Heterosis %
Grain yield per plant gms/plant

4.2.7 Heterosis

Heterosis is an universal phenomena and exploitation of heterosis is a quick and convenient way of combining desirable characters and hence assumes greater significance in the development of hybrids. It is often exploited to increase the yield potential of crop plants where there is a availability of cytoplasmic male sterility and fertility restoration systems. Hybrids have become an integral part of agricultural to boost productivity as they would respond very well to higher fertilizer levels.

High heterosis for grain yield in rice is due to simultaneous heterosis for more than one trait. Hence, in the present study an attempt was made to measure the magnitude of heterosis in rice due to emphasis laid on contributions of different morphological traits.

The commercial exploitation of heterosis in rice has been a recent development. It is obviously important that the crosses are compared with released hybrids rather than merely comparing with their mid/better parent. So in the present study the performance of the experimental crosses were compared with that of the most popular released hybrids *viz.*, KRH-2 and PA 6201 in order to estimate the magnitude of standard heterosis. The crosses with high heterotic potential could be isolated for further evaluation at different locations and seasons.

In present investigation, efforts were made to know the nature and magnitude of heterosis and in the form of average heterosis, heterobeltiosis and standard heterosis for single plant yield and its components in 65 rice hybrids at three locations and in pooled analysis. Heterosis is estimated in 65 hybrids for 12 characters *viz.*, days to 50% flowering, plant height, productive tillers/plant, flag leaf length, flag leaf width, panicle length, panicle weight, filled grains/panicle, spikelet fertility percentage, 1000 grain weight, yield per plant and productivity/day in three locations and expressed as a average heterosis, Heterobeltiosis and standard heterosis over check PA 6201. The negative heterotic values for days to 50% flowering and plant height indicates earliness and short stature which are desirable. For other characters positive estimates were considered as desirable. The character wise performance of hybrid is presented in table 4.27 to 4.39.

4.2.7.1 Days to 50% flowering: At Kunaram 32 hybrids (Table 4.28) recorded significant negative average heterosis ranging from -3.12 (APMS 6A x JGL 16284) to -18.51 (IT 58025A x JGL 11160). Significant negative heterobeltiosis was observed in 41 hybrids, ranged from -3.71 (APMS 8A x JGL 11110-2) to -22.29 (IR 58025A x JGL 11160). The significant negative standard heterosis was recorded in 8 hybrids ranged from -5.50 (IR 68897A x JGL 11110-1) to -13.75 (IR 58025A x JGL 11160). At Warangal, 39 hybrids recorded significant negative average heterosis, ranged from -22.95 (IR 58025A x JGL 3855) to- 2.57 (APMS 6A x JGL 11160). Significant negative heterobeltiosis was observed in 45 hybrid ranging from -24.92 (IR 58025A x JGL 3855) to -1.59 (IR 68897A XJGL16284). The significant negative standard heterosis, ranged from -15.16 (IR 58025A x JGL 3855) to -2.53 (IR 58025A x JGL 17211) i.e. in 22 hybrids, when compared with check PA 6201.

At Kampasagar, 14 hybrids recorded significant negative average heterosis, ranged from -13.19 (APMS 6A x JGL 11160) to -8.84 (IR 68897A x JGL 17211). Significant negative heterobeltiosis was observed in 19 hybrids ranging from -16.31 (CMS 16A x JGL 3855) to -9.48 (IR 58025A x JGL 3844). The significant negative standard heterosis is recorded in 3 hybrids, which ranged from -12.69 (IR 68897A x JGL 11118) to -10.00 (IR 68897A x JGL 11110-1) when compared with best check PA 6201.

In pooled analysis for days to 50% flowering 38 hybrids recorded significant average negative heterosis, ranging from -16.42 (IR 58025A x JGL 11160) to -2.50 (APMS 58025A x JGL 11110-1). The significant negative heterobeltiosis was recorded in 41 hybrids which, ranged from -18.24 (IR 58025A x JGL 11160) to -3.18 (APMS 58025Ax JGL 11110-1). The negative standard heterosis was observed in 11 hybrids which ranged from -11.98 (IR 68897A x JGL 11118) to -3.57 (APMS 8A x JGL 3855), when compared with check PA 6201 (Table 4.27).

Early maturing hybrids are desirable as they produce more yields per day and fit well in multiple cropping systems.Majority of the hybrids exhibited significant negative values of heterosis and heterobeltiosis imply early flowering in hybrids. Significant positive and negative heterosis and heterobeltiosis for this trait was reported by Deoraj *et al.* (2007) and Roy *et al.* (2009). Out of 65 hybrids, the significant negative standard heterosis was observed in 11 hybrids over check PA 6201. Highest significant negative standard heterosis (-11.98), heterobeltiosis (-17.50) and average heterosis (-15.55) was observed in IR 68897Ax JGL 11118. The other hybrids IR 68897A x JGL 11110-1 (-9.44), IR 58025A x JGL 11160 (-9-18), IR68897A x JGL 11160 (-7.55) and IR 68897A x JGL 8605 (-5.9) also reported negative standard heterosis over check PA 6201 (Table 4.39 and Figure 4.7). Presence of both negative and positive standard heterosis of similar magnitude was observed in their studies by Mishra and Pandey (1998), Singh *et al.* (2006), Deoraj *et al.*(2007), Rosamma and Vijay Kumar (2007) and Akarsh Parihar and Palhak (2008).

Table 4.27. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA-6201) for days to 50% flowering at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A X JGL11110-2	-7.03**	-8.78**	0.00	2.13**	0.65	12.64**
IR 68897A X JGL11110-1	-6.46**	-10.42**	-5.50**	-22.88**	-23.49**	-13.00**
IR 68897A X JGL17211	0.00	-2.48	8.25**	-20.06**	-20.45**	-10.11**
IR 68897A X JGL16284	-8.40**	-10.80**	-0.69	-0.80	-1.59*	11.91**
IR 68897A X JGL13515	-6.69**	-8.72**	0.69	-19.68**	-19.68**	-10.11**
IR 68897A X JGL11160	-17.36**	-19.44**	-11.68**	-12.99**	-14.92**	-3.25**
IR 68897A X JGL11118	-12.67**	-15.84**	-12.37**	-21.59**	-21.59**	-10.83**
IR 68897A X JGL11111	-7.03**	-9.91**	0.00	-7.01**	-7.30**	5.42**
IR 68897A X JGL8605	-16.43**	-19.14**	-9.97**	-12.38**	-12.38**	-0.36
IR 68897A X JGL8292	-9.94**	-12.46**	-3.44	-6.56**	-7.30**	5.42**
IR 68897A X JGL3855	-13.56**	-15.05**	-6.87**	-10.64**	-11.94**	-1.44
IR 68897A X JGL3844	-9.00**	-12.99**	-7.90**	-11.36**	-12.06**	0.00
IR 68897A X JGL1798	-10.94**	-13.00**	-3.44	-9.15**	-9.58**	2.17*
APMS 8A X JGL11110-2	-1.27	-3.70*	7.22**	2.08**	1.27	15.16**
APMS 8A X JGL11110-1	-1.11	-3.12	6.87**	0.65	0.65	12.64**
APMS 8A X JGL17211	-3.32*	-4.08*	5.15*	5.98**	5.98**	15.16**
APMS 8A X JGL16284	1.85	-3.50	4.12*	-11.04**	-13.02**	-1.08
APMS 8A X JGL13515	-1.73	-3.10	7.56**	3.58**	1.60*	14.80**
APMS 8A X JGL11160	-1.57	-3.09	7.90**	4.55**	2.22**	16.25**
APMS 8A X JGL11118	-0.79	-1.87	8.25**	2.45**	0.97	13.00**
APMS 8A X JGL11111	-3.76*	-3.76*	5.50**	-20.00**	-22.84**	-9.75**
APMS 8A X JGL8605	2.33	-3.76*	5.50**	-7.98**	-9.26**	6.14**
APMS 8A X JGL8292	-4.05*	-4.64*	5.84**	-22.76**	-24.07**	-11.19**
APMS 8A X JGL3855	-6.69**	-7.41**	3.09	-22.69**	-23.77**	-10.83**
APMS 8A X JGL3844	-5.00**	-5.30**	4.47*	-11.04**	-12.96**	1.81*
APMS 8A X JGL1798	2.25	-0.31	9.28**	1.46*	-0.95	13.00**
CMS 16A X JGL11110-2	6.51**	2.64	6.87**	0.79	0.63	14.80**
CMS 16A X JGL11110-1	1.60	-1.55	9.28**	-22.42**	-22.78**	-11.91**
CMS 16A X JGL17211	-2.07	-5.25**	5.50**	0.16	0.00	14.08**
CMS 16A X JGL16284	-0.32	-3.12	6.87**	0.96	0.00	14.08**
CMS 16A X JGL13515	6.76**	-0.94	8.59**	-16.72**	-18.94**	-11.91**
CMS 16A X JGL11160	9.75**	8.19**	4.47*	3.00**	-1.90*	11.55**
CMS 16A X JGL11118	5.03**	-3.10	7.56**	-0.33	-4.79**	7.58**
CMS 16A X JGL11111	2.51	-5.56**	5.15*	-17.67**	-21.59**	-10.83**
CMS 16A X JGL8605	4.71**	-3.12	6.87**	-17.98**	-21.29**	-11.91**
CMS 16A X JGL8292	-4.13*	-5.33**	3.78	8.01**	2.99**	11.91**
CMS 16A X JGL3855	-10.81**	-15.11**	-9.28**	-18.03**	-23.49**	-13.00**
CMS 16A X JGL3844	-7.57**	-9.29**	0.69	4.44**	-2.24**	10.47**
CMS 16A X JGL1798	-3.31*	-5.25**	5.50**	10.20**	2.86**	16.97**
APMS 6A X JGL11110-2	-9.18**	-10.59**	-1.37	5.32**	-0.97	10.83**
APMS 6A X JGL11110-1	-6.27**	-6.27**	2.75	0.82	-0.96	11.55**
APMS 6A X JGL17211	0.33	-5.64**	3.44	-3.35**	-3.81**	9.39**
APMS 6A X JGL16284	-3.12*	-3.72*	6.87**	-0.80	-0.96	11.91**

Table 4.27 (cont.)

Hybrid	Kunaram			Warangal		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A X JGL13515	-7.00**	-7.72**	2.75	-6.86**	-7.30**	5.42**
APMS 6A X JGL11160	-10.94**	-11.21**	-2.06	-2.57**	-2.88**	9.39**
APMS 6A X JGL11118	-4.81**	-6.90**	2.06	-0.49	-1.94*	9.75**
APMS 6A X JGL11111	4.78**	0.66	5.50**	-18.40**	-19.05**	-7.94**
APMS 6A X JGL8605	-2.55	-5.26**	5.15*	-2.73**	-3.19**	9.39**
APMS 6A X JGL8292	-3.34*	-6.17**	4.47*	-9.76**	-10.48**	1.81*
APMS 6A X JGL3855	-2.56	-4.98**	4.81*	-0.32	-0.32	11.55**
APMS 6A X JGL3844	-3.30*	-3.45	5.84**	-7.29**	-9.49**	3.25**
APMS 6A X JGL1798	3.17	-2.83	6.19**	-1.11	-1.27	12.64**
IR 58025A X JGL11110-2	-2.03	-2.79	7.90**	-2.70**	-3.16**	10.47**
IR 58025A X JGL11110-1	-2.49	-3.40	7.56**	-3.96**	-4.11**	9.39**
IR 58025A X JGL17211	-2.97	-3.43	6.53**	-13.74**	-14.56**	-2.53**
IR 58025A X JGL16284	0.33	-3.76*	5.50**	-0.16	-1.92*	10.47**
IR 58025A X JGL13515	9.06**	6.83**	7.56**	-0.48	-0.95	12.64**
IR 58025A X JGL11160	-18.51**	-22.29**	-13.75**	-21.28**	-21.41**	-11.19**
IR 58025A X JGL11118	-7.62**	-12.04**	-2.06	-20.26**	-20.63**	-9.75**
IR 58025A X JGL11111	0.33	-4.05*	5.84**	-18.01**	-18.27**	-7.94**
IR 58025A X JGL8605	4.25*	0.00	9.62**	4.35**	3.65**	12.64**
IR 58025A X JGL8292	11.15**	8.87**	9.62**	-17.32**	-19.68**	-8.66**
IR 58025A X JGL3855	1.62	-3.10	7.56**	-22.95**	-24.92**	-15.16**
IR 58025A X JGL3844	-2.43	-7.10**	3.44	-20.26**	-22.54**	-11.91**
IR 58025A X JGL1798	-3.91*	-8.10**	1.37	-19.93**	-21.61**	-12.27**
Hybrid	**Kampasagar**			**Pooled**		
	Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
IR 68897A X JGL11110-2	0.16	-1.09	6.00	-1.62	-2.19	6.11**
IR 68897A X JGL11110-1	-10.03 **	-13.86 **	-10.00 **	-13.34**	-15.54**	-9.44**
IR 68897A X JGL17211	-8.84 **	-10.85 **	-2.55	-9.60**	-11.16**	-1.33
IR 68897A X JGL16284	-5.65	-7.65 *	0.76	-4.96**	-6.72**	3.87*
IR 68897A X JGL13515	-12.18 **	-13.80 **	-6.48	-12.82**	-14.00**	-5.22**
IR 68897A X JGL11160	-11.81 **	-13.71 **	-7.52 *	-14.07**	-14.78**	-7.55**
IR 68897A X JGL11118	-11.87 **	-14.86 **	-12.69 **	-15.55**	-17.50**	-11.98**
IR 68897A X JGL11111	-3.19	-6.18	2.55	-5.76**	-7.62**	2.61
IR 68897A X JGL8605	-12.22 **	-14.85 **	-7.10	-13.66**	-15.49**	-5.90**
IR 68897A X JGL8292	-3.33	-5.98	2.00	-6.63**	-8.2**	1.26
IR 68897A X JGL3855	-11.15 **	-11.84 **	-5.52	-11.80**	-12.12**	-4.66**
IR 68897A X JGL3844	0.69	-4.05	1.24	-6.68**	-9.24**	-2.26
IR 68897A X JGL1798	-9.21 **	-10.79 **	-2.48	-9.77**	-1.14**	-1.31
APMS 8A X JGL11110-2	2.44	0.76	9.93 **	1.07	-0.59	10.70**
APMS 8A X JGL11110-1	1.39	0.00	8.48 *	0.30	-0.85	9.28**
APMS 8A X JGL17211	0.48	0.32	7.86 *	0.97	0.75	9.30**
APMS 8A X JGL16284	-7.91 *	-13.02 **	-6.48	-5.76**	-8.48**	-1.14
APMS 8A X JGL13515	1.84	1.01	10.41 **	1.20	-0.19	10.86**
APMS 8A X JGL11160	1.18	0.44	9.59 *	1.35	-0.17	11.17**
APMS 8A X JGL11118	1.02	0.57	9.10 *	.88	-0.13	10.07**
APMS 8A X JGL11111	1.41	0.89	9.24 *	-7.43**	-8.69**	1.84
APMS 8A X JGL8605	1.49	-4.46	3.45	-1.54	-5.85**	5.01**

Table 4.27 (cont.)

Hybrid	Kampasagar			Pooled		
	Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A X JGL8292	-10.87 **	-11.29 **	-3.03	-12.54**	-12.43**	-2.66
APMS 8A X JGL3855	-11.04 **	-11.38 **	-3.31	-13.47**	-13. 54* *	-3.57*
APMS 8A X JGL3844	-3.79	-3.88	4.28	-6.61**	-7.17**	3.54*
APMS 8A X JGL1798	6.22 *	4.44	11.93 **	3.30*	2.66	11.38**
CMS 16A X JGL11110-2	9.70 **	5.46	9.24 *	5.52**	2.87	10.23**
CMS 16A X JGL11110-1	-5.15	-7.63 *	0.97	-8.69**	-10.30**	-0.37
CMS 16A X JGL17211	1.36	-1.20	7.79 *	-0.19	-2.07	9.04**
CMS 16A X JGL16284	2.89	0.57	9.10 *	1.17	-0.23	9.95**
CMS 16A X JGL13515	-5.02	-10.42 **	-4.00	-4.95**	-9.93**	-2.28
CMS 16A X JGL11160	12.78 **	12.41 **	7.45	8.36**	5.89**	7.76**
CMS 16A X JGL11118	5.06	-1.83	7.31	3.25*	-3.23*	7.48**
CMS 16A X JGL11111	-8.01 *	-13.97 **	-6.14	-7.74**	-13.63**	-3.82*
CMS 16A X JGL8605	3.32	-3.12	5.10	-3.34*	-9.07**	0.21
CMS 16A X JGL8292	2.69	1.99	9.31 *	2.012	-0.19	8.28**
CMS 16A X JGL3855	-12.09 **	-16.31 **	-11.52 **	-13.64**	-14.48**	11.24**
CMS 16A X JGL3844	-4.75	-6.31	2.41	-2.80	-5.98**	4.43**
CMS 16A X JGL1798	-1.57	-3.10	5.72	1.58	-1.86	9.28**
APMS 6A X JGL11110-2	-3.41	-4.64	3.45	-2.62*	-5.46**	4.20**
APMS 6A X JGL11110-1	0.45	0.32	7.79 *	-1.72	-2.33	7.30**
APMS 6A X JGL17211	5.98	0.13	7.59 *	0.89	-2.82	6.76**
APMS 6A X JGL16284	-1.50	-2.33	6.76	-1.81	-2.35	8.46**
APMS 6A X JGL13515	-7.83 *	-8.53 *	-0.21	-7.23**	-7.85**	2.61
APMS 6A X JGL11160	-13.19 **	-13.60 **	-6.28	-8.93**	-9.07**	0.21
APMS 6A X JGL11118	-5.12	-6.31	0.41	-3.48**	-4.15**	3.99*
APMS 6A X JGL11111	4.86	0.40	4.90	-3.28*	-5.64**	0.96
APMS 6A X JGL8605	-2.19	-4.35	4.55	-2.49	-4.28**	6.32**
APMS 6A X JGL8292	-4.29	-6.32	2.21	-5.80**	-7.64**	2.84
APMS 6A X JGL3855	-3.76	-5.53	2.48	-2.21	-3.64**	6.20**
APMS 6A X JGL3844	-1.42	-1.87	5.17	-3.99**	-4.56**	4.78**
APMS 6A X JGL1798	3.35	-1.82	4.28	1.74	-1.97	7.62**
IR 58025A X JGL11110-2	-1.31	-2.71	6.34	-2.02	-2.58	8.21**
IR 58025A X JGL11110-1	-1.02	-2.34	6.55	-2.50*	-3.18*	7.81**
IR 58025A X JGL17211	-3.18	-4.20	3.93	-6.61**	-6.79**	2.73
IR 58025A X JGL16284	-2.95	-3.60	3.31	-0.93	-1.96	6.36**
IR 58025A X JGL13515	5.17	0.13	5.86	4.44**	2.24	8.62**
IR 58025A X JGL11160	-9.49 **	-10.98 **	-2.69	-16.42**	-18.24**	-9.18**
IR 58025A X JGL11118	-12.10 **	-13.46 **	-5.59	-13.36**	-15.34**	-5.73**
IR 58025A X JGL11111	-2.19	-3.43	4.76	-6.66**	-8.33**	1.03
IR 58025A X JGL8605	3.20	-0.45	6.69	3.93**	1.03	9.60**
IR 58025A X JGL8292	11.59 **	9.35 *	8.90 *	1.35	1.02	3.47*
IR 58025A X JGL3855	1.16	-3.34	5.66	-6.71**	-1035**	-0.42
IR 58025A X JGL3844	-5.35	-9.48 **	-1.24	-9.34**	-12.98**	-3.10
IR 58025A X JGL1798	-6.46 *	-10.30 **	-2.69	-10.09**	-13.26	-4.41**

* Significant at 5% level; ** Significant at 1% level

Table 4.28. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA-6201) for plant height at Kunaram , Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	26.43 **	3.01 *	5.88 **	-24.11 **	-28.55 **	-31.44 **
IR 68897A	X	JGL11110-1	-21.70 **	-22.29 **	-20.12 **	-29.17 **	-31.83 **	-34.58 **
IR 68897A	X	JGL17211	-7.79 **	-12.65 **	-10.22 **	-36.54 **	-40.25 **	-42.66 **
IR 68897A	X	JGL16284	0.16	-6.02 **	-3.41 *	-34.13 **	-36.69 **	-34.13 **
IR 68897A	X	JGL13515	-7.98 **	-11.45 **	-8.98 **	-37.61 **	-41.45 **	-35.93 **
IR 68897A	X	JGL11160	7.98 **	-11.82 **	-9.91 **	-36.48 **	-43.45 **	-38.62 **
IR 68897A	X	JGL11118	-9.59 **	-10.00 **	-8.05 **	-27.77 **	-34.34 **	-28.74 **
IR 68897A	X	JGL11111	-0.16	-5.15 **	-3.10 *	-23.01 **	-31.45 **	-25.60 **
IR 68897A	X	JGL8605	0.81	-5.15 **	-3.10 *	-33.80 **	-35.17 **	-29.64 **
IR 68897A	X	JGL8292	0.78	-2.73 *	-0.62	-28.02 **	-28.32 **	-21.56 **
IR 68897A	X	JGL3855	19.39 **	-0.32	-3.72 **	-25.50 **	-33.79 **	-27.84 **
IR 68897A	X	JGL3844	7.67 **	5.20 **	6.50 **	-33.38 **	-39.56 **	-34.13 **
IR 68897A	X	JGL1798	-4.11 **	-6.41 **	-9.60 **	-27.36 **	-35.44 **	-29.64 **
APMS 8A	X	JGL11110-2	2.49	-0.96	-4.33 **	-25.93 **	-27.61 **	-21.11 **
APMS 8A	X	JGL11110-1	-1.13	-1.92	-5.26 **	-30.64 **	-30.78 **	-24.25 **
APMS 8A	X	JGL17211	17.32 **	-0.33	-7.74 **	-20.14 **	-20.14 **	-32.34 **
APMS 8A	X	JGL16284	-37.70 **	-40.37 **	-39.63 **	-31.84 **	-33.39 **	-40.87 **
APMS 8A	X	JGL13515	7.72 **	7.36 **	-0.62	-13.25 **	-13.25 **	-26.50 **
APMS 8A	X	JGL11160	-6.44 **	-7.69 **	-14.55 **	-21.65 **	-28.92 **	-26.05 **
APMS 8A	X	JGL11118	5.61 **	4.23 **	-0.93	-24.75 **	-33.24 **	-26.95 **
APMS 8A	X	JGL11111	18.57 **	-2.47	-2.17	-15.74 **	-20.31 **	-24.25 **
APMS 8A	X	JGL8605	-5.38 **	-5.81 **	-4.64 **	-23.94 **	-26.46 **	-30.09 **
APMS 8A	X	JGL8292	-9.82 **	-13.58 **	-13.31 **	-20.73 **	-25.04 **	-28.74 **
APMS 8A	X	JGL3855	-2.11	-7.10 **	-6.81 **	-35.64 **	-38.42 **	-35.93 **
APMS 8A	X	JGL3844	4.60 **	1.85	2.17	-30.31 **	-34.88 **	-28.74 **
APMS 8A	X	JGL1798	21.15 **	6.12 **	-8.67 **	-35.65 **	-43.71 **	-36.38 **
CMS 16A	X	JGL11110-2	-0.17	-7.65 **	-6.50 **	-30.27 **	-37.75 **	-29.64 **
CMS 16A	X	JGL11110-1	0.17	-3.03 *	-10.84 **	-30.20 **	-38.94 **	-30.99 **
CMS 16A	X	JGL17211	6.15 **	3.78 *	-6.50 **	-30.62 **	-33.38 **	-24.70 **
CMS 16A	X	JGL16284	-0.85	-5.54 **	-10.22 **	-31.49 **	-32.58 **	-23.80 **
CMS 16A	X	JGL13515	21.77 **	5.23 **	-6.50 **	-30.87 **	-37.77 **	-34.13 **
CMS 16A	X	JGL11160	-0.65	-6.73 **	-5.57 **	-25.38 **	-31.40 **	-27.40 **
CMS 16A	X	JGL11118	5.48 **	3.70 *	-4.64 **	-31.34 **	-38.19 **	-34.58 **
CMS 16A	X	JGL11111	-10.03 **	-10.65 **	-19.50 **	-37.23 **	-37.77 **	-34.13 **
CMS 16A	X	JGL8605	-3.03 *	-6.19 **	-10.84 **	-42.98 **	-43.91 **	-38.62 **
CMS 16A	X	JGL8292	31.07 **	8.07 **	7.74 **	-20.51 **	-27.03 **	-26.05 **
CMS 16A	X	JGL3855	-12.48 **	-13.15 **	-12.07 **	-35.91 **	-39.88 **	-39.07 **
CMS 16A	X	JGL3844	1.45	-2.48	-2.79 *	-21.00 **	-27.47 **	-26.50 **
CMS 16A	X	JGL1798	-4.40 **	-9.01 **	-9.29 **	-29.74 **	-30.65 **	-27.84 **
APMS 6A	X	JGL11110-2	-0.48	-2.80 *	-3.10 *	-30.68 **	-33.24 **	-26.95 **
APMS 6A	X	JGL11110-1	27.42 **	8.39 **	0.00	-27.97 **	-37.30 **	-28.29 **
APMS 6A	X	JGL17211	-0.80	-5.20 **	-4.02 **	-31.17 **	-38.87 **	-30.09 **
APMS 6A	X	JGL16284	4.54 **	4.36 **	-3.72 **	-26.62 **	-36.13 **	-26.95 **

Table 4.28 (cont.)								
Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	2.89 *	1.68	-6.19 **	-34.75 **	-37.70 **	-28.74 **
APMS 6A	X	JGL11160	2.48	0.98	-4.02 **	-41.94 **	-43.19 **	-35.03 **
APMS 6A	X	JGL11118	22.99 **	2.56	-0.62	-11.58 **	-15.81 **	-21.11 **
APMS 6A	X	JGL11111	6.25 **	3.98 **	5.26 **	18.46 **	15.34 **	8.08 **
APMS 6A	X	JGL8605	-13.11 **	-15.34 **	-17.96 **	22.65 **	16.77 **	9.43 **
APMS 6A	X	JGL8292	-0.66	-4.15 **	-7.12 **	9.77 **	4.32 **	8.53 **
APMS 6A	X	JGL3855	-6.13 **	-7.03 **	-9.91 **	9.95 **	2.05	11.68 **
APMS 6A	X	JGL3844	15.77 **	-0.68	-10.22 **	9.27 **	-4.73 **	8.53 **
APMS 6A	X	JGL1798	-7.92 **	-12.84 **	-11.76 **	-5.32 **	-15.77 **	-4.04 **
IR 58025A	X	JGL11110-2	4.24 **	3.37 *	-4.95 **	0.23	-12.61 **	-0.45
IR 58025A	X	JGL11110-1	8.40 **	8.22 **	-2.17	-7.01 **	-11.04 **	1.35
IR 58025A	X	JGL17211	-2.17	-4.56 **	-9.29 **	-18.50 **	-20.11 **	-8.98 **
IR 58025A	X	JGL16284	20.66 **	6.18 **	-9.60 **	-5.51 **	-16.62 **	-7.63 **
IR 58025A	X	JGL13515	-4.32 **	-11.93 **	-10.84 **	5.18 **	-5.27 **	4.94 **
IR 58025A	X	JGL11160	2.80 *	-1.01	-8.98 **	7.35 **	-5.27 **	4.94 **
IR 58025A	X	JGL11118	2.12	-0.69	-10.53 **	-5.64 **	-8.51 **	1.35
IR 58025A	X	JGL11111	13.06 **	7.17 **	1.86	-23.05 **	-23.51 **	-15.27 **
IR 58025A	X	JGL8605	-0.59	-15.89 **	-21.36 **	16.48 **	14.97 **	0.00
IR 58025A	X	JGL8292	27.19 **	22.32 **	23.84 **	15.33 **	14.17 **	1.35
IR 58025A	X	JGL3855	-0.50	-1.32	-7.74 **	7.59 **	6.20 **	-7.63 **
IR 58025A	X	JGL3844	-16.36 **	-17.88 **	-23.22 **	4.23 **	-4.32 **	-0.45
IR 58025A	X	JGL1798	-9.36 **	-10.10 **	-14.55 **	5.95 **	-4.92 **	4.04 **
Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-1.49	-11.45 **	6.57	-0.66	-12.14**	-7.21**
IR 68897A	X	JGL11110-1	-23.76 **	-30.86 **	-16.79 **	-24.81**	-28.30**	-24.28**
IR 68897A	X	JGL17211	-14.97 **	-21.78 **	-5.86	-19.56**	-24.70**	-20.48**
IR 68897A	X	JGL16284	-8.46 *	-16.56 **	0.43	-14.64**	-17.82**	-13.21**
IR 68897A	X	JGL13515	-15.23 **	-22.20 **	-6.36	-20.75**	-22.16**	-17.80**
IR 68897A	X	JGL11160	-11.92 **	-17.57 **	-9.21 *	-14.83**	-25.05**	-19.94**
IR 68897A	X	JGL11118	-13.77 **	-18.55 **	-10.29 *	-17.18**	-21.45**	-16.09**
IR 68897A	X	JGL11111	6.32	1.95	12.29 **	-6.01**	-12.49**	-6.52**
IR 68897A	X	JGL8605	-7.34 *	-12.00 **	-3.07	-14.50**	-18.13**	-12.55**
IR 68897A	X	JGL8292	-4.47	-8.63 *	0.64	-11.53**	-13.60**	-7.71**
IR 68897A	X	JGL3855	-2.12	-5.23	-2.86	-4.40**	-14.43**	-1.06**
IR 68897A	X	JGL3844	6.77	4.39	7.00	-7.17**	-10.32**	-7.83**
IR 68897A	X	JGL1798	-7.79 *	-8.43 *	-6.14	-13.49**	-17.99**	-5.71**
APMS 8A	X	JGL11110-2	8.36 *	6.55	9.21 *	-6.51**	-8.80**	-6.26**
APMS 8A	X	JGL11110-1	10.31 **	9.27 *	12.00 **	-8.97**	-9.39**	-6.87**
APMS 8A	X	JGL17211	4.05	-1.33	5.64	-0.18	-7.03**	-12.51**
APMS 8A	X	JGL16284	-19.44 **	-22.88 **	-17.43 **	-29.19**	-30.52**	-33.44**
APMS 8A	X	JGL13515	8.85 *	5.80	13.29 **	1.30	0.22	-5.69**
APMS 8A	X	JGL11160	3.53	-0.33	6.71	-8.57**	-10.27**	-12.29**
APMS 8A	X	JGL11118	6.78	3.54	10.86 *	-4.74**	-8.35**	-6.68**
APMS 8A	X	JGL11111	8.30 *	5.58	6.71	2.98*	-6.13**	-7.39**
APMS 8A	X	JGL8605	-1.29	-2.83	-1.79	-10.38**	-11.68**	-12.86**

Table 4.28 (cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-7.00	-7.00	-6.00	-12.59**	-15.50**	-16.63**
APMS 8A	X	JGL3855	-4.93	-5.87	-4.86	15.08**	-15.48**	-16.61**
APMS 8A	X	JGL3844	1.81	1.55	2.64	-8.93**	-10.34**	-8.71**
APMS 8A	X	JGL1798	5.96	5.88	1.64	-5.97**	-14.27**	-15.46**
CMS 16A	X	JGL11110-2	3.87	2.77	0.64	-10.10**	-11.38**	-12.61**
CMS 16A	X	JGL11110-1	3.30	0.64	1.71	10.09**	-13.05**	-14.27**
CMS 16A	X	JGL17211	2.82	1.15	0.21	-9.33**	-9.72**	-10.98**
CMS 16A	X	JGL16284	7.78 *	5.26	5.86	-8.98**	-11.86**	-10.26**
CMS 16A	X	JGL13515	5.57	4.32	0.14	-11.13**	5.47**	-14.36**
CMS 16A	X	JGL11160	6.08	3.79	1.64	-7.84**	-7.31**	-11.20**
CMS 16A	X	JGL11118	7.15	3.25	4.36	-9.33**	-5.13**	-12.63**
CMS 16A	X	JGL11111	-10.26 **	-12.69 **	-13.50 **	-20.01**	-21.15**	-22.92**
CMS 16A	X	JGL8605	-0.07	-3.48	-2.93	-15.30**	-19.84**	-18.38**
CMS 16A	X	JGL8292	11.63 **	8.16	10.71 *	-4.45**	18.95**	-3.42.**
CMS 16A	X	JGL3855	0.43	-1.74	0.57	-18.79**	-14.33**	-17.92**
CMS 16A	X	JGL3844	0.42	-0.21	2.14	-10.73**	-2.03	-9.77**
CMS 16A	X	JGL1798	-3.33	-4.88	-2.64	-14.83**	-11.93**	-13.92**
APMS 6A	X	JGL11110-2	2.78	1.88	4.29	-10.36**	-11.02**	-9.39**
APMS 6A	X	JGL11110-1	1.36	-4.60	3.79	-13.36**	12.13**	-8.95**
APMS 6A	X	JGL17211	-2.90	-7.75 *	0.36	-16.26**	-8.15**	-12.01**
APMS 6A	X	JGL16284	-3.47	-6.89	1.29	-14.83**	-2.83*	-10.50**
APMS 6A	X	JGL13515	-6.74	-10.90 **	-3.07	17.49**	-11.30**	-13.30**
APMS 6A	X	JGL11160	-10.00 **	-13.39 **	-5.79	-19.68**	-17.12**	-15.60**
APMS 6A	X	JGL11118	4.73	4.12	1.14	-3.37*	14.05**	-7.40**
APMS 6A	X	JGL11111	8.46 *	8.02	5.79	11.05**	11.08**	6.42**
APMS 6A	X	JGL8605	12.86 **	10.67 *	11.86 **	5.09**	9.35**	0.72
APMS 6A	X	JGL8292	-1.20	-2.16	-3.07	4.00**	1.97	-0.33
APMS 6A	X	JGL3855	-3.11	-4.76	-4.21	3.81**	-2.30	-0.51
APMS 6A	X	JGL3844	2.09	1.93	-2.14	-1.49	21.78**	-1.12
APMS 6A	X	JGL1798	8.96 *	7.73	5.50	-4.21**	0.36	-3.85
IR 58025A	X	JGL11110-2	8.31 *	5.44	6.57	-0.28	8.68**	0.10
IR 58025A	X	JGL11110-1	5.24	3.46	2.50	0.11	2.80*	0.48
IR 58025A	X	JGL17211	-0.87	-3.27	-2.71	-7.56**	-8.88**	-7.21**
IR 58025A	X	JGL16284	3.74	2.16	-1.93	-3.37*	15.02**	-6.61**
IR 58025A	X	JGL13515	6.96	4.30	2.14	2.09	2.99*	-1.33
IR 58025A	X	JGL11160	-2.06	-5.94	-4.93	0.56	5.53**	-2.81*
IR 58025A	X	JGL11118	-3.05	-5.98	-6.86	-1.91	-3.01*	-5.20**
IR 58025A	X	JGL11111	8.00 *	3.98	4.57	-0.09	-5.17**	-3.44**
IR 58025A	X	JGL8605	-3.68	-3.85	-7.36	-1.73	1.38**	-9.56**
IR 58025A	X	JGL8292	20.88 **	19.91 **	17.43 **	23.77**	18.89**	13.91**
IR 58025A	X	JGL3855	0.72	-1.63	-0.57	2.62	2.54	-5.56**
IR 58025A	X	JGL3844	-11.77 **	-12.98 **	-13.79 **	-4.69**	10.26**	-12.28**
IR 58025A	X	JGL1798	-7.07	-9.02 *	-8.50 *	2.02	-7.80**	-6.12**

* Significant at 5% level; ** Significant at 1% level

4.2.7.2 Plant height (cm)

At Kunaram 19 hybrids recorded significant average heterosis for plant height ranging from -37.70 (APMS 8A x JGL 3844) to -3.03 (CMS 16A x JGL 11111). The significant negative heterobeltiosis was recorded in 34 hybrids for plane height, the ranging from -40.37 (APMS 8A x JGL 16284) to -2.73 (IR68897A x JGL 8292). The negative standard heterosis was observed in 51 hybrids over PA 6201 and it ranged between -39.63 (APMS 8A x JGL 16284) to -2.79 (CMS 16A x JGL 3844).

At Warangal, 52 hybrids recorded significant average negative heterosis ranging from -42.98 (CMS 16A x JGL 8605) to -5.32 (APMS 6A x JGL 1798) for plant height. The significant negative heterobeltiosis was recorded in 58 hybrids, with a range of -43.91 (CMS 16A x JGL 8605) to -4.32 (IR 58025A x JGL 3844). The significant negative standard heterosis was observed in 51 hybrids, with a range from -42.66 (IR 68897A x JGL 17211) to -4.04 (APMS 6A x JGL 1798), when compared with highest yielding check PA 6201.

At Kampasagar the average negative heterosis was observed in 12 hybrids with a range from -23.76 (IR 68897A x JGL 11110-1) to -7.34 (IR68897A x JGL 8605). The average negative heterobeltiosis was observed in 17 hybrids ranged from -30.86 (IR 68897A x JGL 11110-1) to -7.75 (APMS 6A x JGL 17211. The significant negative standard heterosis was recorded in 7 hybrids and it ranged from -17.43 (APMS 8A x JGL 16284) to -8.50 (IR 58025A x JGL 1798).

In pooled analysis for plant height, the average significant negative heterosis was observed in 43 hybrids and it ranged from -29.19 (APMS 8A x JGL 16284) to -3.37 (APMS 6A x JGL 16284). The average significant negative heterobeltiosis was recorded in 44 hybrids, with a range of -30.52 (APMS 8A x JGL 16284) to -2.83 (APMS 6A x JGL 16284). The significant negative standard heterosis was recorded in 57 hybrids, with a range of -33.44 (PMS 8A x JGL 16284) to -1.06 (IR68897A x JGL 3855), when compared with check PA 6201 (Table 4.28).

Short plant type is an important trait of hybrid to withstand lodging. Hence, heterosis in negative direction which implies short stature is desirable for this trait.The hybrid APMS 8A x JGL 16284 recorded, highest standard heterosis (33.44) over the check PA 6201, with relative high standard heterosis over check KRH-2 (35.81), heterobeltiosis (-30.52) and average heterosis (-29.19), out of 65 hybrids, 57 hybrids, recorded significant standard heterosis over the check PA 6201. The other hybrids IR 68897A x JGL 11110-1 (-24.28), CMS 16A x JGL 11111 (-22.92), IR 68897A x JGL 17211 (-20.48) and IR 68897A x JGL 11160 (-19.94) also recorded high standard heterosis over check PA 6201(Table 4.39 and Figure 4.7). Both positive and negative heterosis was expressed over standard checks, mid parent and better parent by several rice researchers viz., Ghosh (2002), Doeraj *et al.* (2007), Hariramakrishnan *et al.* (2009) and Roy et al. (2009).Standard heterosis of similar nature was reported by Singh *et al.* (2006a & 2006b), Anju Choudhary *et al.* (2007), Doeraj *et al.* (2007), Rosamma and Vijaykumar (2007) and Akarsh Parihar and Pathak (2008).

4.2.7.3 Productive tillers/plant

At Kunaram, the positive significant average heterosis was recorded in 13 hybrids, with a range from 113.95 (APMS 6A x JGL 11111) to 30.23 (IR 58025A x JGL 11118). The significant positive heterobeltiosis was recorded in 6 hybrids, with a range of 91.67 (APMS 6A x JGL 11111) to 40.91 (APMS 6A x JGL 11110-1). The significant positive standard heterosis was observed in only one hybrid APMS 6A x JGL 11111 (39.39) when compared to check PA 6201(Table 4.29).

At Warangal, the positive significant average heterosis was recorded in 36 hybrids with range of 158.62 (IR 58025A x JGL 11160) to 16.52 (IR 68897A x JGL 8292). The significant heterobeltiosis was recorded in 30 hybrids with a range of 141.94 (IR 58025A x JGL 11160) to 9.84 (IR68897A x JGL 8292). Positive significant standard heterosis was recorded in 37 hybrids with a range of 102.58 (APMS 8A x JGL 11118) to 15.38 (APMS 6A x JGL 11118), when compared with check PA 6201.

At Kampasagar the significant average heterosis recorded in 38 hybrids with a range of 141.32 (IR 58025A x JGL 16284) to 22.50 (APMS 8A x JGL 3844). The significant heterobeltiosis recorded in 28 hybrids with a range of 135.48 (IR 58025A x JGL 16284) to 23.76 (APMS 8A x JGL11118). The significant standard heterosis is recorded in 32 hybrids and it ranged from 138.46 (IR 68897A x JGL 1798) to 28.38 (CMS 16A x JGL 3844), when compared to the check PA 6201.

In pooled analysis, 49 hybrids recorded positive significant average heterosis and it ranged from 90.68 (APMS 8A x JGL 11111) to 9.09 (APMS 8A x JGL 11110-1). The significant heterobeltiosis was recorded in 41 hybrids, with a range of 90.68 (APMS 8A x JGL 11111) to 9.09 (APMS 8A x JGL 11110-1). The significant standard heterosis was recorded in 29 hybrids and it ranged from 59.33 (APMS 8A x JGL 11118) to 13.40 (CMS 16A x JGL 8292) when compared to check PA 6201 (Table 4.29).

Number of productive tillers per plant is known to directly contribute towards grain yield and can be exploited. More the number of productive tillers more will be the yield and vice versa. Hence, heterosis over better parent and standard checks in positive direction is desirable for this trait. Among the 65 hybrids studied, 29 hybrids recorded significant standard heterosis over the best check PA 6201 in pooled analysis. The hybrid APMS 8A x JGL 11118 (59.33) recorded the highest standard heterosis over the best check PA 6201, with relative high standard heterosis when compared with check KRH-2 (57.08), heterobeltiosis (54.52) and average heterosis (54.52). The hybrid IR 68897A x JGL 8292 (53.11), IR 68897A x JGL 3855 (51.20), APMS 6A x JGL 16284 (49.28) and APMS 8A x JGL 3844 (44.50) also recorded high standard heterosis over best check PA 6201(Table 4.39 and Figure 4.7). In the present investigation majority of the hybrids recorded significant positive heterosis and heterobeltiosis. Mid parental heterosis both positive and negative directions were reported by Reddy and Nerkar (1995), Joshi *et al.* (2004), Shantala *et al.* (2006), Doeraj *et al.* (2007) and Hariramakrishnan *et al.* (2009). Heterobeltiosis of positive nature was observed by Pandey *et al*. (1995), Jayamani et al. (1997), Verma *et al.* (2004), whereas Mishra and Pandey (1998), Singh *et al*. (2006 a), Doeraj *et al*. (2007), Akarsh Parihar and Pathak (2008) and Roy *et al*. (2009) reported both heterobeltiosis and standard heterosis in both positive and negative directions

4.2.7.4 Flag leaf length (cms)

At Kunaram the significant positive average heterosis was recorded in 35 hybrids, with a range from 71.48 (APMS 8A x JGL 11111) to 8.75 (APMS 8A x JGL 11160). The positive significant heterobeltiosis was recorded in only 18 hybrids, which ranged from 65.98 (APMS 8A x JGL 11111) to 10.11 (APMS 6A x JGL 11110-2). The significant standard heterosis was observed in 23 hybrids, ranging from 43.77 (IR 6897A x JGL 11160) to 9.96 (APMS 6A x JGL 3844), when compared with check PA 6201.

At Warangal, positive significant average heterosis was observed in 30 hybrids, ranging from 80.43 (APMS 8A x JGL 16284) to15.70 (IR 68897A x JGL 11111). The significant heterobeltiosis was observed in 17 hybrids with a range from 69.39 (APMS 8A x JGL 16284) to 21.43 (CMS 16A x JGL 8605). The significant positive standard heterosis was observed in 4 hybrids, with a range from 72.92 (APMS 8A x JGL 17211) to 18.03 (APMS 8A x JGL 111160) when compared with check PA 6201.

At Kampasagar, the positive significant average heterosis was recorded in 25 hybrids ranging from 50.52 (IR 58025A x JGL 11111) to 15.79 (CMS 16A x JGL

Table 4.29. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for productive tillers/plant at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-22.45	-38.71 **	-42.42 **	52.11 **	35.00 **	38.46 **
IR 68897A	X	JGL11110-1	-8.00	-25.81 *	-30.30 **	1.49	-15.00 *	-12.82
IR 68897A	X	JGL17211	-32.08 *	-41.94 **	-45.45 **	-29.58 **	-37.50 **	-35.90 **
IR 68897A	X	JGL16284	-16.98	-29.03 *	-33.33 **	-9.43 *	-27.27 **	23.08 **
IR 68897A	X	JGL13515	-10.34	-16.13	-21.21	-34.04 **	-42.59 **	-20.51 **
IR 68897A	X	JGL11160	6.67	-11.11	-27.27 *	0.00	-24.59 **	17.95 *
IR 68897A	X	JGL11118	13.04	-3.70	-21.21	22.73 **	-11.48 *	38.46 **
IR 68897A	X	JGL11111	22.45	11.11	-9.09	-6.52	-29.51 **	10.26
IR 68897A	X	JGL8605	30.61 *	18.52	-3.03	0.79	-3.03	64.10 **
IR 68897A	X	JGL8292	7.41	7.41	-12.12	16.52 **	9.84 *	71.79 **
IR 68897A	X	JGL3855	-2.22	-18.52	-33.33 **	86.49 **	60.47 **	76.92 **
IR 68897A	X	JGL3844	13.04	-3.70	-21.21	88.57 **	53.49 **	69.23 **
IR 68897A	X	JGL1798	2.04	-7.41	-24.24 *	89.19 **	62.79 **	79.49 **
APMS 8A	X	JGL11110-2	-22.45	-29.63 *	-42.42 **	-22.94 **	-36.36 **	7.69
APMS 8A	X	JGL11110-1	14.81	14.81	-6.06	7.22	-3.70	33.33 **
APMS 8A	X	JGL17211	-4.55	-19.23	-36.36 **	52.73 **	35.48 **	7.69
APMS 8A	X	JGL16284	-11.11	-23.08	-39.39 **	41.18 **	33.33 **	-7.69
APMS 8A	X	JGL13515	-4.17	-11.54	-30.30 **	85.45 **	64.52 **	30.77 **
APMS 8A	X	JGL11160	-33.33 *	-38.46 **	-51.52 **	0.00	-31.82 **	15.38 *
APMS 8A	X	JGL11118	-5.66	-7.41	-24.24 *	102.56 **	46.30 **	102.56 **
APMS 8A	X	JGL11111	30.23 *	12.00	-15.15	100.00 **	64.58 **	102.56 **
APMS 8A	X	JGL8605	18.18	4.00	-21.21	38.67 **	8.33	33.33 **
APMS 8A	X	JGL8292	-36.17 *	-40.00 **	-54.55 **	-1.27	-18.75 **	0.00
APMS 8A	X	JGL3855	-14.89	-20.00	-39.39 **	-36.84 **	-45.45 **	-7.69
APMS 8A	X	JGL3844	-11.54	-14.81	-30.30 **	54.90 **	46.30 **	102.56 **
APMS 8A	X	JGL1798	26.32	20.00	-27.27 *	6.33	-12.50 *	7.69
CMS 16A	X	JGL11110-2	7.69	5.00	-36.36 **	78.67 **	39.58 **	71.79 **
CMS 16A	X	JGL11110-1	-4.76	-9.09	-39.39 **	-24.05 **	-37.50 **	-23.08 **
CMS 16A	X	JGL17211	33.33 *	27.27	-15.15	-15.79 **	-27.27 **	23.08 **
CMS 16A	X	JGL16284	19.15	3.70	-15.15	47.06 **	38.89 **	92.31 **
CMS 16A	X	JGL13515	29.73	26.32	-27.27 *	6.33	-12.50 *	7.69
CMS 16A	X	JGL11160	26.32	26.32	-27.27 *	76.00 **	37.50 **	69.23 **
CMS 16A	X	JGL11118	17.07	9.09	-27.27 *	59.49 **	31.25 **	61.54 **
CMS 16A	X	JGL11111	17.07	9.09	-27.27 *	-26.32 **	-36.36 **	7.69
CMS 16A	X	JGL8605	-17.39	-29.63 *	-42.42 **	5.88	0.00	38.46 **
CMS 16A	X	JGL8292	19.05	4.17	-24.24 *	96.43 **	77.42 **	41.03 **
CMS 16A	X	JGL3855	11.63	0.00	-27.27 *	-7.69	-11.11	-38.46 **
CMS 16A	X	JGL3844	13.04	8.33	-21.21	128.57 **	106.45 **	64.10 **
CMS 16A	X	JGL1798	4.35	0.00	-27.27 *	27.47 **	-12.12 **	48.72 **
APMS 6A	X	JGL11110-2	21.57	14.81	-6.06	21.52 **	-11.11 *	23.08 **
APMS 6A	X	JGL11110-1	65.85 **	47.83 **	3.03	122.86 **	100.00 **	100.00 **
APMS 6A	X	JGL17211	38.10 *	26.09	-12.12	30.30 **	10.26	10.26
APMS 6A	X	JGL16284	24.44	21.74	-15.15	57.14 **	41.03 **	41.03 **

Table 4.29 (cont.)								
Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	33.33 *	30.43	-9.09	-37.14 **	-50.00 **	-15.38 *
APMS 6A	X	JGL11160	-4.00	-11.11	-27.27 *	61.29 **	38.89 **	92.31 **
APMS 6A	X	JGL11118	38.10 *	20.83	-12.12	34.33 **	25.00 **	15.38 *
APMS 6A	X	JGL11111	113.95 **	91.67 **	39.39 **	-1.59	-13.89	-20.51 **
APMS 6A	X	JGL8605	-8.70	-12.50	-36.36 **	43.28 **	33.33 **	23.08 **
APMS 6A	X	JGL8292	56.52 **	50.00 **	9.09	31.37 **	1.52	71.79 **
APMS 6A	X	JGL3855	9.80	3.70	-15.15	-17.78 **	-31.48 **	-5.13
APMS 6A	X	JGL3844	72.97 **	68.42 **	-3.03	41.82 **	25.81 **	0.00
APMS 6A	X	JGL1798	63.16 **	63.16 **	-6.06	92.16 **	81.48 **	25.64 **
IR 58025A	X	JGL11110-2	21.95	13.64	-24.24 *	67.27 **	48.39 **	17.95 *
IR 58025A	X	JGL11110-1	51.22 **	40.91 *	-6.06	-31.11 **	-53.03 **	-20.51 **
IR 58025A	X	JGL17211	-4.35	-18.52	-33.33 **	-7.69	-33.33 **	-7.69
IR 58025A	X	JGL16284	2.56	-4.76	-39.39 **	17.24 *	9.68	-12.82
IR 58025A	X	JGL13515	15.00	9.52	-30.30 **	59.26 **	59.26 **	10.26
IR 58025A	X	JGL11160	2.33	0.00	-33.33 **	158.62 **	141.94 **	92.31 **
IR 58025A	X	JGL11118	30.23 *	27.27	-15.15	-29.03 **	-50.00 **	-15.38 *
IR 58025A	X	JGL11111	16.67	3.70	-15.15	-11.11	-33.33 **	-7.69
IR 58025A	X	JGL8605	-37.78 *	-48.15 **	-57.58 **	87.10 **	87.10 **	48.72 **
IR 58025A	X	JGL8292	8.70	-7.41	-24.24 *	-6.90	-12.90	-30.77 **
IR 58025A	X	JGL3855	6.12	-3.70	-21.21	122.58 **	122.58 **	76.92 **
IR 58025A	X	JGL3844	18.37	7.41	-12.12	-17.53 **	-39.39 **	2.56
IR 58025A	X	JGL1798	-25.93 *	-25.93	-39.39 **	-8.24	-27.78 **	0.00
Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	57.02 **	53.23 **	46.15 **	33.52**	33.52**	15.31*
IR 68897A	X	JGL11110-1	-19.35	-23.08	-23.08	-8.38	-8.38	-21.53**
IR 68897A	X	JGL17211	-33.80 **	-43.37 **	-27.69 *	-31.79**	-31.79**	-36.36**
IR 68897A	X	JGL16284	-24.84 **	-39.80 **	-9.23	-16.21**	-16.21**	-4.78
IR 68897A	X	JGL13515	3.75	-17.82 *	27.69 *	-15.09**	-15.09**	-5.74
IR 68897A	X	JGL11160	134.65 **	129.23 **	129.23 **	44.14**	44.14**	38.28**
IR 68897A	X	JGL11118	36.92 **	36.92 **	36.92 **	25.13**	25.13**	19.14**
IR 68897A	X	JGL11111	56.76 **	39.76 **	78.46 **	21.86**	21.86**	25.36**
IR 68897A	X	JGL8605	82.82 **	52.04 **	129.23 **	32.43**	32.43**	63.16**
IR 68897A	X	JGL8292	54.22 **	26.73 **	96.92 **	26.98**	26.98**	53.11**
IR 68897A	X	JGL3855	74.03 **	45.65 **	106.15 **	61.22**	61.2**	51.20**
IR 68897A	X	JGL3844	47.77 **	26.09 **	78.46 **	54.24**	54.24**	43.54**
IR 68897A	X	JGL1798	77.14 **	68.48 **	138.46 **	63.90**	63.90**	65.07**
APMS 8A	X	JGL11110-2	6.32	3.06	55.38 **	-11.86**	-11.86**	6.70
APMS 8A	X	JGL11110-1	7.77	2.97	60.00 **	9.09*	9.09*	29.19**
APMS 8A	X	JGL17211	0.00	-4.41	0.00	16.46*	16.46*	-8.61
APMS 8A	X	JGL16284	-20.30	-22.06	-18.46	1.54	1.54	-21.05**
APMS 8A	X	JGL13515	41.72 **	28.92 **	64.62 **	42.86**	42.86**	22.01**
APMS 8A	X	JGL11160	32.53 **	12.24	69.23 **	4.98	4.98	11.00
APMS 8A	X	JGL11118	47.93 **	23.76 **	92.31 **	54.52**	54.52**	59.33**
APMS 8A	X	JGL11111	121.49 **	116.13 **	106.15 **	90.68**	90.68**	66.51**
APMS 8A	X	JGL8605	33.87 **	27.69 *	27.69 *	32.04**	32.04**	14.35*

Table 4.29(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-4.23	-18.07	4.62	-10.66	-10.66	-15.79**
APMS 8A	X	JGL3855	40.13 **	12.24	69.23 **	-7.31	-7.31	6.22
APMS 8A	X	JGL3844	22.50 **	-2.97	50.77 **	29.06**	29.06**	44.50**
APMS 8A	X	JGL1798	13.04	4.84	0.00	12.89*	12.89*	-5.74
CMS 16A	X	JGL11110-2	50.85 **	36.92 **	36.92 **	53.18**	53.18**	26.79**
CMS 16A	X	JGL11110-1	44.12 **	18.07	50.77 **	4.76	4.76	-5.26
CMS 16A	X	JGL17211	-13.91	-33.67 **	0.00	-6.26	-6.26	3.83
CMS 16A	X	JGL16284	-15.58	-35.64 **	0.00	19.91**	19.91**	29.67**
CMS 16A	X	JGL13515	33.83 **	25.35 *	36.92 **	21.10**	2.1.10**	5.74
CMS 16A	X	JGL11160	57.35 **	50.70 **	64.62 **	58.56**	58.56**	37.32**
CMS 16A	X	JGL11118	-7.79	-14.46	9.23	24.37**	24.37**	17.22**
CMS 16A	X	JGL11111	-15.98	-27.55 **	9.23	-15.24**	-15.24**	-2.87
CMS 16A	X	JGL8605	-31.40 **	-41.58 **	-9.23	-12.39**	-12.39**	-7.91
CMS 16A	X	JGL8292	27.27 *	24.19	18.46	49.53**	49.53**	13.40*
CMS 16A	X	JGL3855	38.71 **	32.31 **	32.31 **	15.92*	15.92*	-12.92.*
CMS 16A	X	JGL3844	33.80 **	14.46	46.15 **	58.96**	58.96**	31.58**
CMS 16A	X	JGL1798	59.24 **	27.55 **	92.31 **	34.11**	34.11**	38.28**
APMS 6A	X	JGL11110-2	41.25 **	11.88	73.85 **	29.05**	29.05**	29.67**
APMS 6A	X	JGL11110-1	70.70 **	41.05 **	106.15 **	88.92**	88.92**	71.29**
APMS 6A	X	JGL17211	60.00 **	34.74 **	96.92 **	44.68**	44.68**	30.14**
APMS 6A	X	JGL16284	64.04 **	53.68 **	124.62 **	52.94**	52.94**	49.28**
APMS 6A	X	JGL13515	-38.86 **	-39.80 **	-9.23	-24.95**	-74.95**	-7.48
APMS 6A	X	JGL11160	-42.86 **	-44.55 **	-13.85	5.39	5..39	21.53**
APMS 6A	X	JGL11118	72.58 **	72.58 **	64.62 **	49.12**	49.12**	22.01**
APMS 6A	X	JGL11111	2.36	0.00	0.00	20.33**	39.49**	4.78
APMS 6A	X	JGL8605	14.48	0.00	27.69 *	21.43**	16.93*	5.74
APMS 6A	X	JGL8292	-3.75	-21.43 **	18.46	55.49**	3.28	35.41**
APMS 6A	X	JGL3855	5.52	-14.85	32.31 **	18.68**	-17.87**	3.35
APMS 6A	X	JGL3844	-4.84	-4.84	-9.23	35.81**	25.63**	-3.83
APMS 6A	X	JGL1798	63.78 **	60.00 **	60.00 **	78.38**	68.15**	26.32**
IR 58025A	X	JGL11110-2	14.48	0.00	27.69 *	52.03**	19.05**	7.66
IR 58025A	X	JGL11110-1	-37.50 **	-48.98 **	-23.08	17.57*	-36.50**	-16.75**
IR 58025A	X	JGL17211	57.06 **	26.73 **	96.92 **	64.86**	-7.22	16.75**
IR 58025A	X	JGL16284	141.32 **	135.48 **	124.62 **	63.87**	58.75**	21.53**
IR 58025A	X	JGL13515	58.06 **	50.77 **	50.77 **	48.39**	46.50**	10.05
IR 58025A	X	JGL11160	38.03 **	18.07	50.77 **	88.39**	54.50**	59.71**
IR 58025A	X	JGL11118	36.31 **	9.18	64.62 **	47.74**	-16.42**	9.57
IR 58025A	X	JGL11111	-18.75 *	-35.64 **	0.00	24.52**	-26.62**	-7.66
IR 58025A	X	JGL8605	44.35 **	33.87 **	27.69 *	34.32**	41.88**	8.61
IR 58025A	X	JGL8292	-10.17	-18.46	-18.46	-7.10	0.00	-24.88**
IR 58025A	X	JGL3855	26.47 **	3.61	32.31 **	63.31**	46.03**	32.06**
IR 58025A	X	JGL3844	-21.85 *	-39.80 **	-9.23	16.57*	-28.10**	-5.74
IR 58025A	X	JGL1798	35.06 **	2.97	60.00 **	31.36**	-15.59**	6.22

* Significant at 5% level; ** Significant at 1% level

Table 4.30. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for flag leaf length at Kunaram , Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-8.13	-21.27 **	-14.18 **	24.53 **	17.86	37.50 **
IR 68897A	X	JGL11110-1	-19.96 **	-21.11 **	-14.00 **	-2.86	-8.93	6.25
IR 68897A	X	JGL17211	-14.89 **	-27.09 **	-20.52 **	-0.95	-7.14	8.33
IR 68897A	X	JGL16284	8.91 *	-2.94	5.81	-9.84	-16.67 *	14.58
IR 68897A	X	JGL13515	-3.60	-8.32	-0.06	25.00 **	25.00 **	45.83 **
IR 68897A	X	JGL11160	41.01 **	14.02 **	43.77 **	8.20	-8.33	37.50 **
IR 68897A	X	JGL11118	-23.29 **	-29.44 **	-11.03 *	2.48	-13.89	29.17 **
IR 68897A	X	JGL11111	-3.40	-21.92 **	-1.54	15.70 *	-2.78	45.83 **
IR 68897A	X	JGL8605	-0.56	-16.65 **	5.10	-21.74 **	-25.00 **	12.50
IR 68897A	X	JGL8292	-16.12 **	-25.35 **	-5.87	-4.69	-15.28 *	27.08 *
IR 68897A	X	JGL3855	-0.44	-14.77 **	-6.88	3.70	-3.45	16.67
IR 68897A	X	JGL3844	-15.63 **	-16.94 **	-9.25	25.23 **	15.52	39.58 **
IR 68897A	X	JGL1798	-6.69	-20.14 **	-12.75 **	15.89	6.90	29.17 **
APMS 8A	X	JGL11110-2	2.68	-8.58	-0.12	8.06	1.52	39.58 **
APMS 8A	X	JGL11110-1	22.17 **	16.07 **	26.81 **	29.82 **	27.59 **	54.17 **
APMS 8A	X	JGL17211	16.02 **	-2.39	11.27 *	78.49 **	66.00 **	72.92 **
APMS 8A	X	JGL16284	-1.32	-4.84	8.48	80.43 **	69.39 **	72.92 **
APMS 8A	X	JGL13515	9.50 *	-7.91	4.98	34.78 **	26.53 *	29.17 **
APMS 8A	X	JGL11160	8.75 *	-4.94	8.36	32.11 **	9.09	50.00 **
APMS 8A	X	JGL11118	6.26	-1.04	12.81 **	39.39 **	23.21 *	43.75 **
APMS 8A	X	JGL11111	71.48 **	65.98 **	38.02 **	-3.77	-8.93	6.25
APMS 8A	X	JGL8605	20.24 **	7.34	13.64 **	16.19	8.93	27.08 *
APMS 8A	X	JGL8292	20.24 **	16.33 **	-3.26	0.95	-5.36	10.42
APMS 8A	X	JGL3855	18.03 **	16.55 **	-0.59	-21.31 **	-27.27 **	0.00
APMS 8A	X	JGL3844	-1.83	-9.41	-10.91 *	21.43 **	21.43 *	41.67 **
APMS 8A	X	JGL1798	9.64 *	-9.36 *	7.95	25.00 **	12.90	45.83 **
CMS 16A	X	JGL11110-2	-0.76	-6.27	11.63 *	9.91	-1.61	27.08 *
CMS 16A	X	JGL11110-1	16.12 **	-4.03	14.29 **	8.11	-3.23	25.00 *
CMS 16A	X	JGL17211	24.09 **	6.47	26.81 **	6.25	3.03	41.67 **
CMS 16A	X	JGL16284	6.06	-3.19	15.30 **	11.86	6.45	37.50 **
CMS 16A	X	JGL13515	23.44 **	13.93 **	4.80	12.87	11.76	18.75
CMS 16A	X	JGL11160	16.25 **	8.63	15.01 **	20.00 *	17.65	25.00 *
CMS 16A	X	JGL11118	20.06 **	10.77 *	1.90	14.00	11.76	18.75
CMS 16A	X	JGL11111	1.24	-2.45	-10.26 *	-12.82	-22.73 **	6.25
CMS 16A	X	JGL8605	12.18 **	8.56	6.76	27.10 **	21.43 *	41.67 **
CMS 16A	X	JGL8292	35.00 **	6.79	42.76 **	38.30 **	30.00 **	35.42 **
CMS 16A	X	JGL3855	-12.45 **	-21.56 **	4.86	5.38	0.00	2.08
CMS 16A	X	JGL3844	7.27	-15.17 **	13.40 **	41.94 **	34.69 **	37.50 **
CMS 16A	X	JGL1798	-1.79	-19.57 **	7.53	-25.45 **	-37.88 **	-14.58
APMS 6A	X	JGL11110-2	-13.09 **	-24.58 **	0.83	22.00 *	8.93	27.08 *
APMS 6A	X	JGL11110-1	27.08 **	10.11 *	16.90 **	34.74 **	28.00 **	33.33 **
APMS 6A	X	JGL17211	-4.22	-4.36	1.54	29.79 **	24.49 *	27.08 *
APMS 6A	X	JGL16284	11.83 *	-3.13	2.85	48.94 **	42.86 **	45.83 **

Table 4.30(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-20.45 **	-28.27 **	-23.84 **	18.92 *	0.00	37.50 **
APMS 6A	X	JGL11160	-3.25	-6.82	-1.07	-8.91	-17.86	-4.17
APMS 6A	X	JGL11118	20.82 **	1.18	16.67 **	3.03	2.00	6.25
APMS 6A	X	JGL11111	19.71 **	14.81 **	32.38 **	24.49 **	24.49 *	27.08 *
APMS 6A	X	JGL8605	9.37 *	-8.44 *	5.58	26.53 **	26.53 *	29.17 **
APMS 6A	X	JGL8292	20.46 **	4.78	20.82 **	-21.74 **	-31.82 **	-6.25
APMS 6A	X	JGL3855	-11.16 **	-17.70 **	-5.10	-37.14 **	-41.07 **	-31.25 **
APMS 6A	X	JGL3844	37.54 **	33.96 **	9.96 *	-34.55 **	-40.00 **	-25.00 *
APMS 6A	X	JGL1798	19.03 **	5.66	11.86 *	-24.77 **	-31.67 **	-14.58
IR 58025A	X	JGL11110-2	22.15 **	18.93 **	-2.37	24.77 **	13.33	41.67 **
IR 58025A	X	JGL11110-1	27.57 **	25.17 **	6.76	-31.75 **	-34.85 **	-10.42
IR 58025A	X	JGL17211	43.20 **	31.36 **	29.18 **	-22.41 **	-25.00 **	-6.25
IR 58025A	X	JGL16284	37.13 **	36.45 **	7.24	-13.33	-22.00 *	-18.75
IR 58025A	X	JGL13515	5.08	-8.46	-3.08	37.08 **	24.49 *	27.08 *
IR 58025A	X	JGL11160	32.55 **	31.85 **	3.62	-5.62	-14.29	-12.50
IR 58025A	X	JGL11118	14.30 **	9.81	-6.35	-22.64 **	-37.88 **	-14.58
IR 58025A	X	JGL11111	58.70 **	42.76 **	40.39 **	37.50 **	17.86	37.50 **
IR 58025A	X	JGL8605	7.73	-1.52	-7.47	18.00 *	18.00	22.92 *
IR 58025A	X	JGL8292	23.48 **	16.53 **	23.37 **	-33.33 **	-34.00 **	-31.25 **
IR 58025A	X	JGL3855	33.68 **	22.16 **	14.77 **	39.39 **	38.00 **	43.75 **
IR 58025A	X	JGL3844	-0.73	-5.30	-11.03 *	-20.69 **	-30.30 **	-4.17
IR 58025A	X	JGL1798	-1.73	-3.92	-5.52	-20.75 *	-25.00 **	-12.50

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	8.91	3.77	27.91 **	8.48*	-0.61	14.97**
IR 68897A	X	JGL11110-1	-5.88	-9.43	11.63	-10.10**	-13.47**	0.09
IR 68897A	X	JGL17211	-16.67 *	-24.53 **	-6.98	-10.67**	-19.73**	-7.16
IR 68897A	X	JGL16284	20.41 **	11.32	37.21 **	5.39	1.88	17.84**
IR 68897A	X	JGL13515	-6.42	-8.93	18.60	4.98	4.05	20.36**
IR 68897A	X	JGL11160	32.71 **	20.34 **	65.12 **	26.78**	7.89*	47.96**
IR 68897A	X	JGL11118	7.41	-1.69	34.88 **	-5.39	-15.79**	15.49**
IR 68897A	X	JGL11111	-1.96	-15.25 *	16.28	3.88	-13.14**	19.11**
IR 68897A	X	JGL8605	9.62	-3.39	32.56 **	-5.73	-15.75**	15.53**
IR 68897A	X	JGL8292	0.87	-1.69	34.88 **	-6.86*	-14.84**	16.78**
IR 68897A	X	JGL3855	6.54	-3.39	32.56 **	3.29	-7.32*	12.32**
IR 68897A	X	JGL3844	-1.85	-10.17	23.26 *	1.82	-4.15	6.17**
IR 68897A	X	JGL1798	13.73	-1.69	34.88 **	7.63*	-5.25	14.83**
APMS 8A	X	JGL11110-2	21.15 **	6.78	46.51 **	10.36**	4.33	26.45**
APMS 8A	X	JGL11110-1	20.87 **	17.80 *	61.63 **	24.26**	20.38**	45.90**
APMS 8A	X	JGL17211	12.73	0.00	44.19 **	33.55**	22.75**	40.99**
APMS 8A	X	JGL16284	-6.31	-16.13 *	20.93 *	20.02**	15.91**	33.13**
APMS 8A	X	JGL13515	23.81 **	4.84	51.16 **	22.06**	10.02*	26.36**
APMS 8A	X	JGL11160	8.41	-6.45	34.88 **	16.40**	1.91**	29.69**
APMS 8A	X	JGL11118	18.64 **	12.90	62.79 **	20.36**	19.72**	37.50**
APMS 8A	X	JGL11111	24.73 **	20.83 *	34.88 **	28.90**	26.29**	26.74**
APMS 8A	X	JGL8605	-4.26	-8.16	4.65	11.30**	7.85	15.40**

Table 4.30(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	6.82	4.44	9.30	8.93*	4.49	4.87
APMS 8A	X	JGL3855	13.33	13.33	18.60	1.00	-2.56	5.21
APMS 8A	X	JGL3844	8.91	-1.79	27.91 **	9.88**	3.47	17.57**
APMS 8A	X	JGL1798	1.89	-6.90	25.58 *	12.37**	-1.21	25.45**
CMS 16A	X	JGL11110-2	8.41	0.00	34.88 **	5.53	-2.78	23.46**
CMS 16A	X	JGL11110-1	8.91	3.77	27.91 **	9.25**	-5.72	19.72**
CMS 16A	X	JGL17211	-5.88	-9.43	11.63	19.28**	10.34**	40.13**
CMS 16A	X	JGL16284	-16.67 *	-24.53 **	-6.98	11.12**	5.28	33.70**
CMS 16A	X	JGL13515	20.41 **	11.32	37.21 **	14.87**	9.38*	16.44**
CMS 16A	X	JGL11160	-6.42	-8.93	18.60	22.62**	22.31**	30.87**
CMS 16A	X	JGL11118	2.97	-10.34	20.93 *	21.25**	13.12**	20.43**
CMS 16A	X	JGL11111	30.10 **	15.52 *	55.81 **	-6.58	-7.24	0.16
CMS 16A	X	JGL8605	15.79 *	13.79	53.49 **	11.12**	7.61	22.28**
CMS 16A	X	JGL8292	8.82	2.78	29.07 **	29.68**	13.95**	44.86**
CMS 16A	X	JGL3855	32.04 **	25.93 **	58.14 **	-8.93**	-16.14**	6.61
CMS 16A	X	JGL3844	29.90 **	16.67 *	46.51 **	18.78**	2.46	30.25**
CMS 16A	X	JGL1798	-7.07	-14.81	6.98	-9.02**	-15.87**	6.95
APMS 6A	X	JGL11110-2	-5.45	-7.14	20.93 *	-4.82	-9.87**	14.58**
APMS 6A	X	JGL11110-1	17.24 **	0.00	58.14 **	23.67**	14.42**	29.55**
APMS 6A	X	JGL17211	-16.24 *	-27.94 **	13.95	13.56**	10.44**	25.05**
APMS 6A	X	JGL16284	11.71	-8.82	44.19 **	26.20**	14.49**	29.62**
APMS 6A	X	JGL13515	-0.88	-17.65 **	30.23 **	-6.14	-8.32*	3.80
APMS 6A	X	JGL11160	-17.74 **	-25.00 **	18.60	-10.34**	-10.50**	1.70
APMS 6A	X	JGL11118	10.91	-1.61	41.86 **	11.92**	1.59	19.95**
APMS 6A	X	JGL11111	18.92 **	6.45	53.49 **	18.56**	13.00**	33.42**
APMS 6A	X	JGL8605	20.00 **	1.61	46.51 **	14.59**	2.03	20.47**
APMS 6A	X	JGL8292	-17.76 *	-29.03 **	2.33	4.53	0.06	18.14**
APMS 6A	X	JGL3855	-18.47 **	-22.42 **	11.86	-20.64**	-22.13**	-8.06
APMS 6A	X	JGL3844	11.11	0.00	39.53 **	3.69	1.12	2.45
APMS 6A	X	JGL1798	11.93	1.67	41.86 **	7.53*	4.68	12.00**
IR 58025A	X	JGL11110-2	8.74	-6.67	30.23 **	16.47**	11.22*	12.68**
IR 58025A	X	JGL11110-1	16.19 *	1.67	41.86 **	5.17	1.93	10.05*
IR 58025A	X	JGL17211	-15.52 *	-18.33 *	13.95	14.79**	8.57*	23.37**
IR 58025A	X	JGL16284	16.48 *	10.42	23.26 *	16.35**	9.55*	5.48
IR 58025A	X	JGL13515	32.61 **	24.49 **	41.86 **	19.91**	7.60	15.13**
IR 58025A	X	JGL11160	0.00	0.00	0.00	19.78**	15.13**	6.14
IR 58025A	X	JGL11118	34.09 **	31.11 **	37.21 **	-0.29	-10.89**	-3.78
IR 58025A	X	JGL11111	29.29 **	14.29	48.84 **	49.03**	30.27**	48.03**
IR 58025A	X	JGL8605	25.84 **	16.67	30.23 **	7.91	3.36	8.70
IR 58025A	X	JGL8292	20.00 *	10.20	25.58 *	3.32	2.43	9.60*
IR 58025A	X	JGL3855	33.33 **	30.23 **	30.23 **	33.22**	25.00**	31.45**
IR 58025A	X	JGL3844	11.63	6.67	11.63	-7.56*	-8.77*	-1.49
IR 58025A	X	JGL1798	50.52 **	30.36 **	69.77 **	-11.14**	-14.45**	-2.79

* Significant at 5% level; ** Significant at 1% level

16284). The significant positive heterobeltiosis was recorded in 11 hybrids and it ranged from 31.11 (IR 58025A x JGL 11110-1) to 15.52 (CMS 16A x JGL 8605). The significant standard heterosis was recorded in 47 hybrids ranging from 69.77 (IR 58025A x JGL 11111) to 20.93 (CMS16A x JGL 8605), when compared check PA 6201.

In pooled analysis, positive significant average heterosis recorded was in 39 hybrids, and it ranged from 40.03 (IR 58025A x JGL 11111) to 7.53 (APMS 6A x JGL 1798). The significant heterobeltiosis was observed in 22 hybrids, with a range from 30.27 (IR 58025A x JGL 11111) to 7.89 (IR68897A x JGL 11160). Positive significant standard heterosis was observed in 47 hybrids, ranging from 48.03 (IR 58025A x JGL 11111) to 9.60 (IR58025A x JGL 8292), when compared with check PA 6201 (Table 4.30).

Higher flag leaf length is a desirable feature of hybrid rice for efficient photosynthesis at and after flowering. Significant standard heterosis for flag leaf length was observed in 47 hybrids, in pooled analysis over the best check PA 6201. The hybrid IR 58025A x JGL 11111 (48.03) recorded highest standard heterosis over the best check PA 6201, with relative high standard heterosis (36.67) over check KRH-2, heterobeltiosis (30.27) and average heterosis (49.03). The hybrids IR 68897A x JGL 11160 (47.96), APMS 8A x JGL 11110-1 (45.90), CMS 16A x JGL 8292 (44.89) and APMS 8A x JGL 17211 (40.99) also recorded high standard heterosis over best check PA 6201. The heterobeltiosis both on positive and negative directions were reported by Mishra and Pandey (1998)

4.2.7.5 Flag leaf width

The positive significant average heterosis was recorded in 15 hybrids,(Table 4.32) ranging from 88.51 (CMS 16A x JGL 11160) to 15.07 (APMS 6A x JGL 13515). The significant heterobeltiosis in positive direction was observed in 8 hybrids, with a range from 85.78 (CMS 16A x JGL 11160) to 28.56 (APMS 8A x JGL 1798). The significant positive standard heterosis was recorded in 11 hybrids, with a range from 50.78 (CMS 16A x JGL 11160) to 18.20 (CMS16 A x JGL 13515) when compared with check PA 6201 for the character flag leaf width at Kunaram.

The positive significant average heterosis was observed in 4 hybrids, with a range from 114.95 (IR 58025A x JGL 13515) to 11.54 (CMS 16A x JGL 3855). Only two hybrids, IR 58025A x JGL 13515 (98.29) and APMS 6A x JGL 1798 recorded positive significant heterobeltiosis and standard heterosis over high yielding check PA 6201, at Warangal.

Table 4.31. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for flag leaf width at Kunaram , Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-8.06	-16.78	-22.30 *	-18.88 **	-31.76 **	-29.27 **
IR 68897A	X	JGL11110-1	-30.72 **	-36.12 **	-40.35 **	-2.80	-10.34	-36.59 **
IR 68897A	X	JGL17211	-22.15 **	-25.35 **	-24.05 **	-20.55 **	-34.09 **	-29.27 **
IR 68897A	X	JGL16284	21.01 **	16.91	17.09	-29.03 **	-43.30 **	-32.93 **
IR 68897A	X	JGL13515	-4.64	-5.61	-11.87	-45.55 **	-60.90 **	-36.59 **
IR 68897A	X	JGL11160	5.24	-10.65	-3.16	-41.12 **	-48.21 **	-29.27 **
IR 68897A	X	JGL11118	-16.47 *	-27.87 **	-21.82 *	-46.58 **	-61.61 **	-47.56 **
IR 68897A	X	JGL11111	-1.66	-4.67	3.32	-36.00 **	-42.86 **	-21.95 **
IR 68897A	X	JGL8605	-15.02 *	-18.24 *	-11.39	-50.24 **	-53.57 **	-36.59 **
IR 68897A	X	JGL8292	-5.30	-12.68	-5.37	-47.76 **	-51.88 **	-21.95 **
IR 68897A	X	JGL3855	-12.62	-26.30 **	-18.84 *	-41.12 **	-48.21 **	-29.27 **
IR 68897A	X	JGL3844	-19.60 *	-31.03 **	-24.05 **	-27.95 **	-48.21 **	-29.27 **
IR 68897A	X	JGL1798	-22.19 **	-25.15 **	-17.57	-36.00 **	-42.86 **	-21.95 **
APMS 8A	X	JGL11110-2	-7.90	-12.07	-3.16	-44.50 **	-48.21 **	-29.27 **
APMS 8A	X	JGL11110-1	-0.46	-8.90	0.33	-55.10 **	-58.65 **	-32.93 **
APMS 8A	X	JGL17211	37.23 **	15.61	27.70 **	-26.01 **	-27.27 **	-21.95 **
APMS 8A	X	JGL16284	4.68	-10.31	-0.94	-28.47 **	-44.32 **	-40.24 **
APMS 8A	X	JGL13515	8.71	4.42	15.34	-37.50 **	-37.50 **	-32.93 **
APMS 8A	X	JGL11160	-0.23	-4.88	5.06	-30.81 **	-34.02 **	-21.95 **
APMS 8A	X	JGL11118	-11.46	-19.07 *	-10.61	-42.08 **	-51.88 **	-21.95 **
APMS 8A	X	JGL11111	2.29	-11.47	-8.38	-31.76 **	-31.76 **	-29.27 **
APMS 8A	X	JGL8605	63.53 **	44.03 **	49.06 **	-17.91 **	-35.29 **	-32.93 **
APMS 8A	X	JGL8292	-41.26 **	-41.76 **	-39.72 **	-26.01 **	-27.27 **	-21.95 **
APMS 8A	X	JGL3855	-1.02	-2.62	0.78	-42.86 **	-46.39 **	-36.59 **
APMS 8A	X	JGL3844	-29.72 **	-33.81 **	-31.49 **	-30.28 **	-42.86 **	-7.32
APMS 8A	X	JGL1798	44.45 **	28.56 **	24.68 **	-29.27 **	-31.76 **	-29.27 **
CMS 16A	X	JGL11110-2	9.62	-0.65	-3.65	4.69	-15.19 **	-18.29 **
CMS 16A	X	JGL11110-1	12.74	10.10	12.03	-23.35 **	-27.27 **	-21.95 **
CMS 16A	X	JGL17211	1.30	-0.30	-0.15	-27.27 **	-34.02 **	-21.95 **
CMS 16A	X	JGL16284	20.74 *	17.31	13.77	-28.30 **	-42.86 **	-7.32
CMS 16A	X	JGL13515	50.76 **	45.63 **	18.20 *	-27.27 **	-38.82 **	-36.59 **
CMS 16A	X	JGL11160	88.51 **	85.78 **	50.78 **	8.41	0.00	-29.27 **
CMS 16A	X	JGL11118	5.88	-4.83	-3.16	-24.66 **	-37.50 **	-32.93 **
CMS 16A	X	JGL11111	9.27	-1.09	-0.94	-32.90 **	-46.39 **	-36.59 **
CMS 16A	X	JGL8605	-37.67 **	-41.18 **	-46.20 **	-48.69 **	-63.16 **	-40.24 **
CMS 16A	X	JGL8292	2.14	-10.42	-10.13	-17.14 **	-31.76 **	-29.27 **
CMS 16A	X	JGL3855	68.34 **	50.29 **	50.78 **	11.54 *	5.45	-29.27 **
CMS 16A	X	JGL3844	5.09	4.35	6.18	-14.69 **	-30.68 **	-25.61 **
CMS 16A	X	JGL1798	36.08 **	35.96 **	36.41 **	-15.79 **	-34.02 **	-21.95 **
APMS 6A	X	JGL11110-2	34.98 **	29.02 **	29.44 **	-31.91 **	-51.88 **	-21.95 **
APMS 6A	X	JGL11110-1	25.77 **	1.67	24.68 **	-31.76 **	-31.76 **	-29.27 **
APMS 6A	X	JGL17211	1.32	-16.78 *	2.05	-13.43 **	-31.76 **	-29.27 **
APMS 6A	X	JGL16284	-1.27	-9.68	10.76	-32.95 **	-34.09 **	-29.27 **

Table 4.31 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	15.07 *	4.52	28.18 **	-29.67 **	-34.02 **	-21.95 **
APMS 6A	X	JGL11160	-20.92 **	-30.97 **	-15.34	-46.79 **	-56.39 **	-29.27 **
APMS 6A	X	JGL11118	-3.72	-20.38 **	-7.90	-49.45 **	-52.58 **	-43.90 **
APMS 6A	X	JGL11111	10.34	-7.24	7.29	-20.55 **	-40.21 **	-29.27 **
APMS 6A	X	JGL8605	-9.32	-14.77	-1.42	-40.54 **	-43.30 **	-32.93 **
APMS 6A	X	JGL8292	-6.02	-12.32	1.42	-49.48 **	-49.48 **	-40.24 **
APMS 6A	X	JGL3855	-20.41 **	-28.74 **	-17.57	-44.35 **	-51.88 **	-21.95 **
APMS 6A	X	JGL3844	19.00 *	3.73	5.54	-31.76 **	-31.76 **	-29.27 **
APMS 6A	X	JGL1798	33.57 **	18.51 *	20.58 *	67.16 **	31.76 **	36.59 **
IR 58025A	X	JGL11110-2	-11.97	-11.97	-10.43	-5.20	-6.82	0.00
IR 58025A	X	JGL11110-1	2.82	2.02	3.80	-36.26 **	-40.21 **	-29.27 **
IR 58025A	X	JGL17211	-5.16	-9.95	-8.38	-46.79 **	-56.39 **	-29.27 **
IR 58025A	X	JGL16284	12.82	3.89	-6.63	-18.88 **	-31.76 **	-29.27 **
IR 58025A	X	JGL13515	22.32 *	14.79	3.16	114.95 **	98.28 **	40.24 **
IR 58025A	X	JGL11160	-36.42 **	-40.13 **	-39.09 **	-20.55 **	-34.09 **	-29.27 **
IR 58025A	X	JGL11118	-20.06 *	-24.17 **	-24.05 **	-25.16 **	-40.21 **	-29.27 **
IR 58025A	X	JGL11111	12.22	11.24	1.75	-7.85 *	-33.83 **	7.32
IR 58025A	X	JGL8605	-43.50 **	-44.25 **	-56.68 **	14.69 **	-3.53	0.00
IR 58025A	X	JGL8292	-24.36 *	-24.90 *	-40.81 **	8.41	0.00	-29.27 **
IR 58025A	X	JGL3855	-20.63 *	-30.01 **	-28.78 **	-28.77 **	-40.91 **	-36.59 **
IR 58025A	X	JGL3844	-48.75 **	-54.50 **	-54.43 **	-32.90 **	-46.39 **	-36.59 **
IR 58025A	X	JGL1798	-2.72	-10.05	-17.72 *	-23.56 **	-45.11 **	-10.98 **

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	-31.03 **	-38.55 **	-14.06	-20.01**	-21.19**	-22.50**
IR 68897A	X	JGL11110-1	-40.86 **	-50.28 **	-30.47	-27.01**	-35.09**	-36.17**
IR 68897A	X	JGL17211	-29.91 **	-35.20 **	-9.38	-24.41**	-37.98**	-21.78**
IR 68897A	X	JGL16284	5.98	-2.01	37.03 *	-0.63	-6.71	4.53
IR 68897A	X	JGL13515	-27.07 **	-28.49 *	0.00	-27.57**	-36.27**	-17.50**
IR 68897A	X	JGL11160	-9.99	-20.82	14.06	-17.75**	-28.40**	-7.78
IR 68897A	X	JGL11118	-24.28 *	-37.09 **	-9.38	-29.55**	-43.84**	-27.66**
IR 68897A	X	JGL11111	-2.50	-11.06	28.13	-14.78**	-21.46**	1.16
IR 68897A	X	JGL8605	-21.76 *	-28.63 *	2.81	-30.69**	-35.20**	-16.53**
IR 68897A	X	JGL8292	-25.48 *	-27.98 *	3.75	29.39**	-29.56**	-8.82
IR 68897A	X	JGL3855	-32.93 **	-41.49 **	-14.06	-30.23**	-39.55**	-21.28**
IR 68897A	X	JGL3844	-25.16 *	-38.30 **	-9.38	-24.34**	-39.93**	-21.78**
IR 68897A	X	JGL1798	-31.76 **	-38.30 **	-9.38	-30.36--	-36.14**	-16.84**
APMS 8A	X	JGL11110-2	3.53	-6.38	37.50 *	-18.37**	-24.06**	-1.11
APMS 8A	X	JGL11110-1	7.78	3.19	51.56 **	-20.84**	-21.07**	2.78
APMS 8A	X	JGL17211	22.54 *	2.91	65.63 **	9.89*	-2.65	20.39**
APMS 8A	X	JGL16284	-12.80	-30.58 **	11.72	-11.76**	28.57**	-11.66*
APMS 8A	X	JGL13515	8.38	-5.83	51.56 **	-6.96	-12.63**	8.05
APMS 8A	X	JGL11160	0.00	-13.11	39.84 *	-10.82**	-15.01**	5.11
APMS 8A	X	JGL11118	-2.12	-10.19	44.53 **	-20.24**	-22.02**	0.94
APMS 8A	X	JGL11111	-16.47	-28.28 **	9.38	-16.35**	-24.20**	-10.94*
APMS 8A	X	JGL8605	29.89 **	5.53	60.94 **	26.32**	4.31	22.56**

Table 4.31(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-43.55 **	-49.80 **	-23.44	-36.86**	-39.24**	28.61**
APMS 8A	X	JGL3855	-10.71	-20.59	21.09	-19.02**	-20.90**	-7.06
APMS 8A	X	JGL3844	-36.82 **	-40.57 **	-9.38	-32.28**	-35.41**	-16.39**
APMS 8A	X	JGL1798	21.95 *	6.38	56.25 **	10.47*	2.76	14.00**
CMS 16A	X	JGL11110-2	-9.68	-25.53 *	9.38	1.03.	-14.62**	-5.28
CMS 16A	X	JGL11110-1	10.59	0.00	46.88 **	-0.20	-1.25	9.56
CMS 16A	X	JGL17211	-3.53	-12.77	28.13	-10.36**	-10.80*	-0.05
CMS 16A	X	JGL16284	7.78	3.19	51.56 **	-2.80	-9.74*	16.84**
CMS 16A	X	JGL13515	32.28 **	18.75	63.28 **	17.62**	16.35**	11.06*
CMS 16A	X	JGL11160	58.39 **	34.09 **	84.38 **	54.36**	40.45**	31.16**
CMS 16A	X	JGL11118	-1.83	-8.52	25.78	-6.71	-13.25**	-5.78
CMS 16A	X	JGL11111	-3.66	-10.23	23.44	-9.46*	-17.00**	-7.00
CMS 16A	X	JGL8605	-50.57 **	-51.14 **	-32.81 *	-46.35**	-53.82**	-40.22**
CMS 16A	X	JGL8292	-13.40	-17.74	0.00	-9.56*	-10.13	-14.22**
CMS 16A	X	JGL3855	59.22 **	42.03 **	72.66 **	49.68**	35.63**	27.83**
CMS 16A	X	JGL3844	2.73	1.54	23.44	-1.90	-8.39	-0.50
CMS 16A	X	JGL1798	33.94 **	32.39 *	60.94 **	18.39**	8.98*	22.12**
APMS 6A	X	JGL11110-2	-5.37	-9.88	21.09	-3.14	-16.31**	8.34
APMS 6A	X	JGL11110-1	14.12	-3.00	51.56 **	2.09	-10.07*	12.67*
APMS 6A	X	JGL17211	-3.73	-22.50 *	21.09	-4.82	-23.33**	-3.95
APMS 6A	X	JGL16284	-8.52	-19.50	25.78	-14.11**	-19.82**	0.44
APMS 6A	X	JGL13515	18.07	3.90	62.34 **	0.81	-4.51	19.63**
APMS 6A	X	JGL11160	-31.18 **	-36.00 **	0.00	-34.09**	-35.15**	-16.05**
APMS 6A	X	JGL11118	-9.49	-18.75	11.72	-22.52**	-31.16**	-15.44**
APMS 6A	X	JGL11111	22.15	3.41	42.19 **	4.21	-15..42**	3.89
APMS 6A	X	JGL8605	7.32	0.00	37.50 *	-15.17**	-20.08**	-1.83
APMS 6A	X	JGL8292	-3.66	-10.23	23.44	-21.24**	-24.70**	-7.50
APMS 6A	X	JGL3855	-19.54	-20.45	9.38	-29.84**	-31.63**	-11.50*
APMS 6A	X	JGL3844	-3.80	-13.64	18.75	-7.13	-14.21**	-3.39
APMS 6A	X	JGL1798	44.30 **	22.16	67.97 **	47.90**	24.22**	39.89**
IR 58025A	X	JGL11110-2	2.56	-4.43	31.41	-4.83	-6.52	5.27
IR 58025A	X	JGL11110-1	21.95 *	13.64	56.25 **	-5.04	-5.28	6.67
IR 58025A	X	JGL17211	-22.99 *	-23.86 *	4.69	-27.52**	-32.23**	-12.28*
IR 58025A	X	JGL16284	-0.84	-2.88	10.78	-2.74	-5.63	-9.93
IR 58025A	X	JGL13515	15.67	6.16	21.09	46.42**	35.64**	21.78**
IR 58025A	X	JGL11160	26.17 *	23.68	46.88 **	-10.34*	-18.11**	-7.06*
IR 58025A	X	JGL11118	-18.12	-19.74	-4.69	-21.17**	-29.00**	-20.44**
IR 58025A	X	JGL11111	-8.18	-15.12	14.06	-2.13	-17.13**	7.28
IR 58025A	X	JGL8605	-25.31	-31.71 *	-25.31	-16.35**	23.63**	-27.10**
IR 58025A	X	JGL8292	22.69	19.67	14.06	1.68	0.21	-21.00**
IR 58025A	X	JGL3855	-4.48	-15.79	0.00	-18.31**	-29.51**	-23.44**
IR 58025A	X	JGL3844	-20.15	-29.61 *	-16.41	-34.11**	-43.88**	-37.11**
IR 58025A	X	JGL1798	-2.78	-18.60	9.38	-11.23**	-28.59**	-7.56

* Significant at 5% level; ** Significant at 1% level

Table 4.32 Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for panicle length at Kunaram , Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	44.07 **	20.91 **	18.06 **	39.00 **	34.95 **	24.11 **
IR 68897A	X	JGL11110-1	3.65	2.99	0.56	25.12 **	23.30 **	13.39 *
IR 68897A	X	JGL17211	-0.35	-1.39	-1.67	5.36	-2.48	5.36
IR 68897A	X	JGL16284	18.82 **	14.94 **	12.22 **	9.01 *	-2.31	13.39 *
IR 68897A	X	JGL13515	10.87 **	9.53 **	6.94 *	13.71 **	8.74	0.00
IR 68897A	X	JGL11160	15.13 **	-8.62 **	3.06	4.51	-17.75 **	24.11 **
IR 68897A	X	JGL11118	-17.66 **	-23.65 **	-13.89 **	1.12	-19.53 **	21.43 **
IR 68897A	X	JGL11111	9.28 **	2.96	16.11 **	-12.34 **	-24.79 **	13.48 *
IR 68897A	X	JGL8605	1.16	-8.50 **	3.19	-20.94 **	-30.06 **	5.54
IR 68897A	X	JGL8292	5.61 *	-2.59	9.86 **	12.55 **	-12.43 **	32.14 **
IR 68897A	X	JGL3855	18.02 **	-2.59	-0.83	21.89 **	4.41	26.79 **
IR 68897A	X	JGL3844	5.96 *	3.14	5.00	7.63	-6.62	13.39 *
IR 68897A	X	JGL1798	-3.10	-4.09	-2.36	-29.18 **	-33.09 **	-18.75 **
APMS 8A	X	JGL11110-2	2.30	-3.00	-1.25	2.26	0.00	21.43 **
APMS 8A	X	JGL11110-1	11.06 **	7.50 **	9.44 **	5.22	-11.03 *	8.04
APMS 8A	X	JGL17211	26.84 **	7.07 *	3.06	11.89 **	-2.31	13.39 *
APMS 8A	X	JGL16284	19.11 **	19.02 **	14.72 **	-2.61	-13.85 **	0.00
APMS 8A	X	JGL13515	3.61	1.81	1.53	-8.37 *	-11.54 *	2.68
APMS 8A	X	JGL11160	3.70	1.01	-2.78	2.31	2.31	18.75 **
APMS 8A	X	JGL11118	-1.81	-2.31	-5.97 *	16.07 **	0.00	16.07 **
APMS 8A	X	JGL11111	21.21 **	0.98	0.42	-7.09	-24.84 **	5.36
APMS 8A	X	JGL8605	8.65 **	6.98 *	6.39 *	-24.51 **	-38.22 **	-13.39 *
APMS 8A	X	JGL8292	-2.51	-2.65	-2.92	-12.95 **	-22.93 **	8.04
APMS 8A	X	JGL3855	7.94 **	3.49	2.92	-21.95 **	-28.66 **	0.00
APMS 8A	X	JGL3844	9.56 **	7.26 **	6.67 *	-13.15 **	-30.57 **	-2.68
APMS 8A	X	JGL1798	12.46 **	-4.27	-9.72 **	6.61	-6.92	8.04
CMS 16A	X	JGL11110-2	15.08 **	13.83 **	9.72 **	13.04 **	0.00	16.07 **
CMS 16A	X	JGL11110-1	13.39 **	10.31 **	10.00 **	-12.99 **	-16.00 **	-2.50
CMS 16A	X	JGL17211	19.76 **	17.82 **	11.11 **	-4.46	-4.46	10.89 *
CMS 16A	X	JGL16284	0.66	0.15	-4.58	10.89 *	-4.46	10.89 *
CMS 16A	X	JGL13515	24.93 **	7.21 *	-0.83	15.25 **	-2.16	21.43 **
CMS 16A	X	JGL11160	14.12 **	11.82 **	7.78 **	3.77	-10.79 *	10.71 *
CMS 16A	X	JGL11118	-7.08 **	-10.45 **	-10.69 **	-25.38 **	-30.22 **	-13.39 *
CMS 16A	X	JGL11111	9.45 **	8.71 **	0.56	5.58	2.16	26.79 **
CMS 16A	X	JGL8605	11.09 **	9.48 **	4.31	1.29	-15.11 **	5.36
CMS 16A	X	JGL8292	20.94 **	0.98	-0.14	17.48 **	11.01 *	8.04
CMS 16A	X	JGL3855	-0.57	-1.83	-2.92	12.92 **	8.26	5.36
CMS 16A	X	JGL3844	0.84	0.42	0.14	15.83 **	10.08 *	18.93 **
CMS 16A	X	JGL1798	-1.39	-5.20	-6.25 *	-18.66 **	-25.23 **	-13.21 *
APMS 6A	X	JGL11110-2	5.72 *	3.79	2.64	19.31 **	11.10 *	8.12
APMS 6A	X	JGL11110-1	36.69 **	18.20 **	7.36 **	14.54 **	0.00	16.07 **
APMS 6A	X	JGL17211	1.48	-1.44	-5.00	0.09	-11.46 *	2.77
APMS 6A	X	JGL16284	5.39 *	0.70	0.42	1.20	-2.31	13.39 *

Table 4.32 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	10.91 **	10.65 **	0.97	-18.46 **	-18.46 **	-5.36
APMS 6A	X	JGL11160	9.55 **	7.00 *	1.94	5.36	-9.23 *	5.36
APMS 6A	X	JGL11118	7.85 **	-13.80 **	-4.58	9.50 *	-2.42	8.04
APMS 6A	X	JGL11111	-6.64 **	-12.67 **	-3.33	18.75 **	7.26	18.75 **
APMS 6A	X	JGL8605	-19.34 **	-23.34 **	-15.14 **	-11.02 **	-12.10 *	-2.68
APMS 6A	X	JGL8292	0.83	-8.03 **	1.81	-4.72	-6.92	8.04
APMS 6A	X	JGL3855	-6.81 **	-13.30 **	-4.03	8.26	-4.84	5.36
APMS 6A	X	JGL3844	11.50 **	-3.52	-12.50 **	-6.12	-22.30 **	2.68
APMS 6A	X	JGL1798	2.45	-0.58	-4.17	7.26	-10.14 *	18.75 **
IR 58025A	X	JGL11110-2	11.45 **	6.41 *	6.11 *	-3.35	-12.16 **	16.07 **
IR 58025A	X	JGL11110-1	16.95 **	16.59 **	6.39 *	-15.11 **	-20.27 **	5.36
IR 58025A	X	JGL17211	0.97	-1.46	-6.11 *	2.48	-16.22 **	10.71 *
IR 58025A	X	JGL16284	31.98 **	17.76 **	-0.56	26.11 **	20.75 **	14.29 **
IR 58025A	X	JGL13515	-33.79 **	-37.90 **	-40.14 **	32.04 **	28.30 **	21.43 **
IR 58025A	X	JGL11160	13.57 **	4.87	4.58	3.96	-2.48	5.36
IR 58025A	X	JGL11118	13.20 **	8.98 **	-0.56	2.54	-6.92	8.04
IR 58025A	X	JGL11111	23.96 **	16.91 **	11.39 **	27.00 **	19.81 **	13.39 *
IR 58025A	X	JGL8605	6.93 *	-7.24 *	-16.39 **	20.87 **	4.51	24.11 **
IR 58025A	X	JGL8292	4.99 *	1.59	-2.08	3.86	-9.02 *	8.04
IR 58025A	X	JGL3855	14.85 **	9.33 **	9.03 **	-2.36	-6.77	10.71 *
IR 58025A	X	JGL3844	6.58 *	5.94 *	-3.33	-7.98 *	-9.02 *	8.04
IR 58025A	X	JGL1798	6.82 **	3.94	-0.97	11.89 **	-4.51	13.39 *

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	19.54 **	8.33 *	15.56 **	33.43**	19.97**	18.93**
IR 68897A	X	JGL11110-1	-3.23	-6.25	0.00	6.86**	4.44*	4.04
IR 68897A	X	JGL17211	-3.30	-8.33 *	-2.22	0.26	-0.51	0.15
IR 68897A	X	JGL16284	14.61 **	6.25	13.33 **	14.40**	13.93**	12.94**
IR 68897A	X	JGL13515	3.23	0.00	6.67	8.78**	5.78**	4.86*
IR 68897A	X	JGL11160	5.62	-6.00	4.44	8.35**	-11.01**	9.57**
IR 68897A	X	JGL11118	-11.58 **	-16.00 **	-6.67	-9.73**	-19.82**	-1.28
IR 68897A	X	JGL11111	9.68 **	2.00	13.33 **	2.24	-7.08**	14.40**
IR 68897A	X	JGL8605	3.30	-6.00	4.44	-5.80**	-15.29**	4.30
IR 68897A	X	JGL8292	1.05	-4.00	6.67	6.23**	-6.48**	15.14**
IR 68897A	X	JGL3855	5.88	-2.17	0.00	15.01**	-0.19	7.37**
IR 68897A	X	JGL3844	5.49	4.35	6.67	6.29**	0.38	7.98**
IR 68897A	X	JGL1798	-3.37	-6.52	-4.44	-11.42**	-14.27**	-7.77**
APMS 8A	X	JGL11110-2	10.34 **	4.35	6.67	4.89**	0.38	7.98**
APMS 8A	X	JGL11110-1	7.69 *	6.52	8.89 *	8.19**	1.19	8.85**
APMS 8A	X	JGL17211	10.84 **	4.55	2.22	16.45**	3.20	5.73**
APMS 8A	X	JGL16284	12.36 **	11.11 **	11.11 **	10.33**	6.64**	9.26**
APMS 8A	X	JGL13515	5.75	4.55	2.22	0.53	-0.35	2.10
APMS 8A	X	JGL11160	8.24 *	4.55	2.22	4.71*	2.60	5.12*
APMS 8A	X	JGL11118	1.12	0.00	0.00	4.43*	-0.05	2.40
APMS 8A	X	JGL11111	3.61	-2.27	-4.44	5.61**	-9.39**	0.15
APMS 8A	X	JGL8605	10.11 **	8.89 *	8.89 *	-1.44	-8.10**	1.59

Table 4.32(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-1.15	-2.27	-4.44	-5.59**	-9.81**	-0.31
APMS 8A	X	JGL3855	8.24 *	4.55	2.22	-2.47	-7.87**	1.84
APMS 8A	X	JGL3844	5.62	4.44	4.44	1.10	-6.62**	3.22
APMS 8A	X	JGL1798	-1.23	-4.76	-11.11 **	5.82**	-5.31*	-5.12*
CMS 16A	X	JGL11110-2	14.94 **	11.11 **	11.11 **	14.42**	11.79**	12.02**
CMS 16A	X	JGL11110-1	15.29 **	13.95 **	8.89 *	5.58**	5.34*	6.04**
CMS 16A	X	JGL17211	20.48 **	19.05 **	11.11 **	11.88*	10.82**	11.05**
CMS 16A	X	JGL16284	1.15	-2.22	-2.22	3.85**	0.46	0.66
CMS 16A	X	JGL13515	8.43 *	2.27	0.00	15.98**	2.38	5.83**
CMS 16A	X	JGL11160	5.62	4.44	4.44	8.02**	3.96	7.47**
CMS 16A	X	JGL11118	10.34 **	9.09 *	6.67	-7.35**	-8.56**	-5.47*
CMS 16A	X	JGL11111	3.53	0.00	-2.22	6.21**	3.61	7.11**
CMS 16A	X	JGL8605	7.87 *	6.67	6.67	7.01**	1.98	5.42*
CMS 16A	X	JGL8292	5.88	-2.17	0.00	14.42	2.67	2.25
CMS 16A	X	JGL3855	1.10	0.00	2.22	3.72	1.64	1.23
CMS 16A	X	JGL3844	-7.87 *	-10.87 **	-8.89 *	2.27**	1.73	2.40
CMS 16A	X	JGL1798	-3.45	-8.70 *	-6.67	-7.42**	-8.01**	-8.39**
APMS 6A	X	JGL11110-2	-3.30	-4.35	-2.22	6.11**	2.95	2.53
APMS 6A	X	JGL11110-1	18.07 **	11.36 **	8.89 *	22.93	9.88**	10.38**
APMS 6A	X	JGL17211	-5.62	-6.67	-6.67	-1.41*	-3.79	-3.35
APMS 6A	X	JGL16284	5.75	4.55	2.22	4.17	4.07	4.76*
APMS 6A	X	JGL13515	12.94 **	9.09 *	6.67	1.75**	0.66	1.13
APMS 6A	X	JGL11160	3.37	2.22	2.22	6.14**	2.55	3.02
APMS 6A	X	JGL11118	0.00	-10.20 **	-2.22	5.54**	-9.29**	-0.15
APMS 6A	X	JGL11111	-6.38 *	-10.20 **	-2.22	-6.09**	8.13**	3.38
APMS 6A	X	JGL8605	6.52 *	0.00	8.89 *	-12.13**	-3.31	-3.27
APMS 6A	X	JGL8292	0.00	-8.16 *	0.00	-6.46**	4.73*	2.97
APMS 6A	X	JGL3855	-8.51 **	-12.24 **	-4.44	-10.50**	5.19*	-1.48
APMS 6A	X	JGL3844	-2.38	-8.89 *	-8.89 *	-11.99	17.65**	-6.91**
APMS 6A	X	JGL1798	4.44	4.44	4.44	-0.39	10.22**	5.37*
IR 58025A	X	JGL11110-2	-2.27	-4.44	-4.44	0.44	4.62*	5.32*
IR 58025A	X	JGL11110-1	9.30 **	4.44	4.44	-0.34**	7.23**	5.42*
IR 58025A	X	JGL17211	-8.89 **	-8.89 *	-8.89 *	-7.59**	4.37	-2.25
IR 58025A	X	JGL16284	17.50 **	14.63 **	4.44	17.57**	33.23**	5.42*
IR 58025A	X	JGL13515	-37.21 **	-40.00 **	-40.00 **	-13.52**	-18.89**	-22.46**
IR 58025A	X	JGL11160	7.14 *	4.65	0.00	15.12**	2.54	3.22
IR 58025A	X	JGL11118	14.63 **	14.63 **	4.44	15.57**	5.41*	3.63
IR 58025A	X	JGL11111	13.95 **	8.89 *	8.89 *	23.90	18.62**	11.10**
IR 58025A	X	JGL8605	-3.61	-9.09 *	-11.11 **	-3.90	22.62**	-2.97
IR 58025A	X	JGL8292	3.37	2.22	2.22	1.32**	7.01**	2.30
IR 58025A	X	JGL3855	12.64 **	11.36 **	8.89 *	8.41	8.74**	9.46**
IR 58025A	X	JGL3844	5.88	2.27	0.00	0.10	2.81	1.07
IR 58025A	X	JGL1798	1.12	0.00	0.00	2.48	10.49**	3.48

* Significant at 5% level; ** Significant at 1% level

At Kampasagar, positive significant average heterosis was recorded in 12 hybrids, which ranged from 59.22 (CMS 16A x JGL 3855) to 21.95 (IR58025A x JGL 11110-1). The significant heterobeltiosis was recorded in only 3 hybrids, 42.03(CMS 16A x JGL 3855) to 32.39 (CMS 16A x JGL 1798). The significant standard heterosis was observed in 22 hybrids which ranged from 84.38 (CMS 16A x JGL 11160) to 37.03 (IR68897A x JGL 16284), when compared with check PA 6201, for the character flag leaf width.

In Pooled analysis, positive significant average heterosis was recorded in 10 hybrids, which ranged from 54.36 (CMS 16A x JGL 11160) to 9.89 (APMS 8A x JGL 17211). The significant heterobeltiosis was recorded in 8 hybrids, with a range from 40.45 (CMS 16A x JGL 11160) to 8.98 (CMS 16A x JGL 1798). The significant standard positive heterosis was recorded in 13 hybrids, which ranged from 39.89 (APMS 6A x JGL 1798) to 11.06 (CMS 16A x JGL 13515), when compared with check PA 6201 (Table 4.31).

Higher flag leaf width is a desirable feature of hybrid rice for efficient photosynthesis at and after flowering. Significant standard heterosis for flag leaf length was observed in 13 hybrids, over the best check PA 6201. The hybrid APMS 6A x JGL 1798 (39.89) recorded highest standard heterosis over the best check PA 6201. The significant heterobeltiosis was recorded in 8 hybrids, with a range from 40.45 (CMS 16A x JGL 11160) to 8.98 (CMS 16A x JGL 1798). The heterobeltiosis both on positive and negative directions were reported by Mishra and Pandey (1998)

4.2.7.6 Panicle length (cms)

At Kunaram, positive the significant average heterosis was recorded in 42 hybrids (Table 4.32), with a range from 44.07 (IR 68897A x JGL 11110-2) to 4.99 (IR58025A x JGL 8292). The significant positive heterobeltiosis was observed in 25 hybrids with a range from 20.91 (IR 68897A x JGL 11110-2) to 5.94 (IR58025A x JGL 3844). The significant standard heterosis was recorded in 18 hybrids and it ranged from 18.06 (IR 68897A x JGL 11110-2) to 6.11 (IR 58025A x JGL 11110-2) compared to check PA 6201.

At Warangal, the positive significant average heterosis was recorded in 23 hybrids with a range from 39.00 (IR 68897A x JGL 11110-2) to 9.01 (IR 68897A x JGL 16284). The significant heterobeltiosis was recorded in 8 hybrids and it ranged between 34.95 (IR68897AxJGL1110-2) to 10.08 (CMS 16A x JGL 3844). The significant standard heterosis was observed in 32 hybrids, with range from 32.14 (IR 68897A x JGL 8292) to 10.71 (IR 58025A x JGL 3855), when compared with check PA 6201.

At Kampasagar, positive significant average heterosis was observed in 25 hybrids with range from 20.48 (CMS 16A x JGL 17211) to 6.52 (IR 68897A x JGL 8605). The significant heterobeltiosis was recorded in 13 hybrids with range from 8.33 (IR 68897A x JGL 11110-2) to 11.11 (CMS 16A x JGL 11110-2). The positive significant standard heterosis was recorded in 13 hybrids with a range from 15.56 (IR 68897A x JGL 11110-2) to 8.89 (IR58025A x JGL 3855) when compared to check PA 6201.

In Pooled analysis positive significant average heterosis was recorded in 41 hybrids with range from 33.43 (IR 68897A x JGL 11110-2) to 1.32 (IR58025A x JGL 8292). The significant heterobeltiosis was recorded in 23 hybrids, which ranged from 33.23 (IR 58025A x JGL 16284) to 4.44 (IR 68897A x JGL 11110-2). The positive standard heterosis was observed in 28 hybrids with a range from 18.93 (IR 68897A x JGL 11110-2) to 4.76 (APMS 6A x JGL 16284) when compared with PA 6201 (Table 4.32).

Hybrids are generally characterized by having longer panicles, indicating their efficiency in partitioning assimilates into reproductive parts. This is one of the important attribute for higher yields in hybrids. The significant standard heterosis for panicle length was recorded in 23 hybrids when compared with best check PA 6201. The hybrid IR 68897A x JGL 11110-2 (18.93) recorded highest standard heterosis, over best check PA6201, with relatively high standard heterosis (6.75) over check KRH-2, heterobeltiosis (19.97) and average heterosis (33.43). The other hybrids, IR 68897A x JGL 8292 (15.14), IR 68897A x JGL 11111 (14.40), IR 68897A x JGL 16284 (12.94) and CMS 16A x JGL 11110-2 (12.02) also recorded high heterosis over the best check PA 6201(Table 4.41 and Figure 4.9). Significant positive and negative heterosis was exhibited over mid parent and better parent in hybrids. The results are in accordance with Jayamani *et al.* (1997), Vanaja and Babu (2004), Deoraj *et al.* (2007), Hariramakrishnan *et al*. (2009) and Roy *et al*. (2009). Standard heterosis of both positive and negative nature was observed by Singh *et al.* (2006 a), Doeraj *et al.* (2007), Singh *et al.* (2007) and Akarsh Parihar and Pathak (2008).

4.2.7.7 Panicle weight

At Kunaram, the positive significant average heterosis was recorded in 41 hybrids with a range from 143.28 (IR 68897A x JGL 16284) to 16.84 (APMS 6A x JGL 11110-2). The significant heterobeltiosis was recorded in 28 hybrids for panicle weight which ranged from 120.27 (IR 68897A x JGL 16284) to 13.27 (APMS 6A x JGL 11110-2). The positive significant standard heterosis was observed in 19 hybrids

Table 4.33. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for panicle weight at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	46.38 **	36.49 **	-8.18 *	32.11 **	24.14 **	-20.00 **
IR 68897A	X	JGL11110-1	-9.60 *	-22.33 **	-27.27 **	20.00 **	8.33	-13.33 **
IR 68897A	X	JGL17211	19.38 **	4.05	-30.00 **	11.45 *	0.00	-18.89 **
IR 68897A	X	JGL16284	143.28 **	120.27 **	48.18 **	0.00	-17.05 **	-18.89 **
IR 68897A	X	JGL13515	36.14 **	22.83 **	2.73	-30.99 **	-41.67 **	-45.56 **
IR 68897A	X	JGL11160	34.48 **	6.36	6.36	-11.96 **	-39.10 **	-10.00 *
IR 68897A	X	JGL11118	-39.91 **	-41.82 **	-41.82 **	-41.46 **	-54.89 **	-33.33 **
IR 68897A	X	JGL11111	57.58 **	18.18 **	18.18 **	-29.13 **	-45.11 **	-18.89 **
IR 68897A	X	JGL8605	28.24 **	-0.91	-0.91	-10.41 **	-25.56 **	10.00 *
IR 68897A	X	JGL8292	29.70 **	19.09 **	19.09 **	-21.66 **	-36.09 **	-5.56
IR 68897A	X	JGL3855	-20.22 **	-38.66 **	-33.64 **	-23.26 **	-45.45 **	-26.67 **
IR 68897A	X	JGL3844	-6.31	-12.61 **	-5.45	-31.61 **	-45.45 **	-26.67 **
IR 68897A	X	JGL1798	22.99 **	-10.08 **	-2.73	-40.21 **	-52.07 **	-35.56 **
APMS 8A	X	JGL11110-2	28.49 **	-3.36	4.55	-47.37 **	-54.55 **	-38.89 **
APMS 8A	X	JGL11110-1	47.87 **	31.09 **	41.82 **	-23.90 **	-35.54 **	-13.33 **
APMS 8A	X	JGL17211	78.38 **	57.14 **	20.00 **	-7.14	-37.24 **	1.11
APMS 8A	X	JGL16284	34.76 **	22.33 **	14.55 **	-29.95 **	-47.59 **	-15.56 **
APMS 8A	X	JGL13515	88.49 **	55.95 **	19.09 **	-14.68 **	-35.86 **	3.33
APMS 8A	X	JGL11160	137.50 **	103.57 **	55.45 **	-34.76 **	-47.59 **	-15.56 **
APMS 8A	X	JGL11118	26.14 **	20.65 **	0.91	-31.00 **	-45.52 **	-12.22 *
APMS 8A	X	JGL11111	25.29 **	-0.91	-0.91	65.66 **	60.78 **	-8.89
APMS 8A	X	JGL8605	-1.41	-4.55	-4.55	0.00	-16.67 **	-33.33 **
APMS 8A	X	JGL8292	20.00 **	-10.00 *	-10.00 *	14.05 *	-5.48	-23.33 **
APMS 8A	X	JGL3855	3.53	-20.00 **	-20.00 **	-2.94	-25.00 **	-26.67 **
APMS 8A	X	JGL3844	-30.69 **	-36.36 **	-36.36 **	24.24 **	-2.38	-8.89
APMS 8A	X	JGL1798	-27.37 **	-45.24 **	-37.27 **	-20.69 **	-43.90 **	-23.33 **
CMS 16A	X	JGL11110-2	25.76 **	14.29 **	30.91 **	-9.74 *	-28.46 **	-2.22
CMS 16A	X	JGL11110-1	30.39 **	-6.35	7.27	-35.71 **	-48.78 **	-30.00 **
CMS 16A	X	JGL17211	-13.98 **	-36.51 **	-27.27 **	-28.91 **	-39.02 **	-16.67 **
CMS 16A	X	JGL16284	-32.11 **	-41.27 **	-32.73 **	-10.14 **	-24.39 **	3.33
CMS 16A	X	JGL13515	52.66 **	22.86 **	17.27 **	-34.78 **	-54.89 **	-33.33 **
CMS 16A	X	JGL11160	-1.92	-2.86	-7.27	-23.90 **	-41.35 **	-13.33 **
CMS 16A	X	JGL11118	87.50 **	42.86 **	36.36 **	-17.48 **	-36.09 **	-5.56
CMS 16A	X	JGL11111	5.45	-17.14 **	-20.91 **	-53.85 **	-61.65 **	-43.33 **
CMS 16A	X	JGL8605	0.51	-5.71	-10.00 *	-50.23 **	-59.40 **	-40.00 **
CMS 16A	X	JGL8292	44.44 **	19.39 **	6.36	24.41 **	3.95	-12.22 *
CMS 16A	X	JGL3855	39.30 **	35.92 **	27.27 **	-35.14 **	-36.84 **	-46.67 **
CMS 16A	X	JGL3844	25.49 **	-2.04	-12.73 **	0.67	-1.32	-16.67 **
CMS 16A	X	JGL1798	-18.99 **	-34.69 **	-41.82 **	-26.83 **	-31.82 **	-33.33 **
APMS 6A	X	JGL11110-2	16.84 **	13.27 **	0.91	72.50 **	64.29 **	53.33 **
APMS 6A	X	JGL11110-1	43.90 **	18.00 **	7.27	12.57 **	-21.97 **	14.44 **
APMS 6A	X	JGL17211	53.69 **	51.46 **	41.82 **	-5.88	-27.27 **	6.67
APMS 6A	X	JGL16284	50.97 **	17.00 **	6.36	-29.76 **	-45.45 **	-20.00 **

Table 4.33(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-13.75 **	-31.00 **	-37.27 **	-50.91 **	-59.09 **	-40.00 **
APMS 6A	X	JGL11160	35.42 **	30.00 **	18.18 **	-24.07 **	-37.88 **	-8.89
APMS 6A	X	JGL11118	104.88 **	68.00 **	52.73 **	-7.69	-18.18 **	-40.00 **
APMS 6A	X	JGL11111	21.18 **	19.42 **	11.82 **	8.70	4.17	-16.67 **
APMS 6A	X	JGL8605	-14.84 **	-34.00 **	-40.00 **	-17.99 **	-21.92 **	-36.67 **
APMS 6A	X	JGL8292	21.25 **	-3.00	-11.82 **	1.30	-11.36 *	-13.33 **
APMS 6A	X	JGL3855	32.29 **	27.00 **	15.45 **	12.00 *	0.00	-6.67
APMS 6A	X	JGL3844	17.28 **	-11.81 **	1.82	11.27 *	-13.19 **	-12.22 *
APMS 6A	X	JGL1798	-21.74 **	-29.13 **	-18.18 **	-15.34 **	-24.18 **	-23.33 **
IR 58025A	X	JGL11110-2	-10.99 *	-36.22 **	-26.36 **	-23.17 **	-30.77 **	-30.00 **
IR 58025A	X	JGL11110-1	21.93 **	-10.24 **	3.64	-41.90 **	-42.86 **	-42.22 **
IR 58025A	X	JGL17211	3.20	-11.02 **	2.73	-37.14 **	-39.56 **	-38.89 **
IR 58025A	X	JGL16284	76.67 **	65.62 **	-3.64	15.87 **	-2.67	-18.89 **
IR 58025A	X	JGL13515	-13.21 **	-33.01 **	-37.27 **	3.40	1.33	-15.56 **
IR 58025A	X	JGL11160	24.32 **	23.21 **	-37.27 **	41.89 **	40.00 **	16.67 **
IR 58025A	X	JGL11118	18.97 **	15.00 *	-37.27 **	-19.02 **	-25.00 **	-26.67 **
IR 58025A	X	JGL11111	110.81 **	69.57 **	41.82 **	-15.72 **	-20.24 **	-25.56 **
IR 58025A	X	JGL8605	-43.75 **	-60.63 **	-42.73 **	50.00 **	27.40 **	3.33
IR 58025A	X	JGL8292	20.15 **	-1.25	43.64 **	-32.41 **	-32.88 **	-45.56 **
IR 58025A	X	JGL3855	-4.19	-35.63 **	-6.36	-16.44 **	-16.44 **	-32.22 **
IR 58025A	X	JGL3844	-20.00 **	-45.00 **	-20.00 **	-16.77 **	-23.86 **	-25.56 **
IR 58025A	X	JGL1798	-40.48 **	-53.13 **	-31.82 **	7.01	0.00	-6.67
Hybrid			**Kampasagar**			**Pooled**		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	85.61 **	74.32 **	40.22 **	56.48**	53.30**	3.42
IR 68897A	X	JGL11110-1	17.20 **	0.00	0.00	7.76**	-6.37**	-14.38**
IR 68897A	X	JGL17211	-12.88 **	-27.55 **	-22.83 **	4.49	-2.21	-2.32**
IR 68897A	X	JGL16284	56.69 **	33.70 **	33.70 **	64.30**	49.58**	22.95**
IR 68897A	X	JGL13515	-14.44 **	-34.43 **	-13.04 **	-2.22	-18.79**	-17.12**
IR 68897A	X	JGL11160	120.14 **	106.76 **	66.30 **	41.25**	13.96**	20.21**
IR 68897A	X	JGL11118	28.66 **	9.78 **	9.78 **	-21.74**	-26.95**	-22.95**
IR 68897A	X	JGL11111	57.06 **	30.61 **	39.13 **	23.97**	7.47**	13.36**
IR 68897A	X	JGL8605	14.65 **	-2.17	-2.17	8.76**	-3.25	2.05
IR 68897A	X	JGL8292	-4.81	-27.05 **	-3.26	0.66	-0.97	4.45
IR 68897A	X	JGL3855	-18.82 **	-28.13 **	-25.00 **	-20.76**	-38.10**	-28.77**
IR 68897A	X	JGL3844	2.13	0.00	4.35	-11.77**	-20.83**	-8.90**
IR 68897A	X	JGL1798	-32.99 **	-33.67 **	-29.35 **	-18.15**	-31.55**	-21.23**
APMS 8A	X	JGL11110-2	17.02 **	14.58 **	19.57 **	-2.78	-16.67**	-4.11*
APMS 8A	X	JGL11110-1	11.93 **	0.00	32.61 **	12.30**	5.95**	21.92**
APMS 8A	X	JGL17211	127.74 **	110.81 **	69.57 **	57.59**	29.79**	29.79**
APMS 8A	X	JGL16284	58.71 **	33.70 **	33.70 **	16.28**	11.30**	11.30**
APMS 8A	X	JGL13515	-37.89 **	-48.98 **	-45.65 **	5.79**	-6.16**	-6.16**
APMS 8A	X	JGL11160	7.10 *	-9.78 **	-9.78 **	24.06**	13.01**	13.01**
APMS 8A	X	JGL11118	-10.27 **	-31.97 **	-9.78 **	-7.46**	-8.39**	-6.51**
APMS 8A	X	JGL11111	38.81 **	25.68 **	1.09	39.56**	30.28**	-2.74
APMS 8A	X	JGL8605	17.11 **	-3.26	-3.26	4.74*	-4.87*	-13.01**

Table 4.33 (cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-17.72 **	-33.67 **	-29.35 **	4.95*	3.10	-20.21**
APMS 8A	X	JGL3855	-2.63	-19.57 **	-19.57 **	-0.44	-5.00*	-21.92**
APMS 8A	X	JGL3844	14.29 **	-14.75 **	13.04 **	-0.78	-14.09**	-12.33**
APMS 8A	X	JGL1798	-2.26	-12.16 **	-29.35 **	-18.31**	-34.09**	-30.48**
CMS 16A	X	JGL11110-2	45.70 **	19.57 **	19.57 **	18.96*/*	11.04**	17.12**
CMS 16A	X	JGL11110-1	55.41 **	24.49 **	32.61 **	13.48**	-1.62	3.77*
CMS 16A	X	JGL17211	106.62 **	69.57 **	69.57 **	13.50**	0.97	6.51**
CMS 16A	X	JGL16284	35.91 **	0.82	33.70 **	-4.29*	-5.84**	-0.68
CMS 16A	X	JGL13515	28.09 **	9.62 **	23.91 **	14.12**	-11.40**	3.77
CMS 16A	X	JGL11160	28.57 **	21.15 **	36.96 **	0.49	-10.53**	4.79*
CMS 16A	X	JGL11118	-7.92 **	-10.58 **	1.09	15.49**	-4.09*	12.33**
CMS 16A	X	JGL11111	3.06	-2.88	9.78 **	-17.87**	-30.12**	-18.15**
CMS 16A	X	JGL8605	-31.86 **	-36.89 **	-16.30 **	-28.12**	-32.75**	-21.23**
CMS 16A	X	JGL8292	-10.34 **	-12.16 **	-29.35 **	20.28**	6.53**	-10.62**
CMS 16A	X	JGL3855	5.52	-6.52	-6.52	7.03**	2.62	-6.16**
CMS 16A	X	JGL3844	8.88 **	-6.12	0.00	11.68**	7.35**	-9.93**
CMS 16A	X	JGL1798	46.01 **	29.35 **	29.35 **	0.21	-0.82	16.78**
APMS 6A	X	JGL11110-2	13.99 **	-9.84 **	19.57 **	32.23**	20.47**	22.95**
APMS 6A	X	JGL11110-1	70.63 **	64.86 **	32.61 **	40.00**	13.95**	17.47**
APMS 6A	X	JGL17211	77.64 **	55.43 **	55.43 **	39.08**	31.23**	35.27**
APMS 6A	X	JGL16284	46.11 **	24.49 **	32.61 **	18.03**	3.32	6.51**
APMS 6A	X	JGL13515	-8.07 *	-19.57 **	-19.57 **	-27.17**	-34.55**	-32.53**
APMS 6A	X	JGL11160	31.94 **	3.28	36.96 **	12.85**	12.29**	15.75**
APMS 6A	X	JGL11118	32.86 **	25.68 **	1.09	49.64**	35.78**	7.88**
APMS 6A	X	JGL11111	1.27	-13.04 **	-13.04 **	11.42**	4.12	-4.79*
APMS 6A	X	JGL8605	-41.46 **	-51.02 **	-47.83 **	-25.33**	26.29**	-41.44**
APMS 6A	X	JGL8292	-17.72 **	-29.35 **	-29.35 **	1.69	0.00	-17.81**
APMS 6A	X	JGL3855	-8.51 **	-29.51 **	-6.52	12.08**	-0.34	1.71
APMS 6A	X	JGL3844	11.29 *	-6.76	-25.00 **	13.79**	-2.99	-10.96**
APMS 6A	X	JGL1798	-15.49 **	-34.78 **	-34.78 **	18.13**	-18.28**	-25.00**
IR 58025A	X	JGL11110-2	48.65 **	12.24 **	19.57 **	2.83	-5.22*	-13.01**
IR 58025A	X	JGL11110-1	71.83 **	32.61 **	32.61 **	13.39**	7.46**	-1.37
IR 58025A	X	JGL17211	66.28 **	17.21 **	55.43 **	9.89**	4.36*	6.51**
IR 58025A	X	JGL16284	64.86 **	64.86 **	32.61 **	52.79**	46.83**	3.08
IR 58025A	X	JGL13515	-10.84 **	-19.57 **	-19.57 **	-7.20**	-17.98**	-25.00**
IR 58025A	X	JGL11160	77.91 **	56.12 **	66.30 **	51.74**	44.69**	11.99**
IR 58025A	X	JGL11118	21.69 **	9.78 **	9.78 **	6.07**	-1.67	-19.18**
IR 58025A	X	JGL11111	30.61 **	4.92	39.13 **	39.56**	17.79**	20.21**
IR 58025A	X	JGL8605	-35.57 **	-36.00 **	-47.83 **	-17.91**	-33.77**	-30.14**
IR 58025A	X	JGL8292	-22.16 **	-29.35 **	-29.35 **	-5.39**	-11.69**	-6.85**
IR 58025A	X	JGL3855	-0.58	-12.24 **	-6.52	-6.37**	-18.83**	-14.38**
IR 58025A	X	JGL3844	-17.37 **	-25.00 **	-25.00 **	-18.25**	-27.27**	-23.29**
IR 58025A	X	JGL1798	-39.09 **	-50.82 **	-34.78 **	-27.72**	-28.90**	-25.00**

* Significant at 5% level; ** Significant at 1% level

which ranged from 55.45 (APMS 8A x JGL 11160) to 11.82 (APMS 6A x JGL 11111) when compared with check PA 6201, for the character panicle weight.

At Warangal, the positive significant average heterosis was recorded in 14 hybrids, with a range from 72.50 (APMS 6A x JGL 11110-2) to 11.27 (APMS 6A x JGL 3844). The significant heterobeltiosis was observed in 5 hybrids ranging from 64.29 (APMS 6A x JGL 11110-2) to 24.14 (IR 58025A x JGL 11110-2). The positive significant standard heterosis was observed in 4 hybrids which ranged from 53.33 (APMS 6A x JGL 11110-2) to 10.00 (IR68897A x JGL 8605), when compared with check PA 6201.

At Kampasagar, the positive significant average heterosis was recorded in 37 hybrids, with a range from 127.74 (APMS 8A x JGL 17211) to 7.10 (APMS 8A x JGL 11118). The significant heterobeltiosis was observed in 25 hybrids, which ranged from 110.81 (APMS 8A x JGL 17211) to 9.62 (CMS 16A x JGL 13515). The positive significant standard heterosis was recorded in 30 hybrids for panicle weight, which ranged from 69.57 (APMS 8A x JGL 17211) to 9.78 (IR 58025A x JGL 11118) when compared with check PA 6201 (Table 4.33).

In pooled analysis, positive significant average heterosis was recorded in 38 hybrids, with a range from 64.30 (IR 68897A x JGL 16284) to 4.74 (APMS 8A x JGL 8605). The significant heterobeltiosis was observed in 23 hybrids, which ranged from 53.30 (IR68897 A x JGL 11110.2) to 4.36 (IR58025A x JGL 17211). The positive significant standard heterosis was recorded in 30 hybrids out of 23 hybrids tested for panicle weight and it ranged from 35.27 (APMS 6A x JGL 17211) to 3.77 (CMS 16A A x JGL 11160) when compared with check PA 6201 (Table 4.33).

Panicle weight is positively associated with grain yield and is known to contribute grain yield via more number of filled grains. The hybrid APMS 6A x JGL 17211 (35.27) recorded the highest standard heterosis over best check PA 6201 with relative high standard heterosis over check KRH-2 (24.21), heterobeltiosis (31.23) and average heterosis (39.08). The other hybrids APMS 8A x JGL 17211 (29.79), IR 68897A x JGL 16284 (22.95), APMS 6A x JGL 11110-2 (22.95) and APMS 8A x JGL 11110-1 (21.92) recorded high standard heterosis over the best check PA 6201. Most of the hybrids expressed significant positive heterosis and heterobeltiosis for this trait. In contrary to this heterosis and heterobeltiosis for both positive and negative nature in their studies were reported by Lokaprakash *et al.* (1992) and Ghosh (2002), while Lingaraju (1997) observed standard heterosis of similar nature in his experiment (Table 4.39 and Figure 4.7).

Table 4.34 Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for filled grains per panicle panicle at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	10.49	-12.08	3.98	-12.92 *	-32.68 **	36.92 **
IR 68897A	X	JGL11110-1	-9.66	-21.93	-7.67	-14.51 **	-33.81 **	34.62 **
IR 68897A	X	JGL17211	5.88	-10.65	5.67	-26.35 **	-38.80 **	24.46 **
IR 68897A	X	JGL16284	56.66 **	41.38 **	67.20 **	-6.36	-9.76 *	83.54 **
IR 68897A	X	JGL13515	-21.86 *	-26.26 *	-1.72	-63.24 **	-70.73 **	0.46
IR 68897A	X	JGL11160	-3.72	-31.25 **	12.34	-35.70 **	-55.24 **	26.77 **
IR 68897A	X	JGL11118	-44.10 **	-57.31 **	-30.25 *	-48.87 **	-64.37 **	0.92
IR 68897A	X	JGL11111	20.24	-9.95	47.14 **	-39.10 **	-55.08 **	27.23 **
IR 68897A	X	JGL8605	-10.75	-29.37 **	15.40	-29.83 **	-41.55 **	65.54 **
IR 68897A	X	JGL8292	-40.90 **	-46.35 **	-12.34	-50.10 **	-54.46 **	56.31 **
IR 68897A	X	JGL3855	-28.40 *	-48.85 **	-16.54	-47.75 **	-63.60 **	2.77
IR 68897A	X	JGL3844	-3.55	-26.31 **	20.23	-40.08 **	-58.20 **	18.00 *
IR 68897A	X	JGL1798	-25.93 *	-44.50 **	-9.44	-42.51 **	-57.55 **	19.85 *
APMS 8A	X	JGL11110-2	14.97	-8.98	48.51 **	-25.78 **	-38.09 **	74.77 **
APMS 8A	X	JGL11110-1	23.71 **	12.38	83.37 **	-34.83 **	-40.61 **	103.85 **
APMS 8A	X	JGL17211	32.85 **	-10.12	78.02 **	19.39 **	-18.43 **	147.23 **
APMS 8A	X	JGL16284	6.99	-23.24 **	52.03 **	-25.49 **	-49.04 **	54.46 **
APMS 8A	X	JGL13515	2.23	-27.89 **	42.82 **	-4.75	-31.22 **	108.46 **
APMS 8A	X	JGL11160	10.23	-18.40 *	61.62 **	-44.12 **	-54.67 **	37.38 **
APMS 8A	X	JGL11118	-36.94 **	-47.25 **	4.46	-65.63 **	-67.64 **	11.08
APMS 8A	X	JGL11111	49.45 **	11.94	57.21 **	91.22 **	86.68 **	117.69 **
APMS 8A	X	JGL8605	55.74 **	25.64 *	76.45 **	3.03	0.79	17.54
APMS 8A	X	JGL8292	43.45 **	13.27	59.07 **	-3.12	-9.60	21.69 *
APMS 8A	X	JGL3855	0.13	-16.00	17.97	2.42	-17.13 **	56.31 **
APMS 8A	X	JGL3844	6.73	4.01	46.08 **	-24.59 **	-49.48 **	73.38 **
APMS 8A	X	JGL1798	-16.66	-41.84 **	2.83	-13.06 **	-34.35 **	42.92 **
CMS 16A	X	JGL11110-2	29.12 **	-3.98	69.78 **	45.42 **	9.96 *	139.38 **
CMS 16A	X	JGL11110-1	42.31 **	3.88	83.69 **	-12.84 **	-29.47 **	53.54 **
CMS 16A	X	JGL17211	-22.24 *	-40.19 **	5.75	7.61 *	0.42	118.62 **
CMS 16A	X	JGL16284	-39.22 **	-46.70 **	-5.75	-24.52 **	-38.32 **	111.69 **
CMS 16A	X	JGL13515	41.86 **	7.83	44.96 **	29.94 **	-12.52 **	180.46 **
CMS 16A	X	JGL11160	5.62	-13.35	16.49	-30.87 **	-53.41 **	49.38 **
CMS 16A	X	JGL11118	57.24 **	26.19 *	69.63 **	-35.59 **	-54.27 **	46.62 **
CMS 16A	X	JGL11111	-1.86	-16.18	12.68	-54.20 **	-63.63 **	16.62
CMS 16A	X	JGL8605	-26.62 **	-26.93 *	-1.77	-61.81 **	-63.07 **	26.77 **
CMS 16A	X	JGL8292	80.29 **	38.92 **	79.59 **	19.00 **	13.60	38.77 **
CMS 16A	X	JGL3855	37.45 **	14.52	48.05 **	15.60 *	10.58	35.08 **
CMS 16A	X	JGL3844	-28.03 *	-41.38 **	-24.21	-11.68	-15.77 *	13.38
CMS 16A	X	JGL1798	-36.81 **	-45.14 **	-29.08	-34.46 **	-46.00 **	1.85
APMS 6A	X	JGL11110-2	23.22 *	21.37	61.76 **	61.98 **	9.82 **	276.92 **
APMS 6A	X	JGL11110-1	32.81 **	-7.67	65.43 **	16.97 **	-18.58 **	130.62 **
APMS 6A	X	JGL17211	47.10 **	8.91	95.13 **	-21.75 **	-45.46 **	54.46 **
APMS 6A	X	JGL16284	39.22 **	1.21	81.34 **	-54.57 **	-66.49 **	-5.08

Table 4.34 (cont.)								
Hybrid			**Kunaram**			**Warangal**		
			Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
APMS 6A	**X**	**JGL13515**	-22.87 *	-40.94 **	5.81	-40.59 **	-50.52 **	40.15 **
APMS 6A	**X**	**JGL11160**	13.88	-0.70	77.90 **	-8.25 **	-16.27 **	187.38 **
APMS 6A	**X**	**JGL11118**	42.50 **	-2.73	86.35 **	-35.31 **	-46.99 **	-7.85
APMS 6A	**X**	**JGL11111**	25.60 **	-8.96	74.41 **	23.13 **	1.06	75.69 **
APMS 6A	**X**	**JGL8605**	-31.44 **	-51.17 **	-6.44	-43.54 **	-49.91 **	-12.92
APMS 6A	**X**	**JGL8292**	-15.75	-36.94 **	20.81	-15.03 **	-18.35 **	54.00 **
APMS 6A	**X**	**JGL3855**	-5.49	-19.87 *	53.52 **	-47.40 **	-60.38 **	36.00 **
APMS 6A	**X**	**JGL3844**	0.34	-31.80 **	32.71 *	-33.53 **	-52.37 **	22.15 *
APMS 6A	**X**	**JGL1798**	-26.70 **	-47.12 **	2.89	-14.55 **	-38.69 **	57.23 **
IR 58025A	**X**	**JGL11110-2**	-28.68 **	-49.43 **	-1.60	-46.50 **	-59.21 **	4.62
IR 58025A	**X**	**JGL11110-1**	-38.65 **	-54.32 **	-11.10	-54.03 **	-60.11 **	2.31
IR 58025A	**X**	**JGL17211**	-37.52 **	-47.36 **	2.43	-55.11 **	-60.78 **	34.62 **
IR 58025A	**X**	**JGL16284**	139.18 **	137.59 **	68.43 **	60.98 **	50.28 **	66.92 **
IR 58025A	**X**	**JGL13515**	2.42	-6.64	-19.58	60.62 **	49.66 **	66.92 **
IR 58025A	**X**	**JGL11160**	29.61	21.29	-1.35	83.74 **	57.60 **	112.15 **
IR 58025A	**X**	**JGL11118**	4.15	-9.14	-13.51	-5.51	-28.63 **	34.62 **
IR 58025A	**X**	**JGL11111**	69.69 **	29.98 **	73.24 **	-42.32 **	-63.07 **	26.77 **
IR 58025A	**X**	**JGL8605**	-32.54 **	-50.82 **	-24.90	9.69	-10.30 *	56.77 **
IR 58025A	**X**	**JGL8292**	52.95 **	19.62 *	82.68 **	-44.52 **	-54.56 **	-20.58 *
IR 58025A	**X**	**JGL3855**	39.99 **	7.27	63.82 **	-12.98 *	-22.98 **	34.62 **
IR 58025A	**X**	**JGL3844**	-36.32 **	-48.31 **	-21.06	-34.04 **	-36.46 **	19.85 *
IR 58025A	**X**	**JGL1798**	-43.42 **	-47.02 **	-19.09	-22.54 **	-41.55 **	100.62 **
Hybrid			**Kampasagar**			**Pooled**		
			Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
IR 68897A	**X**	**JGL11110-2**	3.41	-7.67	21.18 **	-0.39	-18.45**	19.17**
IR 68897A	**X**	**JGL11110-1**	-15.01 **	-15.34 **	11.11 *	-13.27**	24.29**	10.64
IR 68897A	**X**	**JGL17211**	-39.60 **	-40.48 **	-21.88 **	-22.05**	-21.01**	0.82
IR 68897A	**X**	**JGL16284**	-7.15 *	-8.70 *	23.96 **	10.86**	6.75	56.00**
IR 68897A	**X**	**JGL13515**	-18.22 **	-23.08 **	14.58 **	-38.77**	-46.57**	4.77
IR 68897A	**X**	**JGL11160**	-7.87 **	-33.08 **	52.43 **	-16.30**	-40.37**	30.77**
IR 68897A	**X**	**JGL11118**	-52.09 **	-62.35 **	-14.24 *	-48.81**	-61.69**	-15.97**
IR 68897A	**X**	**JGL11111**	-6.74 *	-27.29 **	65.63 **	-10.56**	-32.33**	48.41**
IR 68897A	**X**	**JGL8605**	-40.59 **	-52.59 **	7.99	-28.73**	-42.38**	26.37**
IR 68897A	**X**	**JGL8292**	-60.74 **	-67.53 **	-26.04 **	-51.19**	-53.77**	1.39
IR 68897A	**X**	**JGL3855**	-30.25 **	-38.83 **	-16.32 **	-36.40**	-52.28**	-11.20
IR 68897A	**X**	**JGL3844**	-36.28 **	-37.82 **	-14.93 **	-27.54**	-42.55**	6.90
IR 68897A	**X**	**JGL1798**	-78.45 **	-79.19 **	-71.53 **	-49.05**	-59.12**	-23.94**
APMS 8A	**X**	**JGL11110-2**	-6.50	-6.85	27.43 **	-7.88*	-20.44**	48.03**
APMS 8A	**X**	**JGL11110-1**	10.09 **	5.59	57.29 **	-6.06*	-8.47**	79.51**
APMS 8A	**X**	**JGL17211**	0.32	-27.06 **	65.63 **	16.48**	-18.88**	92.38**
APMS 8A	**X**	**JGL16284**	-30.22 **	-45.11 **	24.65 **	-17.50**	-39.79**	42.79**
APMS 8A	**X**	**JGL13515**	-73.36 **	-79.20 **	-52.78 **	-27.88**	-46.83**	26.09**
APMS 8A	**X**	**JGL11160**	-38.18 **	-50.61 **	12.15 *	-26.37**	-42.18**	37.12**
APMS 8A	**X**	**JGL11118**	-55.68 **	-63.30 **	-16.67 **	-54.48**	-58.42**	-1.38
APMS 8A	**X**	**JGL11111**	16.23 **	14.33 **	21.88 **	49.76**	32.19**	60.89**
APMS 8A	**X**	**JGL8605**	8.80 *	-1.07	28.82 **	24.11**	17.64**	43.17**

Table 4.34(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	5.04	-3.54	22.92 **	15.96**	11.59*	35.81**
APMS 8A	X	JGL3855	-28.94 **	-36.57 **	-13.89 *	-9.05*	-13.62**	16.88**
APMS 8A	X	JGL3844	16.85 **	0.23	49.31 **	-2.66	-21.13**	54.68**
APMS 8A	X	JGL1798	-23.40 **	-33.33 **	-31.25 **	-17.13**	-33.11**	1.41
CMS 16A	X	JGL11110-2	27.06 **	0.80	31.25 **	34.14**	15.29**	74.79**
CMS 16A	X	JGL11110-1	33.22 **	6.54	35.76 **	19.74**	4.31	58.14**
CMS 16A	X	JGL17211	39.12 **	8.70 *	47.57 **	5.69	0.01	51.61**
CMS 16A	X	JGL16284	10.02 *	-16.78 **	23.96 **	-21.22**	-30.16**	39.97**
CMS 16A	X	JGL13515	37.38 **	14.64 **	76.74 **	35.49**	0.57	93.35**
CMS 16A	X	JGL11160	59.95 **	47.52 **	127.43 **	9.93**	-13.87**	65.59**
CMS 16A	X	JGL11118	10.48 **	0.90	55.56 **	3.86	-17.68**	58.27**
CMS 16A	X	JGL11111	2.99	-3.15	49.31 **	-22.4**	-33.94**	27.01**
CMS 16A	X	JGL8605	17.53 **	15.54 **	78.13 **	-30.53**	-31.21**	34.91**
CMS 16A	X	JGL8292	2.91	-9.46 *	22.92 **	32.80**	14.10**	47.97**
CMS 16A	X	JGL3855	-14.10 **	-15.86 **	14.24 *	10.84*	2.00	32.28**
CMS 16A	X	JGL3844	-31.40 **	-33.50 **	-9.72	-24.64**	-29.62**	-8.73
CMS 16A	X	JGL1798	-25.32 **	-25.32 **	1.39	-31.80**	-33.21**	-9.63
APMS 6A	X	JGL11110-2	-25.61 **	-28.90 **	5.90	22.85**	2.04	100.13**
APMS 6A	X	JGL11110-1	-25.85 **	-35.87 **	-9.38	8.80*	-19.45**	56.10**
APMS 6A	X	JGL17211	27.11 **	22.11 **	72.57 **	16.18**	-9.24**	75.90**
APMS 6A	X	JGL16284	14.47 **	8.85 *	53.82 **	-3.47	-23.71**	47.85**
APMS 6A	X	JGL13515	-38.10 **	-39.31 **	-14.24 *	-34.43**	-44.32**	7.91
APMS 6A	X	JGL11160	12.92 **	10.02 **	63.89 **	3.94	3.33	102.64**
APMS 6A	X	JGL11118	45.45 **	12.80 **	111.11 **	21.93**	-8.36*	69.66**
APMS 6A	X	JGL11111	0.22	-15.03 **	59.03 **	15.04**	-8.62**	69.19**
APMS 6A	X	JGL8605	-39.29 **	-48.98 **	-4.51	-37.86**	-50.05**	-7.51
APMS 6A	X	JGL8292	-54.19 **	-60.48 **	-26.04 **	-29.55**	-39.03**	12.89*
APMS 6A	X	JGL3855	-50.21 **	-55.29 **	-16.32 **	-35.23**	-37.04**	23.48**
APMS 6A	X	JGL3844	5.66	-5.72	-2.78	-7.18**	-31.30**	16.29**
APMS 6A	X	JGL1798	-34.87 **	-47.20 **	-31.25 **	-24.58**	-38.15**	5.33
IR 58025A	X	JGL11110-2	26.00 **	3.00	31.25 **	-20.81**	-34.24**	11.98*
IR 58025A	X	JGL11110-1	25.32 **	0.00	35.76 **	-28.33**	-35.69**	9.51
IR 58025A	X	JGL17211	28.40 **	-0.93	47.57 **	-30.39**	-34.97**	27.53**
IR 58025A	X	JGL16284	-1.24	-16.20 **	23.96 **	52.81**	43.75**	51.93*-*
IR 58025A	X	JGL13515	-32.08 **	-36.15 **	-5.56	1.59	0.04	9.05
IR 58025A	X	JGL11160	-37.70 **	-42.02 **	-14.24 *	14.47**	10.99*	24.89**
IR 58025A	X	JGL11118	48.84 **	42.72 **	111.11 **	20.08**	6.93	44.69**
IR 58025A	X	JGL11111	7.13 *	6.76	59.03 **	3.01	-20.74**	55.45**
IR 58025A	X	JGL8605	-4.84	-7.41	-4.51	-9.70*	-24.54**	4.71
IR 58025A	X	JGL8292	114.94 **	88.00 **	144.79 **	42.91**	27.59**	77.04**
IR 58025A	X	JGL3855	-25.62 **	-34.33 **	-16.32 **	0.98	-8.57*	26.87**
IR 58025A	X	JGL3844	-16.67 **	-28.39 **	-2.78	-29.44**	-30.32**	-3.31
IR 58025A	X	JGL1798	-44.23 **	-53.85 **	-31.25 **	-34.84**	-44.37**	9.10

* Significant at 5% level; ** Significant at 1% level

Table 4.35 .Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for spikelet fertility percentage at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	7.80 **	2.99	-6.13 *	-3.36 *	-10.98 **	2.82
IR 68897A	X	JGL11110-1	-3.09	-5.25	-17.69 **	7.72 **	-1.57	13.68 **
IR 68897A	X	JGL17211	17.93 **	14.37 **	-5.07 *	4.89 **	-0.52	14.89 **
IR 68897A	X	JGL16284	3.92	-5.54 *	-4.14	-5.64 **	-7.84 **	6.44 **
IR 68897A	X	JGL13515	-9.04 **	-15.36 **	-18.40 **	-0.81	-4.18 **	10.66 **
IR 68897A	X	JGL11160	-2.02	-5.08 *	-7.73 **	-7.68 **	-13.88 **	-3.22
IR 68897A	X	JGL11118	-7.86 **	-12.76 **	-15.20 **	-5.18 **	-12.27 **	-1.41
IR 68897A	X	JGL11111	-12.24 **	-20.91 **	-23.12 **	-20.44 **	-23.55 **	-14.08 **
IR 68897A	X	JGL8605	-2.59	-4.64 *	-3.23	-13.54 **	-14.42 **	-3.82 *
IR 68897A	X	JGL8292	-1.38	-1.79	-4.53	-12.03 **	-13.88 **	-3.22
IR 68897A	X	JGL3855	8.24 **	4.60	-4.66	-15.97 **	-18.80 **	-15.29 **
IR 68897A	X	JGL3844	0.54	-0.54	-13.60 **	-15.85 **	-19.38 **	-15.90 **
IR 68897A	X	JGL1798	-44.30 **	-46.59 **	-54.60 **	-23.16 **	-23.43 **	-20.12 **
APMS 8A	X	JGL11110-2	-3.91	-11.71 **	-10.40 **	-3.54 *	-6.07 **	3.42
APMS 8A	X	JGL11110-1	8.90 **	2.47	-1.21	-1.28	-2.80	4.63 *
APMS 8A	X	JGL17211	5.50 *	2.85	-1.30	-26.47 **	-30.77 **	-23.74 **
APMS 8A	X	JGL16284	7.11 **	2.04	-2.08	12.28 **	4.86 **	15.49 **
APMS 8A	X	JGL13515	11.01 **	0.62	-3.44	0.17	-2.82	7.04 **
APMS 8A	X	JGL11160	-6.04 **	-8.59 **	-7.24 **	-6.63 **	-6.65 **	2.82
APMS 8A	X	JGL11118	0.46	0.23	-3.37	-16.67 **	-17.61 **	-9.26 **
APMS 8A	X	JGL11111	-33.93 **	-35.78 **	-38.00 **	9.48 **	2.03	14.89 **
APMS 8A	X	JGL8605	7.27 **	1.90	-1.63	2.84	-4.94 **	7.04 **
APMS 8A	X	JGL8292	13.72 **	2.81	-0.76	6.29 **	2.03	14.89 **
APMS 8A	X	JGL3855	-18.52 **	-20.51 **	-19.33 **	-8.75 **	-9.76 **	1.61
APMS 8A	X	JGL3844	-4.93 *	-4.99 *	-8.29 **	-2.25	-4.40 **	7.65 **
APMS 8A	X	JGL1798	-23.53 **	-28.31 **	-25.33 **	-30.95 **	-35.32 **	-27.97 **
CMS 16A	X	JGL11110-2	-4.51 *	-12.43 **	-8.80 **	-11.71 **	-17.97 **	-8.65 **
CMS 16A	X	JGL11110-1	-11.57 **	-22.67 **	-19.47 **	0.72	-2.79	8.25 **
CMS 16A	X	JGL17211	-9.22 **	-10.38 **	-6.67 **	-32.77 **	-33.15 **	-25.55 **
CMS 16A	X	JGL16284	-7.99 **	-11.41 **	-7.73 **	1.06	-0.63	10.66 **
CMS 16A	X	JGL13515	-13.60 **	-14.37 **	-20.53 **	-0.52	-8.79 **	6.44 **
CMS 16A	X	JGL11160	2.36	-0.91	-8.04 **	8.25 **	-1.55	14.89 **
CMS 16A	X	JGL11118	-8.42 **	-12.34 **	-11.04 **	-3.48 *	-6.21 **	9.46 **
CMS 16A	X	JGL11111	4.31 *	2.36	-1.32	1.35	-2.59	13.68 **
CMS 16A	X	JGL8605	-13.34 **	-16.86 **	-17.52 **	-12.54 **	-17.19 **	-9.86 **
CMS 16A	X	JGL8292	-8.03 **	-13.75 **	-14.44 **	13.58 **	6.65 **	16.10 **
CMS 16A	X	JGL3855	-48.97 **	-54.42 **	-54.78 **	-30.48 **	-32.16 **	-26.16 **
CMS 16A	X	JGL3844	-49.45 **	-50.01 **	-49.27 **	-52.40 **	-52.67 **	-47.89 **
CMS 16A	X	JGL1798	-8.39 **	-9.68 **	-10.40 **	3.35 *	2.77	11.87 **
APMS 6A	X	JGL11110-2	0.59	-3.24	-4.53	-9.73 **	-13.61 **	-8.05 **
APMS 6A	X	JGL11110-1	-4.59 *	-10.29 **	-11.49 **	2.39	-2.84	3.42
APMS 6A	X	JGL17211	-1.58	-11.89 **	-13.07 **	-4.39 **	-5.67 **	0.40
APMS 6A	X	JGL16284	-4.03	-5.36 *	-3.96	5.56 **	3.80 *	14.29 **

Table 4.35 (cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	-1.58	-2.70	-4.00	2.82	2.24	10.06 **
APMS 6A	X	JGL11160	-11.74 **	-16.53 **	-14.67 **	-20.39 **	-23.82 **	-18.91 **
APMS 6A	X	JGL11118	0.88	-6.70 **	-4.61	8.70 **	3.15	9.79 **
APMS 6A	X	JGL11111	-3.73	-15.14 **	-13.25 **	-49.19 **	-49.87 **	-46.64 **
APMS 6A	X	JGL8605	-13.56 **	-13.88 **	-11.96 **	-22.88 **	-24.16 **	-16.50 **
APMS 6A	X	JGL8292	-11.07 **	-13.61 **	-11.68 **	-14.81 **	-15.28 **	-8.81 **
APMS 6A	X	JGL3855	-0.77	-5.12 *	-5.21 *	5.35 **	2.66	5.23 **
APMS 6A	X	JGL3844	-52.51 **	-55.61 **	-55.65 **	16.01 **	12.09 **	14.89 **
APMS 6A	X	JGL1798	4.92 *	-6.58 **	-6.67 **	-11.93 **	-12.39 **	-9.26 **
IR 58025A	X	JGL11110-2	-18.26 **	-18.89 **	-17.69 **	1.83	-1.68	8.25 **
IR 58025A	X	JGL11110-1	-47.03 **	-47.96 **	-48.01 **	8.92 **	6.32 **	14.45 **
IR 58025A	X	JGL17211	10.92 **	6.33 *	-3.09	15.09 **	11.67 **	15.49 **
IR 58025A	X	JGL16284	4.39	2.42	-11.03 **	3.34 *	-0.58	2.82
IR 58025A	X	JGL13515	22.00 **	17.92 **	-1.43	8.67 **	8.58 **	12.47 **
IR 58025A	X	JGL11160	-5.46 *	-13.79 **	-12.52 **	7.05 **	3.80 *	14.29 **
IR 58025A	X	JGL11118	-0.81	-7.41 **	-10.73 **	-8.87 **	-10.65 **	-3.82 *
IR 58025A	X	JGL11111	-9.26 **	-13.97 **	-12.51 **	-9.91 **	-16.81 **	-4.43 *
IR 58025A	X	JGL8605	4.79 *	-2.85	-1.19	6.31 **	-2.63	11.87 **
IR 58025A	X	JGL8292	0.73	-11.01 **	-9.49 **	1.31	-3.68 *	10.66 **
IR 58025A	X	JGL3855	-52.23 **	-52.28 **	-51.47 **	-2.16	-4.20 **	10.06 **
IR 58025A	X	JGL3844	-59.62 **	-60.67 **	-60.00 **	0.54	-2.63	11.87 **
IR 58025A	X	JGL1798	-8.42 **	-12.34 **	-11.04 **	-3.48 *	-6.21 **	9.46 **
Hybrid			**Kampasagar**			**Pooled**		
			Mid	**Better**	**PA- 6201**	**Mid**	**Better**	**PA- 6201**
IR 68897A	X	JGL11110-2	-15.95 **	-28.65 **	-25.95 **	-3.82**	-7.77**	-10.19**
IR 68897A	X	JGL11110-1	12.77 **	-3.21	-2.16	5.88**	3.04*	-2.69*
IR 68897A	X	JGL17211	11.25 **	-2.26	-6.49 **	10.95**	9.39**	0.59
IR 68897A	X	JGL16284	-3.49	-16.02 **	-17.84 **	-1.79	-8.24**	-5.59**
IR 68897A	X	JGL13515	18.59 **	3.93	0.00	2.42*	-2..94*	-3.3*
IR 68897A	X	JGL11160	6.15 **	-1.04	2.70	-1.12	-0.14	-2.76*
IR 68897A	X	JGL11118	-4.25 *	-9.63 **	-8.65 **	-5.75**	-3.32*	-8.70**
IR 68897A	X	JGL11111	1.46	-1.69	-5.95 **	-10.52**	-6.95**	-14.44**
IR 68897A	X	JGL8605	-30.26 **	-33.15 **	-34.59 **	-15.12**	-16.60**	-14.19**
IR 68897A	X	JGL8292	-5.23 **	-8.43 **	-11.89 **	-6.24**	-6.47**	-6.66**
IR 68897A	X	JGL3855	-23.86 **	-26.04 **	-23.24 **	-11.10**	-12.02**	-14.32**
IR 68897A	X	JGL3844	-2.17	-3.74	-2.70	-5.75**	-5.29**	-10.56**
IR 68897A	X	JGL1798	-54.75 **	-55.25 **	-56.22 **	-40.79**	-39.69**	-44.54**
APMS 8A	X	JGL11110-2	1.66	1.66	-0.54	-1.90	-5.48**	-2.76*
APMS 8A	X	JGL11110-1	-14.21 **	-14.92 **	-16.76 **	-2.40*	-4.57**	-4.76**
APMS 8A	X	JGL17211	-12.81 **	-16.67 **	-13.51 **	-11.18**	-10.05**	-12.41**
APMS 8A	X	JGL16284	-8.84 **	-11.76 **	-10.81 **	3.28**	6.24**	0.33
APMS 8A	X	JGL13515	5.11 **	4.52 *	0.00	5.28**	9.81**	0.97
APMS 8A	X	JGL11160	6.74 **	4.97 *	2.70	-2.07	-3.51**	-0.73
APMS 8A	X	JGL11118	-9.35 **	-10.11 **	-13.51 **	-8.51**	-8.49**	-8.67**
APMS 8A	X	JGL11111	-12.47 **	-14.06 **	-10.81 **	-12.39**	-10.01**	-12.37**
APMS 8A	X	JGL8605	-4.84 **	-5.35 *	-4.32 *	1.58	6.01**	0.11

Table 4.35(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	0.55	-1.62	-1.62	6.63**	12.84**	3.76**
APMS 8A	X	JGL3855	-19.67 **	-20.54 **	-20.54 **	-15.64**	-15.73**	-13.30**
APMS 8A	X	JGL3844	-16.80 **	-18.38 **	-18.38 **	-7.99**	-6.67**	-6.85**
APMS 8A	X	JGL1798	-47.28 **	-49.48 **	-47.57 **	-34.00**	-32.00**	-33.79**
CMS 16A	X	JGL11110-2	-9.09 **	-11.76 **	-10.81 **	-8.39**	-4.11**	-9.45**
CMS 16A	X	JGL11110-1	-0.28	-0.56	-4.86 *	-3.61**	2.32	-5.92**
CMS 16A	X	JGL17211	-3.08	-4.42 *	-6.49 **	-15.03**	-14.87**	-12.42**
CMS 16A	X	JGL16284	-14.12 **	-14.61 **	-17.84 **	-6.97**	-8.53**	-5.54**
CMS 16A	X	JGL13515	-9.81 **	-11.46 **	-8.11 **	-7.96**	-10.32**	-7.96**
CMS 16A	X	JGL11160	-3.76 *	-4.28 *	-3.24	2.16*	-1.92	0.67
CMS 16A	X	JGL11118	-8.84 **	-10.81 **	-10.81 **	-7.31**	-12.13**	-9.82**
CMS 16A	X	JGL11111	-0.55	-1.62	-1.62	-4.14**	-4.25**	-1.49
CMS 16A	X	JGL8605	4.13 *	2.16	2.16	3.24**	1.82	4.50**
CMS 16A	X	JGL8292	-22.02 **	-23.44 **	-20.54 **	-16..13**	-8.20**	-16.20**
CMS 16A	X	JGL3855	-2.15	-2.67	-1.62	0.94	-3.01*	-0.63
CMS 16A	X	JGL3844	-14.36 **	-16.22 **	-16.22 **	-30.77**	-34.32**	-32.71**
CMS 16A	X	JGL1798	-26.78 **	-27.57 **	-27.57 **	-42.91**	-43.03**	-41.39**
APMS 6A	X	JGL11110-2	-8.54 **	-10.27 **	-10.27 **	-4.57**	-5.80**	-3.50**
APMS 6A	X	JGL11110-1	-2.70	-6.25 **	-2.70	-3.83**	-5.19**	-4.99**
APMS 6A	X	JGL17211	-5.21 **	-7.49 **	-6.49 **	-2..57*	-5.38**	-5.18**
APMS 6A	X	JGL16284	-0.28	-0.56	-4.32 *	-2.08	-6.12**	-5.92**
APMS 6A	X	JGL13515	-1.95	-2.76	-4.86 *	-0.20	-1.49	1.35
APMS 6A	X	JGL11160	0.56	0.56	-3.24	0.58	0.37	0.59
APMS 6A	X	JGL11118	-11.29 **	-14.06 **	-10.81 **	-14.31**	-16.18**	-14.65**
APMS 6A	X	JGL11111	-12.26 **	-13.90 **	-12.97 **	-1.21	-4.80**	-3.05*
APMS 6A	X	JGL8605	-26.61 **	-27.22 **	-29.19 **	-26.73**	-30.28**	-29.01**
APMS 6A	X	JGL8292	-18.56 **	-18.78 **	-20.54 **	-18.23**	-18.65**	-16.31**
APMS 6A	X	JGL3855	1.68	1.11	-1.62	-8.09**	-9.00**	-7.34**
APMS 6A	X	JGL3844	-16.89 **	-19.27 **	-16.22 **	-4.52**	-5.77**	-5.78**
APMS 6A	X	JGL1798	-27.17 **	-28.34 **	-27.57 **	-22.11**	-24.28**	-24.28**
IR 58025A	X	JGL11110-2	-7.26 **	-8.29 **	-10.27 **	-4.87**	-8.70**	-8.70**
IR 58025A	X	JGL11110-1	-0.55	-0.55	-2.70	-5.91**	-7.23**	-4.56**
IR 58025A	X	JGL17211	-3.62	-4.42 *	-6.49 **	-14.42**	-14.50**	-14.51**
IR 58025A	X	JGL16284	-6.10 **	-7.81 **	-4.32 *	6.07**	4.96**	2.20
IR 58025A	X	JGL13515	-5.38 **	-5.88 **	-4.86 *	0.49	0.02	-4.65**
IR 58025A	X	JGL11160	-1.10	-3.24	-3.24	9.17**	7.23**	2.23
IR 58025A	X	JGL11118	-9.84 **	-10.81 **	-10.81 **	-2.81*	-6.38**	-3.68**
IR 58025A	X	JGL11111	-11.29 **	-12.97 **	-12.97 **	-7.12**	-9.20**	-9.38**
IR 58025A	X	JGL8605	-29.76 **	-31.77 **	-29.19 **	-16.51**	-19.33**	-15.75**
IR 58025A	X	JGL8292	-8.15 **	-9.63 **	-8.65 **	0.84	-3.99**	0.27
IR 58025A	X	JGL3855	3.35	2.21	0.00	1.82	-4.27**	-0.02
IR 58025A	X	JGL3844	0.55	0.55	-1.62	-18.38**	-18.98**	-15.39**
IR 58025A	X	JGL1798	-13.65 **	-14.36 **	-16.22 **	-24.43**	-26.10**	-22.82**

* Significant at 5% level; ** Significant at 1% level

4.2.7.8 Filled grains per panicle

The significant positive average heterosis was recorded in 23 hybrids, ranging from 139.18 (IR 58025A X JGL 16284) to 23.22 (APMS 6A x JGL 11110-2) at Kunaram (Table 4.36). The significant positive heterobeltiosis was observed in only 9 hybrids, which ranged from 137.59 (IR 58025A x JGL 16284) to 19.62 (IR 58025A x JGL 8292). The significant positive standard heterosis was recorded in 27 hybrids, with a range from 95.13 (APMS 6A x JGL 17211) to 32.71 (APMS 6A x JGL 3844), when compared with check PA 6201.

At Warangal, the significant positive average heterosis was recorded in 14 hybrids, and it ranged from 91.22 (APMS 8A x JGL 11111) to 7.61(CMS16 A x JGL 17211). The significant heterobeltiosis was recorded in 8 hybrids, which ranged from 86.68 (APMS 8A x JGL 11111) to 9.82 (APMS 6A x JGL 11110-2). The significant positive standard heterosis was recorded in 51 hybrids, which ranged from 276.92 (APMS 6A x JGL 11110-2) to 18.00 (IR 68897A x JGL 3844) when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was recorded in 22 hybrids, ranged from 114.94 (IR 58025A x JGL 8292) to 7.13 (IR58025A x JGL 11111). The significant positive heterobeltiosis was observed in 11 hybrids with range from 88.00 (IR 58025A x JGL 8292) to 8.70 (CMS16 A x JGL 17211). The significant positive standard heterosis was recorded in 38 hybrids, ranging between 144.79 (IR 58025A x JGL 8292) to 11.11 (IR 68897A x JGL 11110-1) when compared with check PA 6201.

In Pooled analysis, the significant positive average heterosis was recorded in 20 hybrids, which ranged between 52.81 (IR 58025A x JGL 16284) to 8.80 (APMS 6A x JGL 11110-1. The significant heterobeltiosis was recorded in 9 hybrids with a range from 43.75 (IR 58025A x JGL 16284) to 10.99 (IR 58025A x JGL 11160). The significant positive standard heterosis was recorded in 45 hybrids with a range from 102.64 (APMS 6A x JGL 11160) to 11.98 (IR58025A x JGL 11110-2) when compared with check PA 6201, for the character number of filled grains per panicle (Table 4.34).

The number of filled grains per panicle is the most important yield contributing character in the hybrids. Out of 65 hybrids, significant standard heterosis was recorded in 45 hybrids over the best check PA 6201. The hybrid APMS 6A x JGL 11160 (102.64) recorded the highest positive standard heterosis over the best check PA 6201. The heterobeltiosis recorded was 3.33 while average heterosis was 3.94 only. The other better hybrids with positive significant standard heterosis are APMS 6A x JGL

Table 4.36 Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for 1000 grain weight at Kunaram, Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	12.50	8.62	-11.27	28.52 **	17.36 **	-18.16 **
IR 68897A	X	JGL11110-1	-12.61	-20.00 **	-26.76 **	-22.50 **	-24.62 **	-44.39 **
IR 68897A	X	JGL17211	-7.27	-8.93	-28.17 **	-28.34 **	-32.87 **	-46.41 **
IR 68897A	X	JGL16284	23.53 **	16.67	-11.27	14.90 **	11.58 **	-22.20 **
IR 68897A	X	JGL13515	11.32	9.26	-16.90 **	-14.90 **	-17.36 **	-42.38 **
IR 68897A	X	JGL11160	8.26	1.72	-16.90 **	38.52 **	38.52 **	-20.18 **
IR 68897A	X	JGL11118	-1.72	-12.31	-19.72 **	9.22 **	-2.74	-28.25 **
IR 68897A	X	JGL11111	-2.80	-7.14	-26.76 **	-16.15 **	-27.81 **	-42.38 **
IR 68897A	X	JGL8605	13.13	9.80	-21.13 **	13.09 **	6.14 *	-30.27 **
IR 68897A	X	JGL8292	26.21 **	25.00 **	-8.45	26.18 **	18.43 **	-22.20 **
IR 68897A	X	JGL3855	10.28	1.72	-16.90 **	13.09 **	6.14 *	-30.27 **
IR 68897A	X	JGL3844	-1.75	-13.85	-21.13 **	0.00	-5.47 *	-30.27 **
IR 68897A	X	JGL1798	18.10 *	10.71	-12.68	-6.93 **	-15.17 **	-32.29 **
APMS 8A	X	JGL11110-2	-3.09	-4.08	-33.80 **	-12.29 **	-12.29 **	-42.38 **
APMS 8A	X	JGL11110-1	-4.95	-7.69	-32.39 **	-18.43 **	-18.43 **	-46.41 **
APMS 8A	X	JGL17211	-15.32 *	-18.97 *	-33.80 **	0.00	-3.27	-40.36 **
APMS 8A	X	JGL16284	-10.17	-18.46 **	-25.35 **	-14.90 **	-21.88 **	-42.38 **
APMS 8A	X	JGL13515	-4.59	-7.14	-26.76 **	-4.28	-15.17 **	-32.29 **
APMS 8A	X	JGL11160	-0.99	-5.66	-29.58 **	-3.17	-6.14 *	-38.34 **
APMS 8A	X	JGL11118	-12.38	-13.21	-35.21 **	0.00	-3.07	-36.32 **
APMS 8A	X	JGL11111	-14.81 *	-20.69 **	-35.21 **	-3.50	-3.50	-44.39 **
APMS 8A	X	JGL8605	-20.00 **	-29.23 **	-35.21 **	-12.29 **	-21.88 **	-42.38 **
APMS 8A	X	JGL8292	-18.87 *	-23.21 **	-39.44 **	-24.96 **	-35.39 **	-48.43 **
APMS 8A	X	JGL3855	-8.16	-10.00	-36.62 **	-9.82 **	-15.36 **	-44.39 **
APMS 8A	X	JGL3844	-1.96	-3.85	-29.58 **	6.55 *	0.00	-34.31 **
APMS 8A	X	JGL1798	-9.26	-15.52	-30.99 **	-1.72	-3.38	-42.38 **
CMS 16A	X	JGL11110-2	-13.04	-23.08 **	-29.58 **	-13.61 **	-21.88 **	-42.38 **
CMS 16A	X	JGL11110-1	-9.43	-14.29	-32.39 **	-26.05 **	-35.39 **	-48.43 **
CMS 16A	X	JGL17211	14.29	12.00	-21.13 **	4.83	0.00	-34.31 **
CMS 16A	X	JGL16284	-7.84	-9.62	-33.80 **	-14.49 **	-18.43 **	-46.41 **
CMS 16A	X	JGL13515	-15.32 *	-18.97 *	-33.80 **	10.51 **	10.51 **	-36.32 **
CMS 16A	X	JGL11160	-10.17	-18.46 **	-25.35 **	0.00	-10.94 **	-34.31 **
CMS 16A	X	JGL11118	-8.26	-10.71	-29.58 **	-7.34 **	-20.22 **	-36.32 **
CMS 16A	X	JGL11111	-4.95	-9.43	-32.39 **	-13.09 **	-18.43 **	-46.41 **
CMS 16A	X	JGL8605	-6.67	-7.55	-30.99 **	-9.82 **	-15.36 **	-44.39 **
CMS 16A	X	JGL8292	0.88	-1.72	-19.72 **	18.30 **	12.68 **	-28.25 **
CMS 16A	X	JGL3855	-13.33 *	-20.00 **	-26.76 **	-22.02 **	-27.36 **	-46.41 **
CMS 16A	X	JGL3844	-8.11	-8.93	-28.17 **	5.63 *	-5.06 *	-24.22 **
CMS 16A	X	JGL1798	-2.91	-9.09	-29.58 **	-1.56	-3.07	-36.32 **
APMS 6A	X	JGL11110-2	-4.67	-7.27	-28.17 **	-10.92 **	-12.29 **	-42.38 **
APMS 6A	X	JGL11110-1	11.71	6.90	-12.68	5.16	3.38	-38.34 **
APMS 6A	X	JGL17211	-3.39	-12.31	-19.72 **	13.61 **	2.74	-24.22 **
APMS 6A	X	JGL16284	-10.09	-12.50	-30.99 **	-17.36 **	-27.81 **	-42.38 **

Table 4.36 (cont.)

Hybrid			Kunaram Mid	Kunaram Better	Kunaram PA- 6201	Warangal Mid	Warangal Better	Warangal PA- 6201
APMS 6A	X	JGL13515	0.99	-3.77	-28.17 **	11.27 **	6.14 *	-30.27 **
APMS 6A	X	JGL11160	0.95	0.00	-25.35 **	8.05 **	3.07	-32.29 **
APMS 6A	X	JGL11118	-4.27	-5.08	-21.13 **	19.60 **	17.51 **	-32.29 **
APMS 6A	X	JGL11111	-17.74 **	-21.54 **	-28.17 **	7.80 **	-5.47 *	-30.27 **
APMS 6A	X	JGL8605	-18.26 **	-20.34 **	-33.80 **	-8.94 **	-22.75 **	-38.34 **
APMS 6A	X	JGL8292	0.93	-8.47	-23.94 **	4.99	-3.07	-36.32 **
APMS 6A	X	JGL3855	-0.90	-6.78	-22.54 **	18.30 **	9.22 **	-28.25 **
APMS 6A	X	JGL3844	-6.09	-6.90	-23.94 **	17.88 **	2.59	-20.18 **
APMS 6A	X	JGL1798	-13.11 *	-18.46 **	-25.35 **	-10.65 **	-12.97 **	-32.29 **
IR 58025A	X	JGL11110-2	0.88	0.00	-19.72 **	-14.08 **	-15.17 **	-32.29 **
IR 58025A	X	JGL11110-1	0.95	-7.02	-25.35 **	-14.06 **	-20.75 **	-38.34 **
IR 58025A	X	JGL17211	-4.59	-8.77	-26.76 **	-11.25 **	-18.16 **	-36.32 **
IR 58025A	X	JGL16284	-7.27	-12.07	-28.17 **	0.00	-3.27	-40.36 **
IR 58025A	X	JGL13515	-5.98	-15.38 *	-22.54 **	-2.98	-10.94 **	-34.31 **
IR 58025A	X	JGL11160	-7.41	-10.71	-29.58 **	-21.39 **	-30.34 **	-44.39 **
IR 58025A	X	JGL11118	2.00	-1.92	-28.17 **	0.00	-3.07	-36.32 **
IR 58025A	X	JGL11111	7.69	7.69	-21.13 **	6.34 *	3.07	-32.29 **
IR 58025A	X	JGL8605	-11.48	-15.63 *	-23.94 **	24.51 **	24.51 **	-28.25 **
IR 58025A	X	JGL8292	-24.03 **	-24.62 **	-30.99 **	-6.14 *	-16.41 **	-38.34 **
IR 58025A	X	JGL3855	-23.33 **	-28.13 **	-35.21 **	-16.15 **	-27.81 **	-42.38 **
IR 58025A	X	JGL3844	-3.57	-15.63 *	-23.94 **	19.64 **	12.29 **	-26.23 **
IR 58025A	X	JGL1798	-8.26	-10.71	-29.58 **	-6.55 *	-12.29 **	-42.38 **

Hybrid			Kampasagar Mid	Kampasagar Better	Kampasagar PA- 6201	Pooled Mid	Pooled Better	Pooled PA- 6201
IR 68897A	X	JGL11110-2	38.79 **	25.78 **	17.52 **	26.65**	-23.96**	-4.44*
IR 68897A	X	JGL11110-1	5.04	-6.72	-8.76 *	-9.57**	-16.59**	-27.12**
IR 68897A	X	JGL17211	17.82 **	14.42 **	-13.14 **	-6.67**	-8.52**	-29.70**
IR 68897A	X	JGL16284	60.62 **	49.04 **	13.14 **	32.59**	25.66**	-7.25**
IR 68897A	X	JGL13515	7.32	5.77	-19.71 **	1.46	-0.63	-26.66**
IR 68897A	X	JGL11160	46.55 **	32.81 **	24.09 **	30.90**	23.36**	-4.91*
IR 68897A	X	JGL11118	40.34 **	24.63 **	21.90 **	16.53**	3.75	-9.35**
IR 68897A	X	JGL11111	5.94	2.88	-21.90 **	-4.35	-9.74**	-30.63**
IR 68897A	X	JGL8605	76.17 **	63.46 **	24.09 **	34.30**	32.23**	-9.82**
IR 68897A	X	JGL8292	62.93 **	60.58 **	21.90 **	38.87**	36.34**	-3.51
IR 68897A	X	JGL3855	-4.04	-16.41 **	-21.90 **	5.96*	-0.30	-23.15**
IR 68897A	X	JGL3844	24.89 **	6.72	4.38	7.98**	-4.01	-16.13**
IR 68897A	X	JGL1798	63.73 **	61.22 **	15.33 **	23.57**	16.43**	-10.52**
APMS 8A	X	JGL11110-2	45.65 **	41.05 **	-2.19	9.42**	7.91*	-26.66**
APMS 8A	X	JGL11110-1	15.31 **	11.88 *	-17.52 **	-2.70	-4.63	-32.50**
APMS 8A	X	JGL17211	30.25 **	21.09 **	13.14 **	5.96*	2.43	-21.04**
APMS 8A	X	JGL16284	-2.46	-11.19 **	-13.14 **	-8.81**	-16.86**	27.36**
APMS 8A	X	JGL13515	49.04 **	40.91 **	13.14 **	13.04**	9.43**	-15.90**
APMS 8A	X	JGL11160	-4.52	-13.64 **	-30.66 **	-2.88	-6.83*	-32.97**
APMS 8A	X	JGL11118	32.70 **	27.27 **	2.19	7.05**	6.18*	-23.62**
APMS 8A	X	JGL11111	3.93	-7.03	-13.14 **	-4.71	-10.92**	-31.33**
APMS 8A	X	JGL8605	-1.28	-13.43 **	-15.33 **	-11.06**	-21.41**	-31.33**

Table 4.36(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	-19.60 **	-20.79 **	-41.61 **	-21.13**	-26.17**	-43.26**
APMS 8A	X	JGL3855	25.26 **	17.82 **	-13.14 **	2.46	1.74	-31.80**
APMS 8A	X	JGL3844	23.76 **	23.76 **	-8.76 *	9.50**	6.61*	-24.55**
APMS 8A	X	JGL1798	-12.93 **	-21.09 **	-26.28 **	-8.52**	-13.65**	-34.44**
CMS 16A	X	JGL11110-2	12.61 **	0.00	-2.19	-4.05	-14.45 **	-25.25**
CMS 16A	X	JGL11110-1	11.88 **	8.65	-17.52 **	-8.05**	-13.08**	-33.20**
CMS 16A	X	JGL17211	60.62 **	49.04 **	13.14 **	26.77**	24.60**	-14.73**
CMS 16A	X	JGL16284	16.10 **	14.42 **	-13.14 **	-1.68	-3.30	-31.57**
CMS 16A	X	JGL13515	-6.22	-11.72 **	-17.52 **	-4.89	-8.49**	-29.46**
CMS 16A	X	JGL11160	-30.36 **	-35.82 **	-37.23 **	-14.59**	22.48**	-32.27**
CMS 16A	X	JGL11118	-21.33 **	-26.55 **	-39.42 **	-2.32**	15.52**	-35.07**
CMS 16A	X	JGL11111	5.94	-5.31	-21.90 **	-3.75	-7.22*	-33.90**
CMS 16A	X	JGL8605	11.21 **	5.31	-13.14 **	-1.32	-1.64	29.93**
CMS 16A	X	JGL8292	-26.14 **	-30.47 **	-35.04 **	-4.33	-6.07*	-27.59**
CMS 16A	X	JGL3855	20.65 **	11.19 **	8.76 *	-3.76	-10.97**	-22.21**
CMS 16A	X	JGL3844	24.17 **	15.93 **	-4.38	6.96**	5.17	-19.17**
CMS 16A	X	JGL1798	53.47 **	37.17 **	13.14 **	16.49**	10.07**	-18.24**
APMS 6A	X	JGL11110-2	-11.21 **	-15.93 **	-30.66 **	-8.87**	-11.02**	-33.90**
APMS 6A	X	JGL11110-1	-15.13 **	-21.09 **	-26.28 **	-0.16	-3.94	-25.95**
APMS 6A	X	JGL17211	27.05 **	15.67 **	13.14 **	12.53**	2.14	-10.76**
APMS 6A	X	JGL16284	14.42 **	8.18	-13.14 **	-4.42	-7.91**	-29.23**
APMS 6A	X	JGL13515	7.54	-2.73	-21.90 **	6.47*	2.63	-26.89**
APMS 6A	X	JGL11160	-18.48 **	-21.82 **	-37.23 **	-3.62	-3.94	-31.57**
APMS 6A	X	JGL11118	-35.91 **	-36.64 **	-39.42 **	-10.58**	-10.85**	-30.87**
APMS 6A	X	JGL11111	-14.72 **	-15.67 **	-17.52 **	-9.64**	-14.72**	-25.49**
APMS 6A	X	JGL8605	-30.13 **	-38.93 **	-41.61 **	-19.54**	-19.90**	-37.88**
APMS 6A	X	JGL8292	-2.73	-18.32 **	-21.90 **	0.81	-6.63*	-27.59**
APMS 6A	X	JGL3855	2.59	-9.16 *	-13.14 **	5.83*	1.21	-21.51**
APMS 6A	X	JGL3844	-15.13 **	-21.09 **	-26.28 **	-2.09	-3.53	-23.38**
APMS 6A	X	JGL1798	-31.97 **	-38.06 **	-39.42 **	-18.79**	-22.48**	32.27**
IR 58025A	X	JGL11110-2	2.88	-2.73	-21.90 **	-3.74	-5.30	-24.79**
IR 58025A	X	JGL11110-1	-16.58 **	-24.55 **	-39.42 **	-9.80**	-17.37**	-34.37**
IR 58025A	X	JGL17211	-7.11	-10.91 *	-28.47 **	-7.63**	-12.66	-30.63**
IR 58025A	X	JGL16284	-7.76 *	-16.41 **	-21.90 **	-5.40*	-9.71**	-30.40**
IR 58025A	X	JGL13515	-25.21 **	-33.58 **	-35.04 **	-11.88**	-20.61**	-30.63**
IR 58025A	X	JGL11160	-5.94	-8.65	-30.66 **	-11.62**	-15.52**	-35.07**
IR 58025A	X	JGL11118	10.88 *	2.88	-21.90 **	4.29	1.33	-28.99**
IR 58025A	X	JGL11111	10.24 *	8.65	-17.52 **	8.14**	7.60*	-23.85**
IR 58025A	X	JGL8605	-17.52 **	-22.60 **	-17.52 **	-4.93*	-8.90**	-23.38**
IR 58025A	X	JGL8292	-23.57 **	-26.71 **	-21.90 **	-19.09**	-20.61**	-30.63**
IR 58025A	X	JGL3855	-14.75 **	-28.77 **	-24.09 **	-18.16**	-21.69**	-34.14**
IR 58025A	X	JGL3844	-8.94 *	-26.71 **	-21.90 **	1.09	-9.73**	-24.08**
IR 58025A	X	JGL1798	-10.93 **	-24.66 **	-19.71 **	-8.91**	-16.13**	-29.46**

* Significant at 5% level; ** Significant at 1% level

11110-2 (100.13), CMS 16A x JGL 13515 (93.35), APMS 8A x JGL 17211 (92.38) and APMS 8A x JGL 11110-1 (79.51), over the best check PA 6201 (Table 4.39 and Figure 4.7). Relative heterosis and heterobeltiosis of both positive and negative nature was reported by Hariramakrishna *et al*. (2009) and Roy *et al*. (2009). Earlier rice workers viz., Singh *et al.* (2006 a), Rosamma and Vijaykumar (2007) and Akarsh Parihar and Pathak (2008) reported both positive and negative heterobeltiosis and standard heterosis values for this trait.

4.2.7.9 Spikelet fertility percentage

At Kunaram, the significant positive average heterosis was recorded in 16 hybrids, (Table 4.37) ranging from 22.00 (IR 58025A x JGL 11160) to 4.31 (CMS16A x JGL 8605). The significant positive heterobeltiosis was recorded in only 3 hybrids viz., IR 68897A x JGL17211, IR 58025A x JGL 17211 (17.92) and IR 58025A x JGL 13515 (6.33). None of the hybrid recorded significant positive standard heterosis, when compared with check PA 6201, for the character spikelet fertility percentage.

At Warangal, the significant positive average heterosis was recorded in 18 hybrids, which ranged from 16.01 (APMS 6A x JGL 1798) to 3.34 (IR 58025A x JGL 13515). The Significant heterobeltiosis was recorded in 8 hybrids which ranged between 12.09 (APMS 6A x JGL 1798) to 3.80 (IR 58025A x JGL 11118). The significant standard heterosis was recorded in 33 hybrids, which ranged from 16.10 (CMS 16A x JGL 3855) to 4.63 (APMS 8A x JGL 11110-1) when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was recorded in 7 hybrids, which ranged between 18.59 (IR 68897A x JGL 13515) to 4.13 (CMS16A x JGL 8605).The significant heterobeltiosis was recorded in 2 hybrids viz; APMS 8A x JGL l1160 (4.97) and APMS 8A x JGL 13515(4.52). None of the hybrid recorded significant standard heterosis over PA 6201, for the character spikelet fertility percentage.

In pooled analysis, for the character spikelet fertility percentage, the significant positive average heterosis was recorded in 10 hybrids which ranged between 10.95 (IR 68897A x JGL 17211) to 2.16 (CMS 16A x JGL 11160). The significant heterobeltiosis was recorded in 8 hybrids, ranged between 12.84 (APMS 8A x JGL 8292) to 3.04 (IR 68897A x JGL 11110-1). The significant standard positive heterosis was recorded in two hybrids viz., CMS 16A x JGL 8605 (4.5) and APMS 8A x JGL 8292 (3.76), when compared with check PA 6201 (Table 4.35).

Table 4.37. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for single plant yield at Kunaram, Warangal, Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	1.89	-13.81 **	-20.10 **	2.06	-14.83 **	-21.46 **
IR 68897A	X	JGL11110-1	-2.54	-16.84 **	-22.90 **	-2.76	-18.08 **	-24.46 **
IR 68897A	X	JGL17211	-8.18 **	-21.48 **	-27.20 **	-8.90 **	-23.06 **	-29.05 **
IR 68897A	X	JGL16284	7.93 **	-6.71 **	-13.51 **	8.61 **	-7.20 *	-14.42 **
IR 68897A	X	JGL13515	8.30 **	-9.58 **	-16.17 **	9.04 **	-10.29 **	-17.27 **
IR 68897A	X	JGL11160	12.96 **	1.03	-17.84 **	14.21 **	1.12	-19.05 **
IR 68897A	X	JGL11118	-14.31 **	-22.65 **	-37.10 **	-15.67 **	-24.57 **	-39.62 **
IR 68897A	X	JGL11111	13.28 **	2.51	-16.64 **	14.53 **	2.72	-17.77 **
IR 68897A	X	JGL8605	9.62 **	0.35	-18.39 **	10.52 **	0.39	-19.64 **
IR 68897A	X	JGL8292	26.65 **	11.68 **	-9.18 **	29.24 **	12.67 **	-9.81 **
IR 68897A	X	JGL3855	-5.86 **	-18.82 **	-28.15 **	-6.39	-20.27 **	-30.06 **
IR 68897A	X	JGL3844	2.82	-10.54 **	-20.83 **	3.08	-11.36 **	-22.24 **
IR 68897A	X	JGL1798	-2.79	-15.23 **	-24.98 **	-3.04	-16.40 **	-26.67 **
APMS 8A	X	JGL11110-2	42.42 **	25.58 **	11.13 **	46.18 **	27.56 **	11.89 **
APMS 8A	X	JGL11110-1	42.02 **	20.84 **	6.94 **	45.89 **	22.44 **	7.40 **
APMS 8A	X	JGL17211	11.24 **	-2.59	-16.85 **	12.29 **	-2.79	-17.99 **
APMS 8A	X	JGL16284	8.02 **	-4.54	-18.52 **	8.76 **	-4.91	-19.78 **
APMS 8A	X	JGL13515	26.82 **	12.34 **	-4.11 *	29.28 **	13.33 **	-4.39
APMS 8A	X	JGL11160	-1.97	-12.18 **	-25.04 **	-2.15	-13.16 **	-26.74 **
APMS 8A	X	JGL11118	-7.85 **	-20.40 **	-32.06 **	-8.59 *	-22.04 **	-34.24 **
APMS 8A	X	JGL11111	27.70 **	16.11 **	-9.01 **	30.41 **	17.52 **	-9.63 **
APMS 8A	X	JGL8605	38.28 **	26.92 **	-0.53	41.99 **	29.30 **	-0.57
APMS 8A	X	JGL8292	9.92 **	1.15	-20.73 **	10.88 **	1.25	-22.14 **
APMS 8A	X	JGL3855	20.32 **	12.03 **	-12.20 **	22.26 **	13.09 **	-13.03 **
APMS 8A	X	JGL3844	6.25 *	-4.78	-25.38 **	6.87	-5.20	-27.10 **
APMS 8A	X	JGL1798	-11.62 **	-17.89 **	-38.62 **	-12.78 **	-19.55 **	-41.24 **
CMS 16A	X	JGL11110-2	2.46	-3.89	-28.15 **	2.70	-4.25	-30.06 **
CMS 16A	X	JGL11110-1	6.99 **	0.63	-24.78 **	2.63	-4.04	-29.91 **
CMS 16A	X	JGL17211	-10.66 **	-14.95 **	-36.42 **	-51.08 **	-53.65 **	-66.15 **
CMS 16A	X	JGL16284	17.60 **	7.65 **	-19.53 **	14.20 **	3.63	-24.30 **
CMS 16A	X	JGL13515	21.53 **	11.55 **	-14.39 **	18.62 **	8.00 *	-18.83 **
CMS 16A	X	JGL11160	7.56 **	-0.33	-23.51 **	3.31	-4.94	-28.55 **
CMS 16A	X	JGL11118	18.65 **	10.24 **	-15.40 **	15.50 **	6.57	-19.90 **
CMS 16A	X	JGL11111	-1.54	-7.43 **	-28.96 **	-10.33 **	-16.17 **	-37.00 **
CMS 16A	X	JGL8605	-9.01 **	-17.69 **	-36.83 **	-5.38	-15.22 **	-36.28 **
CMS 16A	X	JGL8292	-4.99 *	-17.43 **	-28.25 **	2.39	-12.08 **	-24.39 **
CMS 16A	X	JGL3855	15.49 **	1.27	-12.00 **	14.73 **	-0.51	-14.44 **
CMS 16A	X	JGL3844	9.26 **	-3.96	-16.55 **	4.64	-9.02 **	-21.76 **
CMS 16A	X	JGL1798	-6.80 **	-17.16 **	-28.02 **	5.17	-7.44 *	-20.40 **
APMS 6A	X	JGL11110-2	32.53 **	13.62 **	-1.27	37.69 **	16.50 **	0.19
APMS 6A	X	JGL11110-1	48.21 **	37.52 **	3.08	45.17 **	33.72 **	-2.04
APMS 6A	X	JGL17211	25.47 **	17.55 **	-11.89 **	35.60 **	26.25 **	-7.52 **
APMS 6A	X	JGL16284	45.83 **	36.98 **	2.67	42.00 **	32.59 **	-2.87

Table 4.37(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	21.51 **	15.52 **	-13.41 **	22.76 **	16.15 **	-14.91 **
APMS 6A	X	JGL11160	23.92 **	13.29 **	-15.08 **	26.10 **	14.28 **	-16.28 **
APMS 6A	X	JGL11118	37.34 **	25.73 **	-2.94	36.01 **	23.47 **	-6.59 *
APMS 6A	X	JGL11111	45.27 **	34.26 **	3.64	44.72 **	32.77 **	0.44
APMS 6A	X	JGL8605	43.92 **	33.35 **	2.94	43.24 **	31.78 **	-0.31
APMS 6A	X	JGL8292	32.48 **	24.21 **	-4.11 *	30.70 **	21.82 **	-7.84 **
APMS 6A	X	JGL3855	12.61 **	1.60	-21.57 **	8.78 *	-2.82	-26.48 **
APMS 6A	X	JGL3844	-4.04	-16.58 **	-27.57 **	-9.09 **	-21.91 **	-32.90 **
APMS 6A	X	JGL1798	-3.29	-15.17 **	-26.35 **	-8.22 *	-20.39 **	-31.59 **
IR 58025A	X	JGL11110-2	1.55	-10.71 **	-22.47 **	1.70	-11.55 **	-23.99 **
IR 58025A	X	JGL11110-1	-1.49	-12.42 **	-23.96 **	-1.64	-13.41 **	-25.59 **
IR 58025A	X	JGL17211	2.89	-11.77 **	-23.39 **	3.15	-12.70 **	-24.98 **
IR 58025A	X	JGL16284	25.16 **	9.99 **	-6.89 **	27.51 **	10.80 **	-7.36 **
IR 58025A	X	JGL13515	15.50 **	2.43	-13.29 **	16.92 **	2.62	-14.20 **
IR 58025A	X	JGL11160	13.09 **	0.53	-14.90 **	14.28 **	0.57	-15.91 **
IR 58025A	X	JGL11118	6.04 **	-4.66 *	-19.29 **	6.59 *	-5.04	-20.60 **
IR 58025A	X	JGL11111	15.23 **	-0.12	-15.45 **	16.68 **	-0.13	-16.50 **
IR 58025A	X	JGL8605	-6.64 **	-16.18 **	-32.43 **	-7.28 *	-17.56 **	-34.63 **
IR 58025A	X	JGL8292	0.64	-8.79 **	-26.48 **	0.70	-9.55 **	-28.28 **
IR 58025A	X	JGL3855	0.05	-9.11 **	-26.73 **	0.04	-9.89 **	-28.55 **
IR 58025A	X	JGL3844	-13.40 **	-20.41 **	-35.84 **	-14.66 **	-22.15 **	-38.27 **
IR 58025A	X	JGL1798	-4.32	-15.31 **	-31.73 **	-4.74	-16.62 **	-33.88 **
Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	2.26	-16.24 **	-23.46 **	2.06	-14.90**	-21.59**
IR 68897A	X	JGL11110-1	-2.97 *	-19.72 **	-26.64 **	-2.74	-18.14**	-24.57**
IR 68897A	X	JGL17211	-9.98 **	-25.32 **	-31.76 **	-8.96**	23.18**	-29.22**
IR 68897A	X	JGL16284	9.48 **	-7.90 **	-15.84 **	8.62**	-7.24**	-14.53**
IR 68897A	X	JGL13515	10.02 **	-11.30 **	-18.94 **	9.07**	-10.34**	-17.39**
IR 68897A	X	JGL11160	15.91 **	1.17	-20.88 **	14.26**	1.10	-19.18**
IR 68897A	X	JGL11118	-17.68 **	-27.35 **	-43.19 **	-15.77**	-24.71**	-39.82**
IR 68897A	X	JGL11111	16.40 **	3.03	-19.43 **	14.63**	2.74	-17.87**
IR 68897A	X	JGL8605	11.70 **	0.38	-21.50 **	10.54**	0.37	-19.76**
IR 68897A	X	JGL8292	32.96 **	14.06 **	-10.80 **	29.39**	12.73**	-9.89**
IR 68897A	X	JGL3855	-7.27 **	-22.38 **	-32.86 **	-6.46**	-20.39**	-30.24**
IR 68897A	X	JGL3844	3.39 *	-12.55 **	-24.36 **	3.08	-11.43**	-22.39**
IR 68897A	X	JGL1798	-3.40 *	-18.06 **	-29.12 **	-3.06	-16.48**	-26.82**
APMS 8A	X	JGL11110-2	51.72 **	30.55 **	12.93 **	46.47**	27.75**	11.94**
APMS 8A	X	JGL11110-1	51.52 **	24.78 **	7.94 **	46.15**	22.57**	7.40**
APMS 8A	X	JGL17211	13.76 **	-3.13 *	-19.66 **	12.34**	-2.82	-18.10**
APMS 8A	X	JGL16284	9.74 **	-5.55 **	-21.66 **	8.78**	-4.97**	-19.91**
APMS 8A	X	JGL13515	32.85 **	14.68 **	-4.89 **	29.45**	13.38**	-4.45**
APMS 8A	X	JGL11160	-2.66	-14.73 **	-29.28 **	-2.23	-13.28**	-26.92**
APMS 8A	X	JGL11118	-9.86 **	-24.51 **	-37.39 **	-8.69**	-22.20**	-34.43**
APMS 8A	X	JGL11111	34.44 **	19.69 **	-10.59 **	30.60**	17.65**	-9.70**
APMS 8A	X	JGL8605	47.47 **	32.80 **	-0.80	42.25**	29.48**	-0.63

Table 4.37(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	12.29 **	1.42	-24.24 **	10.94**	1.27	-22.28**
APMS 8A	X	JGL3855	25.08 **	14.75 **	-14.28 **	22.39**	13.20**	-13.12**
APMS 8A	X	JGL3844	7.68 **	-5.82 **	-29.65 **	6.88**	-5.23**	-27.27**
APMS 8A	X	JGL1798	-14.61 **	-22.03 **	-44.97 **	-12.89**	-19.68**	-44.23**
CMS 16A	X	JGL11110-2	3.03	-4.81 **	-32.82 **	2.71	-4.29*	-30.23**
CMS 16A	X	JGL11110-1	8.65 **	0.70	-28.93 **	6.02**	-0.92	-27.77**
CMS 16A	X	JGL17211	6.16 **	-0.02	-29.44 **	-19.24**	-23.49**	-44.23**
CMS 16A	X	JGL16284	22.02 **	9.39 **	-22.80 **	17.76**	6.82**	-22.13**
CMS 16A	X	JGL13515	26.74 **	14.02 **	-16.82 **	22.09**	11.10**	-16.82**
CMS 16A	X	JGL11160	9.28 **	-0.55	-27.45 **	6.64**	-1.94	-26.41**
CMS 16A	X	JGL11118	23.08 **	12.35 **	-18.03 **	18.90**	9.64**	-17.72**
CMS 16A	X	JGL11111	-2.16	-9.26 **	-33.80 **	-4.67**	-10.91**	-33.14**
CMS 16A	X	JGL8605	-11.52 **	-21.82 **	-42.97 **	-8.53**	-8.10 **	-38.53**
CMS 16A	X	JGL8292	-6.08 **	-20.71 **	-32.84 **	-2.84	-6.63**	-28.37**
CMS 16A	X	JGL3855	18.85 **	1.40	-14.11 **	16.24**	0.71	-13.47**
CMS 16A	X	JGL3844	11.31 **	-4.77 **	-19.33 **	8.32**	-5.90**	-19.15**
CMS 16A	X	JGL1798	-8.52 **	-20.59 **	-32.74 **	-3.30*	-14.95**	-26.92**
APMS 6A	X	JGL11110-2	39.80 **	16.10 **	-1.66	36.43**	15.34**	-0.90
APMS 6A	X	JGL11110-1	60.17 **	46.02 **	3.43 **	50.72**	38.78**	1.47
APMS 6A	X	JGL17211	31.81 **	21.56 **	-13.89 **	30.74**	21.66**	-11.04**
APMS 6A	X	JGL16284	57.14 **	45.39 **	2.99 *	47.89**	38.02**	0.92
APMS 6A	X	JGL13515	26.49 **	18.92 **	-15.76 **	23.41**	16.75**	-14.64**
APMS 6A	X	JGL11160	29.96 **	16.32 **	-17.60 **	26.43**	14.53**	-16.26**
APMS 6A	X	JGL11118	46.57 **	31.56 **	-3.52 **	39.62**	26.71**	-4.34**
APMS 6A	X	JGL11111	56.41 **	42.00 **	4.14 **	48.38**	36.08**	2.72*
APMS 6A	X	JGL8605	54.62 **	40.82 **	3.27 *	46.86**	35.06**	1.95
APMS 6A	X	JGL8292	40.07 **	29.59 **	-4.97 **	34.14**	5.02**	-5.62**
APMS 6A	X	JGL3855	15.69 **	1.99	-25.20 **	12.23**	0.24	-24.33**
APMS 6A	X	JGL3844	-4.97 **	-19.73 **	-32.10 **	-6.01**	-19.32**	-30.75**
APMS 6A	X	JGL1798	-4.02 **	-18.06 **	-30.70 **	-5.16**	-17.80**	-29.44**
IR 58025A	X	JGL11110-2	1.90	-12.76 **	-26.21 **	1.71	-7.61**	-24.13**
IR 58025A	X	JGL11110-1	-1.97	-14.85 **	-27.98 **	-1.68	-13.49**	-25.74**
IR 58025A	X	JGL17211	3.45 *	-14.05 **	-27.30 **	3.14	-2.77**	-25.13**
IR 58025A	X	JGL16284	31.05 **	12.06 **	-7.99 **	27.70**	10.89**	-7.38**
IR 58025A	X	JGL13515	19.18 **	3.01	-15.42 **	17.07**	2.67	-14.25**
IR 58025A	X	JGL11160	16.21 **	0.73	-17.29 **	14.42**	0.61	-15.97**
IR 58025A	X	JGL11118	7.39 **	-5.52 **	-22.43 **	6.63**	-5.05**	-20.70**
IR 58025A	X	JGL11111	18.63 **	-0.25	-18.10 **	16.73**	-0.16	-16.62**
IR 58025A	X	JGL8605	-8.24 **	-19.53 **	-37.75 **	-7.33**	.17.65**	-34.81**
IR 58025A	X	JGL8292	0.78	-10.63 **	-30.87 **	0.70	-9.60**	-28.43**
IR 58025A	X	JGL3855	0.03	-11.03 **	-31.18 **	0.04	-9.95**	-28.71**
IR 58025A	X	JGL3844	-16.64 **	-24.72 **	-41.77 **	-14.79**	-22.29**	-38.48**
IR 58025A	X	JGL1798	-5.46 **	-18.53 **	-36.98 **	-4.80**	-16.71**	-34.07**

* Significant at 5% level; ** Significant at 1% level

The spikelet fertility percentage is yet another important character which directly influences the ultimate product. Significant standard heterosis recorded was in only two hybrids in pooled analysis viz., CMS 16A x JGL 8605 (4.5) and APMS 8A x JGL 8292 (3.76), over best check PA 6201.Standard heterosis of both positive and negative nature was observed by Balasundara (2000), Panwar *et al.* (2002) and Banumurthy *et al.* (2003), whereas similar nature of mid parental heterosis and heterobeltiosis was reported by Hariramakrishnan *et al.* (2009) (Table 4.39 and Figure 4.7).

4.2.7.10 1000 grain weight

At Kunaram, the significant positive standard heterosis was recorded in only 3 hybrids viz., IR 68897A x JGL 8292 (26.21), IR 68897A x JGL 16284 (23.53) and IR68897A x JGL 1798(18.10). The significant heterobeltiosis was recorded in only one hybrids IR 6887 A x JGL 8292 (25.00) for the character 1000 grain weight. None of the hybrid recorded significant standard heterosis, when compared with check PA 6201, for the character 1000 grain weight.

At Warangal, the significant positive average heterosis was recorded in 21 hybrids, ranging from 38.52 (IR 68897A x JGL 11160) to 5.63 (CMS16 Ax JGL3844). The significant heterobeltiosis was recorded in 13 hybrids, ranging from 38.52 (IR 68897A x JGL 11160) to 6.14 (APMS 6A x JGL 13515), where as none of the hybrid recorded significant standard heterosis, when compared with check PA 6201, for the character 1000 grain weight (Table 4.37).

1000 grain weight of a genotype serves as an indicator to the end product i.e. grain yield. The significant standard heterosis was recorded only in three hybrids viz., APMS 6A x JGL 1798 (32.27), CMS 16A x JGL 8605 (29.93) and APMS 8A x JGL 16284 (27.36), over best check PA 6201(Table 4.39 and Figure 4.7). For this character both significant positive and negative heterobeltiosis and standard heterosis was recorded. Similar results were reported by Singh *et al.* (2006 b), Deoraj *et al.* (2007) and Akarsh Parihar and Pathak (2008), whereas only positive nature of relative heterosis was observed by Verma *et al.* (2004), Hariramakrishnan *et al.* (2009) and Roy *et al.* (2009).

4.2.7.11 Single plant yield (gm)

At Kunaram, the significant positive average heterosis was recorded in 39 hybrids, ranging between 48.21 (AMS 6A x JGL 11110-1) to 6.04 (IR 58025A x JGL 11118). The significant heterobeltiosis was recorded in 21 hybrids ranging from 37.52 (APMS 6A x JGL 11110-1) to 7.65 (CMS 16A x JGL 16284). The significant positive

Table 4.38. Estimates of heterosis, heterobeltiosis and standard heterosis (over PA- 6201) for productivity/day at Kunaram, Warangal,Kampasagar and Pooled.

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	7.46 **	-10.19 **	-20.10 **	0.27	-11.15 **	-23.18 **
IR 68897A	X	JGL11110-1	3.04	-9.53 **	-19.51 **	18.03 **	3.97	-10.11 **
IR 68897A	X	JGL17211	-8.52 **	-23.03 **	-31.52 **	9.95 **	-2.86	-16.01 **
IR 68897A	X	JGL16284	15.04 **	-2.29	-13.06 **	6.51 **	-5.25 *	-18.08 **
IR 68897A	X	JGL13515	13.80 **	-6.28 *	-16.62 **	25.09 **	8.84 **	-5.90 **
IR 68897A	X	JGL11160	30.19 **	14.42 **	-9.79 **	21.40 **	13.11 **	-12.54 **
IR 68897A	X	JGL11118	-4.92	-11.90 **	-30.54 **	5.12 *	-2.67	-24.75 **
IR 68897A	X	JGL11111	19.42 **	5.72 *	-16.65 **	15.72 **	7.49 **	-16.89 **
IR 68897A	X	JGL8605	25.28 **	12.04 **	-11.67 **	17.84 **	10.25 **	-14.75 **
IR 68897A	X	JGL8292	36.75 **	18.30 **	-6.74 **	25.85 **	15.01 **	-11.08 **
IR 68897A	X	JGL3855	4.97	-10.51 **	-24.19 **	3.63	-6.70 **	-22.21 **
IR 68897A	X	JGL3844	10.87 **	-0.54	-15.74 **	11.14 **	-0.53	-17.07 **
IR 68897A	X	JGL1798	5.88 *	-9.09 **	-22.99 **	4.57	-6.12 *	-21.73 **
APMS 8A	X	JGL11110-2	43.41 **	24.33 **	5.33 *	29.80 **	17.33 **	-2.17
APMS 8A	X	JGL11110-1	42.82 **	19.94 **	1.60	31.06 **	15.83 **	-3.42
APMS 8A	X	JGL17211	14.12 **	-0.59	-19.99 **	4.09	-5.99 *	-22.15 **
APMS 8A	X	JGL16284	6.91 *	-1.86	-21.01 **	15.09 **	3.31	-14.45 **
APMS 8A	X	JGL13515	28.37 **	12.63 **	-9.35 **	17.08 **	5.42 *	-12.70 **
APMS 8A	X	JGL11160	-0.91	-12.18 **	-29.31 **	-4.71	-13.60 **	-28.46 **
APMS 8A	X	JGL11118	-7.40 *	-20.59 **	-36.08 **	-7.52 **	-18.03 **	-32.12 **
APMS 8A	X	JGL11111	31.56 **	19.61 **	-12.69 **	42.49 **	35.76 **	0.09
APMS 8A	X	JGL8605	36.09 **	30.76 **	-4.55 *	36.50 **	29.22 **	-4.73 *
APMS 8A	X	JGL8292	13.49 **	3.97	-24.10 **	29.52 **	23.02 **	-9.31 **
APMS 8A	X	JGL3855	26.92 **	17.51 **	-14.22 **	39.06 **	33.05 **	-1.91
APMS 8A	X	JGL3844	10.55 **	-1.13	-27.83 **	13.64 **	6.15 *	-21.74 **
APMS 8A	X	JGL1798	-13.28 **	-20.90 **	-42.68 **	-9.36 **	-12.85 **	-36.96 **
CMS 16A	X	JGL11110-2	-2.31	-5.81	-31.74 **	1.39	-3.15	-29.94 **
CMS 16A	X	JGL11110-1	5.45	-3.08	-29.76 **	21.60 **	16.54 **	-15.70 **
CMS 16A	X	JGL17211	-9.10 **	-15.56 **	-38.81 **	-34.30 **	-36.56 **	-54.11 **
CMS 16A	X	JGL16284	17.59 **	5.50	-23.54 **	8.73 **	2.47	-25.88 **
CMS 16A	X	JGL13515	14.52 **	-0.27	-19.67 **	28.72 **	18.50 **	-5.95 **
CMS 16A	X	JGL11160	0.09	-8.16 **	-26.02 **	-0.24	-8.73 **	-27.56 **
CMS 16A	X	JGL11118	13.22 **	-0.70	-20.01 **	10.33 **	1.26	-19.63 **
CMS 16A	X	JGL11111	-4.25	-15.17 **	-31.67 **	5.61 *	-2.38	-22.52 **
CMS 16A	X	JGL8605	-13.09 **	-25.49 **	-39.98 **	9.85 **	-0.79	-21.25 **
CMS 16A	X	JGL8292	-2.01	-15.55 **	-30.28 **	-4.42	-16.89 **	-24.93 **
CMS 16A	X	JGL3855	26.42 **	14.72 **	-5.30 *	26.51 **	9.38 **	-1.20
CMS 16A	X	JGL3844	15.86 **	0.56	-16.98 **	-0.95	-14.11 **	-22.42 **
CMS 16A	X	JGL1798	-4.57	-16.35 **	-30.94 **	-4.17	-16.36 **	-24.45 **
APMS 6A	X	JGL11110-2	42.41 **	20.86 **	-0.23	20.07 **	2.57	-7.35 **
APMS 6A	X	JGL11110-1	55.98 **	44.72 **	1.04	29.72 **	24.03 **	-9.23 **
APMS 6A	X	JGL17211	25.28 **	22.99 **	-14.13 **	26.93 **	20.58 **	-11.75 **
APMS 6A	X	JGL16284	50.75 **	40.96 **	-1.58	28.80 **	22.76 **	-10.16 **

Table 4.38(cont.)

Hybrid			Kunaram			Warangal		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 6A	X	JGL13515	28.51 **	21.48 **	-15.19 **	21.26 **	16.44 **	-14.79 **
APMS 6A	X	JGL11160	35.51 **	23.62 **	-13.69 **	19.62 **	12.11 **	-17.95 **
APMS 6A	X	JGL11118	42.45 **	28.37 **	-4.42	24.90 **	17.98 **	-11.42 **
APMS 6A	X	JGL11111	40.35 **	33.58 **	-0.54	52.10 **	42.76 **	7.19 **
APMS 6A	X	JGL8605	46.53 **	33.04 **	-0.94	32.00 **	24.29 **	-6.68 **
APMS 6A	X	JGL8292	35.74 **	24.54 **	-7.27 **	30.36 **	23.66 **	-7.15 **
APMS 6A	X	JGL3855	14.57 **	1.57	-24.37 **	6.23 *	-1.61	-26.13 **
APMS 6A	X	JGL3844	-1.51	-14.47 **	-30.66 **	-1.10	-9.81 **	-26.91 **
APMS 6A	X	JGL1798	-5.18	-13.25 **	-29.67 **	-4.86 *	-13.77 **	-30.12 **
IR 58025A	X	JGL11110-2	3.11	-9.81 **	-26.89 **	3.30	-6.08 *	-23.89 **
IR 58025A	X	JGL11110-1	0.37	-11.33 **	-28.12 **	1.78	-6.81 **	-24.48 **
IR 58025A	X	JGL17211	5.33	-9.94 **	-26.99 **	13.66 **	1.71	-17.58 **
IR 58025A	X	JGL16284	24.16 **	6.12 *	-10.64 **	19.30 **	9.27 **	-12.30 **
IR 58025A	X	JGL13515	8.23 **	-2.65	-18.03 **	11.96 **	1.92	-18.21 **
IR 58025A	X	JGL11160	31.19 **	12.92 **	-4.92 *	31.08 **	19.70 **	-3.93
IR 58025A	X	JGL11118	12.27 **	-2.42	-17.83 **	22.97 **	13.09 **	-9.24 **
IR 58025A	X	JGL11111	14.18 **	-3.88	-19.06 **	28.93 **	15.87 **	-7.01 **
IR 58025A	X	JGL8605	-10.03 **	-21.50 **	-37.06 **	-7.68 **	-15.35 **	-32.22 **
IR 58025A	X	JGL8292	-7.12 **	-14.59 **	-31.52 **	14.39 **	4.23	-16.53 **
IR 58025A	X	JGL3855	-1.70	-13.61 **	-30.73 **	20.01 **	9.70 **	-12.15 **
IR 58025A	X	JGL3844	-12.02 **	-21.90 **	-37.38 **	4.44	-3.86	-23.01 **
IR 58025A	X	JGL1798	-1.83	-15.67 **	-32.38 **	12.72 **	1.40	-18.80 **
Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
IR 68897A	X	JGL11110-2	1.91	-17.38 **	-27.77 **	2.63	-12.75**	-23.74**
IR 68897A	X	JGL11110-1	8.67 *	-6.72	-18.45 **	11.26**	-2.82	-15.06**
IR 68897A	X	JGL17211	-0.76	-19.15 **	-29.32 **	2.02	-13.10**	-24.05**
IR 68897A	X	JGL16284	15.49 **	-4.55	-16.55 **	11.33**	-4.25*	-16.31**
IR 68897A	X	JGL13515	25.60 **	-0.17	-12.72 **	22.26**	2.11	-10.75**
IR 68897A	X	JGL11160	30.95 **	12.08 **	-14.46 **	26.39**	13.16**	-12.39**
IR 68897A	X	JGL11118	-6.26	-14.65 **	-34.86 **	-0.88	-8.65**	-29.28**
IR 68897A	X	JGL11111	19.60 **	2.91	-21.45 **	17.79**	5.67**	-18.19**
IR 68897A	X	JGL8605	26.73 **	10.76 *	-15.46 **	22.32**	10.88**	-14.15**
IR 68897A	X	JGL8292	36.73 **	14.54 **	-12.58 **	31.76**	15.75**	-10.38**
IR 68897A	X	JGL3855	4.29	-13.29 **	-28.94 **	4.17*	-9.64**	-24.73**
IR 68897A	X	JGL3844	3.55	-8.63 *	-25.13 **	8.87**	-2.91	-19.12**
IR 68897A	X	JGL1798	6.08	-11.34 **	-27.35 **	5.34**	-8.45**	-23.73**
APMS 8A	X	JGL11110-2	47.55 **	25.17 **	2.57	38.42**	21.50**	1.21
APMS 8A	X	JGL11110-1	48.82 **	21.22 **	-0.67	39.13**	18.51**	-1.28
APMS 8A	X	JGL17211	13.13 **	-3.60	-25.64 **	9.19**	-3.89	-22.62**
APMS 8A	X	JGL16284	20.31 **	9.02 *	-15.91 **	14.40**	3.58	-16.61**
APMS 8A	X	JGL13515	30.15 **	11.50 *	-14.00 **	23.65**	9.05**	-12.21**
APMS 8A	X	JGL11160	-4.03	-16.50 **	-35.59 **	-3.53	-14.06**	-30.81**
APMS 8A	X	JGL11118	-10.91 *	-25.68 **	-42.67 **	-8.42**	-20.88**	-36.30**
APMS 8A	X	JGL11111	32.65 **	18.60 **	-18.25 **	36.92**	26.58**	-8.73**
APMS 8A	X	JGL8605	45.54 **	38.92 **	-4.24	38.97**	32.39**	-4.54**

Table 4.38(cont.)

Hybrid			Kampasagar			Pooled		
			Mid	Better	PA- 6201	Mid	Better	PA- 6201
APMS 8A	X	JGL8292	27.16 **	14.33 **	-21.18 **	24.66**	15.48**	-16.73**
APMS 8A	X	JGL3855	41.37 **	29.22 **	-10.92 **	36.51**	27.83**	-7.83**
APMS 8A	X	JGL3844	11.92 *	-2.20	-32.58 **	12.36**	1.84	-26.57**
APMS 8A	X	JGL1798	-19.82 **	-27.93 **	-50.92 **	-13.27**	-19.31**	-42.62**
CMS 16A	X	JGL11110-2	-6.06	-9.80	-38.58 **	-1.73	-5.76*	-32.99**
CMS 16A	X	JGL11110-1	25.75 **	13.68 **	-22.59 **	18.49**	10.48**	-21.44**
CMS 16A	X	JGL17211	4.41	-4.03	-34.65 **	-16.89**	-21.66**	-44.30**
CMS 16A	X	JGL16284	18.12 **	3.77	-29.34 **	13.64**	3.65	-26.30**
CMS 16A	X	JGL13515	33.37 **	13.73 **	-12.42 **	26.29**	12.08**	-11.48**
CMS 16A	X	JGL11160	-3.45	-12.45 **	-32.58 **	-1.08	-9.66**	-28.65**
CMS 16A	X	JGL11118	15.52 **	-0.97	-23.74 **	12.54**	0.09	-20.95**
CMS 16A	X	JGL11111	6.65	-7.14	-28.49 **	3.30	-7.19**	-26.70**
CMS 16A	X	JGL8605	-15.69 **	-29.62 **	-45.81 **	-3.30	-15.78**	-33.48**
CMS 16A	X	JGL8292	-8.58	-23.26 **	-38.58 **	-4.94*	-18.33**	-30.40**
CMS 16A	X	JGL3855	36.22 **	21.43 **	-2.81	29.23**	14.11**	-2.75
CMS 16A	X	JGL3844	16.61 **	-1.61	-21.25 **	8.18**	-6.88**	-20.64**
CMS 16A	X	JGL1798	-7.35	-20.63 **	-36.47 **	-5.15**	-17.55**	-29.73**
APMS 6A	X	JGL11110-2	44.51 **	18.79 **	-4.92	32.44**	11.76**	-4.76**
APMS 6A	X	JGL11110-1	59.49 **	45.56 **	-4.18	44.64**	35.46**	-5.03**
APMS 6A	X	JGL17211	24.40 **	21.40 **	-20.08 **	25.78**	31.44**	-14.85**
APMS 6A	X	JGL16284	59.45 **	46.36 **	-3.65	42.90**	34.12**	-5.97**
APMS 6A	X	JGL13515	37.52 **	28.38 **	-15.48 **	27.62**	21.09**	-15.10**
APMS 6A	X	JGL11160	50.85 **	34.49 **	-11.46 **	32.23**	21.38*-*	-4.90**
APMS 6A	X	JGL11118	54.22 **	36.81 **	-4.00	37.56**	26.10**	-7.37**
APMS 6A	X	JGL11111	49.37 **	41.38 **	-0.79	48.17**	39.92**	-2.78
APMS 6A	X	JGL8605	57.83 **	40.79 **	-1.20	42.96**	31.32**	-3.54*
APMS 6A	X	JGL8292	46.09 **	32.47 **	-7.04 *	36.15**	26.40**	-7.15**
APMS 6A	X	JGL3855	19.71 **	3.83	-27.14 **	12.12**	0.78	-25.97**
APMS 6A	X	JGL3844	-3.57	-18.84 **	-35.47 **	-1.90	-13.69**	-30.45**
APMS 6A	X	JGL1798	-6.67	-16.56 **	-33.65 **	-5.47**	-14.45**	-31.06**
IR 58025A	X	JGL11110-2	2.99	-12.87 **	-30.72 **	3.16	-9.06**	-26.71**
IR 58025A	X	JGL11110-1	-1.08	-15.03 **	-32.44 **	0.60	10.42**	-27.80**
IR 58025A	X	JGL17211	6.84	-11.95 **	-29.99 **	9.57**	-5.38*	-23.75*
IR 58025A	X	JGL16284	34.88 **	14.69 **	-11.08 **	24.91**	9.96**	-11.50**
IR 58025A	X	JGL13515	13.85 **	2.93	-20.20 **	11.48**	0.95	-18.75**
IR 58025A	X	JGL11160	30.11 **	11.23 *	-13.77 **	30.84**	15.41**	-7.12**
IR 58025A	X	JGL11118	22.28 **	6.16	-17.69 **	19.91**	6.84**	-14.01**
IR 58025A	X	JGL11111	21.00 **	0.73	-21.91 **	22.79**	6.10**	-14.61**
IR 58025A	X	JGL8605	-11.76 *	-25.00 **	-41.79 **	-9.43**	-19.79**	-36.34**
IR 58025A	X	JGL8292	-9.56 *	-18.27 **	-36.56 **	1.72	-7.32**	-26.43**
IR 58025A	X	JGL3855	-1.90	-16.18 **	-34.94 **	8.16**	-4.02	-23.82**
IR 58025A	X	JGL3844	-12.14 **	-23.76 **	-40.82 **	-4.56*	-14.44**	-32.09**
IR 58025A	X	JGL1798	0.33	-16.52 **	-35.20 **	5.45**	-8.34**	-27.25**

* Significant at 5% level; ** Significant at 1% level

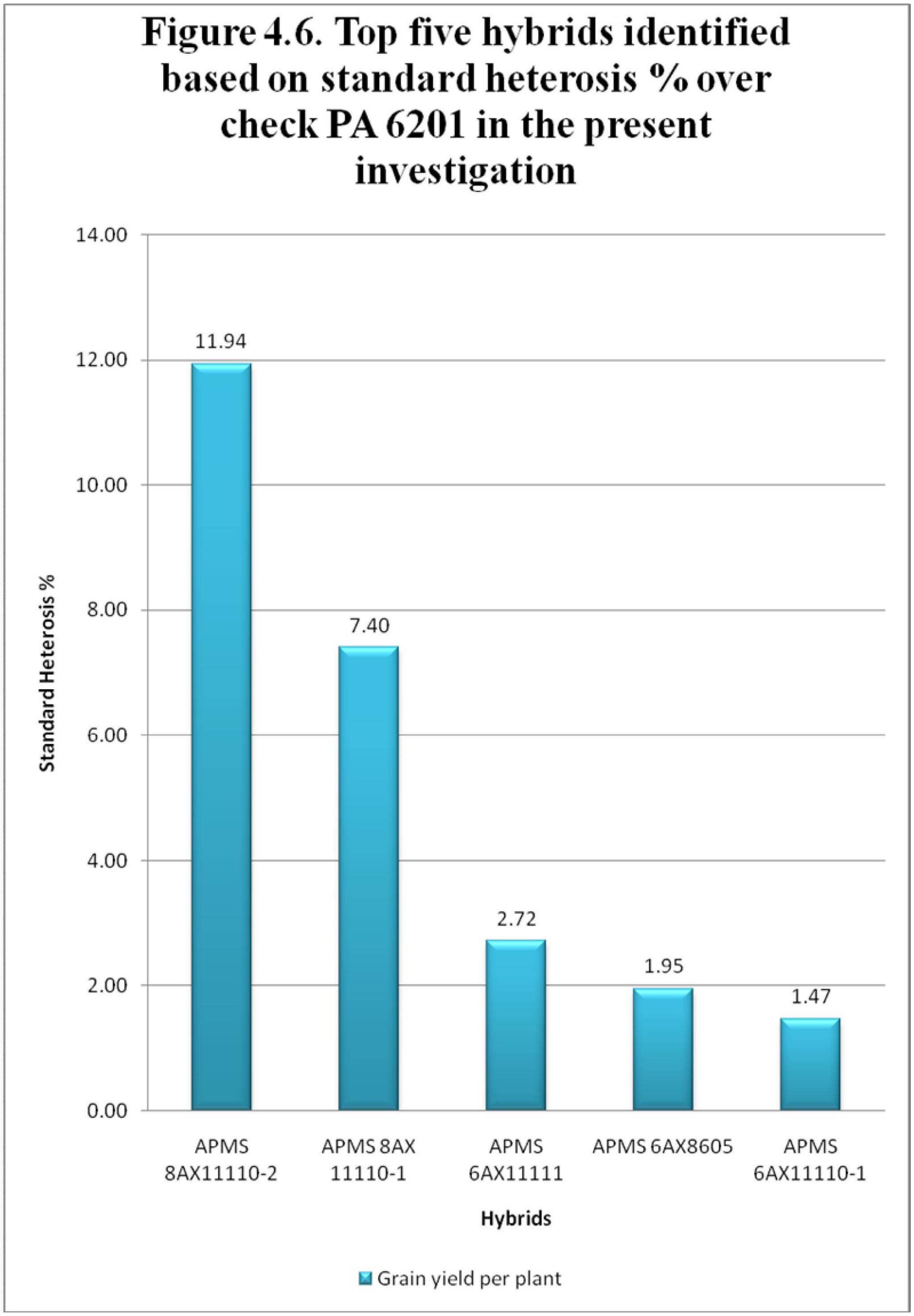


Figure 4.6. Top five hybrids identified based on standard heterosis % over check PA 6201 in the present investigation
Standard Heterosis %
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
11.94
7.40
2.72
1.95
1.47
APMS 8AX11110-2
APMS 8AX 11110-1
APMS 6AX11111
APMS 6AX8605
APMS 6AX11110-1
Hybrids
Grain yield per plant

Table 4.39 Standard heterosis, heterobeltiosis and average heterosis for top five crosses for each trait in rice

Character/ cross			Heterosis			
			Standard Heterosis		Heterobeltiosis	Average Heterosis
			over PA 6201	over KRH 2		
Days to 50% flowering						
IR 68897A	X	JGL11118	-11.98**	-9.36**	-17.50**	-15.55**
IR 68897A	X	JGL11110-1	-9.44**	-6.75**	-15.54**	-13.34**
IR 58025A	X	JGL11160	-9.18**	-6.48**	-18.24**	-16.42**
IR 68897A	X	JGL11160	-7.55**	-4.80**	-14.78**	-14.07**
IR 68897A	X	JGL8605	-5.9**	-3.10	-15.49**	-13.66**
Plant height						
APMS 8A	X	JGL16284	-33.44**	-35.81**	-30.52**	-29.19**
IR 68897A	X	JGL11110-1	-24.28**	-26.88**	-28.30**	-24.81**
CMS 16A	X	JGL11111	-22.92**	-21.15**	-21.45**	-20.01**
IR 68897A	X	JGL17211	-20.48**	-23.32**	-24.70**	-19.56**
IR 68897A	X	JGL11160	-19.94**	-22.80**	-25.05**	-14.83**
Panicle length						
IR 68897A	X	JGL11110-2	18.93**	6.75**	19.97**	33.43**
IR 68897A	X	JGL8292	15.14**	3.35	-6.48**	6.23**
IR 68897A	X	JGL11111	14.40**	2.69	-7.08**	2.24
IR 68897A	X	JGL16284	12.94**	1.38	13.93**	14.40**
CMS 16A	X	JGL11110-2	12.02**	0.55	11.79**	14.42**
Panicle weight						
APMS 6A	X	JGL17211	35.27**	24.21**	31.23**	39.08**
APMS 8A	X	JGL17211	29.79**	19.18**	29.79**	57.59**
IR 68897A	X	JGL16284	22.95**	12.89**	49.58**	64.30**
APMS 6A	X	JGL11110-2	22.95**	12.89**	20.47**	32.23**
APMS 8A	X	JGL11110-1	21.92**	11.95**	5.95**	12.30**
Flag leaf length						
IR 58025A	X	JGL11111	48.03**	36.67**	30.27**	49.03**
IR 68897A	X	JGL11160	47.96**	36.61**	7.89*	26.78**
APMS 8A	X	JGL11110-1	45.9**	34.71**	20.38**	24.26**
CMS 16A	X	JGL8292	44.86**	33.74**	13.95**	29.68**
APMS 8A	X	JGL17211	40.99**	30.17**	22.75**	33.55**
Flag leaf width						
APMS 6A	X	JGL1798	39.89**	14.41**	24.22**	47.90**
CMS 16A	X	JGL11160	31.16**	7.27	40.45**	54.36**
APMS 8A	X	JGL8292	28.61**	-41.62**	-39.24**	-36.86**
CMS 16A	X	JGL3855	27.83**	4.54	35.63**	49.68**
APMS 8A	X	JGL8605	22.56**	0.23	4.31	26.32**
Productive tillers per plant						
APMS 8A	X	JGL11118	59.33**	57.08**	54.52**	54.52**
IR 68897A	X	JGL8292	53.11**	50.94**	49.53**	26.98**
IR 68897A	X	JGL3855	51.20**	49.06**	61.20**	61.22**
APMS 6A	X	JGL16284	49.28**	47.17**	52.94**	52.94**
APMS 8A	X	JGL3844	44.50**	42.45**	29.06**	29.06**
1000-grain weight						
APMS 6A	X	JGL1798	32.27**	-32.43**	-22.48**	18.78**
CMS 16A	X	JGL8605	29.93**	-3.09**	-1.64	-1.32
APMS 8A	X	JGL16284	27.36**	-27.53**	-16.86**	-8.81**
IR 68897A	X	JGL8292	-3.51	-3.73	36.34**	38.87**
IR 68897A	X	JGL11110-2	-4.44*	-4.67*	-23.96**	26.65**
Spikelet fertility						
CMS 16A	X	JGL8605	4.5**	1.64	1.82	3.24**
APMS 8A	X	JGL8292	3.76**	0.93	12.84**	6.63**
IR 58025A	X	JGL11160	2.23	-0.56	7.23**	9.17**
IR 58025A	X	JGL16284	2.2	0.59	4.96**	6.07**

Table 4.39 (cont.)						
Character/ cross			Heterosis			
			Standard Heterosis over PA 6201	over KRH 2	Heterobeltiosis	Average Heterosis
APMS 6A	X	JGL13515	1.35	-1.42	-1.49	-0.20
Filled grains per panicle						
APMS 6A	X	JGL11160	102.64**	64.42**	3.33	3.94
APMS 6A	X	JGL11110-2	100.13**	62.38**	2.04	22.85**
CMS 16A	X	JGL13515	93.35**	58.88**	0.57	35.49**
APMS 8A	X	JGL17211	92.38**	56.09**	-18.88**	16.48**
APMS 8A	X	JGL11110-1	79.51**	45.65**	-8.47**	-6.06*
Grain yield per plant						
APMS 8A	X	JGL11110-2	11.94**	23.15**	27.75**	46.47
APMS 8A	X	JGL11110-1	7.40**	18.16**	22.57**	46.15**
APMS 6A	X	JGL11111	2.72*	13.01**	36.08**	48.38**
APMS 6A	X	JGL8605	1.95	12.17**	35.06**	46.86**
APMS 6A	X	JGL11110-1	1.47	11.64**	38.78**	50.72**
Productivity per day						
APMS 8A	X	JGL11110-2	1.21	8.22**	21.50**	38.42**
APMS 8A	X	JGL11110-1	-1.28	5.56**	18.51**	39.13**
CMS 16A	X	JGL3855	-2.75	3.98*	14.11**	29.23**
APMS 6A	X	JGL11111	-2.78	9.90**	39.92**	48.17**
APMS 6A	X	JGL8605	-3.54*	3.14	31.32**	42.96**

standard heterosis was observed in only two hybrids *viz.*, APMS 8A x JGL 11110-2 (11.13) and APMS 8A x JGL 11110-1 (6.94), when compared to check PA 6201, for the character single plant yield (Table 4.37)

At Warangal, the significant positive average heterosis was recorded in 36 hybrids, ranging from 46.18 (APMS 8A x JGL 11110-2) to 6.59 (IR 58025A x JGL 3844). The significant heterobeltiosis was recorded in 19 hybrids ranging from 33.72 (APMS 6A x JGL 11110-1) to 8.00 (CMS16A x JGL 13515). The positive significant standard heterosis was recorded in only two hybrids *viz.*, APMS 8A x JGL 11110-2 (11.89) and APMS 8A x JGL 11110-1 (7.40), when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was observed in 42 hybrids out of 65 hybrids tested, ranging from 60.17 (APMS 6A x JGL 11110-1) to 3.39 (IR68897A x JGL 3844). The significant heterobeltiosis was recorded in 21 hybrids ranging from 46.02 (APMS 6A x JGL 11110-1) to 9.39 (CMS 16A x JGL 16284). The significant standard heterosis was recorded in 6 hybrids ranged from 12.93 (APMS 8A x JGL 11110-2) to 2.99 (APMS 6A x JGL 16284), when compared with check PA 6201.

In pooled analysis, the significant positive average heterosis was recorded in 39 hybrids ranging from 50.72 (APMS 6A x JGL 11110-1) to 6.02 (CMS 16A x JGL 11110-1). The significant heterobeltiosis was observed in 23 hybrids ranging from 38.78 (APMS 6A x JGL 11110-1) to 5.02 (APMS 6A x JGL 8292). The significant standard heterosis was observed in 7 hybrids, ranging from 24.57 (IR 68897A x JGL 11110-1) to 1.94 (APMS 8A x JGL 11110-2), when compared with check PA 6201, for the character, single plant yield (Table 4.37).

Heterosis for single plant yield is mainly because of simultaneous manifestation of heterosis for yield component traits. Out of 65 hybrids studied, the significant standard heterosis is observed in 7 hybrids, over best check PA 6201, top hybrids are APMS 8A x JGL11110-2, APMS 8A x JGL11110-1 andAPMS 6A x JGL11111 (Table 4.39 and Figure 4.7).

4.2.7.12 Productivity/day (kg/ha)

At Kunaram, the significant positive average heterosis was recorded in 40 hybrids, ranging from 55.98 (APMS 6A x JGL 11110-1) to 5.88 (IR 68897A x JGL 1798). The significant heterobeltiosis was recorded in 23 hybrids, ranging from 44.72

(APMS 6A x JGL 11110-1) to 5.72 (IR 68897A x JGL 11111).Only one hybrid (APMS 8A x JGL11110-2) recorded significant standard heterosis (5.33) when compared with checks PA 6201, for the character productivity/day.

At Warangal, the significant positive average heterosis was observed in 46 hybrids ranging between 52.10 (APMS 6A x JGL 11111) to 5.12 (IR 68897A x JGL 11118). The significant heterobeltiosis was recorded in 30 hybrids ranging from 42.76 (APMS 6A x JGL 11111) to 5.42 (APMS 8A x JGL 13515). The significant standard heterosis was recorded in only one hybrid *viz.*, APMS 6A x JGL 11111 (7.19), when compared with check PA 6201.

At Kampasagar, the significant positive average heterosis was recorded in 39 hybrids ranging from 59.49 (APMS 6A x JGL 11110-1) to 8.67 (IR68897A x JGL 11110-1). The significant heterobeltiosis was recorded in 26 hybrids, ranging between 46.36 (APMS 6A x JGL 16284) to 9.02 (APMS 8A x JGL 16284). None of the hybrids recorded significant standard heterosis when compared with check PA 6201 for the character productivity/day.

In pooled analysis, the significant positive average heterosis was recorded in 45 hybrids out of 65 hybrids tested, ranging between 48.17 (APMS 6A x JGL 11111) to 4.17 (IR 68897A x JGL 3855). The significant heterobeltiosis was recorded in 29 hybrids ranging from 39.92 (APMS 6A x JGL 11111) to 5.67 (IR 68897A x JGL 11111). Whereas no hybrids recorded significant standard heterosis when compared with checks PA 6201, for the character productivity/day (Table 4.38).

Table 4.40. Overall performance of top 20 heterotic hybrids for grain yield per plant in rice

	Hybrid			Average Heterosis %	Heterobeltiosis %	Standard Heterosis %		Mean performance	*Sca* effect	Stable/ unstable
						Over PA-6201	Over KRH-2			
1	**APMS 6A**	**X**	**JGL11110-1**	50.72**	38.78**	1.47	11.64**	28.30	2.71**	Stable
2	**APMS 6A**	**X**	**JGL11111**	48.38**	36.08**	2.72*	13.01**	28.65	2.44**	Stable
3	**APMS 6A**	**X**	**JGL16284**	47.89**	30.02**	0.92	11.02**	28.14	1.92**	Stable
4	**APMS 6A**	**X**	**JGL8605**	46.86**	35.06**	1.95*	12.17**	28.43	1.65**	Stable
5	**APMS 8A**	**X**	**JGL11110-2**	46.47**	27.75**	1.94*	23.15**	31.22	7.01**	Stable
6	**APMS 8A**	**X**	**JGL11110-1**	46.15**	22.57**	7.40**	18.16**	29.95	5.48**	Stable
7	**APMS 8A**	**X**	**JGL8605**	42.25**	29.48**	-0.63	9.32**	27.71	3.93**	Stable
8	**APMS 6A**	**X**	**JGL11118**	39.62**	26.71**	-4.34	5.24**	26.68	0.54*	Stable
9	**APMS 6A**	**X**	**JGL11110-2**	36.43**	15.34**	-0.90	9.02**	27.64	4.77**	Stable
10	**APMS 6A**	**X**	**JGL8292**	34.14**	5.02**	-5.62	3.83*	26.32	0.41	Stable
11	**APMS 6A**	**X**	**JGL17211**	30.74**	21.66**	7.04**	-2.13	24.81	-0.84**	Unstable
12	**APMS 8A**	**X**	**JGL11111**	30.6**	17.65**	-9.70**	-0.66	25.18	1.46**	Stable
13	**APMS 8A**	**X**	**JGL13515**	29.45**	13.38**	-4.45**	5.13**	26.65	4.01**	Stable
14	**IR 68897A**	**X**	**JGL8292**	29.39**	12.73**	-9.89**	-0.86	25.13	3.25**	Stable
15	**IR 58025A**	**X**	**JGL16284**	27.7**	10.89**	-7.38**	1.89	25.83	2.22**	Stable
16	**APMS 6A**	**X**	**JGL11160**	26.43**	14.53**	-16.26**	-7.87**	23.35	-2.25**	Stable
17	**APMS 6A**	**X**	**JGL13515**	23.41**	16.75**	-14.64**	-5.66**	23.81	-1.54**	Stable
18	**APMS 8A**	**X**	**JGL3855**	22.39**	13.20**	-13.12**	-4.42**	24.23	1.23**	Stable
19	**CMS 16A**	**X**	**JGL13515**	22.09**	11.10**	16.62**	-8.27**	23.25	2.85**	Stable
20	**CMS 16A**	**X**	**JGL11118**	18.9**	9.64**	-17.72**	-9.47**	22.95	1.9**	Stable
								CD at 5 % =3.76	SE ij = 0.81	

The productivity/day indicates the efficiency of hybrid with reference to its duration. Out of 65 hybrids studied, no hybrid recorded significant standard heterosis, over check PA 6201, while 3 hybrids were significant over check KRH-2 viz., APMS 8A x JGL 11110-2 (6.22), APMS 8A x JGL 11110-1 (5.56) and APMS 6A x JGL 11111 (9.90) (Table 4.41 and Figure 4.9).

The top twenty hybrids based on the average heterosis, are APMS 6A x JGL 11110-1, APMS 6A x JGL 11111, APMS 6A X JGL 16284, APMS 6A x JGL 8605, APMS 8A x JGL 11110-2, APMS 8A x JGL 8605, APMS 6A x JGL 11118, APMS 6A x JGL 11110-2, APMS 6A x JGL 8292, APMS 6A x JGL 17211, APMS 8A x JGL 11111, APMS 8A x JGL 11111, APMS 8A x JGL 13515, IR 68897A x JGL 8292, IR 58025A x JGL 16284, APMS 6A x JGL 11160, APMS 6A x JGL 13515, APMS 8A x JGL 3855, CMS 16A x JGL 13515 and CMS 16A x JGL 11118. The average heterosis ranged from APMS 6A x JGL 11110-1 (50.72) to CMS 16A x JGL 11118(18.90). The heterobeltiosis is also significant for all the hybrids ranged between 38.78 (APMS 6A x JGL 11110-1) to 5.02 (APMS 6A x JGL 8292). The standard heterosis for these 20 hybrids is significant for only three hybrids, 7.40 (APMS 8A x JGL 11110-1), 7.04 (APMS 6A x JGL 17211) and 16.62 (CMS 16A x JGL 11118) when compared with check PA 6201(Table 4.42and Figure 4.10).

The standard heterosis is significant for only 10 hybrids ranged between 5.13 (APMS 8A x JGL 13515) to 18.16 (APMS 8A x JGL 11110-1). The sca effects are significant for 15 hybrids ranged between 1.23 (APMS 8A x JGL 3855) to 7.01 (APMS 8A x JGL 11110-2), and the mean performance ranged from 22.95 (CMS 16A x JGL 11118) to 31.22 (APMS 8A x JGL 11110-2). Among the twenty hybrids only one hybrid was unstable, while all other 19 hybrids are found to be stable over three environments tested (Table 4.40). Heterosis and heterobeltiosis of both positive and negative nature was reported which was supported by Peng and Virmani (1991), Lokaprakash *et al.* (1992), Pandey *et al.* (1995), Jayamani *et al.* (1997), Ganeshan *et al.* (1997) and Narsimhan *et al*. (2007). Superiority of positive mid parental heterosis was observed by Reddy and Nerkar (1995), Verma *et al*. (2004), Deoraj *et al.* (2007) and Roy *et al.* (2009). Standard heterosis of mixed trend was observed in their studies by Ghosh (2002),Anand Kumar *et al.* (2006), Singh *et al*. (2006 a), Doeraj *et al.* (2007), Eradappa *et al.* (2007), Rosamma and Vijayakumar (2007), Singh *et al.* (2007) and Akarsh Parihar and Pathak (2008).

On the whole, 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 hybrids APMS 6A x JGL11110-1, APMS 8A x JGL11111, APMS 8A x JGL11110-1, APMS 6A x JGL 11111 recorded significant positive standard heterosis over check KRH -2 and APMS 8A x JGL11110-1 recorded significant positive standard heterosis over check PA- 6201 for productive tillers/ plant , the hybrids APMS 6A x JGL11111, APMS 6A x JGL 8292 recorded significant positive standard heterosis over check KRH -2 and APMS 6A x JGL11110-1, APMS 8A x JGL11110-1, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check PA- 6201 for panicle length. The hybrids APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL11110-1, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check KRH -2 and APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL11110-1, APMS 8A x JGL11110-2, APMS 6A x JGL8292 recorded significant positive standard heterosis over check PA- 6201 for filled grains/ panicle. The hybrids APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check KRH -2 and APMS 6A x JGL11111, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check PA- 6201 for 1000 grain weight. The hybrids APMS 8A x JGL11110-2A, PMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL8605, APMS 6A x JGL11110-1, APMS 6A x JGL8292 recorded significant positive standard heterosis over check KRH -2 and APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL8605, APMS 8A x JGL11110-2 recorded significant positive standard heterosis over check PA- 6201 for single plant yield.

Figure 4.7. Top five hybrids identified based on standard heterosis (%) over check PA 6201 along with average heterosis and heterobeltiosis in the present investigation

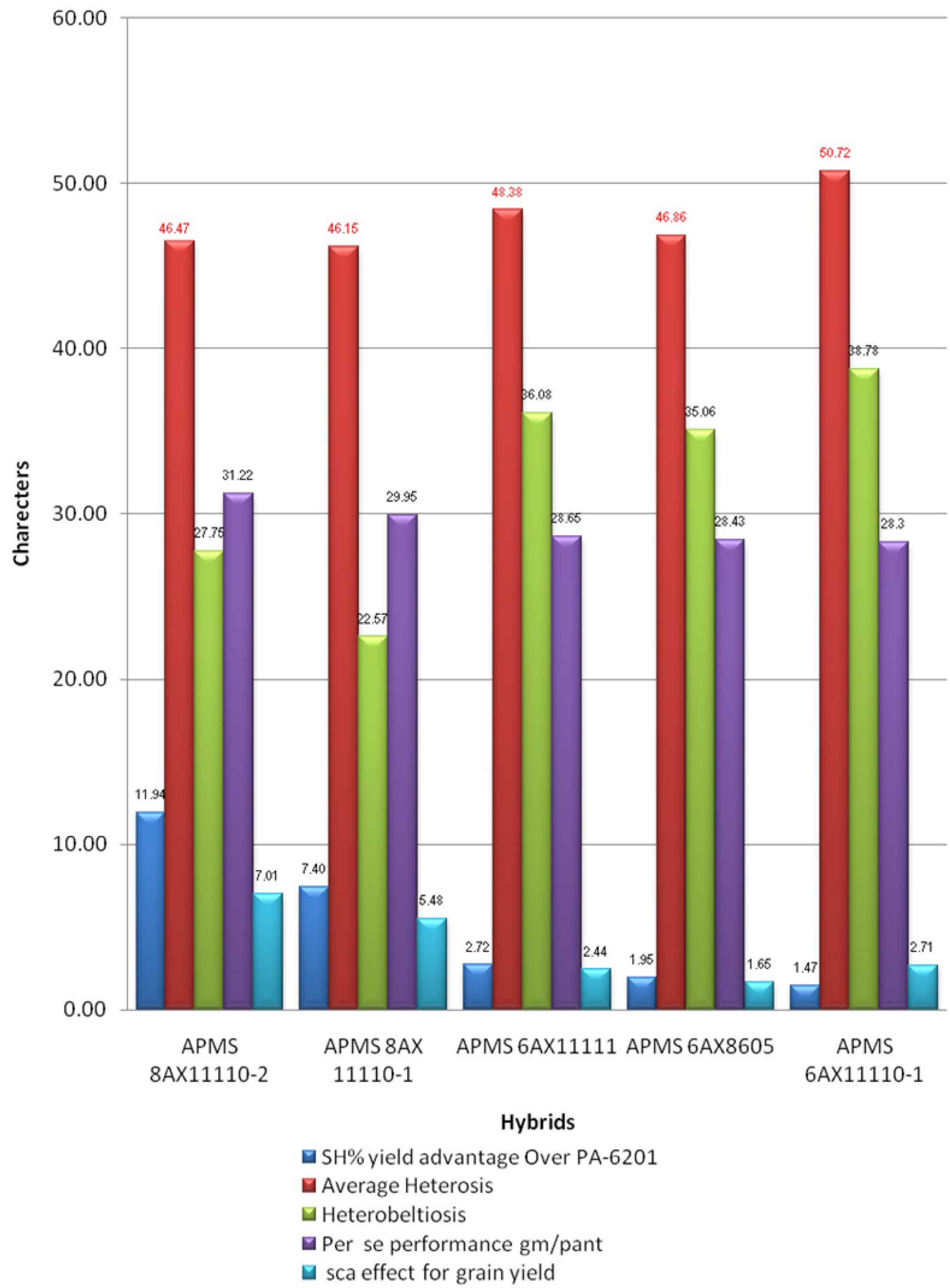
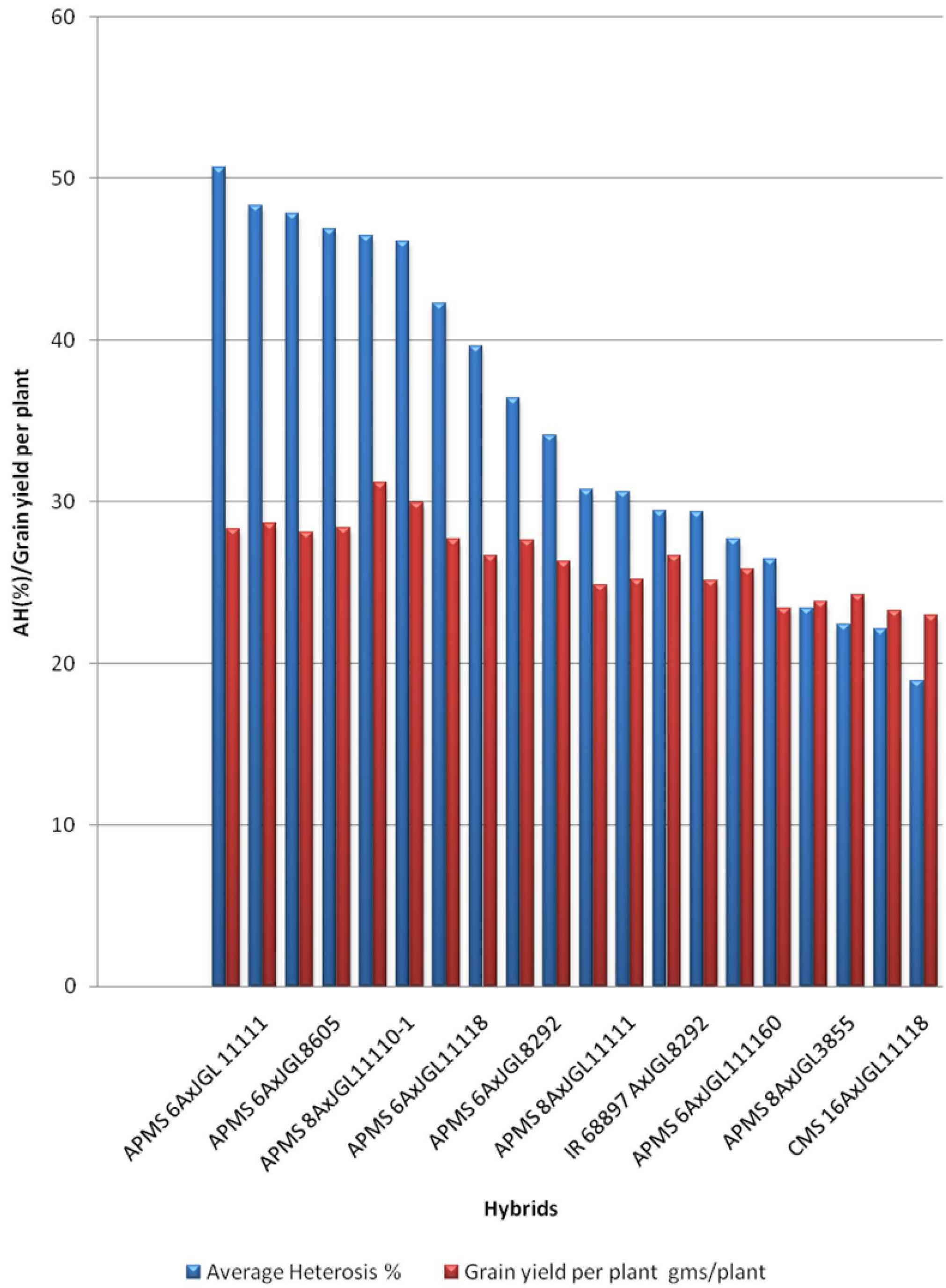


Figure 4.8. Top twenty heterotic hybrids based on average heterosis (%) with grain yield/plant



4.3 Stability

Rice is the staple and important cereal crop of India, being photo insensitive in nature, due to its buffering capacity it is being cultivated round the year in different agro-climatic zones of the country. However, the hybrids and breeding material likely to interact differently with different environments. The presently cultivated varieties and hybrids though having high yield potential, they are erratic in their performance under varied conditions of cultivation. Lack of hybrids suitable to specific locations accounts for the decline in the area and productivity in rice, apart from the biotic and abiotic stresses. This warrants the attention of the plant breeders to evolve superior hybrids that would sustain well in the strainful situation. Therefore, assessment of its adaptability is of important concern. Productivity of a population is the function of its adaptation, whereas stability is the statistical measure of genotype x environment interaction (Kandil *et al.* 1990).

Relative ranking of genotype in different seasons for a given attribute is rarely the same. This results in difficulty in detecting superior genotypes. Therefore, it is necessarily to select genotype(s) showing a high degree of stable performance over a wide range of environments. Precise knowledge on the nature and magnitude of genotype x environmental interaction is important in understanding the stability in yield of a particular variety or a hybrid before it is being recommended for a given situation(s). The yielding ability and response to environmental changes are the two independent attributes of a genotype and are governed by separate genetic systems (Finlay and Wilkinson, 1963). Testing of genotypes under different environmental situations differing in unpredictable variation is an accepted approach for selecting stable genotypes (Eberhart and Russel, 1966).

However, little information is available on the stability of rice hybrids. Young and Virmani (1990) also observed varying magnitude of heterosis over environments and stressed the need to evaluate hybrids across environments to identify stable hybrids with high yield that shows least interaction with environment. Therefore, an attempt was made to study the stability parameters of the hybrids developed and evaluated at different agro-climatic zones in Andhra Pradesh in the present investigation, using Eberhart and Russel (1966) model.

Genotype x Environment interactions is of major importance to plant breeders in developing new crop varieties and hybrids which perform consistently over a wide range of environments. Hence, there is a need to identify a stable hybrid. The data collected on twelve characters for 88 genotypes over three locations viz., Kunaram, Warangal and Kampasagar constituting three environments was used to estimate genotype and environment interaction for yield and yield components by following the model suggested by Eberhart and Russel (1966).

4.3.1 Pooled analysis of variance

The mean square values from pooled analysis, of variance are presented in table 4.41. The pooled analysis of variance revealed that the variances for genotypes were significant for gallmidge damaged plants (%) and silver shoots (%). This indicates the presence of genetic variability among genotypes for these characters. The variances for environments were significant. Significant variation due to environment (linear) was observed. The linear component of genotype x environment was insignificant, suggesting that, the genotypes are not differing from their linear response to environment. The pooled deviation was significant indicating non linear response and unpredictable nature of genotype by significantly differing for stability.

Table 4.41. Analysis of variance for gall midge damaged plants (%)and silver shoots (%) for stability in rice

Source	d.f	(ASIN) Damaged Plants %	(ASIN) Silver Shoots%
Rep. within Environment	6	18.18	2.7
Varieties	88	269.87 **	16.73 **
Env. + (Var.* Env.)	178	72.31 *	3.73 *
Environments	2	1877.93 **	82.53 **
Var.* Env.	176	51.79	2.83
Environments (Linear)	1	3755.87 **	165.05 **
Var.* Env.(Linear)	88	56.46	3.11
Pooled Deviation	89	46.59 **	2.53 **
Pooled Error	528	4.01	0.24
Total	266	137.66	8.03

* Significant at 5% level; ** Significant at 1% level

The mean square values for pooled analysis of variance are presented in table 4.42. The pooled analysis of variance revealed that, the variances for genotypes were significant for days to 50% flowering, flag leaf width, panicle length, spikelet fertility (%), 1000 grain weight, yield per plant and productivity/day. This indicates the presence of genetic variability among genotypes for these characters. The variances for environments were significant for days to 50% flowering, plant height, flag leaf width and flag leaf length, panicle weight, 1000 grain weigh, yield/plant and productivity per day. The analysis revealed that the genotypes and environments were significant for days to 50% flowering, flag leaf width, flag leaf length, spikelet fertility% and productivity/day.

Partitioning the sum of squares into that of varieties, environments + (genotypes x environments) and pooled error revealed that mean squares due to environment + (genotypes x environments) were significant for eight characters viz., days to 50% flowering, productive tillers/plant, flag leaf width, flag leaf length, spikelet fertility%,1000 grain weight, single plant yield and productivity/day.

Sum of squares due to E+ (G x E) was further portioned into that of environment (linear), genotypes x environment (linear) and pooled deviation. Significant variation due to environment (linear) was observed for 11 characters except for spikelet fertility (%) revealing the linear contribution of environmental effects and additive environment

Table 4.42. Analysis of variance for yield and yield components for stability in rice

Source	d.f	Days to 50% flowering	Plant Height cm	Productive Tillers/ Plant	Flag Leaf Length cm	Flag Leaf Width cm	Panicle Length cm
Replication within Environment	6	124.77 **	123.68	25.94	46.5	0.1 **	11.56 **
Varieties	87	94.92 **	201	24.35 **	35.16 *	0.15 **	6.85 **
Env.+(Var.*Env.)	176	29.8 **	156.79	28.77 **	14.89	0.06 **	5.88 **
Environments	2	240.89 **	1307.87 **	1401.6 **	46.89	0.9 **	236.66 **
Var.* Env.	174	27.38 **	143.56	12.99	14.52	0.05 **	3.22 **
Environments (Linear)	1	481.78 **	2615.74 **	2803.21 **	93.78 *	1.81 **	473.32 **
Var.* Env.(Linear)	87	48.23 **	84.84	12.65	6.06	0.09 **	5.21 **
Pooled Deviation	88	6.45 **	199.99 **	13.18 **	22.72 **	0.02 **	1.22 **
Pooled Error	522	2.82	3.43	0.72	2.13	0.01	0.34
Total	263	51.34	171.42	27.31	21.59	0.09	6.2

Table 4.42(cont.)								
Source	**d.f**	**Flag Leaf Width cm**	**Filled Grains/ Panicle**	**Spikelet Fertility %**	**1000 Grain Weight gm**	**Yield/ Plant gm**	**Productivity/ Day (kg / ha)**	
Replication within Environment	6	0.10 **	469.22	84.57	33.04 **	26.61 **	378.42	0.10
Varieties	87	0.15 **	6264.40 **	233.22 **	20.25 **	33.35 **	341.85	0.15
Env.+(Var.*Env.)	176	0.06 **	2603.64	87.54 **	8.05 **	4.77 **	607.44	0.06
Environments	2	0.90 **	3573.39	85.19	252.98 **	379.00 **	51471.17	0.90
Var.* Env.	174	0.05 **	2592.49	87.57 **	5.24 **	0.47	22.80	0.05
Environments (Linear)	1	1.81 **	7146.78	170.38	505.95 **	758.00 **	102942.34	1.81
Var.* Env.(Linear)	87	0.09 **	1858.38	120.06 **	7.82 **	0.06	39.32	0.09
Pooled Deviation	88	0.02 **	3288.80 **	54.45 **	2.62 **	0.87 **	6.21	0.02
Pooled Error	522	0.01	100.13	1.77	0.56	0.17	3.16	0.01
Total	263	0.09	3814.61	135.73	12.09	14.23	519.59	0.09

* Significant at 5% level; ** Significant at 1% level

variance on this character.The linear component of genotype x environment was significant for 6 characters and non-significant for plant height, productive tillers/plant, flag leaf length, panicle weight, filled grains per panicle and yield/plant, suggesting that the significant genotypes are significantly differing for their linear response to environments.

The mean sum of squares for pooled deviation was significant for all the twelve characters indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability.

In the present investigation, 88 genotypes which including 65 hybrids, 18 parents and five checks were subjected to pooled analysis of variance for 12 characters. Significant genotype x environment interactions implying differential behavior of genotypes for yield and it's components under three different locations. Similar reports were earlier reported by Leenakumary (1994), Hegde and Vidyachandra (1998), Arumugam *et al.* (2007), Panwar *et al.* (2008) and Ramya and Senthil kumar (2008).

Partitioning of sum of squares into that of varieties, environments + (genotypes x environment) and pooled error revealed that mean squares due to genotypes were highly significant for all the characters studied, indicating the presence of genetic variability in the experimental material (Arumugam *et al.*2007; Panwar *et al.*2008 and

Krishnappa *et al.*2009). Mean squares due to environments + (genotypes x environments) were significant for eight characters *viz.*, plant height, panicle weight, number of productive tillers per plant, flag leaf length, flag leaf width, number of filled grains per panicle,1000-grain weight and single plant yield depicted the existence of GE interaction. These findings are in conformity with Young and Virmani (1990), Deshpande *et al*. (2003), Deshpande and Dalvi (2006), Panwar *et al*. (2008) and Ramya Senthil kumar (2008) and Krishnappa *et al*. (2009).

Sum of squares due to E + (G x E) was further partitioned into that of environment (linear), genotype x environment (linear) and pooled deviation. Significant variation due to environment (linear) was observed for all the 12 characters studied revealing the linear contribution of environmental effects and additive environment variance on these characters. Similar results were reported earlier by Hegde and Vidyachandra (1998), Lohithaswa *et al.* (1999), Deshphande *et al.* (2003), Arumugam *et al.* (2007), Panwar *et al.* (2008), Ramya and Senthil kumar (2008) and Krishnappa *et al.*(2009) for yield and it’s components. The linear component of genotype x environment was significant for all the characters except days to 50% flowering, panicle length, and spikelet fertility percentage suggesting that the genotypes significantly differing for their linear response to environments. Similar results were observed by Lohithaswa *et al.* (1999), Panwar *et al.* (2008), Ramya and Senthil kumar (2008) and Krishnappa *et al.* (2009) for yield and its components. Higher magnitude of environment (linear) effects in comparison to GE (linear) may be responsible for high adaption in relation to yield and its components.

The mean sum of squares for pooled deviation was significant for all the twelve characters indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability. Significant non-linear responses were observed earlier by Hegde and Vidyachandra (1998), Lohithaswa *et al.* (1999), Deshphande *et al.* (2002), Arumugam *et al.* (2007), Panwar *et al.* (2008), Ramya and Senthil kumar (2008) and Krishnappa *et al.* (2009), while both significant and non-significant linear responses were reported by Young and Virmani (1990), Deshphande *et al*. (2003) and Lavanya *et al*. (2005) for yield and its components.

4.3.2 Environmental Indices

Environmental indices for twelve characters viz., days to 50% flowering, plant height, panicle length, panicle weight, number of productive tillers/plant, flag leaf length, flag leaf width, number of filled grains/panicle, spikelet fertility%, 1000 grain weight, single plant yield and productivity/day are presented in table 4.45.

The Kunaram was found to be the most favourable location for plant height, panicle length, panicle weight, number of productive tillers/plant, flag leaf length, flag leaf width, number of filled grains/panicle, 1000 grain weight and single plant yield. Warangal was the next best favourable location for panicle length, panicle weight, number of productive tillers, flag leaf width, number of filled grains/panicle, spikelet fertility %, 1000 grain weight and single plant yield.Kampasagar best favourable location for days to 50% flowering and spikelet fertility %.

Environmental index reveals the favorability of an environment at a particular location. Breeze (1969) pointed out that the estimates of environmental index can provide the basis for identifying the favourable environments for the expression of maximum potential of the genotype. Karimnagar was found to be the most favourable location for plant height, panicle weight, number of productive tillers per plant, flag leaf length, number of filled grains per panicle, 1000-grain weight and single plant yield while, Warangal was the next best favourable location for plant height, panicle weight, number of productive tillers per plant, number of filled grains per panicle, 1000-grain weight and single plant yield. (4.43

Table 4.43. Environmental indices for yield and yield components in rice

Characters		Locations		
		Kunaram	Warangal	Kampasagar
Days to 50% flowering	**Ij**	1.40	0.43	-1.83
Plant height	**ij**	-1.633	0.808	0.825
Panicle length (cm)	**Ij**	1.45	0.33	-1.78
Panicle weight	**Ij**	0.138	0.049	-0.187
No. of productive tillers/plant	**ij**	0.223	0.219	-0.442
Flag leaf length	**Ij**	0.289	-0.277	-0.013
Flag leaf width (cm)	**Ij**	0.03	0.08	-0.11
No. of filled grains /panicle	**ij**	5.269	4.481	-9.750
Spikelet fertility %	**Ij**	-1.10	0.30	0.80
1000-grain weight	**Ij**	0.027	0.016	-0.042
Single plant yield	**ij**	1.500	0.126	-1.626
Productivity/ Day	**ij**	-16.75	-1098	27.73

The results are in broad agreement with the results reported by Lohithaswa *et al.* (1999). Since certain genotypes are searching for its favourable environment to express its fullest potential of yield and yield attributes. Hence, an appropriate genotype has to be bred for each season.

4.3.3 Stability parameters

According to Eberhart and Russel (1996), a stable genotype is one which shows (i) high mean yield (ii) regression co-efficient (bi=1) equal to unity and (iii) a mean square deviation from regression (S^2di) near to zero. In interpreting the results of the present investigation, S^2di was considered as the measure of stability as suggested by Breeze (1969). Then the type of stability (measure of response or sensitivity to environmental changes) was decided on regression coefficient (bi) and mean value (Finlay and Wilkinson, 1963), if bi is equal to unity, a genotype is considered to have average stability. If bi is more than unity, it is suggested to have less than average stability. If bi was less than unity, it is reported have more than average stability (widely adoptable to differing environmental conditions). The estimation of stability parameters i.e., mean (μ), regression coefficient (bi) and a mean square deviation from regression (S^2di) for the fourteen characters are furnished below.

Once it is known that genotypes interact with the environments significantly, the next task is to find out the most stable genotypes. The stability parameters *i.e.,* high mean performance (μ), regression coefficient (bi) and deviation from regression (S^2di) were estimated for each genotype for each character separately. Both linear regression (bi) and deviation from regression (S^2di) components of genotype x environment interaction should be considered along with mean in judging the phenotypic stability of a genotype (Eberhart and Russel, 1966).

4.3.3.1 Gallmidge infested plants (%): Among all genotypes tested, for the character gallmidge infested plants (%) 3 testers 5 lines and 35 hybrids had non- significant deviation from regression, (S^2di) values i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.44).

Among the lines and testers, IR 68897A, APMS 6A, JGL 16284, JGL 11111 , JGL 8292, JGL 3855and JGL 1798, recorded the less the unit of bi values, with gall midge resistance and thus possessed more than average stability and are adoptable to poor environments.

Among the hybrids, CMS 16A x JGL11110-1 and CMS 16A x JGL3855 recorded the unit of bi value, and thus possessed average stability and are adoptable to all environments possessing the gall midge resistance. While the hybrids IR 68897A x

JGL11110-2, CMS 16A x JGL3844, APMS 6A x JGL8292, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR 58025A x JGL11110-1, IR 58025A x JGL17211,IR 58025A x JGL384, IR 58025A x JGL1798 recorded the less the unit of bi value with gall midge resistance and are adoptable to poor environments (Table 4.44).

4.3.3.2 Silver shoots (%): Among all genotypes tested, for the character, silver shoots (%), 3 testers, 5 lines and 40 hybrids had non- significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily within the range of the minimum deviation from the regression whose performance can be predicted (Table 4.44).

Among the lines and testers for the character silver shoots (%), IR 68897A, APMS 6A, JGL 16284, JGL 11111, JGL 8292, JGL 3855, JGL 1798 recorded the less than the unit of bi value and thus possessed more than average stability and are adaptable to poor environments with gall midge resistance.

In the stability analysis hybrid IR68897A x JGL17211 recorded unit of bi value and thus possessed average stability and are adoptable to all environments, where as hybrids IR68897A x JGL11110-2, CMS 16A x JGL11110-2, CMS 16A xJGL17211, CMS 16AxJGL3844, CMSAxJGL1798, APMS6Ax JGL13515, APMS 6A x JGL11111, APMS 6A x JGL8292, APMS 6A x JGL3855, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR58025Ax JGL11110-1, IR58025A x JGL16284, IR58025A x JGL17211, IR58025A x JGL11118, IR58025A x JGL8605, IR 58025A x JGL8292, IR 58025A x JGL3844, IR 58025A x JGL1798 recorded the less than unit of bi value, and thus possessed more than average stability and more adoptable to poor environments along with gall midge resistance, while all other hybrids are unstable for this character (Table 4.44).

The reaction of genotypes towards the gallmidge at three locations is different; the incidence recorded was more at Warangal, followed by Kampasagar and Kunaram. This may be due to the different biotypes existing at three locations. The R lines used are taken from RARS, Jagtial, which may be resistant to gallmidge biotype 3, Hence the hybrids developed with these R lines also shown resistance reaction at RARS, Jagtial, Hence the damaged plants and silver shoots (%) was less at RARS, Jagtial, where as it is high at RARS, Warangal which may be due to existence of different biotypes of gallmidge at Warangal as well as at Kampasagar, due to which the incidence percentage varied, accordingly. However, some hybrids exhibited resistance reaction at all the three locations indicating the resistance of hybrids to different biotypes.

Table 4.44. Mean performance and stability parameters for gall midge damaged plant %(ASIN) and silver shoots % (ASIN) in rice

Parent/Cross	Gall midge damaged Plant %(ASIN)			Silver Shoots % (ASIN)		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	27.57	50.64	0.47 **	9.30	4.68	0.70 **
IR 68897A	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
APMS 6A	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
APMS 8A	27.27	11.13	0.54	9.45	0.63	1.05
CMS 16A	23.53	49.97	-0.33 **	8.23	4.91	-0.21 **
Lines						
JGL 11110-2	13.06	113.46	2.96 **	6.17	7.73	3.18 **
JGL 11110-1	11.87	84.33	2.56 **	5.79	5.13	2.61 **
JGL 17211	9.05	32.05	1.64 **	4.91	1.04	1.28 *
JGL 16284	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 13515	9.40	37.34	1.76 **	4.99	1.30	1.41 *
JGL 11160	12.41	97.01	2.74 **	5.98	6.40	2.90 **
JGL 11118	11.87	84.33	2.56 **	5.79	5.13	2.61 **
JGL 11111	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 8605	9.05	32.05	1.64 **	4.91	1.04	1.28 *
JGL 8292	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 3855	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 3844	13.87	135.60	3.22 **	6.42	9.80	3.57 **
JGL 1798	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
Crosses	4.06	-4.17	0.00	4.06	-0.27	0.00
IR 68897A X JGL11110-2	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 68897A X JGL11110-1	7.52	13.22 *	1.14	4.71	0.50 *	0.99
IR 68897A X JGL17211	4.06	-4.17	0.00 *	4.06	-0.27	0.00
IR 68897A X JGL16284	12.21	81.79 *	0.94	5.48	2.78 *	0.79
IR 68897A X JGL13515	6.78	6.58	0.89 **	4.36	-0.10	0.45 **
IR 68897A X JGL11160	6.98	8.27	0.96	4.51	0.11	0.69
IR 68897A X JGL11118	10.49	55.95	2.11	5.37	2.85	1.99
IR 68897A X JGL11111	10.49	55.95	2.11 **	5.37	2.85	1.99 **
IR 68897A X JGL8605	16.94	213.91	1.48 **	6.90	11.93	1.57 **
IR 68897A X JGL8292	6.78	6.58	0.89 **	4.45	0.02	0.60 **
IR 68897A X JGL3855	24.98	515.50	2.51	9.38	28.26	3.38
IR 68897A X JGL3844	9.05	32.05	1.64 **	4.91	1.04	1.28 **
IR 68897A X JGL1798	7.52	13.22	1.14 **	4.71	0.50	0.99 *
APMS 8A X JGL11110-2	9.05	32.05	1.64 *	4.91	1.04	1.28
APMS 8A X JGL11110-1	4.06	-4.17	0.00 **	4.06	-0.27	0.00 *
APMS 8A X JGL17211	8.36	22.68 *	1.41	5.00	1.33 *	1.42
APMS 8A X JGL16284	8.36	22.68	1.41 *	4.88	0.96	1.25 *
APMS 8A X JGL13515	4.06	-4.17	0.00 *	4.06	-0.27	0.00 *
APMS 8A X JGL11160	14.18	144.54 *	3.32	6.51	10.51 *	3.69
APMS 8A X JGL11118	6.78	6.58	0.89 **	4.36	-0.10	0.45 **
APMS 8A X JGL11111	10.02	47.47	1.96	5.40	2.96	2.02
APMS 8A X JGL8605	4.06	-4.17	0.00 **	4.06	-0.27	0.00 **
APMS 8A X JGL8292	10.49	55.95 *	2.11	5.37	2.85 *	1.99
APMS 8A X JGL3855	4.06	-4.17	0.00 **	4.06	-0.27	0.00 **
APMS 8A X JGL3844	27.57	50.64 *	0.47	9.30	4.68 *	0.70

Table 4.44 (cont.)

Crosses	Gall midge damaged Plant %(ASIN)			Silver Shoots % (ASIN)		
	μ Mean	βi	σ^2di	μ Mean	βi	σ^2di
APMS 8A X JGL1798	4.06	-4.17	0.00 **	5.54	3.68	2.23 **
CMS 16A X JGL11110-2	6.78	6.58 *	0.89	4.06	-0.27 *	0.00
CMS 16A X JGL11110-1	4.06	-4.17	0.00	4.45	0.02	0.60
CMS 16A X JGL17211	10.77	61.28 *	2.21	4.06	-0.27 *	0.00
CMS 16A X JGL16284	6.78	6.58	0.89 **	5.75	4.90	2.56 **
CMS 16A X JGL13515	10.49	55.95	2.11	4.36	-0.10	0.45
CMS 16A X JGL11160	6.98	8.27	0.96 **	5.37	2.85	1.99 **
CMS 16A X JGL11118	8.36	22.68	1.41	4.51	0.11	0.69
CMS 16A X JGL11111	6.98	8.27	0.96 *	4.88	0.96	1.25 *
CMS 16A X JGL8605	6.78	6.58	0.89	4.42	-0.02	0.55
CMS 16A X JGL8292	6.78	6.58	0.89	4.36	-0.10	0.45
CMS 16A X JGL3855	4.06	-4.17	0.00	4.36	-0.10	0.45
CMS 16A X JGL3844	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
CMS 16A X JGL1798	28.47	475.99 *	3.35	4.06	-0.27 *	0.00
APMS 6A X JGL11110-2	18.45	111.05	2.18 **	10.06	26.97	4.11 **
APMS 6A X JGL11110-1	18.12	94.15	2.18 **	7.18	4.95	2.31 **
APMS 6A X JGL17211	16.02	180.33	1.39 **	7.15	4.93	2.27 **
APMS 6A X JGL16284	4.06	-4.17	0.00 **	6.62	9.58	1.42 **
APMS 6A X JGL13515	14.26	32.58 *	1.68	4.06	-0.27 *	0.00
APMS 6A X JGL11160	12.00	72.79	0.94 **	5.84	0.63	1.45
APMS 6A X JGL11118	4.06	-4.17	0.00 **	5.40	2.11	0.78 **
APMS 6A X JGL11111	13.85	28.58 *	1.62	4.06	-0.27 *	0.00
APMS 6A X JGL8605	4.06	-4.17	0.00 **	5.71	0.40	1.36
APMS 6A X JGL8292	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
APMS 6A X JGL3855	19.37	76.31 *	2.54	4.06	-0.27 *	0.00
APMS 6A X JGL3844	4.06	-4.17	0.00 **	7.49	3.07	2.78 **
APMS 6A X JGL1798	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL11110-2	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL11110-1	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL17211	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL16284	19.37	76.31 *	2.54	4.06	-0.27 *	0.00
IR 58025A X JGL13515	13.85	28.58	1.62 **	7.49	3.07	2.78 **
IR 58025A X JGL11160	4.06	-4.17	0.00 **	5.71	0.40	1.36
IR 58025A X JGL11118	29.78	220.07 *	4.27	4.06	-0.27 *	0.00
IR 58025A X JGL11111	4.06	-4.17	0.00 **	10.56	11.48	5.28 **
IR 58025A X JGL8605	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL8292	23.90	130.63 *	3.29	4.06	-0.27 *	0.00
IR 58025A X JGL3855	4.06	-4.17	0.00 **	8.90	6.30	3.93 **
IR 58025A X JGL3844	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL1798	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
KRH - 2	18.64	-4.11 *	0.07	6.51	-0.26 *	0.07
DRRH - 2	33.49	0.67	0.86	11.24	0.18	1.17
PA 6201	40.42	-2.03	-0.05	13.23	-0.16	-0.20
JAYA	28.44	-4.01 *	0.11	9.73	-0.26 *	0.09
IR - 64	20.83	95.10	-2.77 **	8.03	6.87	-2.99 **
TN1	58.19	2.77	1.64	18.22	-0.26 *	2.60
Population Mean		11.17			5.63	
SE of βi		1.05			1.17	

* Significant at 5% level; ** Significant at 1% level

Table 4.45.Mean performance and stability parameters for days to 50% flowering and plant height in rice

Parent/Cross	Days to 50 % flowering			Plant height		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	103.42	1.79	-3.65	84.53	-3.30	13.81 *
IR 68897A	97.02	-3.88	9.52	99.74	2.13	16.77 *
APMS 6A	105.89	0.96	-3.57	95.89	0.70	-4.76
APMS 8A	106.16	0.80	-2.51	101.77	-0.91	277.80 **
CMS 16A	105.07	1.06	-3.53	106.01	-0.63	394.71 **
Lines						
JGL 11110-2	102.22	-0.44	-2.52	109.94	0.12	10.65
JGL 11110-1	101.71	-1.48	1.73	111.21	-0.15	159.36 **
JGL 17211	102.67	-0.28	-3.73	107.00	-0.50	330.80 **
JGL 16284	102.98	1.39	-4.01	97.98	0.34	11.72
JGL 13515	106.33	-0.69	-1.24	102.72	1.26	55.66 **
JGL 11160	102.16	-1.52	-1.25	102.66	-1.99	688.53 **
JGL 11118	92.60	-1.27 *	-4.11	100.32	-0.83	468.10 **
JGL 11111	98.96	4.11	-0.79	105.23	0.59	141.09 **
JGL 8605	104.73	0.58	-2.23	109.40	-2.08	351.47 **
JGL 8292	102.00	-0.61	-3.35	99.78	1.12	82.67 **
JGL 3855	104.67	-0.04	2.01	104.50	-1.35	721.35 **
JGL 3844	101.29	-1.76	0.20	100.62	-1.76	688.70 **
JGL 1798	97.64	-0.56	-2.16	95.81	1.14	15.95 *
Crosses						
IR 68897A X JGL 11110-2	101.16	-1.91	2.99	96.60	3.74	300.45 **
IR 68897A X JGL11110-1	86.33	3.42	-3.18	78.83	1.57	10.27
IR 68897A X JGL17211	94.07	6.49	7.05	82.79	2.95	314.78 **
IR 68897A X JGL16284	99.02	-2.25	-3.54	90.36	2.92	229.17 **
IR 68897A X JGL13515	90.36	4.32	1.04	85.58	2.68	142.98 **
IR 68897A X JGL11160	88.13	-0.93	0.19	83.36	2.95	150.74 **
IR 68897A X JGL11118	83.91	0.84	-4.18	87.36	2.58	10.16
IR 68897A X JGL11111	97.82	0.06	-1.59	97.32	1.42	250.20 **
IR 68897A X JGL8605	89.71	-1.36	-3.48	91.04	2.90	84.23 **
IR 68897A X JGL8292	96.53	-0.84	5.11	96.09	2.40	24.07 *
IR 68897A X JGL3855	90.89	-0.14	-3.80	91.56	2.65	60.61 **
IR 68897A X JGL3844	93.18	-0.33	32.68 **	95.96	4.01	393.52 **
IR 68897A X JGL1798	94.09	-0.18	-4.11	87.76	2.08	46.60 **
APMS 8A X JGL 11110-2	105.53	-0.60	-2.65	97.59	1.12	101.49 **
APMS 8A X JGL11110-1	104.18	-0.02	-3.44	96.96	0.99	208.15 **
APMS 8A X JGL17211	104.20	-1.27	-3.61	91.09	1.69	283.09 **
APMS 8A X JGL16284	94.24	2.39	33.38 **	69.30	-1.04	53.74 **
APMS 8A X JGL13515	105.69	-0.37	-1.92	98.19	1.81	299.76 **
APMS 8A X JGL11160	105.98	-0.79	-4.07	91.31	0.04	144.95 **
APMS 8A X JGL11118	104.93	0.26	-3.93	97.16	1.98	259.26 **
APMS 8A X JGL11111	97.09	6.60	46.48 **	96.42	1.89	124.30 **
APMS 8A X JGL8605	100.11	1.26	-3.53	90.72	2.58	106.47 **
APMS 8A X JGL8292	92.80	6.19	0.58	86.80	1.41	35.63 **
APMS 8A X JGL3855	91.93	5.38	-3.22	86.82	2.91	169.87 **
APMS 8A X JGL3844	98.71	2.41	-2.46	95.04	3.24	154.07 **

Table 4.45 (cont.)

	Days to 50 % flowering			Plant height		
	μ Mean	βi	σ^2di	μ Mean	βi	σ^2di
APMS 8A X JGL1798	106.18	0.73	0.40	88.01	2.15	306.53 **
CMS 16A X JGL 11110-2	105.09	-0.63	-3.24	90.98	2.07	130.88 **
CMS 16A X JGL11110-1	94.98	7.57 *	-3.55	89.26	1.39	170.00 **
CMS 16A X JGL17211	103.96	-0.85	-3.61	92.68	1.73	49.54 **
CMS 16A X JGL16284	104.82	-0.41	-3.14	93.43	0.63	96.67 **
CMS 16A X JGL13515	93.16	7.02	13.92 *	89.16	2.44	219.25 **
CMS 16A X JGL11160	102.73	-0.36	-1.59	92.46	1.97	105.68 **
CMS 16A X JGL11118	102.47	1.62	-3.70	90.97	2.46	323.21 **
CMS 16A X JGL11111	91.69	5.68	14.12 *	80.24	1.39	27.07 *
CMS 16A X JGL8605	95.53	7.29	9.27	84.98	2.32	265.57 **
CMS 16A X JGL8292	103.22	-0.50	6.97	100.56	3.32	246.02 **
CMS 16A X JGL3855	84.62	2.37 *	-4.19	85.46	1.89	355.60 **
CMS 16A X JGL3844	99.56	-1.34 *	-4.21	93.94	2.31	99.92 **
CMS 16A X JGL1798	104.18	-1.90	-2.09	89.62	1.73	58.62 **
APMS 6A X JGL 11110-2	99.33	-1.88	-0.75	94.33	2.13	138.03 **
APMS 6A X JGL11110-1	102.29	-0.76	3.70	94.79	2.77	160.81 **
APMS 6A X JGL17211	101.78	0.07	3.40	91.61	2.52	137.91 **
APMS 6A X JGL16284	103.40	0.07	-4.12	93.18	2.26	95.32 **
APMS 6A X JGL13515	97.82	0.53	-0.25	90.27	2.33	68.52 **
APMS 6A X JGL11160	95.53	-2.35	20.07 *	87.87	3.36	139.82 **
APMS 6A X JGL11118	99.13	-0.93	0.17	96.41	2.33	23.60 *
APMS 6A X JGL11111	96.24	5.71	7.23	110.80	0.72	222.80 **
APMS 6A X JGL8605	101.36	0.26	-3.95	104.86	-3.59	174.48 **
APMS 6A X JGL8292	98.04	2.25	-4.13	103.77	-0.64	465.57 **
APMS 6A X JGL3855	101.24	-0.65	1.48	103.58	-1.23	625.02 **
APMS 6A X JGL3844	99.89	2.37	-3.31	102.94	-1.20	446.35 **
APMS 6A X JGL1798	102.60	-0.51	-0.26	100.10	-1.09	34.15 **
IR 58025A X JGL 11110-2	103.16	0.74	-3.48	104.21	-0.34	61.60 **
IR 58025A X JGL11110-1	102.78	1.01	-4.14	104.61	0.28	140.99 **
IR 58025A X JGL17211	97.93	4.23	-3.41	96.60	0.31	49.49 **
IR 58025A X JGL16284	101.40	-0.08	-0.66	97.23	0.10	58.76 **
IR 58025A X JGL13515	103.56	-0.05	-1.92	102.72	-1.36	239.20 **
IR 58025A X JGL11160	86.58	1.38	70.94 **	101.19	-0.52	397.20 **
IR 58025A X JGL11118	89.87	3.60 *	-4.17	98.70	-0.35	335.33 **
IR 58025A X JGL11111	96.31	5.79	5.34	100.53	2.03	3.63
IR 58025A X JGL8605	104.49	0.53	-0.25	94.16	-1.96	325.66 **
IR 58025A X JGL8292	98.64	7.26	15.04 *	118.59	3.33	-3.06
IR 58025A X JGL3855	94.93	8.51	15.48 *	98.32	0.30	44.46 **
IR 58025A X JGL3844	92.38	5.96 *	-3.78	91.32	-1.73	479.53 **
IR 58025A X JGL1798	91.13	5.45 *	-3.67	97.74	-1.08	473.25 **
KRH - 2	92.58	-5.75	10.28	107.97	1.66	232.44 **
DRRH - 2	92.16	-4.99	15.55 *	108.93	-0.12	274.08 **
PA 6201	95.33	1.53	-3.49	104.11	0.92	150.89 **
JAYA	102.07	-1.81	2.67	101.62	-0.71	327.92 **
IR - 64	95.58	-2.57	4.90	93.91	1.41	15.43 *
Population Mean	**98.63**			**96.09**		
SE of βi		1.09			2.59	
CD at 5%	**4.80**			**9.94**		

* Significant at 5% level; ** Significant at 1% level

Similar results were obtained for gallmidge resistance by Srinivas *et al.* (1994) who studied and reported that gallmidge biotype 3 exists at Jagtial and the biotype pattern at Warangal was different and a change in the pattern of gallmidge reaction was indicated. Pasalu *et al.* (1998) studied the current rice gallmidge biotypes in India and reported the changing biotypes. Bentur *et al.* (1998) reported that the gallmidge is a pest of rice that has been successfully managed through breeding and cultivation of resistant varieties. Laxmi *et al*. (2006) studied a new biotype of Asian rice gallmidge from the Warangal population.

Jian Xian Bin *et al.* (2006) studied the restoring ability of rice varieties and resistance evaluation of F1 generation. Bentur *et al*. (2008) studied the monitoring of virulence of Asian rice gallmidge population in India. Naikebawane *et al.* (2008) reported JGL 384 as a donor for gallmidge resistance.

The pooled analysis of variance revealed that the variances for the genotypes were significant for gallmidge damaged plants percentage and silver shoots percentage, indicating the presence of genetic variability among genotypes for these characters.

4.3.3.3 Days to 50% flowering

For days to 50% flowering among the genotypes all the testers, lines and 56 hybrids are non significant, deviation from the regression (S^2di) values i.e. the genotypes are statistically within the range of minimum deviation from regression and whose performance can be predicted (Table 4.47).

Among the lines and testers, IR 68897A, JGL 1798, JGL 11111, JGL 3844, JGL 11110-1, JGL 8292, JGL 11160, JGL 11110-2, JGL 17211 and JGL 16284 recorded the minimum deviation from regression, recorded unit of bi values and thus possessed average stability and is adoptable to all environments less duration.The line JGL 11118 recorded less than the unit of bi value and thus possessed more than the average stability and is adoptable to poor environments.

Among the hybrids IR 68897A x JGL11118, IR 68897A x JGL11110-1, IR 68897A x JGL11160 recorded with unit regression values (bi). Hence, these hybrids are considered to possess the average stability whose performance does not change with the change in environments. The hybrid CMS 16A x JGL3855 recorded more than one of bi value and considered to possess less than the average stability and are adoptable to favourable environments (Table 4.45).

In respect of days to 50 per cent flowering in the present investigation both linear and non linear components of GE interactions were found to be significant. Similar results were reported by Hegde and Vidyachandra (1998), Deshpande *et al.* (2003) and Shanmuganathan and Ibrahim (2005), while significance of non linear component was reported by Lohithaswa *et al.* (1999). Young and Virmani (1990) reported the significance of linear component of GE interaction for this character.

4.3.3.4 Plant height (cms)

For plant height among the genotypes 1 tester, 3 lines and 4 hybrids had non-significant deviation from the regression (S^2di) values i.e., the genotypes are satisfactorily within the range of minimum deviation from regression and whose performance can be predicted.

Among the lines and testers, APMS 6A and JGL 16284 recorded the minimum deviation from regression, with unit of bi values and thus possessed average stability and was adoptable to all environments with less plant height.

Similarly the hybrid IR 68897A x JGL11110-1 recorded the minimum deviation from regression, with unit of bi values and thus possessed average stability and is adoptable to all environments with less plant height (Table 4.45).

In respect of plant height in the present investigation, both linear and non linear components of GE interactions were found to be in-significant. Among the lines and testers, none of the entry recorded minimum deviation from regression indicating that no entry is stable over environments. Similarly no hybrid recorded minimum deviation from regression for the character plant height indicating the un-stability of the character.

4.3.3.5 Flag leaf length (cms)

Among the all genotypes tested 4 testers, 6 lines and 33 hybrids had non significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.46).

Among the lines and testers, CMS 16A, IR 68897A, IR 58025A, JGL 11160, JGL 17211 and JGL 11110-2 recorded the unit of bi value and thus possessed average stability and is adoptable to all environments.

Among the hybrids, APMS 8A x JGL11110-1, CMS 16A x JGL8292, CMS 16A x JGL17211, APMS 8A x JGL11118, CMS 16A x JGL16284, APMS 6A x JGL11111 and IR 58025A x JGL3855 recorded the unit regression values, Hence, these hybrid were

Table 4.46. Mean performance and stability parameters for flag leaf length and flag leaf width in rice

Parent/Cross	Flag Leaf Length cm			Flag Leaf Width cm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	23.62	-1.65	-0.42	1.19	-1.67	0.02
IR 68897A	26.25	3.83	0.15	0.96	1.15	-0.01
APMS 6A	22.62	-0.04	2.75	1.36	-0.99 *	-0.01
APMS 8A	26.49	0.04	62.04 **	1.40	-1.86 *	-0.01
CMS 16A	27.88	-0.27	-2.62	1.62	-4.73	0.10 **
Lines						
JGL 11110-2	28.38	2.87 *	-2.62	1.23	2.48	0.00
JGL 11110-1	33.64	3.69	8.81 *	1.61	-2.01	0.01
JGL 17211	29.73	0.92	-2.01	1.63	-1.86	0.01
JGL 16284	28.18	1.68	61.77 **	1.55	0.95	0.02
JGL 13515	24.62	0.09	14.85 *	1.47	0.73	0.02
JGL 11160	31.16	3.06	-2.59	1.39	0.91	0.02
JGL 11118	26.12	-0.69	-1.91	1.17	2.11	0.04 *
JGL 11111	31.19	3.78	115.19 **	1.18	2.15	0.00
JGL 8605	27.78	-0.02	39.83 **	1.57	1.30	-0.01
JGL 8292	28.97	2.29	24.60 **	1.54	-0.74 *	-0.01
JGL 3855	24.86	0.31	38.19 **	1.41	0.07	0.00
JGL 3844	20.86	1.20	-1.81	1.12	1.33	-0.01
JGL 1798	25.80	0.39	-1.75	0.99	0.09	-0.01
CROSSES						
IR 68897A X JGL 11110-2	28.21	-3.01	27.95 **	0.97	-0.10	0.00
IR 68897A X JGL11110-1	24.56	-0.03	-1.28	0.80	-0.62 *	-0.01
IR 68897A X JGL17211	22.78	1.11	14.35 *	0.98	0.06	-0.01
IR 68897A X JGL16284	28.91	0.37	0.24	1.31	3.16	0.02
IR 68897A X JGL13515	29.53	0.95	44.66 **	1.03	1.27	0.00
IR 68897A X JGL11160	36.30	3.82	10.19 *	1.15	1.48	0.00
IR 68897A X JGL11118	28.33	-3.11	5.72	0.90	1.49	0.00
IR 68897A X JGL11111	29.22	0.96	50.01 **	1.27	1.65	-0.01
IR 68897A X JGL8605	28.34	0.90	-0.25	1.04	1.39	0.00
IR 68897A X JGL8292	28.65	-2.01	1.47	1.14	0.45	0.01
IR 68897A X JGL3855	27.56	-1.65	-2.52	0.98	-0.03	0.00
IR 68897A X JGL3844	28.50	-1.42	33.24 **	0.98	0.06	-0.01
IR 68897A X JGL1798	28.17	-3.46	6.63	1.04	-0.36	0.00
APMS 8A X JGL 11110-2	31.02	-2.70	4.72	1.24	2.46	-0.01
APMS 8A X JGL11110-1	35.79	0.42	-0.25	1.29	3.39	0.00
APMS 8A X JGL17211	34.59	-0.84	68.31 **	1.51	3.74	-0.01
APMS 8A X JGL16284	32.66	1.75	121.35 **	1.10	2.27	0.02
APMS 8A X JGL13515	31.00	-2.04	-2.56	1.35	3.72	-0.01
APMS 8A X JGL11160	31.82	0.37	24.52 **	1.31	2.18 *	-0.01
APMS 8A X JGL11118	33.73	-2.36	-2.22	1.26	2.03	0.03 *
APMS 8A X JGL11111	31.09	7.47	32.67 **	1.11	1.18	0.00
APMS 8A X JGL8605	28.31	6.09	9.53 *	1.53	4.85	0.11 **
APMS 8A X JGL8292	25.73	2.39	-1.04	0.89	-1.43	-0.01
APMS 8A X 3855	25.81	1.92	1.32	1.16	2.42	0.00
APMS 8A X 3844	28.84	-2.44	33.96 **	1.05	-1.77	0.00

Table 4.46(cont.)

Crosses	Flag Leaf Length cm			Flag Leaf Width cm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	30.78	1.65	26.78 **	1.43	3.84	0.00
CMS 16A X JGL 11110-2	30.29	1.58	-2.42	1.18	0.45	0.00
CMS 16A X JGL11110-1	29.37	4.07	-0.94	1.37	2.62	-0.01
CMS 16A X JGL17211	34.38	1.51	-2.56	1.25	1.58	-0.01
CMS 16A X JGL16284	32.80	-0.44	-2.60	1.46	1.75	-0.01
CMS 16A X JGL13515	28.57	1.17	-2.63	1.39	4.55 *	-0.01
CMS 16A X JGL11160	32.11	-0.83	4.69	1.64	5.58	0.03 *
CMS 16A X JGL11118	29.54	-1.80	-0.32	1.18	2.25	-0.01
CMS 16A X JGL11111	24.57	1.37	-0.88	1.16	2.48	0.00
CMS 16A X JGL8605	30.00	2.13	24.53 **	0.75	-0.57	-0.01
CMS 16A X JGL8292	35.54	4.60	7.34	1.07	0.75	0.00
CMS 16A X JGL3855	26.16	3.62	-0.15	1.60	5.10	0.07 **
CMS 16A X JGL3844	31.96	0.44	-0.82	1.24	1.80	0.01
CMS 16A X JGL1798	26.24	2.35	43.34 **	1.53	3.74	0.02
APMS 6A X JGL 11110-2	28.11	1.57	7.30	1.35	1.93	0.12 **
APMS 6A X JGL11110-1	31.78	1.57	-2.41	1.41	3.65	0.01
APMS 6A X JGL17211	30.68	-3.01	-2.26	1.20	1.89	0.00
APMS 6A X JGL16284	31.80	-2.24	10.77 *	1.26	2.28	0.02
APMS 6A X JGL13515	25.47	-1.52	80.23 **	1.50	3.62	0.00
APMS 6A X JGL11160	24.95	2.84	1.54	1.05	0.64	-0.01
APMS 6A X JGL11118	29.43	2.47	17.89 **	1.06	2.39	0.00
APMS 6A X JGL11111	32.73	4.88	1.89	1.30	2.88 *	-0.01
APMS 6A X JGL8605	29.56	0.92	0.99	1.23	2.77	-0.01
APMS 6A X JGL8292	28.98	3.30	54.78 **	1.16	2.81	0.00
APMS 6A X JGL3855	22.56	2.36	48.77 **	1.11	0.42	-0.01
APMS 6A X JGL3844	25.13	4.04	65.99 **	1.21	1.87	0.01
APMS 6A X JGL1798	27.48	1.66	67.90 **	1.75	-0.76	0.02
IR 58025A X JGL 11110-2	27.64	3.10	65.33 **	1.32	-0.18	0.02
IR 58025A X JGL11110-1	27.00	1.15	41.46 **	1.33	3.39	0.00
IR 58025A X JGL17211	30.27	4.07	79.49 **	1.10	0.98	0.00
IR 58025A X JGL16284	25.88	2.39	54.58 **	1.13	1.27	0.00
IR 58025A X JGL13515	28.24	-0.17	5.00	1.52	-3.36	-0.01
IR 58025A X JGL11160	26.04	1.50	33.68 **	1.11	2.06	0.23 **
IR 58025A X JGL11118	23.61	2.03	10.12 *	0.99	0.25 *	-0.01
IR 58025A X JGL11111	36.32	2.49	11.60 *	1.34	-1.18	-0.01
IR 58025A X JGL8605	26.67	0.60	10.15 *	0.91	-3.54	0.07 **
IR 58025A X JGL8292	26.89	5.04	145.55 **	0.99	0.66	0.08 **
IR 58025A X JGL3855	32.25	1.20	5.96	0.96	0.90	-0.01
IR 58025A X JGL3844	24.17	0.51	-0.74	0.79	-0.35	0.04 *
IR 58025A X JGL1798	23.85	2.15	7.87 *	1.16	-0.42	0.00
KRH - 2	26.57	-4.51	15.57 **	1.53	-3.30	0.11 **
DRRH - 2	27.56	-5.32	-2.06	1.03	0.76	0.01
PA 6201	24.53	4.56 *	-2.63	1.25	-1.25	0.01
JAYA	30.42	1.58	5.03	1.30	-0.88	0.00
IR - 64	21.75	0.43	1.80	1.40	-4.46 *	-0.01
Population Mean	**28.50**			**1.24**		
SE of βi		4.61			1.01	
CD at 5%	**3.66**			**0.22**		

* Significant at 5% level; ** Significant at 1% level

considered to possess the average stability whose performance does not change with change in environment for character flag leaf length with high mean.

4.3.3.6 Flag leaf width (cms)

Among the all genotypes tested 4 testers, 12 lines and 56 hybrids had non significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.47).

Among the lines and testers, 58025A, JGL 17211, JGL 11110-1, JGL 8605, JGL 16284, JGL 13515and JGL 3855 recorded the unit regression values, Hence considered to posses the average stability, whose performance does not change with change in environment. The APMS 8A, APMS 6A and JGL 8292 recorded less the unit of bi value and thus possessed more than average stability and is adoptable to poor environments.

Among the hybrids, APMS 6A x JGL 1798 and CMS 16A x JGL1798 recorded the unit of bi value, and thus possessed average stability and are adoptable to all environments (Table 4.47).

Both linear and non linear components of GE interactions were found to be significant for flag leaf width.

4.3.3.7 Panicle length (cms)

Among the genotypes 3 testers, 10 lines and 56 hybrids had non significant deviation from the regression (S^2di) values i.e., the genotypes is satisfactorily within the range of minimum deviation from the regression whose performance can be predicted (Table 4.47).

Among the lines and testers, APMS 6A, APMS 8A and JGL 17211 with less deviation from regression recorded with unit regression values (bi) with more panicle length. Hence, these genotypes are considered to possess the average stability, whose performance does not change with change in environment. The line JGL 3855 recorded less than unit of bi value and thus possessed more than average stability and is adoptable to poor environments, where as the line JGL 8292 recorded more than one of bi value and considered to possess less than the average stability and are adoptable to favourable environments.

Among the hybrids, IR 68897A x JGL 11110-2, IR 68897A x JGL16284, CMS 16A x JGL 11110-2 and IR 58025A x JGL11111 recorded with unit regression values with more panicle length.Hence, these hybrids are considered to possess the average stability whose performance does not change with change in environment for the

Table 4.47. Mean performance and stability parameters for productive tillers/ panicle length in rice

Parent/Cross	Productive Tillers/ Plant			Panicle Length cm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	8.89	0.62	-0.78	17.19	0.13	7.48 **
IR 68897A	8.72	0.48	1.82	20.77	2.10	1.19
APMS 6A	10.50	0.62	7.86 **	21.87	1.10	0.36
APMS 8A	15.22	1.79	6.06 **	21.36	-0.01	0.65
CMS 16A	14.61	1.23	-1.00	20.34	2.36	2.44 *
Lines						
JGL 11110-2	11.17	0.24	4.34 *	21.53	2.11	4.36 **
JGL 11110-1	13.39	1.11	34.11 **	26.74	-0.49	3.40 **
JGL 17211	12.89	0.82	0.81	23.37	0.50	-0.04
JGL 16284	9.33	0.09	4.97 *	22.26	0.41	-0.24
JGL 13515	11.39	0.76	13.52 **	24.01	-0.88	4.11 **
JGL 11160	10.50	0.95	18.21 **	21.77	0.22	0.62
JGL 11118	11.39	1.16	3.31 *	22.46	-0.33	-0.29
JGL 11111	8.72	0.13	0.36	21.63	1.80	0.45
JGL 8605	12.17	0.92	6.46 **	21.82	0.06	-0.43
JGL 8292	10.11	0.48	-0.34	23.91	1.83 *	-0.47
JGL 3855	8.22	0.37	2.79	22.98	-0.92 *	-0.43
JGL 3844	8.61	0.33	-0.28	19.48	0.88	0.36
JGL 1798	9.39	0.11	-0.04	21.93	-0.15 *	-0.45
Crosses						
IR 68897A X JGL 11110-2	13.39	1.55	-0.89	25.83	1.57	-0.28
IR 68897A X JGL11110-1	9.11	0.36	2.46	22.60	0.88	-0.23
IR 68897A X JGL17211	7.39	0.31 *	-1.00	21.76	1.20	-0.44
IR 68897A X JGL16284	11.06	0.91	12.69 **	24.53	1.82	-0.27
IR 68897A X JGL13515	10.94	0.43	7.00 **	22.78	2.21	-0.11
IR 68897A X JGL11160	16.06	1.57	62.90 **	23.80	0.44	-0.16
IR 68897A X JGL11118	13.83	1.17	0.84	21.44	-0.64 *	-0.39
IR 68897A X JGL11111	14.56	0.89	17.14 **	24.85	2.07 *	-0.47
IR 68897A X JGL8605	18.94	1.72	13.64 **	22.66	1.60	-0.32
IR 68897A X JGL8292	17.78	1.76	-0.59	25.01	0.42	1.57 *
IR 68897A X JGL3855	17.56	2.21	0.51	23.32	-0.04	0.54
IR 68897A X JGL3844	16.67	1.77	-0.72	23.46	1.26	-0.45
IR 68897A X JGL1798	19.17	2.29	11.61 **	20.03	2.62	0.08
APMS 8A X JGL 11110-2	12.39	1.25	7.94 **	23.46	0.36	-0.19
APMS 8A X JGL11110-1	15.00	1.00	-0.41	23.64	1.91	-0.40
APMS 8A X JGL17211	10.61	0.83	1.61	22.97	1.07	-0.31
APMS 8A X JGL16284	9.17	0.59	2.24	23.73	2.78	-0.29
APMS 8A X JGL13515	14.17	1.38	1.76	22.18	1.64	-0.35
APMS 8A X JGL11160	12.89	1.57	11.89 **	22.83	0.37 *	-0.47
APMS 8A X JGL11118	18.50	2.28	3.67 *	22.24	0.29	-0.43
APMS 8A X JGL11111	19.33	2.22	0.29	21.76	1.31	0.26
APMS 8A X JGL8605	13.28	1.05	1.83	22.07	3.04	2.67 *
APMS 8A X JGL8292	9.78	1.06	-0.87	21.66	0.93	-0.14
APMS 8A X JGL3855	12.33	1.11	27.92 **	22.12	1.89	-0.38
APMS 8A X JGL3844	16.78	2.13	29.14 **	22.42	2.33	-0.33

Table 4.47(cont.)

	Productive Tillers/ Plant			Panicle Length cm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	10.94	0.69	1.98 **	20.61	0.39	0.38
CMS 16A X JGL 11110-2	14.72	1.79	14.76	24.33	1.46	-0.42
CMS 16A X JGL11110-1	11.00	0.82	25.59	23.03	2.60	0.09
CMS 16A X JGL17211	12.06	0.67	9.02 **	24.12	1.87	-0.37
CMS 16A X JGL16284	15.06	1.47	79.51	21.87	0.67	-0.46
CMS 16A X JGL13515	12.28	0.91	0.67 **	22.99	0.30	0.06
CMS 16A X JGL11160	15.94	1.78	1.55 **	23.34	1.58	-0.26
CMS 16A X JGL11118	13.61	1.36	29.12 **	20.53	1.90	11.97 **
CMS 16A X JGL11111	11.28	0.74	-0.06 **	23.27	0.02	2.04 *
CMS 16A X JGL8605	11.39	1.23	22.81 *	22.90	1.71	-0.04
CMS 16A X JGL8292	13.17	1.13	8.29 **	22.21	1.17	-0.46
CMS 16A X JGL3855	10.11	0.35	21.91	21.99	1.18	0.12
CMS 16A X JGL3844	15.28	1.52	6.58 **	22.24	0.39	4.96 **
CMS 16A X JGL1798	16.06	1.71	4.70 **	19.90	1.99	-0.18
APMS 6A X JGL 11110-2	15.06	0.97	6.66	22.27	1.31	0.30
APMS 6A X JGL11110-1	19.89	1.90	0.31 **	23.98	1.28	-0.46
APMS 6A X JGL17211	15.11	1.05	32.74 **	20.99	1.09	-0.28
APMS 6A X JGL16284	17.33	1.62	29.61	22.76	0.90	-0.47
APMS 6A X JGL13515	10.28	0.08	-0.42	21.97	2.16	2.21 *
APMS 6A X JGL11160	14.11	1.58	98.19 **	22.38	1.50	-0.45
APMS 6A X JGL11118	14.17	0.92	6.46	21.69	0.85	-0.47
APMS 6A X JGL11111	12.17	-0.69 *	-0.98 *	22.46	0.27	-0.01
APMS 6A X JGL8605	12.28	1.17	-0.60	21.01	0.98	15.00 **
APMS 6A X JGL8292	15.72	0.96	35.43	22.37	1.29	-0.34
APMS 6A X JGL3855	12.00	0.54	2.39	21.40	1.02	-0.38
APMS 6A X JGL3844	11.17	0.16	3.55 **	20.22	0.58	-0.46
APMS 6A X JGL1798	14.67	0.92	1.01 **	22.89	0.31	-0.07
IR 58025A X JGL 11110-2	12.50	0.92	-0.88 *	22.88	1.01	4.08 **
IR 58025A X JGL11110-1	9.67	-0.11	1.28 **	22.90	1.82 *	-0.47
IR 58025A X JGL17211	13.56	1.18	56.34 **	21.23	0.49	0.77
IR 58025A X JGL16284	14.11	1.38	106.01	22.90	0.82	-0.30
IR 58025A X JGL13515	12.78	1.07	4.06 *	16.84	-2.80	8.55 **
IR 58025A X JGL11160	16.22	2.06	20.10	22.42	1.64	-0.14
IR 58025A X JGL11118	12.72	0.61	27.62 **	22.51	1.20	0.07
IR 58025A X JGL11111	10.72	0.32	-0.67 *	24.13	1.71	-0.41
IR 58025A X JGL8605	12.61	1.80	5.40 **	21.08	-1.03	0.37
IR 58025A X JGL8292	8.72	0.09 *	-1.01 **	22.22	1.07	-0.20
IR 58025A X JGL3855	15.33	1.58	23.63	23.78	1.72	-0.44
IR 58025A X JGL3844	10.94	0.33	4.01	21.96	0.96	-0.39
IR 58025A X JGL1798	12.33	1.15	14.81 **	22.48	0.78	-0.38
KRH - 2	11.78	0.16 *	-0.88	24.20	1.67	1.96 *
DRRH - 2	14.83	1.27	39.12 **	22.84	0.87	-0.26
PA 6201	11.61	0.17	1.00	21.72	1.67	-0.40
JAYA	11.56	1.10	16.19 **	21.44	-1.24 *	-0.47
IR - 64	10.39	0.00	-0.66	22.94	0.85	0.46
Population Mean	**12.90**			**22.37**		
SE of βi		0.64			0.48	
CD at 5%	**3.12**			**1.65**		

* Significant at 5% level; **and** Significant at 1% level

character panicle length.The hybrid IR 68897A x JGL11111 recorded more than one of bi value and considered to possess less than the average stability and are adoptable to favourable environments.

Regarding panicle length, the results indicated that the GE interactions, mainly due to both linear and non linear components, which are significant.

4.3.3.8 Productive tillers per plant

Among the genotypes 3 testers, 6 lines and 29 hybrids had non- significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from regression (Table 4.47).Among the lines and testers CMS 16A, JGL 17211 and JGL 8292 recorded with unit regression values (bi). Hence, these hybrids are considered to possess the average stability, whose performance does not change with change in environments.

Among the hybrids APMS 8A x JGL11111, IR 68897A x JGL8292, IR 68897A x JGL3855 and APMS 6A x JGL16284 recorded with unit regression values (bi). Hence, these hybrids are considered to possess the average stability, whose performance does not change with change in environments.

In respect of productive tillers per plant in the present investigation, both linear and non linear components of GE interactions were found to be significant

4.3.3.9 Panicle weight (gm)

Among the genotypes one tester, one line and 14 hybrids had non significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.48).

Among the lines and testers, IR 68897A and JGL 11110-2 recorded with unit regression values (bi) with high mean. Hence, the genotypes were considered to possess the average stability, whose performance does not change with change in environment.

Among the hybrids CMS 16A x JGL 11110-2 recorded with unit regression values; hence these hybrids are considered to possess the average stability, whose performance does not change with change in environment.The hybrids IR 68897A x JGL16284 and APMS 8A x JGL11110-1 recorded more than unit regression values (bi). Hence, these hybrids are considered to possess the less than average stability.

Table 4.48. Mean performance and stability parameters for panicle weight and filled grains/ panicle in rice

Parents/Crosses	Panicle Weight gm			Filled Grains/ Panicle		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	2.10	0.49	0.18 **	123.56	-2.55	473.20 *
IR 68897A	2.97	1.11	0.00	144.58	-1.71	2432.45 **
APMS 6A	2.51	-0.59	0.87 **	149.25	-3.65	951.77 **
APMS 8A	2.67	-0.97	0.25 **	179.47	-5.60 *	-99.92
CMS 16A	3.31	0.34	0.83 **	260.13	-10.89	9184.77 **
Lines						
JGL 11110-2	2.19	0.57	-0.01	193.83	-3.31	201.09
JGL 11110-1	3.42	-0.91	2.29 **	290.90	-6.83	544.56 *
JGL 17211	3.73	-0.11	0.41 **	246.79	-2.65	5376.79 **
JGL 16284	3.24	-2.25	1.80 **	314.56	-3.53	-85.26
JGL 13515	2.42	2.18	0.31 **	161.43	6.12	0.85
JGL 11160	3.42	0.01	3.17 **	201.08	5.92	9724.00 **
JGL 11118	3.80	-1.02	0.13 **	255.01	-9.57	5585.57 **
JGL 11111	2.72	0.76	0.19 **	172.01	2.99	1558.92 **
JGL 8605	3.34	-1.21	1.55 **	257.06	-0.83	5199.91 **
JGL 8292	2.58	1.19	0.23 **	245.58	5.52	2383.15 **
JGL 3855	2.98	1.19	2.66 **	225.88	5.61	15300.27 **
JGL 3844	2.28	-0.66	0.05 *	140.18	-3.55	6827.02 **
JGL 1798	3.42	3.04	1.44 **	184.06	4.50	1642.01 **
Crosses						
IR 68897A X JGL 11110-2	3.36	1.10	1.27 **	158.07	-0.56	279.89
IR 68897A X JGL11110-1	2.78	0.09	0.11 **	146.75	-1.47	48.73
IR 68897A X JGL17211	2.46	0.14	0.00	133.72	2.41	281.33
IR 68897A X JGL16284	3.99	3.22 *	-0.01	206.92	4.63	360.23 *
IR 68897A X JGL13515	2.69	2.28	-0.01	138.97	1.28	1365.75 **
IR 68897A X JGL11160	3.90	1.37	2.05 **	173.46	-0.27	3413.12 **
IR 68897A X JGL11118	2.50	0.20	1.11 **	111.46	-1.15	36.89
IR 68897A X JGL11111	3.68	2.07	0.44 **	196.85	3.63	4344.64 **
IR 68897A X JGL8605	3.31	0.34	0.14 **	167.61	-0.26	174.58
IR 68897A X JGL8292	3.39	1.61	0.30 **	134.49	-1.73	1696.45 **
IR 68897A X JGL3855	2.31	0.25 *	-0.01	117.78	0.62	-72.50
IR 68897A X JGL3844	2.96	1.37	0.06 *	141.79	4.39	4.58
IR 68897A X JGL1798	2.56	1.72	0.26 **	100.89	3.00	4547.59 **
APMS 8A X JGL 11110-2	3.11	2.18	0.38 **	196.35	2.59	-39.04
APMS 8A X JGL11110-1	3.96	2.79 *	-0.01	238.10	3.94 *	-100.80
APMS 8A X JGL17211	4.21	1.53	1.37 **	255.17	0.16	347.91 *
APMS 8A X JGL16284	3.61	1.82	0.30 **	189.39	4.44 *	-100.19
APMS 8A X JGL13515	3.04	1.26	2.94 **	167.25	3.41	13888.43 **
APMS 8A X JGL11160	3.67	3.33	1.39 **	181.88	7.32 *	-100.50
APMS 8A X JGL11118	3.03	1.12	0.11 **	130.81	2.85	-83.80
APMS 8A X JGL11111	3.16	0.96	0.00	213.40	1.29	1939.00 **
APMS 8A X JGL8605	2.82	1.61	0.01	189.90	9.73	626.79 **
APMS 8A X JGL8292	2.59	1.04	0.28 **	180.14	7.48	341.27 *
APMS 8A X JGL3855	2.53	0.78	0.00	155.03	1.66	1120.27 **
APMS 8A X JGL3844	2.84	-0.39	0.58 **	205.17	1.36	199.54

Table 4.48 (cont.)

Crosses			Panicle Length cm			Filled Grains/ Panicle		
			μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A	X	JGL1798	2.26	-0.01	0.00	134.51	1.31	1660.40 **
CMS 16A	X	JGL 11110-2	3.80	1.99	0.03	231.83	1.15	2615.23 **
CMS 16A	X	JGL11110-1	3.37	2.01	0.64 **	209.75	8.11	-28.75
CMS 16A	X	JGL17211	3.46	0.30	4.53 **	201.10	-6.63	-48.84
CMS 16A	X	JGL16284	3.22	-0.62	1.18 **	181.68	-6.62	596.31 **
CMS 16A	X	JGL13515	3.37	2.49	0.21 **	256.46	-6.73	532.36 *
CMS 16A	X	JGL11160	3.40	0.91	0.91 **	219.64	-4.57	15683.74 **
CMS 16A	X	JGL11118	3.64	2.28	0.51 **	209.93	5.81	1337.37 **
CMS 16A	X	JGL11111	2.66	1.33	0.69 **	168.46	0.56	3830.77 **
CMS 16A	X	JGL8605	2.56	1.61 *	-0.01	178.94	-3.28 *	8062.42 **
CMS 16A	X	JGL8292	2.90	1.30	0.85 **	196.26	9.08	-74.85
CMS 16A	X	JGL3855	3.04	3.27	0.08 **	175.46	5.61	-83.41
CMS 16A	X	JGL3844	2.92	0.76	0.01	121.06	-1.34	-53.00
CMS 16A	X	JGL1798	2.70	0.23	2.38 **	119.86	-1.77	692.61 **
APMS 6A	X	JGL 11110-2	3.99	-0.99	0.13 **	265.44	-7.32	29609.11 **
APMS 6A	X	JGL11110-1	3.81	0.55	0.08 **	207.06	2.98	8004.44 **
APMS 6A	X	JGL17211	4.39	2.17	0.16 **	233.31	7.86	2044.09 **
APMS 6A	X	JGL16284	3.46	1.65	0.49 **	196.11	10.64	4663.33 **
APMS 6A	X	JGL13515	2.19	0.55	0.09 **	143.13	1.10	378.15 *
APMS 6A	X	JGL11160	3.76	1.74	0.24 **	268.78	-2.29	2452.42 **
APMS 6A	X	JGL11118	3.50	4.04	0.34 **	225.04	8.84	17597.64 **
APMS 6A	X	JGL11111	3.09	1.68	0.30 **	224.42	4.46	337.03 *
APMS 6A	X	JGL8605	1.90	0.30	0.13 **	122.68	2.37	644.96 **
APMS 6A	X	JGL8292	2.67	0.64	0.38 **	149.74	2.72	2138.42 **
APMS 6A	X	JGL3855	3.30	1.50	0.31 **	163.78	7.66 *	842.93 **
APMS 6A	X	JGL3844	2.89	1.14	0.55 **	155.18	5.20	-98.88
APMS 6A	X	JGL1798	2.43	0.72	0.29 **	139.71	0.43	2577.50 **
IR 58025A	X	JGL 11110-2	2.82	0.70	1.02 **	148.53	0.27	2794.18 **
IR 58025A	X	JGL11110-1	3.20	2.27	1.00 **	145.25	-1.03	3770.33 **
IR 58025A	X	JGL17211	3.46	2.16	2.40 **	169.15	-1.82	2450.00 **
IR 58025A	X	JGL16284	3.34	1.23	0.72 **	201.51	5.83	4.94
IR 58025A	X	JGL13515	2.43	-0.25 *	-0.01	144.64	-4.27	556.26 *
IR 58025A	X	JGL11160	3.63	-1.18	3.32 **	165.65	-4.33	4755.17 **
IR 58025A	X	JGL11118	2.62	0.16	0.81 **	191.92	-6.80	15182.64 **
IR 58025A	X	JGL11111	3.90	3.20	0.13 **	206.18	7.36	2880.49 **
IR 58025A	X	JGL8605	2.27	-1.12	0.61 **	138.89	-4.38	170.58
IR 58025A	X	JGL8292	3.02	3.83	1.29 **	234.83	7.62	32135.28 **
IR 58025A	X	JGL3855	2.78	1.50	-0.01	168.28	9.09	910.24 **
IR 58025A	X	JGL3844	2.49	0.74	0.05 *	128.25	-1.66	-8.61
IR 58025A	X	JGL1798	2.43	-0.35	0.26 **	144.71	-5.14	5838.79 **
KRH - 2			3.53	1.44	2.91 **	163.47	1.22	60.47
DRRH - 2			3.61	1.24	0.03	142.43	2.49	121.03
PA 6201			3.24	0.70	0.04 *	132.64	2.20	391.19 *
JAYA			3.30	0.88	0.08 **	128.49	1.41	38.98
IR - 64			3.00	0.40	0.24 **	138.04	-2.11	547.13 *
Population Mean			**3.08**			**181.46**		
SE of βi				1.26			6.40	
CD at 5%			**0.67**			**43.11**		

* Significant at 5% level; ** Significant at 1% level

Table 4.49. Mean performance and stability parameters for spikelet fertility (%) and 1000 grain weight in rice

Parents/Crosses	Spikelet Fertility %			1000 Grain Weight gm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	87.34	-0.39	121.25 **	18.32	2.09	0.53
IR 68897A	84.70	0.91	114.36 **	20.76	1.20	0.25
APMS 6A	82.48	7.61	20.08 **	18.26	-1.01	-0.66
APMS 8A	92.28	-2.34	-0.82	15.70	-0.43	-0.79
CMS 16A	89.52	-0.72	-2.56	16.82	0.17	-0.53
Lines						
JGL 11110-2	80.16	5.72	353.03 **	17.54	0.02	-0.61
JGL 11110-1	89.07	-0.44	54.16 **	16.20	0.90	-0.01
JGL 17211	85.54	4.44	18.65 **	16.15	-0.13	-0.88
JGL 16284	89.57	0.15	4.47	17.09	0.90	-0.46
JGL 13515	92.09	1.45 *	-2.71	15.93	0.76	-0.13
JGL 11160	92.63	-3.71	17.28 **	16.26	0.76	-0.70
JGL 11118	92.06	4.84	-1.11	16.93	1.35	-0.15
JGL 11111	91.89	-1.25	-1.16	17.65	0.90	-0.26
JGL 8605	89.89	-2.33 *	-2.65	16.93	1.05	-0.14
JGL 8292	91.34	-4.07 *	-2.69	18.43	2.38	1.24
JGL 3855	89.69	-4.11	3.95	18.87	-0.28 *	-0.91
JGL 3844	85.51	5.19	45.05 **	16.65	0.61	-0.25
JGL 1798	93.67	-0.82	11.10 *	19.98	2.97	1.63
Crosses						
IR 68897A X JGL 11110-2	80.56	-4.17	185.68 **	22.70	1.93	3.58 *
IR 68897A X JGL11110-1	87.28	9.08 *	-2.27	17.32	2.08 *	-0.93
IR 68897A X JGL17211	90.22	2.17	28.00 **	16.70	1.93	-0.83
IR 68897A X JGL16284	84.68	-2.83	96.14 **	22.04	1.93	0.78
IR 68897A X JGL13515	86.89	8.73	11.92 *	17.43	1.21	6.48 **
IR 68897A X JGL11160	87.22	-1.31	104.74 **	22.59	2.51	12.25 **
IR 68897A X JGL11118	81.89	1.66	4.50	21.54	2.96	9.07 **
IR 68897A X JGL11111	76.75	1.92	148.27 **	16.48	1.05	0.12
IR 68897A X JGL8605	76.96	-9.22	300.51 **	21.43	3.25	10.91 **
IR 68897A X JGL8292	83.72	-5.09	-1.90	22.93	2.52	1.60
IR 68897A X JGL3855	76.85	-10.77	8.55 *	18.26	0.17	2.03
IR 68897A X JGL3844	80.22	-3.31	183.77 **	19.93	1.93	1.56
IR 68897A X JGL1798	49.74	9.45	231.23 **	21.26	2.82	-0.33
APMS 8A X JGL 11110-2	87.22	1.92	25.79 **	17.43	2.37	3.91 *
APMS 8A X JGL11110-1	85.43	-4.86	75.78 **	16.04	1.64 *	-0.93
APMS 8A X JGL17211	78.57	-14.07	48.15 **	18.76	3.25	13.88 **
APMS 8A X JGL16284	89.99	0.17	88.84 **	17.26	1.64	-0.71
APMS 8A X JGL13515	90.56	-0.46	4.22	19.98	2.66	9.92 **
APMS 8A X JGL11160	89.04	0.49	51.66 **	15.93	0.17	-0.11
APMS 8A X JGL11118	81.92	-8.01 *	-2.37	18.15	2.22	11.24 **
APMS 8A X JGL11111	78.60	19.07	2.32	16.32	1.78	0.60
APMS 8A X JGL8605	89.80	-2.04	-1.95	16.32	1.49	0.58
APMS 8A X JGL8292	93.07	0.57	5.35	13.48	0.17	0.15
APMS 8A X JGL3855	77.76	3.21	41.13 **	16.20	1.78	1.34
APMS 8A X JGL3844	83.55	-0.29	99.39 **	17.93	1.34	1.53

Table 4.49 (cont.)

Crosses			Spikelet Fertility %			1000 Grain Weight gm		
			μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A	X	JGL1798	59.39	-7.58	117.37 **	15.82	0.76	-0.55
CMS 16A	X	JGL 11110-2	81.22	-4.53	8.38 *	17.76	2.37	0.98
CMS 16A	X	JGL11110-1	84.39	7.78	0.00	15.87	1.79 *	-0.92
CMS 16A	X	JGL17211	78.56	-10.84	198.16 **	20.26	2.81	3.08 *
CMS 16A	X	JGL16284	84.72	0.52	124.22 **	16.26	1.93	-0.35
CMS 16A	X	JGL13515	82.56	7.27 *	-2.58	16.76	0.90	0.91
CMS 16A	X	JGL11160	90.29	4.21	4.02	16.09	-0.57	2.83 *
CMS 16A	X	JGL11118	80.89	-3.47	8.55 *	15.43	-0.57	1.41
CMS 16A	X	JGL11111	88.36	4.17	0.46	15.70	1.35	-0.82
CMS 16A	X	JGL8605	93.73	0.99	-2.34	16.65	1.78	-0.76
CMS 16A	X	JGL8292	75.16	-1.69	-0.54	17.20	-0.86	3.98 *
CMS 16A	X	JGL3855	89.13	8.26 *	-2.17	18.48	3.40	1.23
CMS 16A	X	JGL3844	60.35	13.16	279.30 **	19.20	0.89	6.44 **
CMS 16A	X	JGL1798	52.57	1.17	316.42 **	19.43	2.95	10.87 **
APMS 6A	X	JGL 11110-2	86.56	3.43	31.01 **	15.70	0.46	1.56
APMS 6A	X	JGL11110-1	85.22	-5.44	63.15 **	17.59	0.47	13.18 **
APMS 6A	X	JGL17211	85.05	1.65	-1.23	21.20	2.07	6.57 **
APMS 6A	X	JGL16284	84.39	1.77	18.00 **	16.82	1.64	-0.55
APMS 6A	X	JGL13515	90.90	1.60	15.67 **	17.37	0.16	-0.72
APMS 6A	X	JGL11160	90.22	0.41	-1.57	16.26	-0.72	2.09
APMS 6A	X	JGL11118	76.56	-4.92	85.69 **	16.43	-0.86	6.69 **
APMS 6A	X	JGL11111	86.96	-0.74	59.91 **	17.70	0.46	-0.17
APMS 6A	X	JGL8605	63.68	-17.79	78.83 **	14.76	-0.57	0.33
APMS 6A	X	JGL8292	75.07	-6.92 *	-2.33	17.20	0.61	0.00
APMS 6A	X	JGL3855	83.11	-1.75	111.07 **	18.65	0.61	-0.77
APMS 6A	X	JGL3844	84.51	-2.45	60.86 **	18.20	-0.87 *	-0.88
APMS 6A	X	JGL1798	67.91	26.07	118.31 **	16.09	-0.86	2.85 *
IR 58025A	X	JGL 11110-2	81.89	-5.79	10.22 *	17.87	0.32	0.97
IR 58025A	X	JGL11110-1	85.61	7.14	5.55	15.59	-0.42	5.56 **
IR 58025A	X	JGL17211	76.68	24.85	6.77	16.48	0.17	0.15
IR 58025A	X	JGL16284	91.67	1.63	18.83 **	16.54	0.90	-0.63
IR 58025A	X	JGL13515	85.53	1.43	4.05	16.48	-0.42	4.25 *
IR 58025A	X	JGL11160	91.69	-0.13	4.75	15.43	0.61	1.34
IR 58025A	X	JGL11118	86.39	5.31	45.52 **	16.87	0.61	-0.91
IR 58025A	X	JGL11111	81.29	-2.15 *	-2.68	18.09	0.61	-0.45
IR 58025A	X	JGL8605	75.56	-3.72	126.49 **	18.20	0.31	-0.87
IR 58025A	X	JGL8292	89.93	-1.24	38.61 **	16.48	0.75	-0.89
IR 58025A	X	JGL3855	89.67	3.99	1.61	15.65	0.90	-0.77
IR 58025A	X	JGL3844	75.89	25.88	85.79 **	18.04	-0.13 *	-0.93
IR 58025A	X	JGL1798	69.22	28.96 *	-2.53	16.76	1.20	0.25
KRH - 2			92.21	-2.77	12.88 *	23.82	0.76	-0.55
DRRH - 2			91.54	-0.11	0.86	25.59	1.05	0.75
PA 6201			89.69	-4.71	25.77 **	23.76	-0.57 *	-0.92
JAYA			93.20	-3.06 *	-2.64	27.26	0.76	-0.70
IR - 64			94.30	-4.01	-0.73	25.70	-1.90	-0.25
Population Mean			**83.77**			**18.05**		
SE of βι				5.30			0.68	
CD at 5%			**7.72**			**2.11**		

* Significant at 5% level; ** Significant at 1% level

4.3.3.10 Filled grains per panicle

Among the all genotypes tested for the character filled grains per panicle, 1tester, 3lines and 22 hybrids had non- significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.49).

Among the lines and testers, The tester APMS 8A recorded less than unit of bi value and thus possessed more than average stability and is adoptable to poor environments, the line JGL 16284 recorded with unit regression values (bi) with high mean. Hence, the genotypes are considered to possess the average stability, whose performance does not change with change in environment.

Similarly among all hybrids tested, CMS 16A x JGL11110-1, APMS 8A x JGL3844, IR 58025A x JGL16284, CMS 16A x JGL17211, APMS 8A x JGL 11110-2, CMS 16A x JGL8292, APMS 8A x JGL16284, APMS 8A x JGL11160 and CMS 16A x JGL3855 recorded with unit regression values with high mean, hence these hybrids are considered to possess the average stability, whose performance does not change with change in environment, for the character filled grains per panicle.The hybrid APMS 8A X JGL11110-1 recorded more than unit regression values (bi),hence, considered to possess the less than average stability.

In the yield attributing trait, filled grains per panicle, both linear and non linear components of GE interactions were found to be non significant.

4.3.3.11 Spikelet fertility (%)

Among all genotypes tested for the character spikelet fertility (%) 2 testers, 7 lines and 25 hybrids had non significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.49).

Among the lines and testers APMS 8A, CMS 16A, JGL 11118, JGL 11111, JGL 8292 ,JGL 8605, JGL 3855 and JGL 16284 recorded the unit regression values, Hence considered to possess the average stability, whose performance does not change with change in environment. The line JGL 13515 recorded more than unit regression values (bi), hence, considered to possess the less than average stability.

Similarly among all hybrids tested CMS 16A x JGL8605, APMS 8A x JGL8292, IR 58025A x JGL11160, APMS 8A x JGL13515, CMS 16A x JGL11160, APMS 6A x JGL11160,APMS8AxJGL8605,IR58025A x JGL3855 and CMS 16A x JGL11111 recorded minimum deviation from the regression, hence considered to be stable for the character spikelet fertility (%). The hybrid CMS 16A x JGL3855 and IR 68897A x JGL11110-1 recorded more than unit regression values (bi), hence, considered to possess the less than average stability.

With regard to important yield influence trait, spikelet fertility (%), both linear and non linear components of GE interactions were found to be significant.

4.3.3.12 1000 grain weight (gm)

Among all genotypes tested for the character 1000 grain weight all the testers, lines and 45 hybrids had non significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.49).

Among the lines and testers IR 68897A, IR 58025A, JGL 1798 and JGL 8292 recorded the unit regression values, Hence considered to possess the average stability, whose performance does not change with change in environment.The line JGL 3855 recorded lees than unit regression values (bi), hence, considered to possess the more than average stability.

In hybrids IR 68897A x JGL8292, IR 68897A x JGL16284 and IR 68897A x JGL1798 recorded unit regression values, hence these hybrids are considered to possess, the average stability, whose performance does not change with change in environment (Table 4.49).

4.3.3.13 Yield per plant (gm)

Among all the genotypes tested for the character yield/plant, all the lines, testers and 61 hybrids had non- significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.50).

Among the lines and testers all the entries, recorded unit regression values, hence these entries are considered to possess the average stability, whose performance does not change with change in environments.

Similarly, 61hybrids recorded unit regression values, Hence these hybrids are considered to possess the average stability, whose performance does not change with change in environments.The yield of APMS 8A x JGL 11110-2 (31.22) was significantly superior over APMS 8A x JGL11110-1(29.95) followed by,the hybrid APMS 6A x JGL11111 (29.65), APMS 6A x JGL8605 (28.43) and APMS 6A x JGL11110-1(28.30) among the top five hybrids with high mean performance and stability.The important trait single plant yield is non- significant for both linear and non linear components of GE interactions.

Table 4.50. Mean performance and stability parameters for days to yield/ plant and productivity/ day (kg / ha) in rice

Parents/Crosses			Yield/ Plant gm			Productivity/ Day (kg / ha)		
			μ Mean	βi	σ^2di	μ Mean	βi	σ^2di
Testers								
IR 58025A			17.16	1.00	-0.44	75.21	0.88	-1.01
IR 68897A			17.56	1.01	-0.43	83.77	1.20	-4.62
APMS 6A			17.67	1.01	-0.43	74.91	1.24	-5.65
APMS 8A			18.19	1.00	-0.44	82.54	0.87	-6.98
CMS 16A			16.55	1.00	-0.44	88.03	1.25	4.56
Lines								
JGL 11110-2			25.69	1.01	-0.43	86.40	0.99	-7.33
JGL 11110-1			22.29	1.01	-0.43	69.75	1.01	-4.48
JGL 17211			24.44	1.01	-0.43	80.69	0.99	-6.61
JGL 16284			23.50	1.01	-0.44	84.67	0.95	-7.36
JGL 13515			21.40	1.01	-0.43	88.38	0.98	-6.78
JGL 11160			20.33	1.01	-0.43	74.23	0.97	-5.59
JGL 11118			20.93	1.00	-0.44	79.77	1.00 *	6.79
JGL 11111			23.96	1.01	-0.43	75.22	0.96 *	-6.49
JGL 8605			20.39	1.01	-0.43	99.82	1.00	-3.57
JGL 8292			21.05	1.01	-0.43	97.36	1.03	-3.93
JGL 3855			23.94	1.01	-0.43	76.31	0.89	-5.71
JGL 3844			23.29	1.01	-0.43	82.25	1.06	14.39
JGL 1798			22.08	1.01	-0.43	86.59	0.97	-7.38
Crosses								
IR 68897A	X	JGL 11110-2	21.87	1.01	-0.43	68.24	0.89	-1.86
IR 68897A	X	JGL11110-1	21.03	1.00	-0.44	62.82	0.91	2.44
IR 68897A	X	JGL17211	19.74	1.01	-0.43	90.02	1.44	1.24
IR 68897A	X	JGL16284	23.84	1.01	-0.43	94.15	1.08	0.41
IR 68897A	X	JGL13515	23.04	1.01	-0.43	82.13	1.30	-3.03
IR 68897A	X	JGL11160	22.54	1.01	-0.43	90.91	1.33	1.16
IR 68897A	X	JGL11118	16.78	1.01	-0.43	72.42	1.05	-3.55
IR 68897A	X	JGL11111	22.90	1.01	-0.43	56.59	0.90	14.06
IR 68897A	X	JGL8605	22.38	1.01	-0.43	66.09	0.89	1.07
IR 68897A	X	JGL8292	25.13	1.01	-0.43	77.48	1.18	16.09
IR 68897A	X	JGL3855	19.45	1.01	-0.43	54.94	0.19	32.71
IR 68897A	X	JGL3844	21.64	1.01	-0.43	72.69	0.85	-5.25
IR 68897A	X	JGL1798	20.41	1.01	-0.43	87.30	1.28	19.78
APMS 8A	X	JGL 11110-2	31.22	1.00	-0.44	70.37	0.85	-2.81
APMS 8A	X	JGL11110-1	29.95	1.01	-0.43	77.96	0.96	-7.30
APMS 8A	X	JGL17211	22.84	1.01	-0.43	72.29	1.04	0.30
APMS 8A	X	JGL16284	22.33	1.01	-0.43	65.60	1.31	13.82
APMS 8A	X	JGL13515	26.65	1.01	-0.43	68.64	1.03	10.97
APMS 8A	X	JGL11160	20.38	1.01	-0.43	95.91	1.19	6.09
APMS 8A	X	JGL11118	18.29	1.01	-0.43	78.27	0.82	-7.42
APMS 8A	X	JGL11111	25.18	1.01	-0.43	69.30	1.04	-0.55
APMS 8A	X	JGL8605	27.71	1.01	-0.43	93.94	0.96	-7.19
APMS 8A	X	JGL8292	21.67	1.01	-0.43	93.67	0.88	-7.10
APMS 8A	X	JGL3855	24.23	1.01	-0.43	83.97	1.10	-3.72
APMS 8A	X	JGL3844	20.28	1.01	-0.43	92.74	0.88	-1.81

Table 4.50(cont.)

Crosses	Yield/ Plant gm			Productivity/ Day (kg / ha		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	16.33	1.01	-0.43	83.73	0.98	-3.28
CMS 16A X JGL 11110-2	19.46	1.01	-0.43	83.93	0.84	11.36
CMS 16A X JGL11110-1	20.14	1.01	-0.12	91.36	0.87	6.55
CMS 16A X JGL17211	15.55	0.23	54.75 **	101.37	1.38	-5.08 *
CMS 16A X JGL16284	21.72	1.01	-0.11	95.14	0.96	2.94
CMS 16A X JGL13515	23.25	1.01	-0.11	91.57	1.06	-0.50
CMS 16A X JGL11160	20.52	1.01	-0.12	73.01	0.83	-7.25
CMS 16A X JGL11118	22.95	1.01	-0.11	68.60	0.95	-4.24
CMS 16A X JGL11111	18.65	1.02	0.95	68.00	0.82	-6.96
CMS 16A X JGL8605	17.14	1.01	0.33	72.28	0.96	-6.53
CMS 16A X JGL8292	19.98	1.00	1.79 *	71.20	0.97	-5.51
CMS 16A X JGL3855	24.13	1.01	-0.44	75.21	1.15	-5.96
CMS 16A X JGL3844	22.55	1.01	0.08	87.28	0.97 *	-2.01
CMS 16A X JGL1798	20.38	1.01	5.18 **	80.13	0.95	-6.80
APMS 6A X JGL 11110-2	27.64	1.01	-0.16	91.60	1.19	4.27
APMS 6A X JGL11110-1	28.30	1.02	0.58	84.81	1.20	-5.95
APMS 6A X JGL17211	24.81	1.00	1.41 *	84.22	1.32	-5.92
APMS 6A X JGL16284	28.14	1.01	0.78	62.79	0.91	-3.25
APMS 6A X JGL13515	23.81	1.01	-0.47	72.56	1.29	4.07
APMS 6A X JGL11160	23.35	1.01	-0.45	75.14	1.40	3.28
APMS 6A X JGL11118	26.68	1.01	-0.11	66.98	1.19	-1.61
APMS 6A X JGL11111	28.65	1.01	-0.11	71.75	1.22	-4.31
APMS 6A X JGL8605	28.43	1.01	-0.12	86.20	0.95	-4.57
APMS 6A X JGL8292	26.32	1.02	-0.12	76.36	0.88	-7.00
APMS 6A X JGL3855	21.10	1.01	-0.12	82.16	0.95 *	-7.04
APMS 6A X JGL3844	19.31	1.01	-0.11	79.40	1.02	-7.31
APMS 6A X JGL1798	19.68	1.01	-0.11	71.12	0.89	-6.76
IR 58025A X JGL 11110-2	21.16	1.01	-0.43	70.13	0.86	-6.57
IR 58025A X JGL11110-1	20.71	1.01	-0.43	77.89	0.91	-7.43
IR 58025A X JGL17211	20.88	1.01	-0.43	84.05	1.20	-7.25
IR 58025A X JGL16284	25.83	1.00	-0.44	69.15	0.94	-6.03
IR 58025A X JGL13515	23.91	1.00	-0.44	72.45	0.91	-6.60
IR 58025A X JGL11160	23.43	1.00	-0.44	79.48	0.94	-6.09
IR 58025A X JGL11118	22.12	1.00	-0.44	79.38	0.90	-4.71
IR 58025A X JGL11111	23.25	1.01	-0.43	78.28	0.94	-7.20
IR 58025A X JGL8605	18.18	1.01	-0.43	60.37	0.94	0.75
IR 58025A X JGL8292	19.96	1.01	-0.43	64.38	0.76	-6.31
IR 58025A X JGL3855	19.88	1.01	-0.43	60.65	0.91	0.73
IR 58025A X JGL3844	17.16	1.01	-0.43	62.07	0.91	-1.92
IR 58025A X JGL1798	18.39	1.01	-0.43	57.80	0.91	3.10
KRH - 2	25.35	1.00	-0.44	92.24	0.69	17.28
DRRH - 2	22.62	1.00	-0.44	83.62	0.72	6.04
PA 6201	27.89	1.00	-0.44	98.63	1.14	-0.18
JAYA	23.94	1.01	-0.43	81.00	0.87	-5.24
IR - 64	22.13	1.01	-0.43	79.66	0.84	-4.59
Population Mean	**22.25**			**78.68**		
SE of βi			0.32		0.07	
CD at 5%	**0.79**			**4.55**		

* Significant at 5% level; ** Significant at 1% level

4.3.3.14 Productivity/day (kg/ha)

Among all the genotypes tested for the character productivity/day (kg/ha), all the, testers 11 lines and 64 hybrids, had non- significant deviation from regression (S^2di) values, i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression whose performance can be predicted (Table 4.50).

Among the lines and testers IR 58025A, IR 68897A, APMS 6A, APMS 8A, CMS 16A, JGL 11110-2, JGL 11110-1, JGL 17211, JGL 16284, JGL 13515, JGL 11160, JGL 8605, JGL 8292, JGL 3855, JGL 3844 and JGL 1798 recorded unit regression values, hence these entries are considered to possess the average stability, whose performance does not change with change in environments.

Similarly, 63hybrids recorded unit regression values, Hence these hybrids are considered to possess the average stability, whose performance does not change with change in environments.

For productivity per day, both linear and non linear components of GE interaction were found to be significant in the present study, while significant non linear component was reported by Lohithaswa et al. (1999).

The results showed that, the GE interactions for all the characters were mainly due to both linear and non linear components which were supported by Krisnappa et al. (2009) for this trait. Significance of non linear component was observed by Armugam et al. (2007). Significance of linear component was reported by Hegde and Vidyachandra (1998) and significance of non-linear component was reported by Lohithaswa *et al.* (1999) and contradictoringly non-significance of both linear and non-linear GE interactions was reported by Vidhu Francis *et al.* (2005).

The per cent stability ranged from 0 to 100 for the different characters among parents and it ranged between 2 to 98 per cent.Low stability is recorded in characters gall midge infested plants (%),silver shoots(%),days to 50% flowering (earliness) and filled grains per panicle among the parents. Low stability is recorded in characters gall midge infested plants (%), silver shoots (%), days to 50% flowering (earliness), plant height (dwarfness), flag leaf width, 1000 Grain weight, panicle length, panicle weight and filled grains per panicle among the crosses.Out of 65 hybrids tested for single plant yield, 61 hybrids are categorized under group (I) i.e. stable over three environments; the other 4 hybrids are included in group (II), which were unstable. The 100% of the parents, 94% of the crosses 100% of the checks exhibited the stability over three environments, for the important character single plant yield. The 89% of the parents, 98% of the crosses 100% of the checks exhibited the stability over three environments, for the Productivity per day. These results indicate that, the parents and checks are comparatively more stable for different characters, when compared with crosses, while all the parents and checks and majority of the hybrids (94%) are stable for the yield (Table 4.51).

Table 4.51. ***Per cent*** **of stability of parents, rice hybrids and checks in present investigation**

Character	No. of parents	Parents %	No. of crosses	Crosses %	No. of checks	Checks %
Days to 50% flowering (earliness)	1	6	3	5	4	80
Plant height (dwarfness)	2	11	1	2	0	0
Flag leaf length	6	33	7	11	4	80
Flag leaf width	7	39	2	3	3	60
Productive tiller per plant	3	17	4	6	2	40
1000 Grain weight	4	22	3	5	4	80
Panicle length	3	17	4	6	4	80
Panicle weight	2	11	1	2	1	20
Filled grains per panicle	1	6	9	14	3	60
Spikelet fertility%	8	44	9	14	2	40
Grain yield per plant	18	100	61	94	5	100
Productivity per day	16	89	64	98	5	100
Gall midge infested plants (%)	0	0	2	3	2	40
Silver shoots (%)	0	0	1	2	2	40

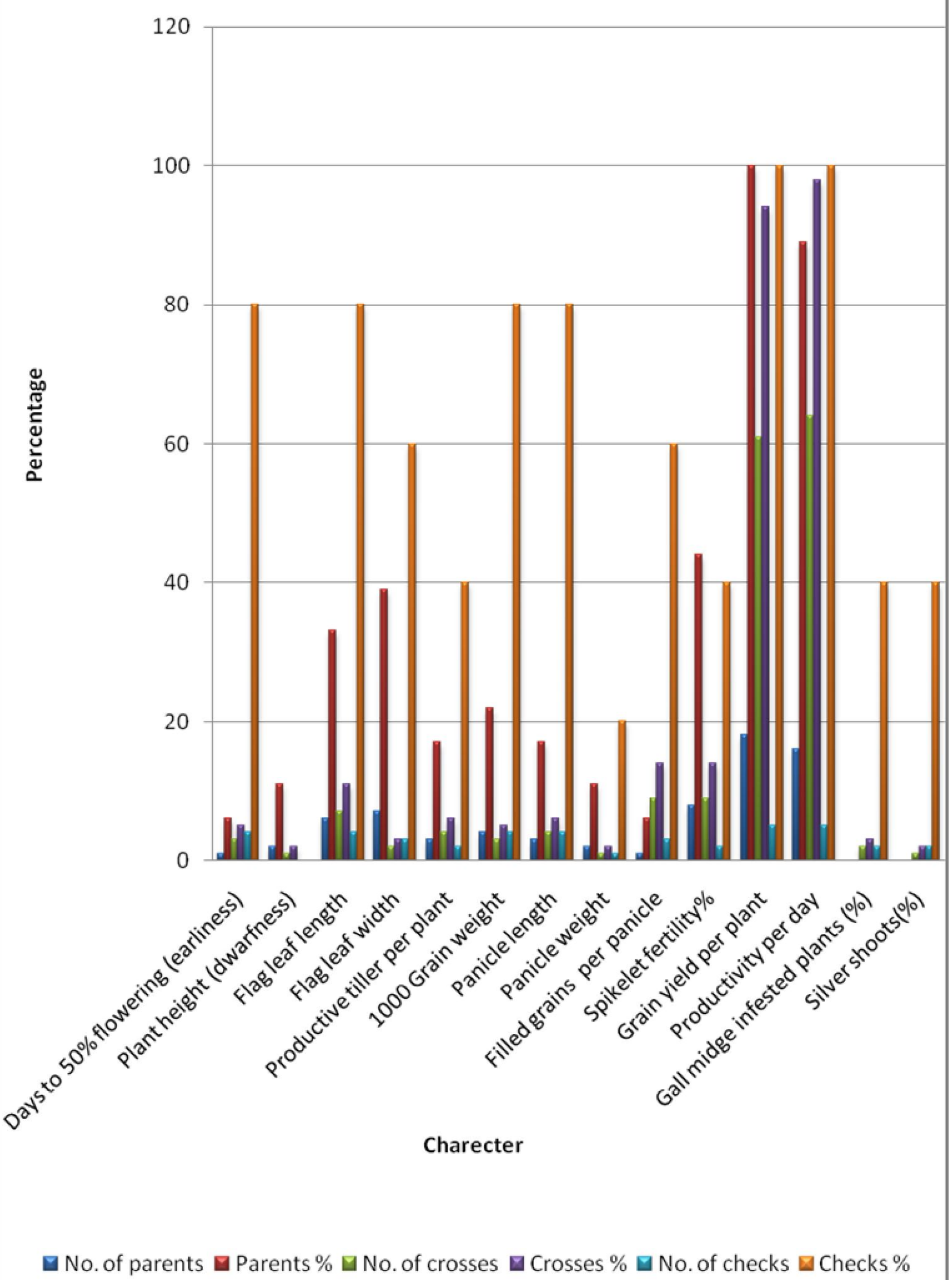


Figure 4.9 :*Per cent* of stability of parents, rice hybrids and checks in present investigation for yield and other characters

Table 4.52. Stable parents for various characters in rice

Character	Group-I	Group-II	Group III
	X > X, bi =1, S^2di=0	**bi >1, S^2di=0**	**bi <1, S^2di=0**
Days to 50% flowering (earliness)	IR 68897A, JGL 1798, JGL 11111, JGL 3844, JGL 11110-1, JGL 8292, JGL 11160, JGL 11110-2, JGL 17211 and JGL 16284	---	JGL 11118
Plant height (dwarfness)	APMS 6A and JGL 16284	---	.---
Flag leaf length	CMS 16A, IR 68897A, IR 58025A, JGL 11160, JGL 17211 and JGL 11110-2	---	---
Flag leaf width	58025A, JGL 17211, JGL 11110-1, JGL 8605, JGL 16284, JGL 13515and JGL 3855	---	APMS 8A, APMS 6A and JGL 8292
Productive tiller per plant	CMS 16A, JGL 17211 and JGL 8292	---	---
1000 Grain weight	IR 68897A, IR 58025A, JGL 1798 and JGL 8292	---	---
Panicle length	APMS 6A, APMS 8A and JGL 17211	JGL 8292	JGL 3855
Panicle weight	IR 68897A and JGL 11110-2	---	JGL 3855
Filled grains per panicle	JGL 16284	---	APMS 8A
Spikelet fertility%	APMS 8A, CMS 16A, JGL 11118, JGL 11111, JGL 8292 ,JGL 8605, JGL 3855 and JGL 16284	JGL 13515	---
Grain yield per plant	IR 58025A, IR 68897A, APMS 6A ,APMS 8A, CMS 16A, JGL 11110-2,JGL 11110-1 ,JGL 17211 , JGL 16284,JGL 13515 , JGL 11160 ,JGL 11118,JGL 11111, JGL 8605, JGL 8292, JGL 3855,JGL 3844 ,GL 1798	---	---
Productivity per day	IR 58025A, IR 68897A, APMS 6A, APMS 8A, CMS 16A, JGL 11110-2, JGL 11110-1, JGL 17211, JGL 16284, JGL 13515, JGL 11160, JGL 8605, JGL 8292, JGL 3855, JGL 3844 and JGL 1798	---	---
Gall midge Damaged Plants %			IR 68897A, APMS 6A, JGL 16284, JGL 11111 , JGL 8292, JGL 3855and JGL 1798,
Gall midge Silver Shoots%			IR 68897A, APMS 6A, JGL 16284, JGL 11111, JGL 8292, JGL 3855 and JGL 1798

Table 4.53. Stable hybrids for various characters in rice with good performance

Character	Group-I	Group-II	Group III
	X > X, bi =1, S^2di=0	bi >1, S^2di=0	bi <1, S^2di=0
Days to 50% flowering (earliness	IR 68897A x JGL11118, IR 68897A x JGL11110-1, IR 68897A x JGL11160	CMS 16A x JGL3855	---
Plant height (dwarfness)	IR 68897A x JGL11110-1	---	---
Flag leaf length	APMS 8A x JGL11110-1, CMS 16A x JGL8292, CMS 16A x JGL17211, APMS 8A x JGL11118, CMS 16A x JGL16284, APMS 6A x JGL11111 and IR 58025A x JGL3855	---	---
Flag leaf width	APMS 6A x JGL 1798 and CMS 16A x JGL1798	---	---
Productive tiller per plant	APMS 8A x JGL11111, IR 68897A x JGL8292, IR 68897A x JGL3855 and APMS 6A x JGL16284	---	---
1000 Grain weight	68897A x JGL8292, IR 68897A x JGL16284 and IR 68897A x JGL1798	---	---
Panicle length	IR 68897A x JGL 11110-2, IR 68897A x JGL16284, CMS 16A x JGL 11110-2 and IR 58025A x JGL11111	IR 68897A x JGL11111	---
Panicle weight	CMS 16A x JGL 11110-2	IR 68897A x JGL16284 and APMS 8A x JGL11110-1	---
Filled grains per panicle	CMS 16A x JGL11110-1, APMS 8A x JGL3844, IR 58025A x JGL16284, CMS 16A x JGL17211, APMS 8A x JGL 11110-2, CMS 16A x JGL8292, APMS 8A x JGL16284, APMS 8A x JGL11160 and CMS 16A x JGL3855	APMS 8A X JGL11110-1	---
Spikelet fertility%	CMS 16A x JGL8605, APMS 8A x JGL8292, IR 58025A x JGL11160, APMS 8A x JGL13515, CMS 16A x JGL11160, APMS 6A x JGL11160,APMS8AxJGL8605,IR58025A x JGL3855 and CMS 16A x JGL11111	CMS 16A x JGL3855 and IR 68897A x JGL11110-1	---
Grain yield per plant	APMS 8A XJGL 11110-2,APMS 8A xJGL11110-1,APMS 6A X GL11111,APMS 6A X JGL8605, APMS 8A X JGL8605	---	---
Productivity per day	CMS 16A X JGL17211, APMS 8A X JGL11160, CMS 16A X JGL16284, IR 68897A X JGL16284, APMS 8A X JGL8605	---	---

Table 4.53 cont.

Character	Group-I	Group-II	Group III
	X > X, bi =1, S^2di=0	**bi >1, S^2di=0**	**bi <1, S^2di=0**
Gall midge Damaged Plants (%)	CMS 16A x JGL11110-1 and CMS 16A x JGL3855		IR 68897A x JGL11110-2, CMS 16A x JGL3844, APMS 6A x JGL8292, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR 58025A x JGL11110-1, IR 58025A x JGL17211,IR 58025A x JGL384, IR 58025A x JGL1798
Gall midge Silver Shoots (%)	IR68897A x JGL17211		IR68897A x JGL11110-2, CMS 16A x JGL11110-2, CMS 16A xJGL17211, CMS 16AxJGL3844, CMSAxJGL1798, APMS6Ax JGL13515, APMS 6A x JGL11111, APMS 6A x JGL8292, APMS 6A x JGL3855, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR58025Ax JGL11110-1, IR58025A x JGL16284, IR58025A x JGL17211, IR58025A x JGL11118, IR58025A x JGL8605, IR 58025A x JGL8292, IR 58025A x JGL3844 and IR 58025A x JGL1798

Table 4.54. Stable hybrids over environments

Stable Hybrids under all environments				
Group I	IR 58025AX13515 IR 58025AX16284 IR 58025AX11160 APMS 8AX 11110-2 IR 58025AX11118 IR 68897AX 11110-1 IR 58025AX8605 APMS 8AX17211 APMS 6AX11160 IR 68897AX11118 IR 68897AX11111 APMS 8AX3855 IR 68897AX1798 APMS 8AX1798 IR 58025AX8292 APMS 8AX13515	IR 58025AX 11110-2 IR 68897AX 11110-2 CMS 16AX 11110-2 IR 58025AX1798 APMS 8AX 11110-1 APMS 8AX11111 IR 58025AX3855 APMS 6AX3844 IR 58025AX17211 IR 58025AX3844 IR 68897AX8605 APMS 6AX1798 IR 68897AX8292 CMS 16AX13515 CMS 16AX8605 APMS 6AX11111	IR 68897AX16284 APMS 8AX16284 IR 58025AX 11110-1 APMS 6AX11118 IR 68897AX3855 APMS 8AX11118 IR 58025AX11111 IR 68897AX11160 IR 68897AX13515 CMS 16AX16284 IR 68897AX3844 APMS 8AX8292 IR 68897AX17211 CMS 16AX3844 APMS 8AX3844 APMS 6AX 11110-2	APMS 8AX8605 CMS 16AX11160 APMS 8AX11160 CMS 16AX3855 CMS 16AX11118 APMS 6AX13515 APMS 6AX8605 APMS 6AX3855 CMS 16AX 11110-1 APMS 6AX8292 APMS 6AX 11110-1
Group II	**Unstable Hybrids**			
	CMS 16AX17211 CMS 16AX1798 CMS 16AX8292 APMS6AXJGL17211			

On the whole, among the testers APMS 8A and APMS 6A, among the lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 and JGL 8292 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 two testers APMS 8A and APMS 6A are stable for the characters days to 50(%) flowering, panicle Length, 1000 grain weight and yield/ Plant.

The lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 JGL 8292 were stable for yield and days to 50 % flowering. The lines JGL 11111, JGL 8292 were stable for productive Tillers/ Plant, the lines JGL 11110-2 was stable for filled grains/ panicle , the line JGL 11111, JGL 8292, JGL 8605 was stable for panicle length,the lines JGL 11111, JGL 11110-2, JGL11110-1, JGL8292, JGL11111, JGL11110-2 and JGL 8605 were stable for 1000 grain weight.

The hybrids APMS 6A x JGL11111, APMS 6A x JGL8292 were stable for days to 50 % flowering, the hybrids APMS 8A x JGL11110-1, APMS 6A x JGL8292 were stable for productive tillers/ plant, the hybrids, APMS 6A x JGL11110-1 APMS 8A x JGL11110-1, APMS 8A x JGL 11110-2 were stable for panicle length, the hybrids APMS 8A x JGL 11110-2 were stable for filled grains/ panicle, the hybrids APMS 8A x JGL 11110-2, APMS 6A x JGL11111 were stable for 1000 grain weight and the hybrids APMS 6A x JGL8292, APMS 8A x JGL 11110-2,APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL8605 and APMS 6A x JGL11110-1 were stable for yield/ plant with good mean performance.

It can be concluded that all the genotypes interacted with environment differently for different characters and some of the genotypes are identified as stable for various characters which were studied. The most important character i.e yield per plant, shown stable reaction in most of the genotypes including hybrids,which was the result of all the contributing characters.However, the present study was confined to one season, over three locations viz., Kunaram (Karimnagar district), Warangal, Kampasagar (Nalgonda district). To get more realistic information on stability, the identified promising cross combinations are to be tested extensively over different agro-climatic zones and across the year for their superiority and stability before the commercial release.

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.

Based on the overall study and considering all the parameters, the better hybrids are categorized and depicted in the table 4.55 with all other characters like, *per se* performance, duration, sca effect for grain yield, standard heterosis percentage over check PA 6201, average heterosis, heterobeltiosis, stability, grain type, grain length, grain breadth, LB ratio and reaction to gall midge at Kunaram, Warangal and Kampasagar along with graphs and photographs.

Table 4.55. Most promising hybrids identified based on the overall performance in the present investigation

Hybrid	***APMS 8A X JGL 11110-2***	***APMS 6A X JGL11111***	***APMS 6A X JGL8292***
Duration(days)	136	126	128
***Per se* performance**	31.22 gm/pant	28.65 gm/pant	26.32 gm/pant
***sca* effect for grain yield**	7.01**	2.44**	0.41
SH% yield advantage Over PA-6201	1.94*	4.14**	-4.97**
Average Heterosis	46.47**	56.41**	40.07**
Heterobeltiosis	27.75**	42.00**	59.59**
Stable characters	Grain yield per plant	Grain yield per plant	1000 Grain weight, Panicle weight, Grain yield per plant.
Grain type	Medium slender	Medium slender	Medium slender
Grain length(mm)	7.52	7.71	6.89
Grain breadth(mm)	1.97	2.10	2.11
LB Ratio	3.82	3.67	3.27
Reaction to Gall midge			
KRM	R	R	R
WGL	S	R	R
KSR	R	R	R

Figure 4.10. Most promising hybrids identified based on the over all performance in the present investigation

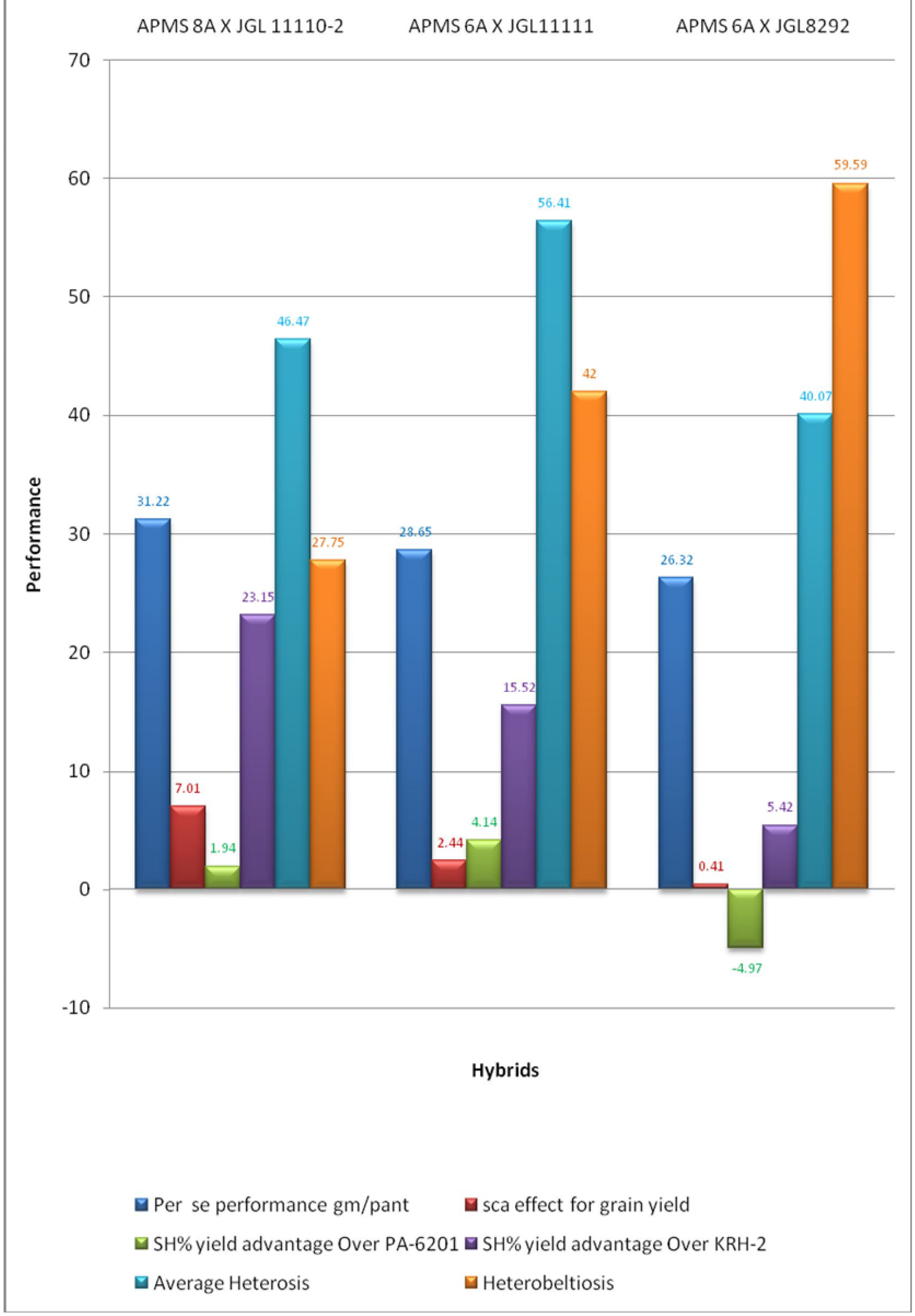
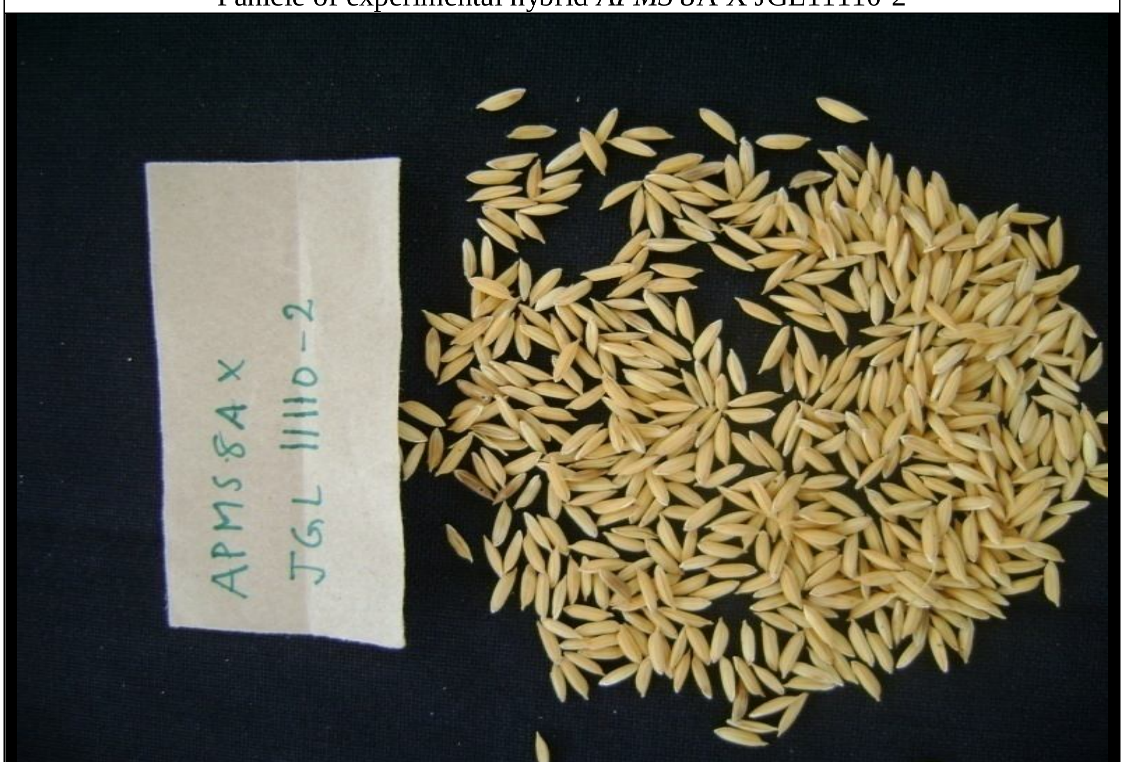


Plate 4.3. Most promising experimental hybrid (*APMS 8A X JGL 11110-2)* identified in the present investigation based on over all performance

Plate 4.4. Most promising experimental hybrid identified in the present investigation based on over all performance(Panicles & Grains)

Panicle of experimental hybrid *APMS 8*A X JGL11110-2



Grains of the promising experimental hybrid
APMS 8A X JGL11110-2

Plate 4.5. Most promising Gall midge Resistant experimental hybrids (*APMS 6A X JGL11111 and APMS 6A X JGL8292*) identified in the present investigation

Plate 4.6. Most promising Gall midge Resistant experimental hybrids identified in the present investigation(Panicles & Grains)

Panicle of promising Gall midge Resistant experimental hybrid *APMS 6A X JGL11111* (middle),male parent *JGL 11111*(top) and corresponding B line of female parent *APMS 6A(bottom)*.

Grains of the promising Gall midge Resistant experimental hybrid *APMS 6A X JGL11111*

Panicle of promising Gall midge Resistant experimental hybrid *APMS* 6A X JGL8292 (middle), corresponding B line of female parent *APMS 6A* (top) and male parent JGL8292 *(bottom)*.

Grains of the promising Gall midge Resistant experimental hybrid *APMS 6A X* JGL8292

Plate 4.7. Three promising experimental hybrids (*APMS 6A X JGL11111,APMS 8A X JGL 11110-2, and APMS 6A X JGL 8292)* identified in the present investigation based on over all performance

Based on the overall performance the best hybrid identified was APMS 8A x JGL 11110-2, with highest single plant yield of 31.22 gm/plant, medium duration (136 days) with high sca effect (7.01), significant standard heterosis (23.15) significant average heterosis (46.47), with significant heterobeltiosis (27.75) over check KRH-2. This hybrid was stable over locations for grain yield, with medium slender grain type, with LB ratio of 3.5, but this is showing susceptibility reaction to gall midge at Warangal. The LB ratio of 3.5 indicates the fineness of the grain which is highly preferred by consumers of Andhra Pradesh (Table 4.55).

The whole investigation was aimed to identify the gall midge resistant hybrids with good performance. Though the hybrid APMS 8A x JGL 11110-2 was showing susceptibility reaction at Warangal location due to biotype variations, this hybrid can be successfully cultivated in northern and southern regions of Telangana regions of Andhra Pradesh, where the gall midge biotype existing at Warangal will not be present, hence the hybrid identified can be considered as gall midge resistant hybrid recommended for specified region.

Based on the objective of investigation i.e.gall midge resistance with high yield, the hybrid APMS 6A x JGL 11111 was the most promising short duration (126 days) gall midge resistant hybrid identified, with 28.65 gm/plant single plant yield, with significant sca effect (2.44), significant standard heterosis over PA 6201 (4.14), followed by KRH-2 (15.52). It recorded the significant high average heterosis (56.41) and heterobeltiosis (42). This hybrid is stable over three locations for grain yield per plant, with medium slender grain type, having LB ratio of 3.19. This hybrid was showing gall midge resistance at all the three locations studied, indicating the gall midge resistance for all the biotypes existing in the Telangana region of Andhra Pradesh. (Table 4.55)

The another gall midge resistant short duration (128 days) hybrid identified was APMS 6A x JGL 8292, with 26.32 gm/plant grain yield. The significant standard heterosis (5.42) recorded over check KRH-2 with high average heterosis (40.07) and heterobeltiosis (59.59). This hybrid is stable over three locations for grain yield, with medium slender grain type, having LB ratio of 2.89. This hybrid was also showing gall midge resistance at all the three locations studied, indicating the gall midge resistance for all the biotypes existing in the Telangana region of Andhra Pradesh (Table 4.55).

4.3 Stability

Rice is the staple and important cereal crop of India, being photo insensitive in nature, due to its buffering capacity it is being cultivated round the year in different agro-climatic zones of the country. However, the hybrids and breeding material likely to interact differently with different environments. The presently cultivated varieties and hybrids though having high yield potential, they are erratic in their performance under varied conditions of cultivation. Lack of hybrids suitable to specific locations accounts for the decline in the area and productivity in rice, apart from the biotic and abiotic stresses. This warrants the attention of the plant breeders to evolve superior hybrids that would sustain well in the strainful situation. Therefore, assessment of its adaptability is of important concern. Productivity of a population is the function of its adaptation, whereas stability is the statistical measure of genotype x environment interaction (Kandil *et al.* 1990).

Relative ranking of genotype in different seasons for a given attribute is rarely the same. This results in difficulty in detecting superior genotypes. Therefore, it is necessarily to select genotype(s) showing a high degree of stable performance over a wide range of environments. Precise knowledge on the nature and magnitude of genotype x environmental interaction is important in understanding the stability in yield of a particular variety or a hybrid before it is being recommended for a given situation(s). The yielding ability and response to environmental changes are the two independent attributes of a genotype and are governed by separate genetic systems (Finlay and Wilkinson, 1963). Testing of genotypes under different environmental situations differing in unpredictable variation is an accepted approach for selecting stable genotypes (Eberhart and Russel, 1966).

However, little information is available on the stability of rice hybrids. Young and Virmani (1990) also observed varying magnitude of heterosis over environments and stressed the need to evaluate hybrids across environments to identify stable hybrids with high yield that shows least interaction with environment. Therefore, an attempt was made to study the stability parameters of the hybrids developed and evaluated at different agro-climatic zones in Andhra Pradesh in the present investigation, using Eberhart and Russel (1966) model.

Genotype x Environment interactions is of major importance to plant breeders in developing new crop varieties and hybrids which perform consistently over a wide range of environments. Hence, there is a need to identify a stable hybrid. The data collected on twelve characters for 88 genotypes over three locations viz., Kunaram, Warangal and Kampasagar constituting three environments was used to estimate genotype and environment interaction for yield and yield components by following the model suggested by Eberhart and Russel (1966).

4.3.1 Pooled analysis of variance

The mean square values from pooled analysis, of variance are presented in table 4.41. The pooled analysis of variance revealed that the variances for genotypes were significant for gallmidge damaged plants (%) and silver shoots (%). This indicates the presence of genetic variability among genotypes for these characters. The variances for environments were significant. Significant variation due to environment (linear) was observed. The linear component of genotype x environment was insignificant, suggesting that, the genotypes are not differing from their linear response to environment. The pooled deviation was significant indicating non linear response and unpredictable nature of genotype by significantly differing for stability.

Table 4.41. Analysis of variance for gall midge damaged plants (%)and silver shoots (%) for stability in rice

Source	d.f	(ASIN) Damaged Plants %	(ASIN) Silver Shoots%
Rep. within Environment	6	18.18	2.7
Varieties	88	269.87 **	16.73 **
Env. + (Var.* Env.)	178	72.31 *	3.73 *
Environments	2	1877.93 **	82.53 **
Var.* Env.	176	51.79	2.83
Environments (Linear)	1	3755.87 **	165.05 **
Var.* Env.(Linear)	88	56.46	3.11
Pooled Deviation	89	46.59 **	2.53 **
Pooled Error	528	4.01	0.24
Total	266	137.66	8.03

* Significant at 5% level; ** Significant at 1% level

The mean square values for pooled analysis of variance are presented in table 4.42. The pooled analysis of variance revealed that, the variances for genotypes were significant for days to 50% flowering, flag leaf width, panicle length, spikelet fertility (%), 1000 grain weight, yield per plant and productivity/day. This indicates the presence of genetic variability among genotypes for these characters. The variances for environments were significant for days to 50% flowering, plant height, flag leaf width and flag leaf length, panicle weight, 1000 grain weigh, yield/plant and productivity per day. The analysis revealed that the genotypes and environments were significant for days to 50% flowering, flag leaf width, flag leaf length, spikelet fertility% and productivity/day.

Partitioning the sum of squares into that of varieties, environments + (genotypes x environments) and pooled error revealed that mean squares due to environment + (genotypes x environments) were significant for eight characters viz., days to 50% flowering, productive tillers/plant, flag leaf width, flag leaf length, spikelet fertility%,1000 grain weight, single plant yield and productivity/day.

Sum of squares due to E+ (G x E) was further portioned into that of environment (linear), genotypes x environment (linear) and pooled deviation. Significant variation due to environment (linear) was observed for 11 characters except for spikelet fertility (%) revealing the linear contribution of environmental effects and additive environment

Table 4.42. Analysis of variance for yield and yield components for stability in rice

Source	d.f	Days to 50% flowering	Plant Height cm	Productive Tillers/ Plant	Flag Leaf Length cm	Flag Leaf Width cm	Panicle Length cm
Replication within Environment	6	124.77 **	123.68	25.94	46.5	0.1 **	11.56 **
Varieties	87	94.92 **	201	24.35 **	35.16 *	0.15 **	6.85 **
Env.+(Var.*Env.)	176	29.8 **	156.79	28.77 **	14.89	0.06 **	5.88 **
Environments	2	240.89 **	1307.87 **	1401.6 **	46.89	0.9 **	236.66 **
Var.* Env.	174	27.38 **	143.56	12.99	14.52	0.05 **	3.22 **
Environments (Linear)	1	481.78 **	2615.74 **	2803.21 **	93.78 *	1.81 **	473.32 **
Var.* Env.(Linear)	87	48.23 **	84.84	12.65	6.06	0.09 **	5.21 **
Pooled Deviation	88	6.45 **	199.99 **	13.18 **	22.72 **	0.02 **	1.22 **
Pooled Error	522	2.82	3.43	0.72	2.13	0.01	0.34
Total	263	51.34	171.42	27.31	21.59	0.09	6.2

Table 4.42(cont.)							
Source	**d.f**	**Flag Leaf Width cm**	**Filled Grains/ Panicle**	**Spikelet Fertility %**	**1000 Grain Weight gm**	**Yield/ Plant gm**	**Productivity/ Day (kg / ha)**
Replication within Environment	6	0.10 **	469.22	84.57	33.04 **	26.61 **	378.42 0.10
Varieties	87	0.15 **	6264.40 **	233.22 **	20.25 **	33.35 **	341.85 0.15
Env.+(Var.*Env.)	176	0.06 **	2603.64	87.54 **	8.05 **	4.77 **	607.44 0.06
Environments	2	0.90 **	3573.39	85.19	252.98 **	379.00 **	51471.17 0.90
Var.* Env.	174	0.05 **	2592.49	87.57 **	5.24 **	0.47	22.80 0.05
Environments (Linear)	1	1.81 **	7146.78	170.38	505.95 **	758.00 **	102942.34 1.81
Var.* Env.(Linear)	87	0.09 **	1858.38	120.06 **	7.82 **	0.06	39.32 0.09
Pooled Deviation	88	0.02 **	3288.80 **	54.45 **	2.62 **	0.87 **	6.21 0.02
Pooled Error	522	0.01	100.13	1.77	0.56	0.17	3.16 0.01
Total	263	0.09	3814.61	135.73	12.09	14.23	519.59 0.09

* Significant at 5% level; ** Significant at 1% level

variance on this character.The linear component of genotype x environment was significant for 6 characters and non-significant for plant height, productive tillers/plant, flag leaf length, panicle weight, filled grains per panicle and yield/plant, suggesting that the significant genotypes are significantly differing for their linear response to environments.

The mean sum of squares for pooled deviation was significant for all the twelve characters indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability.

In the present investigation, 88 genotypes which including 65 hybrids, 18 parents and five checks were subjected to pooled analysis of variance for 12 characters. Significant genotype x environment interactions implying differential behavior of genotypes for yield and it's components under three different locations. Similar reports were earlier reported by Leenakumary (1994), Hegde and Vidyachandra (1998), Arumugam *et al.* (2007), Panwar *et al.* (2008) and Ramya and Senthil kumar (2008).

Partitioning of sum of squares into that of varieties, environments + (genotypes x environment) and pooled error revealed that mean squares due to genotypes were highly significant for all the characters studied, indicating the presence of genetic variability in the experimental material (Arumugam *et al.*2007; Panwar *et al.*2008 and

Krishnappa *et al.*2009). Mean squares due to environments + (genotypes x environments) were significant for eight characters *viz.*, plant height, panicle weight, number of productive tillers per plant, flag leaf length, flag leaf width, number of filled grains per panicle,1000-grain weight and single plant yield depicted the existence of GE interaction. These findings are in conformity with Young and Virmani (1990), Deshpande *et al.* (2003), Deshpande and Dalvi (2006), Panwar *et al.* (2008) and Ramya Senthil kumar (2008) and Krishnappa *et al.* (2009).

Sum of squares due to E + (G x E) was further partitioned into that of environment (linear), genotype x environment (linear) and pooled deviation. Significant variation due to environment (linear) was observed for all the 12 characters studied revealing the linear contribution of environmental effects and additive environment variance on these characters. Similar results were reported earlier by Hegde and Vidyachandra (1998), Lohithaswa *et al.* (1999), Deshphande *et al.* (2003), Arumugam *et al.* (2007), Panwar *et al.* (2008), Ramya and Senthil kumar (2008) and Krishnappa *et al.*(2009) for yield and it's components. The linear component of genotype x environment was significant for all the characters except days to 50% flowering, panicle length, and spikelet fertility percentage suggesting that the genotypes significantly differing for their linear response to environments. Similar results were observed by Lohithaswa *et al.* (1999), Panwar *et al.* (2008), Ramya and Senthil kumar (2008) and Krishnappa *et al.* (2009) for yield and its components. Higher magnitude of environment (linear) effects in comparison to GE (linear) may be responsible for high adaption in relation to yield and its components.

The mean sum of squares for pooled deviation was significant for all the twelve characters indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability. Significant non-linear responses were observed earlier by Hegde and Vidyachandra (1998), Lohithaswa *et al.* (1999), Deshphande *et al.* (2002), Arumugam *et al.* (2007), Panwar *et al.* (2008), Ramya and Senthil kumar (2008) and Krishnappa *et al.* (2009), while both significant and non-significant linear responses were reported by Young and Virmani (1990), Deshphande *et al.* (2003) and Lavanya *et al.* (2005) for yield and its components.

4.3.2 Environmental Indices

Environmental indices for twelve characters viz., days to 50% flowering, plant height, panicle length, panicle weight, number of productive tillers/plant, flag leaf length, flag leaf width, number of filled grains/panicle, spikelet fertility%, 1000 grain weight, single plant yield and productivity/day are presented in table 4.45.

The Kunaram was found to be the most favourable location for plant height, panicle length, panicle weight, number of productive tillers/plant, flag leaf length, flag leaf width, number of filled grains/panicle, 1000 grain weight and single plant yield. Warangal was the next best favourable location for panicle length, panicle weight, number of productive tillers, flag leaf width, number of filled grains/panicle, spikelet fertility %, 1000 grain weight and single plant yield.Kampasagar best favourable location for days to 50% flowering and spikelet fertility %.

Environmental index reveals the favorability of an environment at a particular location. Breeze (1969) pointed out that the estimates of environmental index can provide the basis for identifying the favourable environments for the expression of maximum potential of the genotype. Karimnagar was found to be the most favourable location for plant height, panicle weight, number of productive tillers per plant, flag leaf length, number of filled grains per panicle, 1000-grain weight and single plant yield while, Warangal was the next best favourable location for plant height, panicle weight, number of productive tillers per plant, number of filled grains per panicle, 1000-grain weight and single plant yield. (4.43

Table 4.43. Environmental indices for yield and yield components in rice

Characters		Locations		
		Kunaram	Warangal	Kampasagar
Days to 50% flowering	**Ij**	1.40	0.43	-1.83
Plant height	**ij**	-1.633	0.808	0.825
Panicle length (cm)	**Ij**	1.45	0.33	-1.78
Panicle weight	**Ij**	0.138	0.049	-0.187
No. of productive tillers/plant	**ij**	0.223	0.219	-0.442
Flag leaf length	**Ij**	0.289	-0.277	-0.013
Flag leaf width (cm)	**Ij**	0.03	0.08	-0.11
No. of filled grains /panicle	**ij**	5.269	4.481	-9.750
Spikelet fertility %	**Ij**	-1.10	0.30	0.80
1000-grain weight	**Ij**	0.027	0.016	-0.042
Single plant yield	**ij**	1.500	0.126	-1.626
Productivity/ Day	**ij**	-16.75	-1098	27.73

The results are in broad agreement with the results reported by Lohithaswa *et al.* (1999). Since certain genotypes are searching for its favourable environment to express its fullest potential of yield and yield attributes. Hence, an appropriate genotype has to be bred for each season.

4.3.3 Stability parameters

According to Eberhart and Russel (1996), a stable genotype is one which shows (i) high mean yield (ii) regression co-efficient (bi=1) equal to unity and (iii) a mean square deviation from regression (S^2di) near to zero. In interpreting the results of the present investigation, S^2di was considered as the measure of stability as suggested by Breeze (1969). Then the type of stability (measure of response or sensitivity to environmental changes) was decided on regression coefficient (bi) and mean value (Finlay and Wilkinson, 1963), if bi is equal to unity, a genotype is considered to have average stability. If bi is more than unity, it is suggested to have less than average stability. If bi was less than unity, it is reported have more than average stability (widely adoptable to differing environmental conditions). The estimation of stability parameters i.e., mean (μ), regression coefficient (bi) and a mean square deviation from regression (S^2di) for the fourteen characters are furnished below.

Once it is known that genotypes interact with the environments significantly, the next task is to find out the most stable genotypes. The stability parameters *i.e.,* high mean performance (μ), regression coefficient (bi) and deviation from regression (S^2di) were estimated for each genotype for each character separately. Both linear regression (bi) and deviation from regression (S^2di) components of genotype x environment interaction should be considered along with mean in judging the phenotypic stability of a genotype (Eberhart and Russel, 1966).

4.3.3.1 Gallmidge infested plants (%): Among all genotypes tested, for the character gallmidge infested plants (%) 3 testers 5 lines and 35 hybrids had non- significant deviation from regression, (S^2di) values i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.44).

Among the lines and testers, IR 68897A, APMS 6A, JGL 16284, JGL 11111 , JGL 8292, JGL 3855and JGL 1798, recorded the less the unit of bi values, with gall midge resistance and thus possessed more than average stability and are adoptable to poor environments.

Among the hybrids, CMS 16A x JGL11110-1 and CMS 16A x JGL3855 recorded the unit of bi value, and thus possessed average stability and are adoptable to all environments possessing the gall midge resistance. While the hybrids IR 68897A x

JGL11110-2, CMS 16A x JGL3844, APMS 6A x JGL8292, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR 58025A x JGL11110-1, IR 58025A x JGL17211,IR 58025A x JGL384, IR 58025A x JGL1798 recorded the less the unit of bi value with gall midge resistance and are adoptable to poor environments (Table 4.44).

4.3.3.2 Silver shoots (%): Among all genotypes tested, for the character, silver shoots (%), 3 testers, 5 lines and 40 hybrids had non- significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily within the range of the minimum deviation from the regression whose performance can be predicted (Table 4.44).

Among the lines and testers for the character silver shoots (%), IR 68897A, APMS 6A, JGL 16284, JGL 11111, JGL 8292, JGL 3855, JGL 1798 recorded the less than the unit of bi value and thus possessed more than average stability and are adaptable to poor environments with gall midge resistance.

In the stability analysis hybrid IR68897A x JGL17211 recorded unit of bi value and thus possessed average stability and are adoptable to all environments, where as hybrids IR68897A x JGL11110-2, CMS 16A x JGL11110-2, CMS 16A xJGL17211, CMS 16AxJGL3844, CMSAxJGL1798, APMS6Ax JGL13515, APMS 6A x JGL11111, APMS 6A x JGL8292, APMS 6A x JGL3855, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR58025Ax JGL11110-1, IR58025A x JGL16284, IR58025A x JGL17211, IR58025A x JGL11118, IR58025A x JGL8605, IR 58025A x JGL8292, IR 58025A x JGL3844, IR 58025A x JGL1798 recorded the less than unit of bi value, and thus possessed more than average stability and more adoptable to poor environments along with gall midge resistance, while all other hybrids are unstable for this character (Table 4.44).

The reaction of genotypes towards the gallmidge at three locations is different; the incidence recorded was more at Warangal, followed by Kampasagar and Kunaram. This may be due to the different biotypes existing at three locations. The R lines used are taken from RARS, Jagtial, which may be resistant to gallmidge biotype 3, Hence the hybrids developed with these R lines also shown resistance reaction at RARS, Jagtial, Hence the damaged plants and silver shoots (%) was less at RARS, Jagtial, where as it is high at RARS, Warangal which may be due to existence of different biotypes of gallmidge at Warangal as well as at Kampasagar, due to which the incidence percentage varied, accordingly. However, some hybrids exhibited resistance reaction at all the three locations indicating the resistance of hybrids to different biotypes.

Table 4.44. Mean performance and stability parameters for gall midge damaged plant %(ASIN) and silver shoots % (ASIN) in rice

Parent/Cross	Gall midge damaged Plant %(ASIN)			Silver Shoots % (ASIN)		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	27.57	50.64	0.47 **	9.30	4.68	0.70 **
IR 68897A	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
APMS 6A	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
APMS 8A	27.27	11.13	0.54	9.45	0.63	1.05
CMS 16A	23.53	49.97	-0.33 **	8.23	4.91	-0.21 **
Lines						
JGL 11110-2	13.06	113.46	2.96 **	6.17	7.73	3.18 **
JGL 11110-1	11.87	84.33	2.56 **	5.79	5.13	2.61 **
JGL 17211	9.05	32.05	1.64 **	4.91	1.04	1.28 *
JGL 16284	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 13515	9.40	37.34	1.76 **	4.99	1.30	1.41 *
JGL 11160	12.41	97.01	2.74 **	5.98	6.40	2.90 **
JGL 11118	11.87	84.33	2.56 **	5.79	5.13	2.61 **
JGL 11111	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 8605	9.05	32.05	1.64 **	4.91	1.04	1.28 *
JGL 8292	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 3855	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
JGL 3844	13.87	135.60	3.22 **	6.42	9.80	3.57 **
JGL 1798	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
Crosses	4.06	-4.17	0.00	4.06	-0.27	0.00
IR 68897A X JGL11110-2	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 68897A X JGL11110-1	7.52	13.22 *	1.14	4.71	0.50 *	0.99
IR 68897A X JGL17211	4.06	-4.17	0.00 *	4.06	-0.27	0.00
IR 68897A X JGL16284	12.21	81.79 *	0.94	5.48	2.78 *	0.79
IR 68897A X JGL13515	6.78	6.58	0.89 **	4.36	-0.10	0.45 **
IR 68897A X JGL11160	6.98	8.27	0.96	4.51	0.11	0.69
IR 68897A X JGL11118	10.49	55.95	2.11	5.37	2.85	1.99
IR 68897A X JGL11111	10.49	55.95	2.11 **	5.37	2.85	1.99 **
IR 68897A X JGL8605	16.94	213.91	1.48 **	6.90	11.93	1.57 **
IR 68897A X JGL8292	6.78	6.58	0.89 **	4.45	0.02	0.60 **
IR 68897A X JGL3855	24.98	515.50	2.51	9.38	28.26	3.38
IR 68897A X JGL3844	9.05	32.05	1.64 **	4.91	1.04	1.28 **
IR 68897A X JGL1798	7.52	13.22	1.14 **	4.71	0.50	0.99 *
APMS 8A X JGL11110-2	9.05	32.05	1.64 *	4.91	1.04	1.28
APMS 8A X JGL11110-1	4.06	-4.17	0.00 **	4.06	-0.27	0.00 *
APMS 8A X JGL17211	8.36	22.68 *	1.41	5.00	1.33 *	1.42
APMS 8A X JGL16284	8.36	22.68	1.41 *	4.88	0.96	1.25 *
APMS 8A X JGL13515	4.06	-4.17	0.00 *	4.06	-0.27	0.00 *
APMS 8A X JGL11160	14.18	144.54 *	3.32	6.51	10.51 *	3.69
APMS 8A X JGL11118	6.78	6.58	0.89 **	4.36	-0.10	0.45 **
APMS 8A X JGL11111	10.02	47.47	1.96	5.40	2.96	2.02
APMS 8A X JGL8605	4.06	-4.17	0.00 **	4.06	-0.27	0.00 **
APMS 8A X JGL8292	10.49	55.95 *	2.11	5.37	2.85 *	1.99
APMS 8A X JGL3855	4.06	-4.17	0.00 **	4.06	-0.27	0.00 **
APMS 8A X JGL3844	27.57	50.64 *	0.47	9.30	4.68 *	0.70

Table 4.44 (cont.)

Crosses	Gall midge damaged Plant %(ASIN)			Silver Shoots % (ASIN)		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	4.06	-4.17	0.00 **	5.54	3.68	2.23 **
CMS 16A X JGL11110-2	6.78	6.58 *	0.89	4.06	-0.27 *	0.00
CMS 16A X JGL11110-1	4.06	-4.17	0.00	4.45	0.02	0.60
CMS 16A X JGL17211	10.77	61.28 *	2.21	4.06	-0.27 *	0.00
CMS 16A X JGL16284	6.78	6.58	0.89 **	5.75	4.90	2.56 **
CMS 16A X JGL13515	10.49	55.95	2.11	4.36	-0.10	0.45
CMS 16A X JGL11160	6.98	8.27	0.96 **	5.37	2.85	1.99 **
CMS 16A X JGL11118	8.36	22.68	1.41	4.51	0.11	0.69
CMS 16A X JGL11111	6.98	8.27	0.96 *	4.88	0.96	1.25 *
CMS 16A X JGL8605	6.78	6.58	0.89	4.42	-0.02	0.55
CMS 16A X JGL8292	6.78	6.58	0.89	4.36	-0.10	0.45
CMS 16A X JGL3855	4.06	-4.17	0.00	4.36	-0.10	0.45
CMS 16A X JGL3844	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
CMS 16A X JGL1798	28.47	475.99 *	3.35	4.06	-0.27 *	0.00
APMS 6A X JGL11110-2	18.45	111.05	2.18 **	10.06	26.97	4.11 **
APMS 6A X JGL11110-1	18.12	94.15	2.18 **	7.18	4.95	2.31 **
APMS 6A X JGL17211	16.02	180.33	1.39 **	7.15	4.93	2.27 **
APMS 6A X JGL16284	4.06	-4.17	0.00 **	6.62	9.58	1.42 **
APMS 6A X JGL13515	14.26	32.58 *	1.68	4.06	-0.27 *	0.00
APMS 6A X JGL11160	12.00	72.79	0.94 **	5.84	0.63	1.45
APMS 6A X JGL11118	4.06	-4.17	0.00 **	5.40	2.11	0.78 **
APMS 6A X JGL11111	13.85	28.58 *	1.62	4.06	-0.27 *	0.00
APMS 6A X JGL8605	4.06	-4.17	0.00 **	5.71	0.40	1.36
APMS 6A X JGL8292	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
APMS 6A X JGL3855	19.37	76.31 *	2.54	4.06	-0.27 *	0.00
APMS 6A X JGL3844	4.06	-4.17	0.00 **	7.49	3.07	2.78 **
APMS 6A X JGL1798	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL11110-2	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL11110-1	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL17211	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL16284	19.37	76.31 *	2.54	4.06	-0.27 *	0.00
IR 58025A X JGL13515	13.85	28.58	1.62 **	7.49	3.07	2.78 **
IR 58025A X JGL11160	4.06	-4.17	0.00 **	5.71	0.40	1.36
IR 58025A X JGL11118	29.78	220.07 *	4.27	4.06	-0.27 *	0.00
IR 58025A X JGL11111	4.06	-4.17	0.00 **	10.56	11.48	5.28 **
IR 58025A X JGL8605	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL8292	23.90	130.63 *	3.29	4.06	-0.27 *	0.00
IR 58025A X JGL3855	4.06	-4.17	0.00 **	8.90	6.30	3.93 **
IR 58025A X JGL3844	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
IR 58025A X JGL1798	4.06	-4.17 *	0.00	4.06	-0.27 *	0.00
KRH - 2	18.64	-4.11 *	0.07	6.51	-0.26 *	0.07
DRRH - 2	33.49	0.67	0.86	11.24	0.18	1.17
PA 6201	40.42	-2.03	-0.05	13.23	-0.16	-0.20
JAYA	28.44	-4.01 *	0.11	9.73	-0.26 *	0.09
IR - 64	20.83	95.10	-2.77 **	8.03	6.87	-2.99 **
TN1	58.19	2.77	1.64	18.22	-0.26 *	2.60
Population Mean		11.17			5.63	
SE of βi		1.05			1.17	

* Significant at 5% level; ** Significant at 1% level

Table 4.45.Mean performance and stability parameters for days to 50% flowering and plant height in rice

Parent/Cross	Days to 50 % flowering			Plant height		
	μ Mean	βi	$\sigma^2 di$	μ Mean	βi	$\sigma^2 di$
Testers						
IR 58025A	103.42	1.79	-3.65	84.53	-3.30	13.81 *
IR 68897A	97.02	-3.88	9.52	99.74	2.13	16.77 *
APMS 6A	105.89	0.96	-3.57	95.89	0.70	-4.76
APMS 8A	106.16	0.80	-2.51	101.77	-0.91	277.80 **
CMS 16A	105.07	1.06	-3.53	106.01	-0.63	394.71 **
Lines						
JGL 11110-2	102.22	-0.44	-2.52	109.94	0.12	10.65
JGL 11110-1	101.71	-1.48	1.73	111.21	-0.15	159.36 **
JGL 17211	102.67	-0.28	-3.73	107.00	-0.50	330.80 **
JGL 16284	102.98	1.39	-4.01	97.98	0.34	11.72
JGL 13515	106.33	-0.69	-1.24	102.72	1.26	55.66 **
JGL 11160	102.16	-1.52	-1.25	102.66	-1.99	688.53 **
JGL 11118	92.60	-1.27 *	-4.11	100.32	-0.83	468.10 **
JGL 11111	98.96	4.11	-0.79	105.23	0.59	141.09 **
JGL 8605	104.73	0.58	-2.23	109.40	-2.08	351.47 **
JGL 8292	102.00	-0.61	-3.35	99.78	1.12	82.67 **
JGL 3855	104.67	-0.04	2.01	104.50	-1.35	721.35 **
JGL 3844	101.29	-1.76	0.20	100.62	-1.76	688.70 **
JGL 1798	97.64	-0.56	-2.16	95.81	1.14	15.95 *
Crosses						
IR 68897A X JGL 11110-2	101.16	-1.91	2.99	96.60	3.74	300.45 **
IR 68897A X JGL11110-1	86.33	3.42	-3.18	78.83	1.57	10.27
IR 68897A X JGL17211	94.07	6.49	7.05	82.79	2.95	314.78 **
IR 68897A X JGL16284	99.02	-2.25	-3.54	90.36	2.92	229.17 **
IR 68897A X JGL13515	90.36	4.32	1.04	85.58	2.68	142.98 **
IR 68897A X JGL11160	88.13	-0.93	0.19	83.36	2.95	150.74 **
IR 68897A X JGL11118	83.91	0.84	-4.18	87.36	2.58	10.16
IR 68897A X JGL11111	97.82	0.06	-1.59	97.32	1.42	250.20 **
IR 68897A X JGL8605	89.71	-1.36	-3.48	91.04	2.90	84.23 **
IR 68897A X JGL8292	96.53	-0.84	5.11	96.09	2.40	24.07 *
IR 68897A X JGL3855	90.89	-0.14	-3.80	91.56	2.65	60.61 **
IR 68897A X JGL3844	93.18	-0.33	32.68 **	95.96	4.01	393.52 **
IR 68897A X JGL1798	94.09	-0.18	-4.11	87.76	2.08	46.60 **
APMS 8A X JGL 11110-2	105.53	-0.60	-2.65	97.59	1.12	101.49 **
APMS 8A X JGL11110-1	104.18	-0.02	-3.44	96.96	0.99	208.15 **
APMS 8A X JGL17211	104.20	-1.27	-3.61	91.09	1.69	283.09 **
APMS 8A X JGL16284	94.24	2.39	33.38 **	69.30	-1.04	53.74 **
APMS 8A X JGL13515	105.69	-0.37	-1.92	98.19	1.81	299.76 **
APMS 8A X JGL11160	105.98	-0.79	-4.07	91.31	0.04	144.95 **
APMS 8A X JGL11118	104.93	0.26	-3.93	97.16	1.98	259.26 **
APMS 8A X JGL11111	97.09	6.60	46.48 **	96.42	1.89	124.30 **
APMS 8A X JGL8605	100.11	1.26	-3.53	90.72	2.58	106.47 **
APMS 8A X JGL8292	92.80	6.19	0.58	86.80	1.41	35.63 **
APMS 8A X JGL3855	91.93	5.38	-3.22	86.82	2.91	169.87 **
APMS 8A X JGL3844	98.71	2.41	-2.46	95.04	3.24	154.07 **

Table 4.45 (cont.)

	Days to 50 % flowering			Plant height		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	106.18	0.73	0.40	88.01	2.15	306.53 **
CMS 16A X JGL 11110-2	105.09	-0.63	-3.24	90.98	2.07	130.88 **
CMS 16A X JGL11110-1	94.98	7.57 *	-3.55	89.26	1.39	170.00 **
CMS 16A X JGL17211	103.96	-0.85	-3.61	92.68	1.73	49.54 **
CMS 16A X JGL16284	104.82	-0.41	-3.14	93.43	0.63	96.67 **
CMS 16A X JGL13515	93.16	7.02	13.92 *	89.16	2.44	219.25 **
CMS 16A X JGL11160	102.73	-0.36	-1.59	92.46	1.97	105.68 **
CMS 16A X JGL11118	102.47	1.62	-3.70	90.97	2.46	323.21 **
CMS 16A X JGL11111	91.69	5.68	14.12 *	80.24	1.39	27.07 *
CMS 16A X JGL8605	95.53	7.29	9.27	84.98	2.32	265.57 **
CMS 16A X JGL8292	103.22	-0.50	6.97	100.56	3.32	246.02 **
CMS 16A X JGL3855	84.62	2.37 *	-4.19	85.46	1.89	355.60 **
CMS 16A X JGL3844	99.56	-1.34 *	-4.21	93.94	2.31	99.92 **
CMS 16A X JGL1798	104.18	-1.90	-2.09	89.62	1.73	58.62 **
APMS 6A X JGL 11110-2	99.33	-1.88	-0.75	94.33	2.13	138.03 **
APMS 6A X JGL11110-1	102.29	-0.76	3.70	94.79	2.77	160.81 **
APMS 6A X JGL17211	101.78	0.07	3.40	91.61	2.52	137.91 **
APMS 6A X JGL16284	103.40	0.07	-4.12	93.18	2.26	95.32 **
APMS 6A X JGL13515	97.82	0.53	-0.25	90.27	2.33	68.52 **
APMS 6A X JGL11160	95.53	-2.35	20.07 *	87.87	3.36	139.82 **
APMS 6A X JGL11118	99.13	-0.93	0.17	96.41	2.33	23.60 *
APMS 6A X JGL11111	96.24	5.71	7.23	110.80	0.72	222.80 **
APMS 6A X JGL8605	101.36	0.26	-3.95	104.86	-3.59	174.48 **
APMS 6A X JGL8292	98.04	2.25	-4.13	103.77	-0.64	465.57 **
APMS 6A X JGL3855	101.24	-0.65	1.48	103.58	-1.23	625.02 **
APMS 6A X JGL3844	99.89	2.37	-3.31	102.94	-1.20	446.35 **
APMS 6A X JGL1798	102.60	-0.51	-0.26	100.10	-1.09	34.15 **
IR 58025A X JGL 11110-2	103.16	0.74	-3.48	104.21	-0.34	61.60 **
IR 58025A X JGL11110-1	102.78	1.01	-4.14	104.61	0.28	140.99 **
IR 58025A X JGL17211	97.93	4.23	-3.41	96.60	0.31	49.49 **
IR 58025A X JGL16284	101.40	-0.08	-0.66	97.23	0.10	58.76 **
IR 58025A X JGL13515	103.56	-0.05	-1.92	102.72	-1.36	239.20 **
IR 58025A X JGL11160	86.58	1.38	70.94 **	101.19	-0.52	397.20 **
IR 58025A X JGL11118	89.87	3.60 *	-4.17	98.70	-0.35	335.33 **
IR 58025A X JGL11111	96.31	5.79	5.34	100.53	2.03	3.63
IR 58025A X JGL8605	104.49	0.53	-0.25	94.16	-1.96	325.66 **
IR 58025A X JGL8292	98.64	7.26	15.04 *	118.59	3.33	-3.06
IR 58025A X JGL3855	94.93	8.51	15.48 *	98.32	0.30	44.46 **
IR 58025A X JGL3844	92.38	5.96 *	-3.78	91.32	-1.73	479.53 **
IR 58025A X JGL1798	91.13	5.45 *	-3.67	97.74	-1.08	473.25 **
KRH - 2	92.58	-5.75	10.28	107.97	1.66	232.44 **
DRRH - 2	92.16	-4.99	15.55 *	108.93	-0.12	274.08 **
PA 6201	95.33	1.53	-3.49	104.11	0.92	150.89 **
JAYA	102.07	-1.81	2.67	101.62	-0.71	327.92 **
IR - 64	95.58	-2.57	4.90	93.91	1.41	15.43 *
Population Mean	**98.63**			**96.09**		
SE of βi		1.09			2.59	
CD at 5%	**4.80**			**9.94**		

* Significant at 5% level; ** Significant at 1% level

Similar results were obtained for gallmidge resistance by Srinivas *et al.* (1994) who studied and reported that gallmidge biotype 3 exists at Jagtial and the biotype pattern at Warangal was different and a change in the pattern of gallmidge reaction was indicated. Pasalu *et al.* (1998) studied the current rice gallmidge biotypes in India and reported the changing biotypes. Bentur *et al.* (1998) reported that the gallmidge is a pest of rice that has been successfully managed through breeding and cultivation of resistant varieties. Laxmi *et al.* (2006) studied a new biotype of Asian rice gallmidge from the Warangal population.

Jian Xian Bin *et al.* (2006) studied the restoring ability of rice varieties and resistance evaluation of F1 generation. Bentur *et al.* (2008) studied the monitoring of virulence of Asian rice gallmidge population in India. Naikebawane *et al.* (2008) reported JGL 384 as a donor for gallmidge resistance.

The pooled analysis of variance revealed that the variances for the genotypes were significant for gallmidge damaged plants percentage and silver shoots percentage, indicating the presence of genetic variability among genotypes for these characters.

4.3.3.3 Days to 50% flowering

For days to 50% flowering among the genotypes all the testers, lines and 56 hybrids are non significant, deviation from the regression (S^2di) values i.e. the genotypes are statistically within the range of minimum deviation from regression and whose performance can be predicted (Table 4.47).

Among the lines and testers, IR 68897A, JGL 1798, JGL 11111, JGL 3844, JGL 11110-1, JGL 8292, JGL 11160, JGL 11110-2, JGL 17211 and JGL 16284 recorded the minimum deviation from regression, recorded unit of bi values and thus possessed average stability and is adoptable to all environments less duration.The line JGL 11118 recorded less than the unit of bi value and thus possessed more than the average stability and is adoptable to poor environments.

Among the hybrids IR 68897A x JGL11118, IR 68897A x JGL11110-1, IR 68897A x JGL11160 recorded with unit regression values (bi). Hence, these hybrids are considered to possess the average stability whose performance does not change with the change in environments. The hybrid CMS 16A x JGL3855 recorded more than one of bi value and considered to possess less than the average stability and are adoptable to favourable environments (Table 4.45).

In respect of days to 50 per cent flowering in the present investigation both linear and non linear components of GE interactions were found to be significant. Similar results were reported by Hegde and Vidyachandra (1998), Deshpande *et al.* (2003) and Shanmuganathan and Ibrahim (2005), while significance of non linear component was reported by Lohithaswa *et al.* (1999). Young and Virmani (1990) reported the significance of linear component of GE interaction for this character.

4.3.3.4 Plant height (cms)

For plant height among the genotypes 1 tester, 3 lines and 4 hybrids had non-significant deviation from the regression (S^2di) values i.e., the genotypes are satisfactorily within the range of minimum deviation from regression and whose performance can be predicted.

Among the lines and testers, APMS 6A and JGL 16284 recorded the minimum deviation from regression, with unit of bi values and thus possessed average stability and was adoptable to all environments with less plant height.

Similarly the hybrid IR 68897A x JGL11110-1 recorded the minimum deviation from regression, with unit of bi values and thus possessed average stability and is adoptable to all environments with less plant height (Table 4.45).

In respect of plant height in the present investigation, both linear and non linear components of GE interactions were found to be in-significant. Among the lines and testers, none of the entry recorded minimum deviation from regression indicating that no entry is stable over environments. Similarly no hybrid recorded minimum deviation from regression for the character plant height indicating the un-stability of the character.

4.3.3.5 Flag leaf length (cms)

Among the all genotypes tested 4 testers, 6 lines and 33 hybrids had non significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.46).

Among the lines and testers, CMS 16A, IR 68897A, IR 58025A, JGL 11160, JGL 17211 and JGL 11110-2 recorded the unit of bi value and thus possessed average stability and is adoptable to all environments.

Among the hybrids, APMS 8A x JGL11110-1, CMS 16A x JGL8292, CMS 16A x JGL17211, APMS 8A x JGL11118, CMS 16A x JGL16284, APMS 6A x JGL11111 and IR 58025A x JGL3855 recorded the unit regression values, Hence, these hybrid were

Table 4.46. Mean performance and stability parameters for flag leaf length and flag leaf width in rice

Parent/Cross	Flag Leaf Length cm			Flag Leaf Width cm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	23.62	-1.65	-0.42	1.19	-1.67	0.02
IR 68897A	26.25	3.83	0.15	0.96	1.15	-0.01
APMS 6A	22.62	-0.04	2.75	1.36	-0.99 *	-0.01
APMS 8A	26.49	0.04	62.04 **	1.40	-1.86 *	-0.01
CMS 16A	27.88	-0.27	-2.62	1.62	-4.73	0.10 **
Lines						
JGL 11110-2	28.38	2.87 *	-2.62	1.23	2.48	0.00
JGL 11110-1	33.64	3.69	8.81 *	1.61	-2.01	0.01
JGL 17211	29.73	0.92	-2.01	1.63	-1.86	0.01
JGL 16284	28.18	1.68	61.77 **	1.55	0.95	0.02
JGL 13515	24.62	0.09	14.85 *	1.47	0.73	0.02
JGL 11160	31.16	3.06	-2.59	1.39	0.91	0.02
JGL 11118	26.12	-0.69	-1.91	1.17	2.11	0.04 *
JGL 11111	31.19	3.78	115.19 **	1.18	2.15	0.00
JGL 8605	27.78	-0.02	39.83 **	1.57	1.30	-0.01
JGL 8292	28.97	2.29	24.60 **	1.54	-0.74 *	-0.01
JGL 3855	24.86	0.31	38.19 **	1.41	0.07	0.00
JGL 3844	20.86	1.20	-1.81	1.12	1.33	-0.01
JGL 1798	25.80	0.39	-1.75	0.99	0.09	-0.01
CROSSES						
IR 68897A X JGL 11110-2	28.21	-3.01	27.95 **	0.97	-0.10	0.00
IR 68897A X JGL11110-1	24.56	-0.03	-1.28	0.80	-0.62 *	-0.01
IR 68897A X JGL17211	22.78	1.11	14.35 *	0.98	0.06	-0.01
IR 68897A X JGL16284	28.91	0.37	0.24	1.31	3.16	0.02
IR 68897A X JGL13515	29.53	0.95	44.66 **	1.03	1.27	0.00
IR 68897A X JGL11160	36.30	3.82	10.19 *	1.15	1.48	0.00
IR 68897A X JGL11118	28.33	-3.11	5.72	0.90	1.49	0.00
IR 68897A X JGL11111	29.22	0.96	50.01 **	1.27	1.65	-0.01
IR 68897A X JGL8605	28.34	0.90	-0.25	1.04	1.39	0.00
IR 68897A X JGL8292	28.65	-2.01	1.47	1.14	0.45	0.01
IR 68897A X JGL3855	27.56	-1.65	-2.52	0.98	-0.03	0.00
IR 68897A X JGL3844	28.50	-1.42	33.24 **	0.98	0.06	-0.01
IR 68897A X JGL1798	28.17	-3.46	6.63	1.04	-0.36	0.00
APMS 8A X JGL 11110-2	31.02	-2.70	4.72	1.24	2.46	-0.01
APMS 8A X JGL11110-1	35.79	0.42	-0.25	1.29	3.39	0.00
APMS 8A X JGL17211	34.59	-0.84	68.31 **	1.51	3.74	-0.01
APMS 8A X JGL16284	32.66	1.75	121.35 **	1.10	2.27	0.02
APMS 8A X JGL13515	31.00	-2.04	-2.56	1.35	3.72	-0.01
APMS 8A X JGL11160	31.82	0.37	24.52 **	1.31	2.18 *	-0.01
APMS 8A X JGL11118	33.73	-2.36	-2.22	1.26	2.03	0.03 *
APMS 8A X JGL11111	31.09	7.47	32.67 **	1.11	1.18	0.00
APMS 8A X JGL8605	28.31	6.09	9.53 *	1.53	4.85	0.11 **
APMS 8A X JGL8292	25.73	2.39	-1.04	0.89	-1.43	-0.01
APMS 8A X 3855	25.81	1.92	1.32	1.16	2.42	0.00
APMS 8A X 3844	28.84	-2.44	33.96 **	1.05	-1.77	0.00

Table 4.46(cont.)

Crosses			Flag Leaf Length cm			Flag Leaf Width cm		
			μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A	X	JGL1798	30.78	1.65	26.78 **	1.43	3.84	0.00
CMS 16A	X	JGL 11110-2	30.29	1.58	-2.42	1.18	0.45	0.00
CMS 16A	X	JGL11110-1	29.37	4.07	-0.94	1.37	2.62	-0.01
CMS 16A	X	JGL17211	34.38	1.51	-2.56	1.25	1.58	-0.01
CMS 16A	X	JGL16284	32.80	-0.44	-2.60	1.46	1.75	-0.01
CMS 16A	X	JGL13515	28.57	1.17	-2.63	1.39	4.55 *	-0.01
CMS 16A	X	JGL11160	32.11	-0.83	4.69	1.64	5.58	0.03 *
CMS 16A	X	JGL11118	29.54	-1.80	-0.32	1.18	2.25	-0.01
CMS 16A	X	JGL11111	24.57	1.37	-0.88	1.16	2.48	0.00
CMS 16A	X	JGL8605	30.00	2.13	24.53 **	0.75	-0.57	-0.01
CMS 16A	X	JGL8292	35.54	4.60	7.34	1.07	0.75	0.00
CMS 16A	X	JGL3855	26.16	3.62	-0.15	1.60	5.10	0.07 **
CMS 16A	X	JGL3844	31.96	0.44	-0.82	1.24	1.80	0.01
CMS 16A	X	JGL1798	26.24	2.35	43.34 **	1.53	3.74	0.02
APMS 6A	X	JGL 11110-2	28.11	1.57	7.30	1.35	1.93	0.12 **
APMS 6A	X	JGL11110-1	31.78	1.57	-2.41	1.41	3.65	0.01
APMS 6A	X	JGL17211	30.68	-3.01	-2.26	1.20	1.89	0.00
APMS 6A	X	JGL16284	31.80	-2.24	10.77 *	1.26	2.28	0.02
APMS 6A	X	JGL13515	25.47	-1.52	80.23 **	1.50	3.62	0.00
APMS 6A	X	JGL11160	24.95	2.84	1.54	1.05	0.64	-0.01
APMS 6A	X	JGL11118	29.43	2.47	17.89 **	1.06	2.39	0.00
APMS 6A	X	JGL11111	32.73	4.88	1.89	1.30	2.88 *	-0.01
APMS 6A	X	JGL8605	29.56	0.92	0.99	1.23	2.77	-0.01
APMS 6A	X	JGL8292	28.98	3.30	54.78 **	1.16	2.81	0.00
APMS 6A	X	JGL3855	22.56	2.36	48.77 **	1.11	0.42	-0.01
APMS 6A	X	JGL3844	25.13	4.04	65.99 **	1.21	1.87	0.01
APMS 6A	X	JGL1798	27.48	1.66	67.90 **	1.75	-0.76	0.02
IR 58025A	X	JGL 11110-2	27.64	3.10	65.33 **	1.32	-0.18	0.02
IR 58025A	X	JGL11110-1	27.00	1.15	41.46 **	1.33	3.39	0.00
IR 58025A	X	JGL17211	30.27	4.07	79.49 **	1.10	0.98	0.00
IR 58025A	X	JGL16284	25.88	2.39	54.58 **	1.13	1.27	0.00
IR 58025A	X	JGL13515	28.24	-0.17	5.00	1.52	-3.36	-0.01
IR 58025A	X	JGL11160	26.04	1.50	33.68 **	1.11	2.06	0.23 **
IR 58025A	X	JGL11118	23.61	2.03	10.12 *	0.99	0.25 *	-0.01
IR 58025A	X	JGL11111	36.32	2.49	11.60 *	1.34	-1.18	-0.01
IR 58025A	X	JGL8605	26.67	0.60	10.15 *	0.91	-3.54	0.07 **
IR 58025A	X	JGL8292	26.89	5.04	145.55 **	0.99	0.66	0.08 **
IR 58025A	X	JGL3855	32.25	1.20	5.96	0.96	0.90	-0.01
IR 58025A	X	JGL3844	24.17	0.51	-0.74	0.79	-0.35	0.04 *
IR 58025A	X	JGL1798	23.85	2.15	7.87 *	1.16	-0.42	0.00
KRH - 2			26.57	-4.51	15.57 **	1.53	-3.30	0.11 **
DRRH - 2			27.56	-5.32	-2.06	1.03	0.76	0.01
PA 6201			24.53	4.56 *	-2.63	1.25	-1.25	0.01
JAYA			30.42	1.58	5.03	1.30	-0.88	0.00
IR - 64			21.75	0.43	1.80	1.40	-4.46 *	-0.01
Population Mean			**28.50**			**1.24**		
SE of βi				4.61			1.01	
CD at 5%			**3.66**			**0.22**		

* Significant at 5% level; ** Significant at 1% level

considered to possess the average stability whose performance does not change with change in environment for character flag leaf length with high mean.

4.3.3.6 Flag leaf width (cms)

Among the all genotypes tested 4 testers, 12 lines and 56 hybrids had non significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.47).

Among the lines and testers, 58025A, JGL 17211, JGL 11110-1, JGL 8605, JGL 16284, JGL 13515and JGL 3855 recorded the unit regression values, Hence considered to posses the average stability, whose performance does not change with change in environment. The APMS 8A, APMS 6A and JGL 8292 recorded less the unit of bi value and thus possessed more than average stability and is adoptable to poor environments.

Among the hybrids, APMS 6A x JGL 1798 and CMS 16A x JGL1798 recorded the unit of bi value, and thus possessed average stability and are adoptable to all environments (Table 4.47).

Both linear and non linear components of GE interactions were found to be significant for flag leaf width.

4.3.3.7 Panicle length (cms)

Among the genotypes 3 testers, 10 lines and 56 hybrids had non significant deviation from the regression (S^2di) values i.e., the genotypes is satisfactorily within the range of minimum deviation from the regression whose performance can be predicted (Table 4.47).

Among the lines and testers, APMS 6A, APMS 8A and JGL 17211 with less deviation from regression recorded with unit regression values (bi) with more panicle length. Hence, these genotypes are considered to possess the average stability, whose performance does not change with change in environment. The line JGL 3855 recorded less than unit of bi value and thus possessed more than average stability and is adoptable to poor environments, where as the line JGL 8292 recorded more than one of bi value and considered to possess less than the average stability and are adoptable to favourable environments.

Among the hybrids, IR 68897A x JGL 11110-2, IR 68897A x JGL16284, CMS 16A x JGL 11110-2 and IR 58025A x JGL11111 recorded with unit regression values with more panicle length.Hence, these hybrids are considered to possess the average stability whose performance does not change with change in environment for the

Table 4.47. Mean performance and stability parameters for productive tillers/ panicle length in rice

Parent/Cross	Productive Tillers/ Plant			Panicle Length cm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	8.89	0.62	-0.78	17.19	0.13	7.48 **
IR 68897A	8.72	0.48	1.82	20.77	2.10	1.19
APMS 6A	10.50	0.62	7.86 **	21.87	1.10	0.36
APMS 8A	15.22	1.79	6.06 **	21.36	-0.01	0.65
CMS 16A	14.61	1.23	-1.00	20.34	2.36	2.44 *
Lines						
JGL 11110-2	11.17	0.24	4.34 *	21.53	2.11	4.36 **
JGL 11110-1	13.39	1.11	34.11 **	26.74	-0.49	3.40 **
JGL 17211	12.89	0.82	0.81	23.37	0.50	-0.04
JGL 16284	9.33	0.09	4.97 *	22.26	0.41	-0.24
JGL 13515	11.39	0.76	13.52 **	24.01	-0.88	4.11 **
JGL 11160	10.50	0.95	18.21 **	21.77	0.22	0.62
JGL 11118	11.39	1.16	3.31 *	22.46	-0.33	-0.29
JGL 11111	8.72	0.13	0.36	21.63	1.80	0.45
JGL 8605	12.17	0.92	6.46 **	21.82	0.06	-0.43
JGL 8292	10.11	0.48	-0.34	23.91	1.83 *	-0.47
JGL 3855	8.22	0.37	2.79	22.98	-0.92 *	-0.43
JGL 3844	8.61	0.33	-0.28	19.48	0.88	0.36
JGL 1798	9.39	0.11	-0.04	21.93	-0.15 *	-0.45
Crosses						
IR 68897A X JGL 11110-2	13.39	1.55	-0.89	25.83	1.57	-0.28
IR 68897A X JGL11110-1	9.11	0.36	2.46	22.60	0.88	-0.23
IR 68897A X JGL17211	7.39	0.31 *	-1.00	21.76	1.20	-0.44
IR 68897A X JGL16284	11.06	0.91	12.69 **	24.53	1.82	-0.27
IR 68897A X JGL13515	10.94	0.43	7.00 **	22.78	2.21	-0.11
IR 68897A X JGL11160	16.06	1.57	62.90 **	23.80	0.44	-0.16
IR 68897A X JGL11118	13.83	1.17	0.84	21.44	-0.64 *	-0.39
IR 68897A X JGL11111	14.56	0.89	17.14 **	24.85	2.07 *	-0.47
IR 68897A X JGL8605	18.94	1.72	13.64 **	22.66	1.60	-0.32
IR 68897A X JGL8292	17.78	1.76	-0.59	25.01	0.42	1.57 *
IR 68897A X JGL3855	17.56	2.21	0.51	23.32	-0.04	0.54
IR 68897A X JGL3844	16.67	1.77	-0.72	23.46	1.26	-0.45
IR 68897A X JGL1798	19.17	2.29	11.61 **	20.03	2.62	0.08
APMS 8A X JGL 11110-2	12.39	1.25	7.94 **	23.46	0.36	-0.19
APMS 8A X JGL11110-1	15.00	1.00	-0.41	23.64	1.91	-0.40
APMS 8A X JGL17211	10.61	0.83	1.61	22.97	1.07	-0.31
APMS 8A X JGL16284	9.17	0.59	2.24	23.73	2.78	-0.29
APMS 8A X JGL13515	14.17	1.38	1.76	22.18	1.64	-0.35
APMS 8A X JGL11160	12.89	1.57	11.89 **	22.83	0.37 *	-0.47
APMS 8A X JGL11118	18.50	2.28	3.67 *	22.24	0.29	-0.43
APMS 8A X JGL11111	19.33	2.22	0.29	21.76	1.31	0.26
APMS 8A X JGL8605	13.28	1.05	1.83	22.07	3.04	2.67 *
APMS 8A X JGL8292	9.78	1.06	-0.87	21.66	0.93	-0.14
APMS 8A X JGL3855	12.33	1.11	27.92 **	22.12	1.89	-0.38
APMS 8A X JGL3844	16.78	2.13	29.14 **	22.42	2.33	-0.33

Table 4.47(cont.)

	Productive Tillers/ Plant			Panicle Length cm		
	μ Mean	βi	$\sigma^2 di$	μ Mean	βi	$\sigma^2 di$
APMS 8A X JGL1798	10.94	0.69	1.98 **	20.61	0.39	0.38
CMS 16A X JGL 11110-2	14.72	1.79	14.76	24.33	1.46	-0.42
CMS 16A X JGL11110-1	11.00	0.82	25.59	23.03	2.60	0.09
CMS 16A X JGL17211	12.06	0.67	9.02 **	24.12	1.87	-0.37
CMS 16A X JGL16284	15.06	1.47	79.51	21.87	0.67	-0.46
CMS 16A X JGL13515	12.28	0.91	0.67 **	22.99	0.30	0.06
CMS 16A X JGL11160	15.94	1.78	1.55 **	23.34	1.58	-0.26
CMS 16A X JGL11118	13.61	1.36	29.12 **	20.53	1.90	11.97 **
CMS 16A X JGL11111	11.28	0.74	-0.06 **	23.27	0.02	2.04 *
CMS 16A X JGL8605	11.39	1.23	22.81 *	22.90	1.71	-0.04
CMS 16A X JGL8292	13.17	1.13	8.29 **	22.21	1.17	-0.46
CMS 16A X JGL3855	10.11	0.35	21.91	21.99	1.18	0.12
CMS 16A X JGL3844	15.28	1.52	6.58 **	22.24	0.39	4.96 **
CMS 16A X JGL1798	16.06	1.71	4.70 **	19.90	1.99	-0.18
APMS 6A X JGL 11110-2	15.06	0.97	6.66	22.27	1.31	0.30
APMS 6A X JGL11110-1	19.89	1.90	0.31 **	23.98	1.28	-0.46
APMS 6A X JGL17211	15.11	1.05	32.74 **	20.99	1.09	-0.28
APMS 6A X JGL16284	17.33	1.62	29.61	22.76	0.90	-0.47
APMS 6A X JGL13515	10.28	0.08	-0.42	21.97	2.16	2.21 *
APMS 6A X JGL11160	14.11	1.58	98.19 **	22.38	1.50	-0.45
APMS 6A X JGL11118	14.17	0.92	6.46	21.69	0.85	-0.47
APMS 6A X JGL11111	12.17	-0.69 *	-0.98 *	22.46	0.27	-0.01
APMS 6A X JGL8605	12.28	1.17	-0.60	21.01	0.98	15.00 **
APMS 6A X JGL8292	15.72	0.96	35.43	22.37	1.29	-0.34
APMS 6A X JGL3855	12.00	0.54	2.39	21.40	1.02	-0.38
APMS 6A X JGL3844	11.17	0.16	3.55 **	20.22	0.58	-0.46
APMS 6A X JGL1798	14.67	0.92	1.01 **	22.89	0.31	-0.07
IR 58025A X JGL 11110-2	12.50	0.92	-0.88 *	22.88	1.01	4.08 **
IR 58025A X JGL11110-1	9.67	-0.11	1.28 **	22.90	1.82 *	-0.47
IR 58025A X JGL17211	13.56	1.18	56.34 **	21.23	0.49	0.77
IR 58025A X JGL16284	14.11	1.38	106.01	22.90	0.82	-0.30
IR 58025A X JGL13515	12.78	1.07	4.06 *	16.84	-2.80	8.55 **
IR 58025A X JGL11160	16.22	2.06	20.10	22.42	1.64	-0.14
IR 58025A X JGL11118	12.72	0.61	27.62 **	22.51	1.20	0.07
IR 58025A X JGL11111	10.72	0.32	-0.67 *	24.13	1.71	-0.41
IR 58025A X JGL8605	12.61	1.80	5.40 **	21.08	-1.03	0.37
IR 58025A X JGL8292	8.72	0.09 *	-1.01 **	22.22	1.07	-0.20
IR 58025A X JGL3855	15.33	1.58	23.63	23.78	1.72	-0.44
IR 58025A X JGL3844	10.94	0.33	4.01	21.96	0.96	-0.39
IR 58025A X JGL1798	12.33	1.15	14.81 **	22.48	0.78	-0.38
KRH - 2	11.78	0.16 *	-0.88	24.20	1.67	1.96 *
DRRH - 2	14.83	1.27	39.12 **	22.84	0.87	-0.26
PA 6201	11.61	0.17	1.00	21.72	1.67	-0.40
JAYA	11.56	1.10	16.19 **	21.44	-1.24 *	-0.47
IR - 64	10.39	0.00	-0.66	22.94	0.85	0.46
Population Mean	**12.90**			**22.37**		
SE of βi		0.64			0.48	
CD at 5%	**3.12**			**1.65**		

* Significant at 5% level; **and** Significant at 1% level

character panicle length.The hybrid IR 68897A x JGL11111 recorded more than one of bi value and considered to possess less than the average stability and are adoptable to favourable environments.

Regarding panicle length, the results indicated that the GE interactions, mainly due to both linear and non linear components, which are significant.

4.3.3.8 Productive tillers per plant

Among the genotypes 3 testers, 6 lines and 29 hybrids had non- significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from regression (Table 4.47).Among the lines and testers CMS 16A, JGL 17211 and JGL 8292 recorded with unit regression values (bi). Hence, these hybrids are considered to possess the average stability, whose performance does not change with change in environments.

Among the hybrids APMS 8A x JGL11111, IR 68897A x JGL8292, IR 68897A x JGL3855 and APMS 6A x JGL16284 recorded with unit regression values (bi). Hence, these hybrids are considered to possess the average stability, whose performance does not change with change in environments.

In respect of productive tillers per plant in the present investigation, both linear and non linear components of GE interactions were found to be significant

4.3.3.9 Panicle weight (gm)

Among the genotypes one tester, one line and 14 hybrids had non significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.48).

Among the lines and testers, IR 68897A and JGL 11110-2 recorded with unit regression values (bi) with high mean. Hence, the genotypes were considered to possess the average stability, whose performance does not change with change in environment.

Among the hybrids CMS 16A x JGL 11110-2 recorded with unit regression values; hence these hybrids are considered to possess the average stability, whose performance does not change with change in environment.The hybrids IR 68897A x JGL16284 and APMS 8A x JGL11110-1 recorded more than unit regression values (bi). Hence, these hybrids are considered to possess the less than average stability.

Table 4.48. Mean performance and stability parameters for panicle weight and filled grains/ panicle in rice

Parents/Crosses	Panicle Weight gm			Filled Grains/ Panicle		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
Testers						
IR 58025A	2.10	0.49	0.18 **	123.56	-2.55	473.20 *
IR 68897A	2.97	1.11	0.00	144.58	-1.71	2432.45 **
APMS 6A	2.51	-0.59	0.87 **	149.25	-3.65	951.77 **
APMS 8A	2.67	-0.97	0.25 **	179.47	-5.60 *	-99.92
CMS 16A	3.31	0.34	0.83 **	260.13	-10.89	9184.77 **
Lines						
JGL 11110-2	2.19	0.57	-0.01	193.83	-3.31	201.09
JGL 11110-1	3.42	-0.91	2.29 **	290.90	-6.83	544.56 *
JGL 17211	3.73	-0.11	0.41 **	246.79	-2.65	5376.79 **
JGL 16284	3.24	-2.25	1.80 **	314.56	-3.53	-85.26
JGL 13515	2.42	2.18	0.31 **	161.43	6.12	0.85
JGL 11160	3.42	0.01	3.17 **	201.08	5.92	9724.00 **
JGL 11118	3.80	-1.02	0.13 **	255.01	-9.57	5585.57 **
JGL 11111	2.72	0.76	0.19 **	172.01	2.99	1558.92 **
JGL 8605	3.34	-1.21	1.55 **	257.06	-0.83	5199.91 **
JGL 8292	2.58	1.19	0.23 **	245.58	5.52	2383.15 **
JGL 3855	2.98	1.19	2.66 **	225.88	5.61	15300.27 **
JGL 3844	2.28	-0.66	0.05 *	140.18	-3.55	6827.02 **
JGL 1798	3.42	3.04	1.44 **	184.06	4.50	1642.01 **
Crosses						
IR 68897A X JGL 11110-2	3.36	1.10	1.27 **	158.07	-0.56	279.89
IR 68897A X JGL11110-1	2.78	0.09	0.11 **	146.75	-1.47	48.73
IR 68897A X JGL17211	2.46	0.14	0.00	133.72	2.41	281.33
IR 68897A X JGL16284	3.99	3.22 *	-0.01	206.92	4.63	360.23 *
IR 68897A X JGL13515	2.69	2.28	-0.01	138.97	1.28	1365.75 **
IR 68897A X JGL11160	3.90	1.37	2.05 **	173.46	-0.27	3413.12 **
IR 68897A X JGL11118	2.50	0.20	1.11 **	111.46	-1.15	36.89
IR 68897A X JGL11111	3.68	2.07	0.44 **	196.85	3.63	4344.64 **
IR 68897A X JGL8605	3.31	0.34	0.14 **	167.61	-0.26	174.58
IR 68897A X JGL8292	3.39	1.61	0.30 **	134.49	-1.73	1696.45 **
IR 68897A X JGL3855	2.31	0.25 *	-0.01	117.78	0.62	-72.50
IR 68897A X JGL3844	2.96	1.37	0.06 *	141.79	4.39	4.58
IR 68897A X JGL1798	2.56	1.72	0.26 **	100.89	3.00	4547.59 **
APMS 8A X JGL 11110-2	3.11	2.18	0.38 **	196.35	2.59	-39.04
APMS 8A X JGL11110-1	3.96	2.79 *	-0.01	238.10	3.94 *	-100.80
APMS 8A X JGL17211	4.21	1.53	1.37 **	255.17	0.16	347.91 *
APMS 8A X JGL16284	3.61	1.82	0.30 **	189.39	4.44 *	-100.19
APMS 8A X JGL13515	3.04	1.26	2.94 **	167.25	3.41	13888.43 **
APMS 8A X JGL11160	3.67	3.33	1.39 **	181.88	7.32 *	-100.50
APMS 8A X JGL11118	3.03	1.12	0.11 **	130.81	2.85	-83.80
APMS 8A X JGL11111	3.16	0.96	0.00	213.40	1.29	1939.00 **
APMS 8A X JGL8605	2.82	1.61	0.01	189.90	9.73	626.79 **
APMS 8A X JGL8292	2.59	1.04	0.28 **	180.14	7.48	341.27 *
APMS 8A X JGL3855	2.53	0.78	0.00	155.03	1.66	1120.27 **
APMS 8A X JGL3844	2.84	-0.39	0.58 **	205.17	1.36	199.54

Table 4.48 (cont.)

Crosses			Panicle Length cm			Filled Grains/ Panicle		
			μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A	X	JGL1798	2.26	-0.01	0.00	134.51	1.31	1660.40 **
CMS 16A	X	JGL 11110-2	3.80	1.99	0.03	231.83	1.15	2615.23 **
CMS 16A	X	JGL11110-1	3.37	2.01	0.64 **	209.75	8.11	-28.75
CMS 16A	X	JGL17211	3.46	0.30	4.53 **	201.10	-6.63	-48.84
CMS 16A	X	JGL16284	3.22	-0.62	1.18 **	181.68	-6.62	596.31 **
CMS 16A	X	JGL13515	3.37	2.49	0.21 **	256.46	-6.73	532.36 *
CMS 16A	X	JGL11160	3.40	0.91	0.91 **	219.64	-4.57	15683.74 **
CMS 16A	X	JGL11118	3.64	2.28	0.51 **	209.93	5.81	1337.37 **
CMS 16A	X	JGL11111	2.66	1.33	0.69 **	168.46	0.56	3830.77 **
CMS 16A	X	JGL8605	2.56	1.61 *	-0.01	178.94	-3.28 *	8062.42 **
CMS 16A	X	JGL8292	2.90	1.30	0.85 **	196.26	9.08	-74.85
CMS 16A	X	JGL3855	3.04	3.27	0.08 **	175.46	5.61	-83.41
CMS 16A	X	JGL3844	2.92	0.76	0.01	121.06	-1.34	-53.00
CMS 16A	X	JGL1798	2.70	0.23	2.38 **	119.86	-1.77	692.61 **
APMS 6A	X	JGL 11110-2	3.99	-0.99	0.13 **	265.44	-7.32	29609.11 **
APMS 6A	X	JGL11110-1	3.81	0.55	0.08 **	207.06	2.98	8004.44 **
APMS 6A	X	JGL17211	4.39	2.17	0.16 **	233.31	7.86	2044.09 **
APMS 6A	X	JGL16284	3.46	1.65	0.49 **	196.11	10.64	4663.33 **
APMS 6A	X	JGL13515	2.19	0.55	0.09 **	143.13	1.10	378.15 *
APMS 6A	X	JGL11160	3.76	1.74	0.24 **	268.78	-2.29	2452.42 **
APMS 6A	X	JGL11118	3.50	4.04	0.34 **	225.04	8.84	17597.64 **
APMS 6A	X	JGL11111	3.09	1.68	0.30 **	224.42	4.46	337.03 *
APMS 6A	X	JGL8605	1.90	0.30	0.13 **	122.68	2.37	644.96 **
APMS 6A	X	JGL8292	2.67	0.64	0.38 **	149.74	2.72	2138.42 **
APMS 6A	X	JGL3855	3.30	1.50	0.31 **	163.78	7.66 *	842.93 **
APMS 6A	X	JGL3844	2.89	1.14	0.55 **	155.18	5.20	-98.88
APMS 6A	X	JGL1798	2.43	0.72	0.29 **	139.71	0.43	2577.50 **
IR 58025A	X	JGL 11110-2	2.82	0.70	1.02 **	148.53	0.27	2794.18 **
IR 58025A	X	JGL11110-1	3.20	2.27	1.00 **	145.25	-1.03	3770.33 **
IR 58025A	X	JGL17211	3.46	2.16	2.40 **	169.15	-1.82	2450.00 **
IR 58025A	X	JGL16284	3.34	1.23	0.72 **	201.51	5.83	4.94
IR 58025A	X	JGL13515	2.43	-0.25 *	-0.01	144.64	-4.27	556.26 *
IR 58025A	X	JGL11160	3.63	-1.18	3.32 **	165.65	-4.33	4755.17 **
IR 58025A	X	JGL11118	2.62	0.16	0.81 **	191.92	-6.80	15182.64 **
IR 58025A	X	JGL11111	3.90	3.20	0.13 **	206.18	7.36	2880.49 **
IR 58025A	X	JGL8605	2.27	-1.12	0.61 **	138.89	-4.38	170.58
IR 58025A	X	JGL8292	3.02	3.83	1.29 **	234.83	7.62	32135.28 **
IR 58025A	X	JGL3855	2.78	1.50	-0.01	168.28	9.09	910.24 **
IR 58025A	X	JGL3844	2.49	0.74	0.05 *	128.25	-1.66	-8.61
IR 58025A	X	JGL1798	2.43	-0.35	0.26 **	144.71	-5.14	5838.79 **
KRH - 2			3.53	1.44	2.91 **	163.47	1.22	60.47
DRRH - 2			3.61	1.24	0.03	142.43	2.49	121.03
PA 6201			3.24	0.70	0.04 *	132.64	2.20	391.19 *
JAYA			3.30	0.88	0.08 **	128.49	1.41	38.98
IR - 64			3.00	0.40	0.24 **	138.04	-2.11	547.13 *
Population Mean			**3.08**			**181.46**		
SE of βi				1.26			6.40	
CD at 5%			**0.67**			**43.11**		

* Significant at 5% level; ** Significant at 1% level

Table 4.49. Mean performance and stability parameters for spikelet fertility (%) and 1000 grain weight in rice

Parents/Crosses	Spikelet Fertility %			1000 Grain Weight gm		
	µ Mean	βi	σ²di	µ Mean	βi	σ²di
Testers						
IR 58025A	87.34	-0.39	121.25 **	18.32	2.09	0.53
IR 68897A	84.70	0.91	114.36 **	20.76	1.20	0.25
APMS 6A	82.48	7.61	20.08 **	18.26	-1.01	-0.66
APMS 8A	92.28	-2.34	-0.82	15.70	-0.43	-0.79
CMS 16A	89.52	-0.72	-2.56	16.82	0.17	-0.53
Lines						
JGL 11110-2	80.16	5.72	353.03 **	17.54	0.02	-0.61
JGL 11110-1	89.07	-0.44	54.16 **	16.20	0.90	-0.01
JGL 17211	85.54	4.44	18.65 **	16.15	-0.13	-0.88
JGL 16284	89.57	0.15	4.47	17.09	0.90	-0.46
JGL 13515	92.09	1.45 *	-2.71	15.93	0.76	-0.13
JGL 11160	92.63	-3.71	17.28 **	16.26	0.76	-0.70
JGL 11118	92.06	4.84	-1.11	16.93	1.35	-0.15
JGL 11111	91.89	-1.25	-1.16	17.65	0.90	-0.26
JGL 8605	89.89	-2.33 *	-2.65	16.93	1.05	-0.14
JGL 8292	91.34	-4.07 *	-2.69	18.43	2.38	1.24
JGL 3855	89.69	-4.11	3.95	18.87	-0.28 *	-0.91
JGL 3844	85.51	5.19	45.05 **	16.65	0.61	-0.25
JGL 1798	93.67	-0.82	11.10 *	19.98	2.97	1.63
Crosses						
IR 68897A X JGL 11110-2	80.56	-4.17	185.68 **	22.70	1.93	3.58 *
IR 68897A X JGL11110-1	87.28	9.08 *	-2.27	17.32	2.08 *	-0.93
IR 68897A X JGL17211	90.22	2.17	28.00 **	16.70	1.93	-0.83
IR 68897A X JGL16284	84.68	-2.83	96.14 **	22.04	1.93	0.78
IR 68897A X JGL13515	86.89	8.73	11.92 *	17.43	1.21	6.48 **
IR 68897A X JGL11160	87.22	-1.31	104.74 **	22.59	2.51	12.25 **
IR 68897A X JGL11118	81.89	1.66	4.50	21.54	2.96	9.07 **
IR 68897A X JGL11111	76.75	1.92	148.27 **	16.48	1.05	0.12
IR 68897A X JGL8605	76.96	-9.22	300.51 **	21.43	3.25	10.91 **
IR 68897A X JGL8292	83.72	-5.09	-1.90	22.93	2.52	1.60
IR 68897A X JGL3855	76.85	-10.77	8.55 *	18.26	0.17	2.03
IR 68897A X JGL3844	80.22	-3.31	183.77 **	19.93	1.93	1.56
IR 68897A X JGL1798	49.74	9.45	231.23 **	21.26	2.82	-0.33
APMS 8A X JGL 11110-2	87.22	1.92	25.79 **	17.43	2.37	3.91 *
APMS 8A X JGL11110-1	85.43	-4.86	75.78 **	16.04	1.64 *	-0.93
APMS 8A X JGL17211	78.57	-14.07	48.15 **	18.76	3.25	13.88 **
APMS 8A X JGL16284	89.99	0.17	88.84 **	17.26	1.64	-0.71
APMS 8A X JGL13515	90.56	-0.46	4.22	19.98	2.66	9.92 **
APMS 8A X JGL11160	89.04	0.49	51.66 **	15.93	0.17	-0.11
APMS 8A X JGL11118	81.92	-8.01 *	-2.37	18.15	2.22	11.24 **
APMS 8A X JGL11111	78.60	19.07	2.32	16.32	1.78	0.60
APMS 8A X JGL8605	89.80	-2.04	-1.95	16.32	1.49	0.58
APMS 8A X JGL8292	93.07	0.57	5.35	13.48	0.17	0.15
APMS 8A X JGL3855	77.76	3.21	41.13 **	16.20	1.78	1.34
APMS 8A X JGL3844	83.55	-0.29	99.39 **	17.93	1.34	1.53

Table 4.49 (cont.)

Crosses	Spikelet Fertility %			1000 Grain Weight gm		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	59.39	-7.58	117.37 **	15.82	0.76	-0.55
CMS 16A X JGL 11110-2	81.22	-4.53	8.38 *	17.76	2.37	0.98
CMS 16A X JGL11110-1	84.39	7.78	0.00	15.87	1.79 *	-0.92
CMS 16A X JGL17211	78.56	-10.84	198.16 **	20.26	2.81	3.08 *
CMS 16A X JGL16284	84.72	0.52	124.22 **	16.26	1.93	-0.35
CMS 16A X JGL13515	82.56	7.27 *	-2.58	16.76	0.90	0.91
CMS 16A X JGL11160	90.29	4.21	4.02	16.09	-0.57	2.83 *
CMS 16A X JGL11118	80.89	-3.47	8.55 *	15.43	-0.57	1.41
CMS 16A X JGL11111	88.36	4.17	0.46	15.70	1.35	-0.82
CMS 16A X JGL8605	93.73	0.99	-2.34	16.65	1.78	-0.76
CMS 16A X JGL8292	75.16	-1.69	-0.54	17.20	-0.86	3.98 *
CMS 16A X JGL3855	89.13	8.26 *	-2.17	18.48	3.40	1.23
CMS 16A X JGL3844	60.35	13.16	279.30 **	19.20	0.89	6.44 **
CMS 16A X JGL1798	52.57	1.17	316.42 **	19.43	2.95	10.87 **
APMS 6A X JGL 11110-2	86.56	3.43	31.01 **	15.70	0.46	1.56
APMS 6A X JGL11110-1	85.22	-5.44	63.15 **	17.59	0.47	13.18 **
APMS 6A X JGL17211	85.05	1.65	-1.23	21.20	2.07	6.57 **
APMS 6A X JGL16284	84.39	1.77	18.00 **	16.82	1.64	-0.55
APMS 6A X JGL13515	90.90	1.60	15.67 **	17.37	0.16	-0.72
APMS 6A X JGL11160	90.22	0.41	-1.57	16.26	-0.72	2.09
APMS 6A X JGL11118	76.56	-4.92	85.69 **	16.43	-0.86	6.69 **
APMS 6A X JGL11111	86.96	-0.74	59.91 **	17.70	0.46	-0.17
APMS 6A X JGL8605	63.68	-17.79	78.83 **	14.76	-0.57	0.33
APMS 6A X JGL8292	75.07	-6.92 *	-2.33	17.20	0.61	0.00
APMS 6A X JGL3855	83.11	-1.75	111.07 **	18.65	0.61	-0.77
APMS 6A X JGL3844	84.51	-2.45	60.86 **	18.20	-0.87 *	-0.88
APMS 6A X JGL1798	67.91	26.07	118.31 **	16.09	-0.86	2.85 *
IR 58025A X JGL 11110-2	81.89	-5.79	10.22 *	17.87	0.32	0.97
IR 58025A X JGL11110-1	85.61	7.14	5.55	15.59	-0.42	5.56 **
IR 58025A X JGL17211	76.68	24.85	6.77	16.48	0.17	0.15
IR 58025A X JGL16284	91.67	1.63	18.83 **	16.54	0.90	-0.63
IR 58025A X JGL13515	85.53	1.43	4.05	16.48	-0.42	4.25 *
IR 58025A X JGL11160	91.69	-0.13	4.75	15.43	0.61	1.34
IR 58025A X JGL11118	86.39	5.31	45.52 **	16.87	0.61	-0.91
IR 58025A X JGL11111	81.29	-2.15 *	-2.68	18.09	0.61	-0.45
IR 58025A X JGL8605	75.56	-3.72	126.49 **	18.20	0.31	-0.87
IR 58025A X JGL8292	89.93	-1.24	38.61 **	16.48	0.75	-0.89
IR 58025A X JGL3855	89.67	3.99	1.61	15.65	0.90	-0.77
IR 58025A X JGL3844	75.89	25.88	85.79 **	18.04	-0.13 *	-0.93
IR 58025A X JGL1798	69.22	28.96 *	-2.53	16.76	1.20	0.25
KRH - 2	92.21	-2.77	12.88 *	23.82	0.76	-0.55
DRRH - 2	91.54	-0.11	0.86	25.59	1.05	0.75
PA 6201	89.69	-4.71	25.77 **	23.76	-0.57 *	-0.92
JAYA	93.20	-3.06 *	-2.64	27.26	0.76	-0.70
IR - 64	94.30	-4.01	-0.73	25.70	-1.90	-0.25
Population Mean	**83.77**			**18.05**		
SE of βι		5.30			0.68	
CD at 5%	**7.72**			**2.11**		

* Significant at 5% level; ** Significant at 1% level

4.3.3.10 Filled grains per panicle

Among the all genotypes tested for the character filled grains per panicle, 1tester, 3lines and 22 hybrids had non- significant deviation from the regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.49).

Among the lines and testers, The tester APMS 8A recorded less than unit of bi value and thus possessed more than average stability and is adoptable to poor environments, the line JGL 16284 recorded with unit regression values (bi) with high mean. Hence, the genotypes are considered to possess the average stability, whose performance does not change with change in environment.

Similarly among all hybrids tested, CMS 16A x JGL11110-1, APMS 8A x JGL3844, IR 58025A x JGL16284, CMS 16A x JGL17211, APMS 8A x JGL 11110-2, CMS 16A x JGL8292, APMS 8A x JGL16284, APMS 8A x JGL11160 and CMS 16A x JGL3855 recorded with unit regression values with high mean, hence these hybrids are considered to possess the average stability, whose performance does not change with change in environment, for the character filled grains per panicle.The hybrid APMS 8A X JGL11110-1 recorded more than unit regression values (bi),hence, considered to possess the less than average stability.

In the yield attributing trait, filled grains per panicle, both linear and non linear components of GE interactions were found to be non significant.

4.3.3.11 Spikelet fertility (%)

Among all genotypes tested for the character spikelet fertility (%) 2 testers, 7 lines and 25 hybrids had non significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.49).

Among the lines and testers APMS 8A, CMS 16A, JGL 11118, JGL 11111, JGL 8292 ,JGL 8605, JGL 3855 and JGL 16284 recorded the unit regression values, Hence considered to possess the average stability, whose performance does not change with change in environment. The line JGL 13515 recorded more than unit regression values (bi), hence, considered to possess the less than average stability.

Similarly among all hybrids tested CMS 16A x JGL8605, APMS 8A x JGL8292, IR 58025A x JGL11160, APMS 8A x JGL13515, CMS 16A x JGL11160, APMS 6A x JGL11160,APMS8AxJGL8605,IR58025A x JGL3855 and CMS 16A x JGL11111 recorded minimum deviation from the regression, hence considered to be stable for the character spikelet fertility (%). The hybrid CMS 16A x JGL3855 and IR 68897A x JGL11110-1 recorded more than unit regression values (bi), hence, considered to possess the less than average stability.

With regard to important yield influence trait, spikelet fertility (%), both linear and non linear components of GE interactions were found to be significant.

4.3.3.12 1000 grain weight (gm)

Among all genotypes tested for the character 1000 grain weight all the testers, lines and 45 hybrids had non significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression whose performance can be predicted (Table 4.49).

Among the lines and testers IR 68897A, IR 58025A, JGL 1798 and JGL 8292 recorded the unit regression values, Hence considered to possess the average stability, whose performance does not change with change in environment.The line JGL 3855 recorded lees than unit regression values (bi), hence, considered to possess the more than average stability.

In hybrids IR 68897A x JGL8292, IR 68897A x JGL16284 and IR 68897A x JGL1798 recorded unit regression values, hence these hybrids are considered to possess, the average stability, whose performance does not change with change in environment (Table 4.49).

4.3.3.13 Yield per plant (gm)

Among all the genotypes tested for the character yield/plant, all the lines, testers and 61 hybrids had non- significant deviation from regression (S^2di) values i.e. the genotypes are satisfactorily, within the range of minimum deviation from the regression, whose performance can be predicted (Table 4.50).

Among the lines and testers all the entries, recorded unit regression values, hence these entries are considered to possess the average stability, whose performance does not change with change in environments.

Similarly, 61hybrids recorded unit regression values, Hence these hybrids are considered to possess the average stability, whose performance does not change with change in environments.The yield of APMS 8A x JGL 11110-2 (31.22) was significantly superior over APMS 8A x JGL11110-1(29.95) followed by,the hybrid APMS 6A x JGL11111 (29.65), APMS 6A x JGL8605 (28.43) and APMS 6A x JGL11110-1(28.30) among the top five hybrids with high mean performance and stability.The important trait single plant yield is non- significant for both linear and non linear components of GE interactions.

Table 4.50. Mean performance and stability parameters for days to yield/ plant and productivity/ day (kg / ha) in rice

Parents/Crosses	Yield/ Plant gm			Productivity/ Day (kg / ha)		
	μ Mean	βi	σ^2di	μ Mean	βi	σ^2di
Testers						
IR 58025A	17.16	1.00	-0.44	75.21	0.88	-1.01
IR 68897A	17.56	1.01	-0.43	83.77	1.20	-4.62
APMS 6A	17.67	1.01	-0.43	74.91	1.24	-5.65
APMS 8A	18.19	1.00	-0.44	82.54	0.87	-6.98
CMS 16A	16.55	1.00	-0.44	88.03	1.25	4.56
Lines						
JGL 11110-2	25.69	1.01	-0.43	86.40	0.99	-7.33
JGL 11110-1	22.29	1.01	-0.43	69.75	1.01	-4.48
JGL 17211	24.44	1.01	-0.43	80.69	0.99	-6.61
JGL 16284	23.50	1.01	-0.44	84.67	0.95	-7.36
JGL 13515	21.40	1.01	-0.43	88.38	0.98	-6.78
JGL 11160	20.33	1.01	-0.43	74.23	0.97	-5.59
JGL 11118	20.93	1.00	-0.44	79.77	1.00 *	6.79
JGL 11111	23.96	1.01	-0.43	75.22	0.96 *	-6.49
JGL 8605	20.39	1.01	-0.43	99.82	1.00	-3.57
JGL 8292	21.05	1.01	-0.43	97.36	1.03	-3.93
JGL 3855	23.94	1.01	-0.43	76.31	0.89	-5.71
JGL 3844	23.29	1.01	-0.43	82.25	1.06	14.39
JGL 1798	22.08	1.01	-0.43	86.59	0.97	-7.38
Crosses						
IR 68897A X JGL 11110-2	21.87	1.01	-0.43	68.24	0.89	-1.86
IR 68897A X JGL11110-1	21.03	1.00	-0.44	62.82	0.91	2.44
IR 68897A X JGL17211	19.74	1.01	-0.43	90.02	1.44	1.24
IR 68897A X JGL16284	23.84	1.01	-0.43	94.15	1.08	0.41
IR 68897A X JGL13515	23.04	1.01	-0.43	82.13	1.30	-3.03
IR 68897A X JGL11160	22.54	1.01	-0.43	90.91	1.33	1.16
IR 68897A X JGL11118	16.78	1.01	-0.43	72.42	1.05	-3.55
IR 68897A X JGL11111	22.90	1.01	-0.43	56.59	0.90	14.06
IR 68897A X JGL8605	22.38	1.01	-0.43	66.09	0.89	1.07
IR 68897A X JGL8292	25.13	1.01	-0.43	77.48	1.18	16.09
IR 68897A X JGL3855	19.45	1.01	-0.43	54.94	0.19	32.71
IR 68897A X JGL3844	21.64	1.01	-0.43	72.69	0.85	-5.25
IR 68897A X JGL1798	20.41	1.01	-0.43	87.30	1.28	19.78
APMS 8A X JGL 11110-2	31.22	1.00	-0.44	70.37	0.85	-2.81
APMS 8A X JGL11110-1	29.95	1.01	-0.43	77.96	0.96	-7.30
APMS 8A X JGL17211	22.84	1.01	-0.43	72.29	1.04	0.30
APMS 8A X JGL16284	22.33	1.01	-0.43	65.60	1.31	13.82
APMS 8A X JGL13515	26.65	1.01	-0.43	68.64	1.03	10.97
APMS 8A X JGL11160	20.38	1.01	-0.43	95.91	1.19	6.09
APMS 8A X JGL11118	18.29	1.01	-0.43	78.27	0.82	-7.42
APMS 8A X JGL11111	25.18	1.01	-0.43	69.30	1.04	-0.55
APMS 8A X JGL8605	27.71	1.01	-0.43	93.94	0.96	-7.19
APMS 8A X JGL8292	21.67	1.01	-0.43	93.67	0.88	-7.10
APMS 8A X JGL3855	24.23	1.01	-0.43	83.97	1.10	-3.72
APMS 8A X JGL3844	20.28	1.01	-0.43	92.74	0.88	-1.81

Table 4.50(cont.)

Crosses	Yield/ Plant gm			Productivity/ Day (kg / ha		
	μ Mean	βi	σ²di	μ Mean	βi	σ²di
APMS 8A X JGL1798	16.33	1.01	-0.43	83.73	0.98	-3.28
CMS 16A X JGL 11110-2	19.46	1.01	-0.43	83.93	0.84	11.36
CMS 16A X JGL11110-1	20.14	1.01	-0.12	91.36	0.87	6.55
CMS 16A X JGL17211	15.55	0.23	54.75 **	101.37	1.38	-5.08 *
CMS 16A X JGL16284	21.72	1.01	-0.11	95.14	0.96	2.94
CMS 16A X JGL13515	23.25	1.01	-0.11	91.57	1.06	-0.50
CMS 16A X JGL11160	20.52	1.01	-0.12	73.01	0.83	-7.25
CMS 16A X JGL11118	22.95	1.01	-0.11	68.60	0.95	-4.24
CMS 16A X JGL11111	18.65	1.02	0.95	68.00	0.82	-6.96
CMS 16A X JGL8605	17.14	1.01	0.33	72.28	0.96	-6.53
CMS 16A X JGL8292	19.98	1.00	1.79 *	71.20	0.97	-5.51
CMS 16A X JGL3855	24.13	1.01	-0.44	75.21	1.15	-5.96
CMS 16A X JGL3844	22.55	1.01	0.08	87.28	0.97 *	-2.01
CMS 16A X JGL1798	20.38	1.01	5.18 **	80.13	0.95	-6.80
APMS 6A X JGL 11110-2	27.64	1.01	-0.16	91.60	1.19	4.27
APMS 6A X JGL11110-1	28.30	1.02	0.58	84.81	1.20	-5.95
APMS 6A X JGL17211	24.81	1.00	1.41 *	84.22	1.32	-5.92
APMS 6A X JGL16284	28.14	1.01	0.78	62.79	0.91	-3.25
APMS 6A X JGL13515	23.81	1.01	-0.47	72.56	1.29	4.07
APMS 6A X JGL11160	23.35	1.01	-0.45	75.14	1.40	3.28
APMS 6A X JGL11118	26.68	1.01	-0.11	66.98	1.19	-1.61
APMS 6A X JGL11111	28.65	1.01	-0.11	71.75	1.22	-4.31
APMS 6A X JGL8605	28.43	1.01	-0.12	86.20	0.95	-4.57
APMS 6A X JGL8292	26.32	1.02	-0.12	76.36	0.88	-7.00
APMS 6A X JGL3855	21.10	1.01	-0.12	82.16	0.95 *	-7.04
APMS 6A X JGL3844	19.31	1.01	-0.11	79.40	1.02	-7.31
APMS 6A X JGL1798	19.68	1.01	-0.11	71.12	0.89	-6.76
IR 58025A X JGL 11110-2	21.16	1.01	-0.43	70.13	0.86	-6.57
IR 58025A X JGL11110-1	20.71	1.01	-0.43	77.89	0.91	-7.43
IR 58025A X JGL17211	20.88	1.01	-0.43	84.05	1.20	-7.25
IR 58025A X JGL16284	25.83	1.00	-0.44	69.15	0.94	-6.03
IR 58025A X JGL13515	23.91	1.00	-0.44	72.45	0.91	-6.60
IR 58025A X JGL11160	23.43	1.00	-0.44	79.48	0.94	-6.09
IR 58025A X JGL11118	22.12	1.00	-0.44	79.38	0.90	-4.71
IR 58025A X JGL11111	23.25	1.01	-0.43	78.28	0.94	-7.20
IR 58025A X JGL8605	18.18	1.01	-0.43	60.37	0.94	0.75
IR 58025A X JGL8292	19.96	1.01	-0.43	64.38	0.76	-6.31
IR 58025A X JGL3855	19.88	1.01	-0.43	60.65	0.91	0.73
IR 58025A X JGL3844	17.16	1.01	-0.43	62.07	0.91	-1.92
IR 58025A X JGL1798	18.39	1.01	-0.43	57.80	0.91	3.10
KRH - 2	25.35	1.00	-0.44	92.24	0.69	17.28
DRRH - 2	22.62	1.00	-0.44	83.62	0.72	6.04
PA 6201	27.89	1.00	-0.44	98.63	1.14	-0.18
JAYA	23.94	1.01	-0.43	81.00	0.87	-5.24
IR - 64	22.13	1.01	-0.43	79.66	0.84	-4.59
Population Mean	**22.25**			**78.68**		
SE of βi			0.32		0.07	
CD at 5%	**0.79**			**4.55**		

* Significant at 5% level; ** Significant at 1% level

4.3.3.14 Productivity/day (kg/ha)

Among all the genotypes tested for the character productivity/day (kg/ha), all the, testers 11 lines and 64 hybrids, had non- significant deviation from regression (S^2di) values, i.e. the genotypes are satisfactorily within the range of minimum deviation from the regression whose performance can be predicted (Table 4.50).

Among the lines and testers IR 58025A, IR 68897A, APMS 6A, APMS 8A, CMS 16A, JGL 11110-2, JGL 11110-1, JGL 17211, JGL 16284, JGL 13515, JGL 11160, JGL 8605, JGL 8292, JGL 3855, JGL 3844 and JGL 1798 recorded unit regression values, hence these entries are considered to possess the average stability, whose performance does not change with change in environments.

Similarly, 63hybrids recorded unit regression values, Hence these hybrids are considered to possess the average stability, whose performance does not change with change in environments.

For productivity per day, both linear and non linear components of GE interaction were found to be significant in the present study, while significant non linear component was reported by Lohithaswa et al. (1999).

The results showed that, the GE interactions for all the characters were mainly due to both linear and non linear components which were supported by Krisnappa et al. (2009) for this trait. Significance of non linear component was observed by Armugam et al. (2007). Significance of linear component was reported by Hegde and Vidyachandra (1998) and significance of non-linear component was reported by Lohithaswa *et al.* (1999) and contradictoringly non-significance of both linear and non-linear GE interactions was reported by Vidhu Francis *et al.* (2005).

The per cent stability ranged from 0 to 100 for the different characters among parents and it ranged between 2 to 98 per cent.Low stability is recorded in characters gall midge infested plants (%),silver shoots(%),days to 50% flowering (earliness) and filled grains per panicle among the parents. Low stability is recorded in characters gall midge infested plants (%), silver shoots (%), days to 50% flowering (earliness), plant height (dwarfness), flag leaf width, 1000 Grain weight, panicle length, panicle weight and filled grains per panicle among the crosses.Out of 65 hybrids tested for single plant yield, 61 hybrids are categorized under group (I) i.e. stable over three environments; the other 4 hybrids are included in group (II), which were unstable. The 100% of the parents, 94% of the crosses 100% of the checks exhibited the stability over three environments, for the important character single plant yield. The 89% of the parents, 98% of the crosses 100% of the checks exhibited the stability over three environments, for the Productivity per day. These results indicate that, the parents and checks are comparatively more stable for different characters, when compared with crosses, while all the parents and checks and majority of the hybrids (94%) are stable for the yield (Table 4.51).

Table 4.51. ***Per cent*** **of stability of parents, rice hybrids and checks in present investigation**

Character	No. of parents	Parents %	No. of crosses	Crosses %	No. of checks	Checks %
Days to 50% flowering (earliness)	1	6	3	5	4	80
Plant height (dwarfness)	2	11	1	2	0	0
Flag leaf length	6	33	7	11	4	80
Flag leaf width	7	39	2	3	3	60
Productive tiller per plant	3	17	4	6	2	40
1000 Grain weight	4	22	3	5	4	80
Panicle length	3	17	4	6	4	80
Panicle weight	2	11	1	2	1	20
Filled grains per panicle	1	6	9	14	3	60
Spikelet fertility%	8	44	9	14	2	40
Grain yield per plant	18	100	61	94	5	100
Productivity per day	16	89	64	98	5	100
Gall midge infested plants (%)	0	0	2	3	2	40
Silver shoots (%)	0	0	1	2	2	40

Figure 4.9 :*Per cent* of stability of parents, rice hybrids and checks in present investigation for yield and other characters

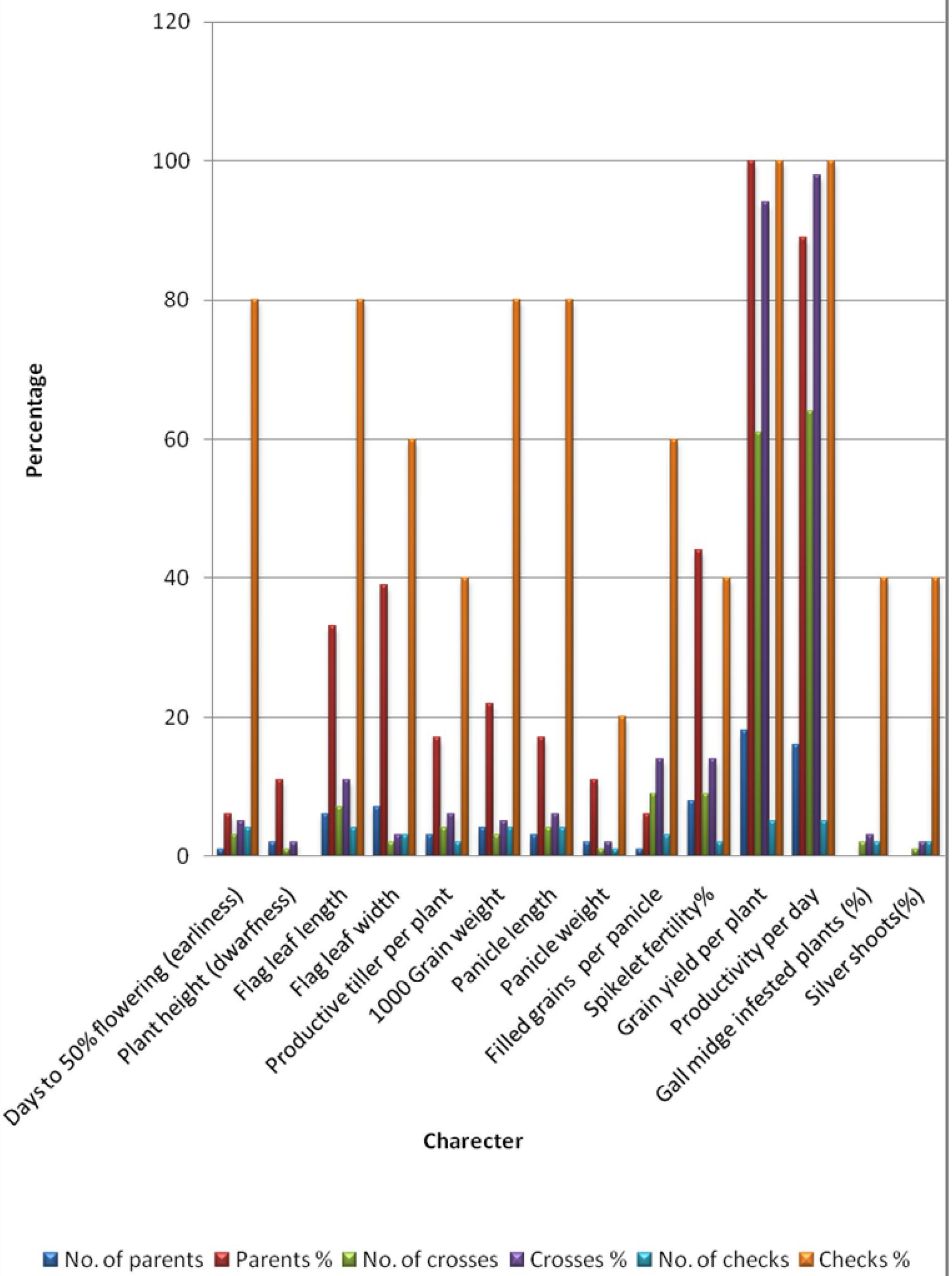


Table 4.52. Stable parents for various characters in rice

Character	Group-I	Group-II	Group III
	X > X, bi =1, S^2di=0	**bi >1, S^2di=0**	**bi <1, S^2di=0**
Days to 50% flowering (earliness)	IR 68897A, JGL 1798, JGL 11111, JGL 3844, JGL 11110-1, JGL 8292, JGL 11160, JGL 11110-2, JGL 17211 and JGL 16284	---	JGL 11118
Plant height (dwarfness)	APMS 6A and JGL 16284	---	.---
Flag leaf length	CMS 16A, IR 68897A, IR 58025A, JGL 11160, JGL 17211 and JGL 11110-2	---	---
Flag leaf width	58025A, JGL 17211, JGL 11110-1, JGL 8605, JGL 16284, JGL 13515and JGL 3855	---	APMS 8A, APMS 6A and JGL 8292
Productive tiller per plant	CMS 16A, JGL 17211 and JGL 8292	---	---
1000 Grain weight	IR 68897A, IR 58025A, JGL 1798 and JGL 8292	---	---
Panicle length	APMS 6A, APMS 8A and JGL 17211	JGL 8292	JGL 3855
Panicle weight	IR 68897A and JGL 11110-2	---	JGL 3855
Filled grains per panicle	JGL 16284	---	APMS 8A
Spikelet fertility%	APMS 8A, CMS 16A, JGL 11118, JGL 11111, JGL 8292 ,JGL 8605, JGL 3855 and JGL 16284	JGL 13515	---
Grain yield per plant	IR 58025A, IR 68897A, APMS 6A ,APMS 8A, CMS 16A, JGL 11110-2,JGL 11110-1 ,JGL 17211 , JGL 16284,JGL 13515 , JGL 11160 ,JGL 11118,JGL 11111, JGL 8605, JGL 8292, JGL 3855,JGL 3844 ,GL 1798	---	---
Productivity per day	IR 58025A, IR 68897A, APMS 6A, APMS 8A, CMS 16A, JGL 11110-2, JGL 11110-1, JGL 17211, JGL 16284, JGL 13515, JGL 11160, JGL 8605, JGL 8292, JGL 3855, JGL 3844 and JGL 1798	---	---
Gall midge Damaged Plants %			IR 68897A, APMS 6A, JGL 16284, JGL 11111 , JGL 8292, JGL 3855and JGL 1798,
Gall midge Silver Shoots%			IR 68897A, APMS 6A, JGL 16284, JGL 11111, JGL 8292, JGL 3855 and JGL 1798

Table 4.53. Stable hybrids for various characters in rice with good performance

Character	Group-I	Group-II	Group III
	$X > X$, $b_i = 1$, $S^2d_i=0$	$b_i > 1$, $S^2d_i=0$	$b_i < 1$, $S^2d_i=0$
Days to 50% flowering (earliness	IR 68897A x JGL11118, IR 68897A x JGL11110-1, IR 68897A x JGL11160	CMS 16A x JGL3855	---
Plant height (dwarfness)	IR 68897A x JGL11110-1	---	---
Flag leaf length	APMS 8A x JGL11110-1, CMS 16A x JGL8292, CMS 16A x JGL17211, APMS 8A x JGL11118, CMS 16A x JGL16284, APMS 6A x JGL11111 and IR 58025A x JGL3855	---	---
Flag leaf width	APMS 6A x JGL 1798 and CMS 16A x JGL1798	---	---
Productive tiller per plant	APMS 8A x JGL11111, IR 68897A x JGL8292, IR 68897A x JGL3855 and APMS 6A x JGL16284	---	---
1000 Grain weight	68897A x JGL8292, IR 68897A x JGL16284 and IR 68897A x JGL1798	---	---
Panicle length	IR 68897A x JGL 11110-2, IR 68897A x JGL16284, CMS 16A x JGL 11110-2 and IR 58025A x JGL11111	IR 68897A x JGL11111	---
Panicle weight	CMS 16A x JGL 11110-2	IR 68897A x JGL16284 and APMS 8A x JGL11110-1	---
Filled grains per panicle	CMS 16A x JGL11110-1, APMS 8A x JGL3844, IR 58025A x JGL16284, CMS 16A x JGL17211, APMS 8A x JGL 11110-2, CMS 16A x JGL8292, APMS 8A x JGL16284, APMS 8A x JGL11160 and CMS 16A x JGL3855	APMS 8A X JGL11110-1	---
Spikelet fertility%	CMS 16A x JGL8605, APMS 8A x JGL8292, IR 58025A x JGL11160, APMS 8A x JGL13515, CMS 16A x JGL11160, APMS 6A x JGL11160,APMS8AxJGL8605,IR58025A x JGL3855 and CMS 16A x JGL11111	CMS 16A x JGL3855 and IR 68897A x JGL11110-1	---
Grain yield per plant	APMS 8A XJGL 11110-2,APMS 8A xJGL11110-1,APMS 6A X GL11111,APMS 6A X JGL8605, APMS 8A X JGL8605	---	---
Productivity per day	CMS 16A X JGL17211, APMS 8A X JGL11160, CMS 16A X JGL16284, IR 68897A X JGL16284, APMS 8A X JGL8605	---	---

Table 4.53 cont.

Character	Group-I	Group-II	Group III
	X > X, bi =1, S^2di=0	**bi >1, S^2di=0**	**bi <1, S^2di=0**
Gall midge Damaged Plants (%)	CMS 16A x JGL11110-1 and CMS 16A x JGL3855		IR 68897A x JGL11110-2, CMS 16A x JGL3844, APMS 6A x JGL8292, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR 58025A x JGL11110-1, IR 58025A x JGL17211,IR 58025A x JGL384, IR 58025A x JGL1798
Gall midge Silver Shoots (%)	IR68897A x JGL17211		IR68897A x JGL11110-2, CMS 16A x JGL11110-2, CMS 16A xJGL17211, CMS 16AxJGL3844, CMSAxJGL1798, APMS6Ax JGL13515, APMS 6A x JGL11111, APMS 6A x JGL8292, APMS 6A x JGL3855, APMS 6A x JGL1798, IR 58025A x JGL11110-2, IR58025Ax JGL11110-1, IR58025A x JGL16284, IR58025A x JGL17211, IR58025A x JGL11118, IR58025A x JGL8605, IR 58025A x JGL8292, IR 58025A x JGL3844 and IR 58025A x JGL1798

Table 4.54. Stable hybrids over environments

Stable Hybrids under all environments				
Group I	IR 58025AX13515 IR 58025AX16284 IR 58025AX11160 APMS 8AX 11110-2 IR 58025AX11118 IR 68897AX 11110-1 IR 58025AX8605 APMS 8AX17211 APMS 6AX11160 IR 68897AX11118 IR 68897AX11111 APMS 8AX3855 IR 68897AX1798 APMS 8AX1798 IR 58025AX8292 APMS 8AX13515	IR 58025AX 11110-2 IR 68897AX 11110-2 CMS 16AX 11110-2 IR 58025AX1798 APMS 8AX 11110-1 APMS 8AX11111 IR 58025AX3855 APMS 6AX3844 IR 58025AX17211 IR 58025AX3844 IR 68897AX8605 APMS 6AX1798 IR 68897AX8292 CMS 16AX13515 CMS 16AX8605 APMS 6AX11111	IR 68897AX16284 APMS 8AX16284 IR 58025AX 11110-1 APMS 6AX11118 IR 68897AX3855 APMS 8AX11118 IR 58025AX11111 IR 68897AX11160 IR 68897AX13515 CMS 16AX16284 IR 68897AX3844 APMS 8AX8292 IR 68897AX17211 CMS 16AX3844 APMS 8AX3844 APMS 6AX 11110-2	APMS 8AX8605 CMS 16AX11160 APMS 8AX11160 CMS 16AX3855 CMS 16AX11118 APMS 6AX13515 APMS 6AX8605 APMS 6AX3855 CMS 16AX 11110-1 APMS 6AX8292 APMS 6AX 11110-1
Group II	**Unstable Hybrids**			
	CMS 16AX17211 CMS 16AX1798 CMS 16AX8292 APMS6AXJGL17211			

On the whole, among the testers APMS 8A and APMS 6A, among the lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 and JGL 8292 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 two testers APMS 8A and APMS 6A are stable for the characters days to 50(%) flowering, panicle Length, 1000 grain weight and yield/ Plant.

The lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 JGL 8292 were stable for yield and days to 50 % flowering. The lines JGL 11111, JGL 8292 were stable for productive Tillers/ Plant, the lines JGL 11110-2 was stable for filled grains/ panicle , the line JGL 11111, JGL 8292, JGL 8605 was stable for panicle length,the lines JGL 11111, JGL 11110-2, JGL11110-1, JGL8292, JGL11111, JGL11110-2 and JGL 8605 were stable for 1000 grain weight.

The hybrids APMS 6A x JGL11111, APMS 6A x JGL8292 were stable for days to 50 % flowering, the hybrids APMS 8A x JGL11110-1, APMS 6A x JGL8292 were stable for productive tillers/ plant, the hybrids, APMS 6A x JGL11110-1 APMS 8A x JGL11110-1, APMS 8A x JGL 11110-2 were stable for panicle length, the hybrids APMS 8A x JGL 11110-2 were stable for filled grains/ panicle, the hybrids APMS 8A x JGL 11110-2, APMS 6A x JGL11111 were stable for 1000 grain weight and the hybrids APMS 6A x JGL8292, APMS 8A x JGL 11110-2,APMS 8A x JGL11110-1, APMS 6A x JGL11111, APMS 6A x JGL8605 and APMS 6A x JGL11110-1 were stable for yield/ plant with good mean performance.

It can be concluded that all the genotypes interacted with environment differently for different characters and some of the genotypes are identified as stable for various characters which were studied. The most important character i.e yield per plant, shown stable reaction in most of the genotypes including hybrids,which was the result of all the contributing characters.However, the present study was confined to one season, over three locations viz., Kunaram (Karimnagar district), Warangal, Kampasagar (Nalgonda district). To get more realistic information on stability, the identified promising cross combinations are to be tested extensively over different agro-climatic zones and across the year for their superiority and stability before the commercial release.

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.

Based on the overall study and considering all the parameters, the better hybrids are categorized and depicted in the table 4.55 with all other characters like, *per se* performance, duration, sca effect for grain yield, standard heterosis percentage over check PA 6201, average heterosis, heterobeltiosis, stability, grain type, grain length, grain breadth, LB ratio and reaction to gall midge at Kunaram, Warangal and Kampasagar along with graphs and photographs.

Table 4.55. Most promising hybrids identified based on the overall performance in the present investigation

Hybrid	***APMS 8A X JGL 11110-2***	***APMS 6A X JGL11111***	***APMS 6A X JGL8292***
Duration(days)	136	126	128
***Per se* performance**	31.22 gm/pant	28.65 gm/pant	26.32 gm/pant
***sca* effect for grain yield**	7.01**	2.44**	0.41
SH% yield advantage Over PA-6201	1.94*	4.14**	-4.97**
Average Heterosis	46.47**	56.41**	40.07**
Heterobeltiosis	27.75**	42.00**	59.59**
Stable characters	Grain yield per plant	Grain yield per plant	1000 Grain weight, Panicle weight, Grain yield per plant.
Grain type	Medium slender	Medium slender	Medium slender
Grain length(mm)	7.52	7.71	6.89
Grain breadth(mm)	1.97	2.10	2.11
LB Ratio	3.82	3.67	3.27
Reaction to Gall midge			
KRM	R	R	R
WGL	S	R	R
KSR	R	R	R

Figure 4.10. Most promising hybrids identified based on the over all performance in the present investigation

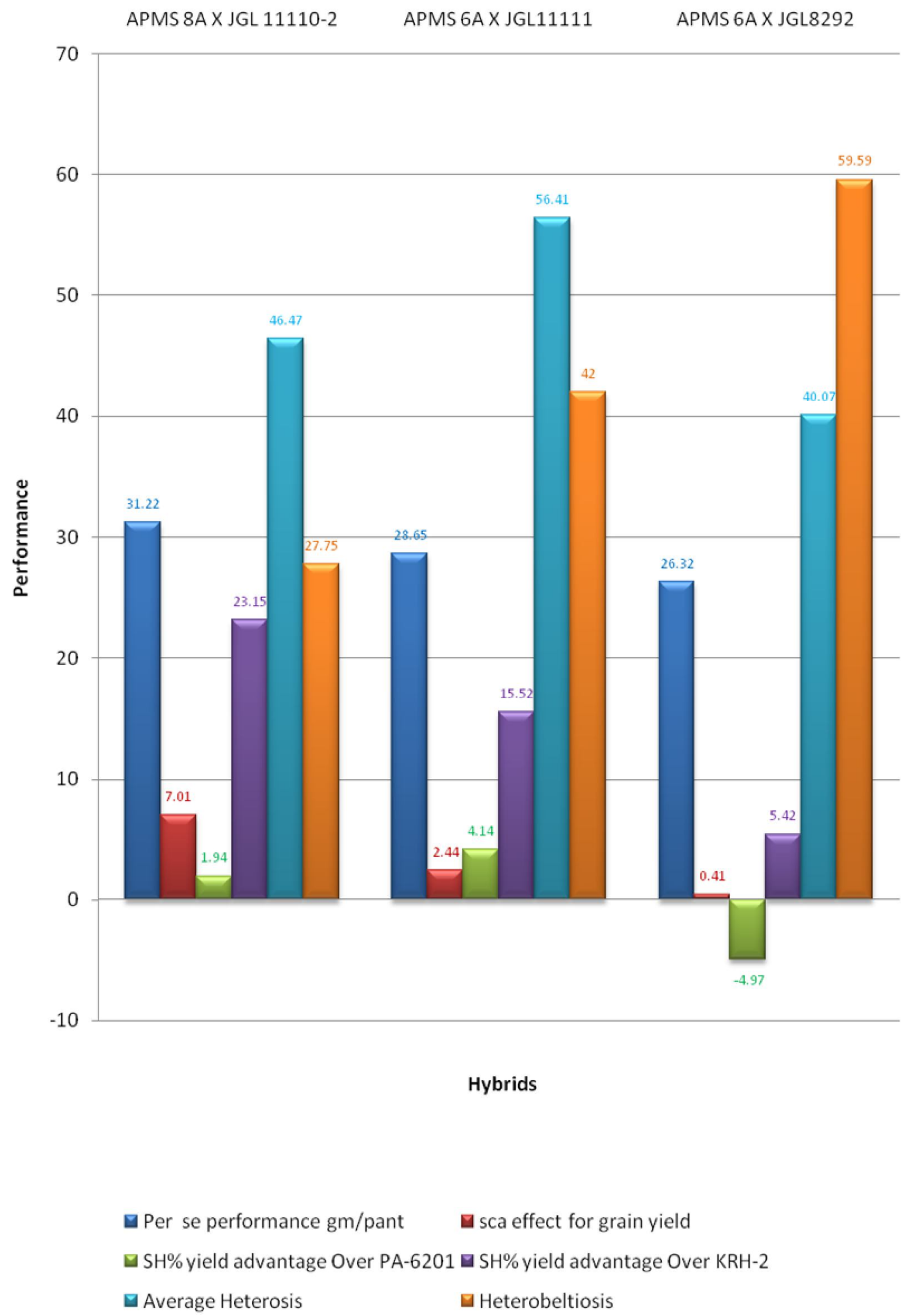
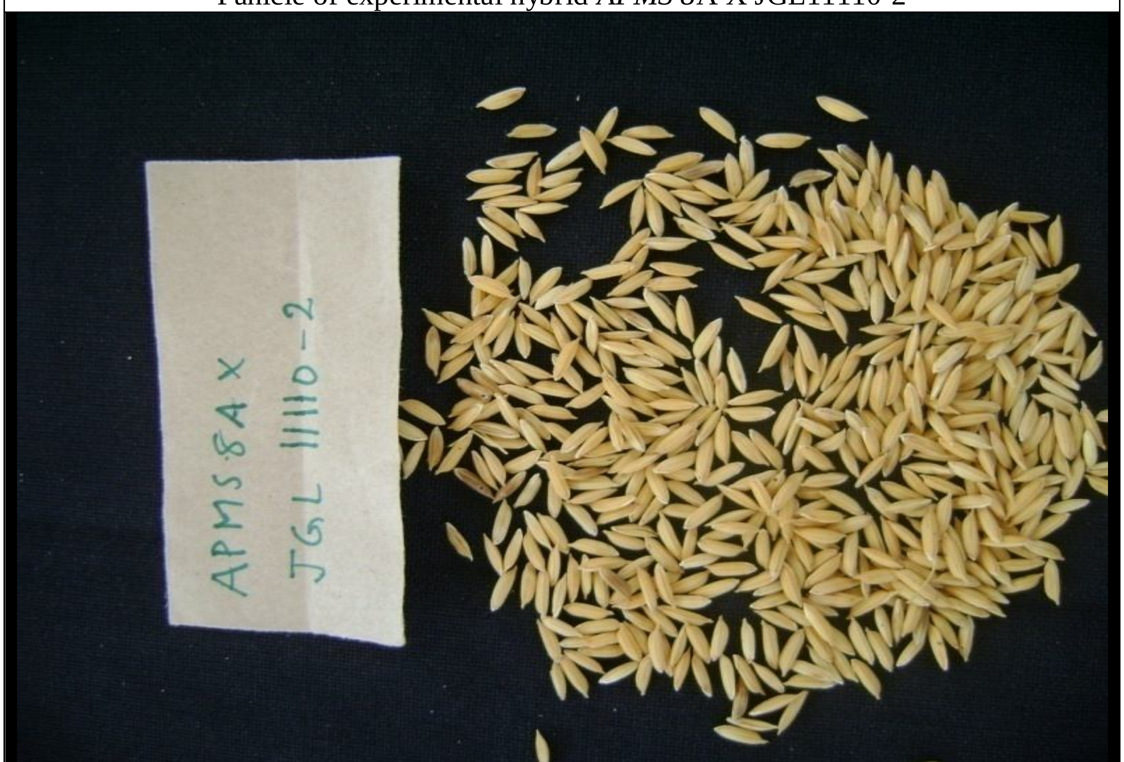


Plate 4.3. Most promising experimental hybrid (*APMS 8A X JGL 11110-2)* identified in the present investigation based on over all performance

Plate 4.4. Most promising experimental hybrid identified in the present investigation based on over all performance(Panicles & Grains)

Panicle of experimental hybrid *APMS 8*A X JGL11110-2



Grains of the promising experimental hybrid
APMS 8A X JGL11110-2

Plate 4.5. Most promising Gall midge Resistant experimental hybrids (*APMS 6A X JGL11111 and APMS 6A X JGL8292*) identified in the present investigation

Plate 4.6. Most promising Gall midge Resistant experimental hybrids identified in the present investigation(Panicles & Grains)

Panicle of promising Gall midge Resistant experimental hybrid *APMS 6A X JGL11111* (middle),male parent *JGL 11111*(top) and corresponding B line of female parent *APMS 6A(bottom)*.

Grains of the promising Gall midge Resistant experimental hybrid *APMS 6A X JGL11111*

Panicle of promising Gall midge Resistant experimental hybrid *APMS* 6A X JGL8292 (middle), corresponding B line of female parent *APMS 6A* (top) and male parent JGL8292 *(bottom)*.

Grains of the promising Gall midge Resistant experimental hybrid *APMS 6A X* JGL8292

Plate 4.7. Three promising experimental hybrids (*APMS 6A X JGL11111,APMS 8A X JGL 11110-2, and APMS 6A X JGL 8292)* identified in the present investigation based on over all performance

Based on the overall performance the best hybrid identified was APMS 8A x JGL 11110-2, with highest single plant yield of 31.22 gm/plant, medium duration (136 days) with high sca effect (7.01), significant standard heterosis (23.15) significant average heterosis (46.47), with significant heterobeltiosis (27.75) over check KRH-2. This hybrid was stable over locations for grain yield, with medium slender grain type, with LB ratio of 3.5, but this is showing susceptibility reaction to gall midge at Warangal. The LB ratio of 3.5 indicates the fineness of the grain which is highly preferred by consumers of Andhra Pradesh (Table 4.55).

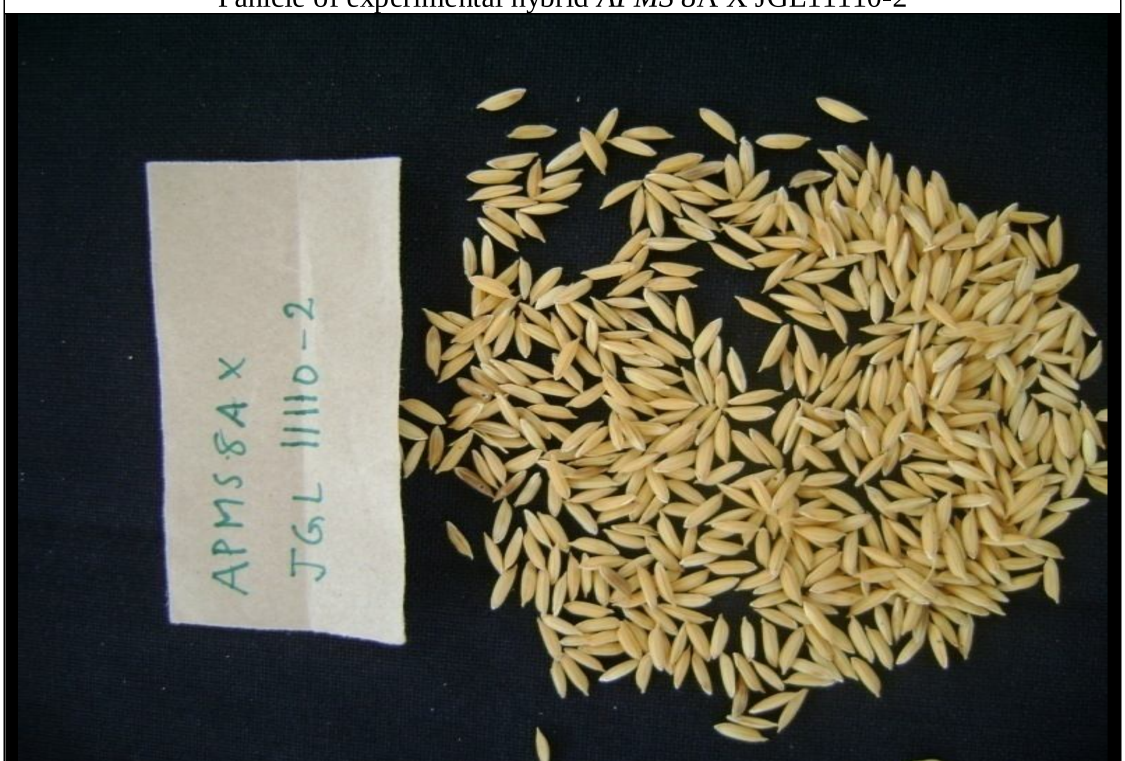
The whole investigation was aimed to identify the gall midge resistant hybrids with good performance. Though the hybrid APMS 8A x JGL 11110-2 was showing susceptibility reaction at Warangal location due to biotype variations, this hybrid can be successfully cultivated in northern and southern regions of Telangana regions of Andhra Pradesh, where the gall midge biotype existing at Warangal will not be present, hence the hybrid identified can be considered as gall midge resistant hybrid recommended for specified region.

Based on the objective of investigation i.e.gall midge resistance with high yield, the hybrid APMS 6A x JGL 11111 was the most promising short duration (126 days) gall midge resistant hybrid identified, with 28.65 gm/plant single plant yield, with significant sca effect (2.44), significant standard heterosis over PA 6201 (4.14), followed by KRH-2 (15.52). It recorded the significant high average heterosis (56.41) and heterobeltiosis (42). This hybrid is stable over three locations for grain yield per plant, with medium slender grain type, having LB ratio of 3.19. This hybrid was showing gall midge resistance at all the three locations studied, indicating the gall midge resistance for all the biotypes existing in the Telangana region of Andhra Pradesh. (Table 4.55)

The another gall midge resistant short duration (128 days) hybrid identified was APMS 6A x JGL 8292, with 26.32 gm/plant grain yield. The significant standard heterosis (5.42) recorded over check KRH-2 with high average heterosis (40.07) and heterobeltiosis (59.59). This hybrid is stable over three locations for grain yield, with medium slender grain type, having LB ratio of 2.89. This hybrid was also showing gall midge resistance at all the three locations studied, indicating the gall midge resistance for all the biotypes existing in the Telangana region of Andhra Pradesh (Table 4.55).

Plate 4.4. Most promising experimental hybrid identified in the present investigation based on over all performance(Panicles & Grains)

Panicle of experimental hybrid *APMS 8*A X JGL11110-2



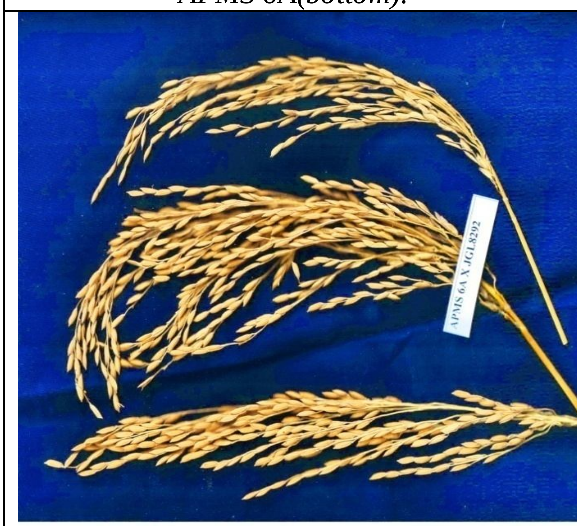
Grains of the promising experimental hybrid
APMS 8A X JGL11110-2

Plate 4.5. Most promising Gall midge Resistant experimental hybrids (*APMS 6A X JGL11111 and APMS 6A X JGL8292*) identified in the present investigation

Plate 4.6. Most promising Gall midge Resistant experimental hybrids identified in the present investigation(Panicles & Grains)

Panicle of promising Gall midge Resistant experimental hybrid *APMS 6A X JGL11111* (middle),male parent *JGL 11111*(top) and corresponding B line of female parent *APMS 6A(bottom)*.

Grains of the promising Gall midge Resistant experimental hybrid *APMS 6A X JGL11111*



Panicle of promising Gall midge Resistant experimental hybrid *APMS* 6A X JGL8292 (middle), corresponding B line of female parent *APMS 6A* (top) and male parent JGL8292 *(bottom)*.

Grains of the promising Gall midge Resistant experimental hybrid *APMS 6A X* JGL8292

Plate 4.7. Three promising experimental hybrids (*APMS 6A X JGL11111,APMS 8A X JGL 11110-2, and APMS 6A X JGL 8292)* identified in the present investigation based on over all performance

Based on the overall performance the best hybrid identified was APMS 8A x JGL 11110-2, with highest single plant yield of 31.22 gm/plant, medium duration (136 days) with high sca effect (7.01), significant standard heterosis (23.15) significant average heterosis (46.47), with significant heterobeltiosis (27.75) over check KRH-2. This hybrid was stable over locations for grain yield, with medium slender grain type, with LB ratio of 3.5, but this is showing susceptibility reaction to gall midge at Warangal. The LB ratio of 3.5 indicates the fineness of the grain which is highly preferred by consumers of Andhra Pradesh (Table 4.55).

The whole investigation was aimed to identify the gall midge resistant hybrids with good performance. Though the hybrid APMS 8A x JGL 11110-2 was showing susceptibility reaction at Warangal location due to biotype variations, this hybrid can be successfully cultivated in northern and southern regions of Telangana regions of Andhra Pradesh, where the gall midge biotype existing at Warangal will not be present, hence the hybrid identified can be considered as gall midge resistant hybrid recommended for specified region.

Based on the objective of investigation i.e., gall midge resistance with high yield, the hybrid APMS 6A x JGL 11111 was the most promising short duration (126

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation entitled **"Development of Gall midge Resistant Hybrids in Rice (*Oryza sativa* L.)"** was carried out at Regional Agriculture Research Station, Jagtial with an aim to develop gall midge resistant hybrids with high yield and of wider adaptability. The main objectives of the investigation were to identify the effective restorers and maintainers among the gall midge resistant lines, to study the reaction of parents and hybrids to gall midge, to study the combining ability through Line x Tester mating design, to estimate the magnitude of heterosis and to assess the stability of experimental hybrids for single plant yield and its components in Telangana region of Andhra Pradesh. Further, an attempt was made to understand the inheritance pattern of fertility restoration for four crosses.

Out of 120 lines screened for restorer and maintainer reaction 22 lines exhibited very high spikelet fertility (>80%), 18 lines exhibited partial fertility (60 to 80%), 35 lines resulted low fertility (10 to 60%) and 45 lines recorded complete sterility/very low fertility (<10%).From the above results, 13 R lines were identified as male parents and crossed with five CMS lines in Line x Tester mating design resulting in 65 hybrids.The 18 parents ,65 hybrids and six checks *viz.*, KRH-2, DRRH-2, PA-6201 Jaya, IR- 64 and TN_1 were evaluated for gall midge resistance, combining ability, heterosis and stability of the hybrids at three locations *viz.*,Kunaram (Karimnagar District), Warangal and Kampasagar (Nalgonda District) of Telangana region of Andhra Pradesh during *Kharif*, 2009.

The data on gallmidge damaged plants and silver shoots (%) pertaining to 65 hybrids, 13 parents and 6 checks over three locations i.e. Kunaram, Warangal and Kampasagar were collected and transformed into angular values (0^0) and analyzed statistically for each environment. The reaction of genotypes towards the gallmidge at three locations is different; the incidence recorded was more at Warangal, followed by Kampasagar and Kunaram. This was due to the different biotypes existing at three locations. The R lines used are taken from RARS, Jagtial, which may be resistant to gallmidge biotype 3, Hence the hybrids developed with these R lines also shown resistance reaction at RARS, Jagtial, Hence the damaged plants (%) and silver shoots (%) was less at RARS, Jagtial, where as it is high at RARS, Warangal which may be due to existence of different biotypes of gallmidge at Warangal as well as at

Kampasagar, due to which the incidence percentage varied. However, some hybrids exhibited resistance reaction at all the three locations indicating the resistance of hybrids to different biotypes.

Segregation pattern for spikelet fertility in F_2 generation of four crosses involving the CMS line APMS 6A and four restorer lines *viz.*, JGL 11110-1, JGL11110-2, JGL 17211 and JGL 16284 along with their F_1s and parents was studied. The results indicated that the CMS lines APMS 6A is completely sterile, where as restorers JGL 1110-2, JGL 11110-1, JGL 17211 and JGL 16284 were fully fertile. The spikelet fertility of F_1 hybrids was more than 94 per cent in all four crosses studied indicating that fertility restoration in the relevant pollinators is under dominant gene control. The results revealed that the F_2 populations of all the four crosses viz., APMS 6A x JGL 11110-2, APMS 6A x JGL 11110-1, APMS 6A x JGL 17211 and APMS 6A x JGL 16284 exhibited a segregating ratio of 15:1 indicating duplicate dominant epistasis.

On the whole based on the overall performance, among the testers APMS 8A and APMS 6A, among the lines JGL 11110-2, JGL 11110-1, JGL 11111, JGL 8605 and JGL 8292, 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 in the present investigation.

The overall study of sca effects of different traits, in the present investigation reveals that sca effects of *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*.The reason ascribed is due to positive interaction between nuclear and cytoplasmic genes appear to be important than the interaction between nuclear genes alone. 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.

Heterosis for single plant yield is mainly because of simultaneous manifestation of heterosis for yield component traits. Out of 65 hybrids studied, the significant standard heterosis is observed in 4 hybrids, over best check PA 6201, these hybrids are IR 68897A x JGL 11110-1 (24.57), CMS 16A x JGL 3844 (19.15), APMS 8A x JGL 11110-1 (7.40) and APMS 6A x JGL 17211 (7.04).

Environmental index reveals the favorability of an environment at a particular location. Karimnagar was found to be the most favourable location for plant height, panicle weight, number of productive tillers per plant, flag leaf length, number of filled grains per panicle, 1000-grain weight and single plant yield while, Warangal was the next best favourable location for plant height, panicle weight, number of productive tillers per plant, number of filled grains per panicle, 1000-grain weight and single plant yield.

Out of 65 hybrids tested for single plant yield, 61 hybrids are categorized under group (I) i.e. stable over three environments; the other 4 hybrids are included in group (II), which was unstable. The 100% of the parents, 94% of the crosses 100% of the checks exhibited the stability over three environments, for the important character single plant yield.

On the whole based on the overall performance, 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 in the present investigation.

Keeping in view of the above facts, by considering all the factors like, *per se* performance, sca effect, standard heterosis over PA 6201and KRH-2, average heterosis, heterobeltiosis, stability, duration, grain type, LB ratio, the most promising hybrids identified were APMS 8A x JGL 11110-2, APMS 6A x JGL 11111 and APMS 6A x JGL 8292.

The best hybrid identified was APMS 8A x JGL 11110-2, with highest single plant yield of 31.22 gm/plant, medium duration (136 days) with high sca effect, significant standard heterosis (23.15) over check KRH-2, significant average heterosis (46.47), with significant heterobeltiosis (27.75). This hybrid was stable over locations for grain yield, with medium slender grain type, with LB ratio of 3.5, but this is showing susceptibility reaction to gallmidge at Warangal. The LB ratio indicates the fineness of the grain which is highly preferred by consumers of Andhra Pradesh.

Based on the objective of investigation i.e.gall midge resistance with high yield, the hybrid APMS 6A x JGL 11111 was the most promising short duration (126 days) gallmidge resistant hybrid identified, with 28.65 gm/plant single plant yield, with significant sca effect, significant standard heterosis over PA 6201 (4.14), followed by KRH-2 (15.52). It recorded the significant high average heterosis (56.41) and heterobeltiosis (42). This hybrid is stable over three locations for grain yield per plant, with medium slender grain type, having LB ratio of 3.19. This hybrid was showing gall midge resistance at all the three locations studied, indicating the gall midge resistance for all the biotypes existing in the Telangana region of Andhra Pradesh.

The another gallmidge resistant short duration (128 days) hybrid identified was APMS 6A x JGL 8292, with 26.32 gm/plant grain yield. The significant standard heterosis (5.42) recorded over check KRH-2 with high average heterosis (40.07) and heterobeltiosis (59.59). This hybrid is stable over three locations for grain yield, with medium slender grain type, having LB ratio of 2.89. This hybrid was also showing gall midge resistance at all the three locations studied, indicating the gall midge resistance for all the biotypes existing in the Telangana region of Andhra Pradesh.

Conclusions

- It can be concluded that in the present investigation, the hybrids *viz.*, APMS 8A x JGL 11110-2 is the best experimental hybrid identified based on the overall performance, with the desirable *sca* effects, high heterosis, high *per se* performance for single plant yield and stable with other important attributes.
- The hybrids APMS 6A x JGL 11111 and APMS 6A x JGL 8292 are the best gall midge resistant experimental hybrids identified, with the desirable *sca* effects, high heterosis and high *per se* performance for single plant yield and stable with other important attributes.

Future strategy

- The hybrids developed may be further tested extensively in different agro-climatic zones over seasons and years for their resistance reaction superiority and stability before commercial release.
- The other gall midge resistant parents can be used to develop rice hybrids with gall midge resistance. The identified gall midge resistant restorers would be useful in future hybrid breeding programmes to develop more restorers with diverse genetic background .The gall midge resistant lines identified as maintainer can beused to develop new gall midge resistant male sterile lines with diverse genetic background.
- On the whole the knowledge and material generated in the investigation could be best utilized in future hybrid rice breeding programmes to develop better hybrids with resistance and other important traits.

LITERATURE CITED

Akarsh P and Pathak A R 2008 Heterosis for various quantitative traits in rice. Oryza 45(3): 181-187.

Allard R W and Bradshaw A P 1964 Implications of genotype environment interactions in applied plant breeding. Crop Science 4: 503-507.

Anand G, Amirthadevarathinam A and Edwin Rogbell 1999 Combining ability and heterosis for cold tolerance in rice. Oryza 36 (2): 114-117.

Anand Kumar, Singh N K and Sharma V K 2006 Combining ability analysis for identifying elite parents for heterotic rice hybrids. Oryza 43(2): 82-86.

Anandakumar C R and Subramanian S 1992 Genetics of fertility restoration in hybrid rice. Theoretical and Applied Genetics 83: 994-996.

Anjuchaudary, Pankaj Sharma, Harpal Singh, Pardhan S K and Pandey M P 2007 Study on heterosis for yield and physiological characters in rice hybrids. Oryza 44 (1): 7-13

Annadurai A and Nadarajan N 2001 Heterosis for yield and its component traits in rice. Madras Agricultural Journal 88(1-3): 184-186.

Arumugam M Rajanna M P and Vidyachandra B 2007 Stability of rice genotypes for yield and yield components over extended dates of sowing under Cauvery commend area in Karnataka. Oryza 44 (2): 104-107.

Babu M S, Satyanarayana P V, Madhuri J and Kumar R V 2000 Combining ability analysis for identifying elite parents for heterotic rice hybrids. Oryza 37(1): 19-22.

Bagheri N, Babaeian-Jelodar N 2011 Genetics and combining ability of fertility restoration of 'wild abortive' cytoplasmic male sterility in rice. African Journal of Biotechnology 10: 46, 9314-9321.

Balasundara 2000 Evaluation of yield, yield attributes and quality parameters in new experimental hybrids of rice (Oryza sativa L.). M. Sc. (Ag.) thesis submitted to University of Agricultural Sciences, Bangalore.

Banumathy S, Thyagarajan K and Vaidyanathan P 2003 Combining ability for yield and yield components in three line hybrid rice. Oryza 40(3&4): 75-77.

Banumathy S and Prasad M N 1991 Studies of combining ability for development of new hybrids in rice. Oryza 28: 439-442.

Banumathy S and Prasad M N 1991 Studies of combining ability for development of new hybrids in rice. Oryza 28 : 439-442.

Bentur, J. S. Cheralu, C. Rao, P. R. M. 2008 Monitoring virulence in Asian rice gall midge populations in India.

Bhadru D 2010 Genetic analysis for heterosis, combining ability, stability and genetics of fertility restoration in hybrid rice (*Oryza sativa* L.). Ph.D thesis, Acharya N.G. Ranga Agricultural University, Hyderabad-30

Bhandarkar S, Rastogi N K and Arvindkumar 2005 Study of heterosis in rice (Oryza sativa L.). Oryza 42 (3) : 218-219.

Bharaj T S Bains S S Sindhu G S and Gagneja M R 1991 Genetics of fertility restoration of 'Wild Abortive' cytoplasmic male sterility in rice (Oryza sativa L.). Euphytica 56: 199-203.

Bharaj T S, Virmani S S and Khush G S 1995 Chromosomal location of fertility restoring genes for 'wild abortive' cytoplasmic male sterility using trisomics in rice. Euphytica 83 : 169-173.

Bisne R and Motiramani N K 2005 Study on gene action and combining ability in rice. Oryza 42 (2) : 153-155.

Bobby T P M and Nadarajan N 1994 Heterosis and combining ability studies in rice hybrids involving CMS lines. Oryza 31: 5-8.

Breeze E L 1969 The measurement and significance of genotype – environment interactions in grasses. Heredity 24:181-200.

Chakraborthy S, Hazarika M H and Hazarika G N 1994 Combining ability analysis in rice. Oryza 31: 281-283.

Comstock R E and Mill R H 1963 Genotype –environment interactions. In: Statistical Genetics and Plant breeding. National Academy of Science Publication.982pp.742-754.

Dalvi V V and Patel D V 2009 Combining ability analysis for yield in hybrid rice. Oryza 46: 97-102.

Deoraj, Singh D N, Madhuviarya and Praveen Singh 2007 Heterosis in rainfed transplanted rice. Oryza 44(3): 264-267.

Deshpande V N and Dalvi V V 2006 Genotype x Environment interactions in hybrid rice. Oryza 43(4): 318-319.

Deshpande V N, Dalvi V V, Awadoot G S and Desai S B 2003 Stability analysis in hybrid rice. Journal of Maharashtra Agricultural Universities 28(1): 87-88.

Deshpande V N, Waghmode B D, Rewale A P and Vanave P B 2002 Stability performance of different rice hybrids at different locations in Maharashtra state. Crop Improvement 29 (2): 203-207.

Devasia J and Rangasamy R 1999 Heterosis in rice hybrids. Madras Agricultural Journal 86(7): 467-469.

Dhakar J M and Vinit Vyas 2006 Combining ability analysis in rice (Oryza sativa L.). Crop Research 31(3): 378 -379.

Dhaliwal T S and Sharma H L 1990 Combining ability and maternal effects for agronomic and grain characters in rice. Oryza 27: 122-128.

Dhanakodi C V and Subramanian M 1994 Genetic analysis of yield components in short duration rice (Oryza sativa L.) varieties. Madras Agricultural Journal 81 (7): 370-373.

Eberhart S A and Russel W A 1966 Stability parameters for comparing varieties. Crop Science 6: 36-40.

Emanuel A M M 1998 Identification of maintainers and restorers in rice (Oryza sativa L.). M. Sc. (Ag.) thesis submitted to University of Agricultural Sciences, Bangalore.

Eradasappa E, Ganapathy K N, Satish R G, Shanthala J and Nadarajan N 2007a Heterosis studies for yield and yield components using CMS lines in rice (Oryza sativa). Crop Research 34(1&2): 152-155.

Eradasappa E, Nadarajan N, Ganapathy K N , Shanthala J and Satish R G 2007b Correlation and path analysis for yield and its attributing traits in rice (Oryza sativa L.). Crop Research 34 (1&2): 156-159.

Falconer D S 1960 Introduction to quantitative genetics . Oliver, Boyd Edinberg , London pp:312-319.

Finlay K W and Wilkinson G N 1963 The analysis of adaptation in a plant breeding programme. Australian Journal of Agricultural Research 14 : 742-754.

Fisher R A and Yates F 1967 Statistical tables for biological, agricultural and medical research, Longman Group Limited, London.

Fukai S and Cooper M 1993 Development of drought resistant cultivar using physio-morphological traits in rice. Field Crops Research 40(2): 67-86.

Ganesan K N, Thyagarajan K, Amarlal and Rangaswamy M 1998 Restorers and maintainers for cytoplasmic genetic male sterile (CMS) lines of rice. Oryza 35 (2) : 163-164.

Ganesan K, Wilfred Manuel W, Vivekanandan P and Arumugam Pillai 1997 Character association and path analysis in rice. Madras Agricultural Journal 84 (10): 614-615.

Gao M W 1981 A preliminary analysis of genotype of hybrid rice with wild rice cytoplasm. Acta Genetic Sinica 8: 66-74.

Ghosh A 1993 Combining ability for yield and its related traits in upland rice. Oryza 30 : 275-279.

Ghosh A 2002 Studies on heterosis in upland rice. Oryza 39: 5-8.

Gnana Sekaran M Vivekanandan P and Muthuramu 2006 Combining ability and heterosis for yield and grain quality in two line rice (Oryza sativa L.)hybrids. Indian Journal of Genetics 66 (1): 6-9.

Gupta K K 1981 Combining ability analysis for yield components in sesame (Sesamum indicum L.). Madras Agricultural Journal 68:281-288.

Haohua H, Xiaoshong P, Huiming G, Changlan Z and Guoyon Y 2006 Fertility behavior of rice (Oryza sativa L.) lines with dominant male sterile gene and inheritance of sterility and fertility restoration. Field Crops Research 98: 30-38.

Hari ramakrishnan S, Ananda kumar C R, Malini N and Saravanan S 2009 Interpretation of hybrid vigour and inbreeding depression of certain crosses in rice (Oryza sativa L.). Crop research 38(1, 2 & 3): 138-140.

Hariprasanna K, Zaman F U, Singh A K and Tomar S M S 2006 Analysis of combining ability status among parents and hybrids in rice (Oryza sativa L.). Indian Journal of Genetics 66(1): 28-30.

Hegde S and Vidyachandra B 1998 Yield stability analysis of rice hybrids. International Rice Research Notes 23(2): 14.

Hemareddy H B, Lohithaswa H C, Rajesh Patil S, Manjunath A, Mahadevappa M and Kulkarni R S 2000 Different fertility restoration behaviour of genotypes of WA O. perennis M S 577A cytosterile systems of rice. Oryza 37 (1) : 26-28.

Hu J and Li Z 1985 A preliminary study on the inheritance of male sterility of rice male sterile lines with four different kinds of cytoplasms. Journal of Huazhong Agricultural College 4 (2) :15-22.

Huang J, Hu J, Xu X, Li S, Yi P, Yang D, Ren F, Liu X and Zhu Y 2003 Fine mapping of the nuclear fertility restorer gene for HL cytoplasmic male sterility in rice. Bot Bull Acad Sinica 44: 285-289.

Ilyas-Ahmed M, Vijayakumar C H M, Viraktamath B C, Ramesha M S and Singh S 1998 Yield stability in rice hybrids. International Rice Research Notes 23(1): 12.

Jadhav, A. V. Arvind Kumar Kakde, S. S. Athare, B. R. Patil, P. V. 2006 Genetics of rice gall midge (Orseolia oryzae Wood Mason) resistance in some new donors. Journal of Soils and Crops. . 16: 2, 339-342.

Jayamani P and Rangaswamy M 2005 Ability of interspecific derivatives in restoring the fertility of CMS lines in rice (Oryza sativa). Oryza 42 (2): 87-92.

Jayamani P, Thiyagarajan K, Rangaswamy M and Sreerangaswamy S R 1997 Utilization of anther derived lines in hybrid rice. Oryza 34 : 1-3.

Jayamani P, Thiyagarajan K and Rangaswamy M 1995 New sources of restorers and maintainers for cytoplasmic genic male sterile (CMS) liens in rice. Madras Agricultural Journal 82 (4) : 324-325.

Jiang XianBin Huang FengKuan Wei SuMei Huang SuoSheng 2006 Restoring ability test of rice varieties resistance to rice gall midge and resistance evaluation of F1 generation of combination. Southwest China Journal of Agricultural Sciences. . 19: 2, 226-230.

Jinks J L 1955 The analysis of continuous variation in diallel cross of Nicotiana rustica varieties. Genetics 39: 767-768.

Johnson H W, Robinson H F and Comstock R E 1955 Estimation of genetic and environmental variability in soyabean Agronomy Jornal 47: 314-318.

Jones J W 1926 Hybrid vigour in rice. Journal of American Society for Agronomy 18: 423-428.

Joshi B, Singh H and Pandey M P 2004 Study of heterosis and inbreeding depression in rice (Oryza sativa L.). Oryza 41(3&4) 64-67.

Kalaiyarasi R, Palaniswamy G A and Vaidyanathan P 2002 The potential and scope of utilizing TG lines in inter-subspecies crosses of rice (Oryza sativa L.). Journal of Genetics and Breeding 56: 137-143.

Kandil A , Ibrahim A F , Marquarld R and Taha R R 1990 Response of some quality traits of sunflower seeds and oil to different environments. Journal of agronomy 164(4): 22-30.

Kempthorne O 1957 An introduction genetic statistics. John Wiley and Sons, Inc: New York.

Kumar G S, Mahadevappa M and Rudraradhya M 1998 Studies on genetic variability, correlation and path analysis in rice during winter across the locations. Karnataka Journal of Agricultural Sciences 11(1): 73-77.

Kumari S L, Valarmathi G, Joseph T, Kankammy M T and Nayar N K 1997 Rice varieties of Kerala as restorers and maintainers for wild abortive cytoplasmic male sterile lines. International Rice Research News 22 (2) : 11-12.

Krishnappa M R, Chandrappa H M and Shadakshari H.G 2009 Stability analysis of medium duration hill zone rice genotypes of Karnataka. Crop Research 38(1, 2 & 3): 141-143.

Lavanya C 2000 Combining ability for yield and its components in hybrid rice. Oryza 37(1) : 11-14.

Lavanya C, Vijayakumar R and Sita devi B 1997 Evaluation of rice hybrids in varying environments. International Rice Research Notes 22 (2): 15-16.

Lavanya C, Vijayakumar R and Sreerama Reddi 2005 Choice of rice hybrids for varying environments. Oryza 42(1): 1-4.

Lakshmi, P. V. Amudhan, S. Bindu, K. H. Cheralu, C. Bentur, J. S. 2006 A new biotype of the Asian rice gall midge Orseolia oryzae (Diptera: Cecidomyiidae) characterized from the Warangal population in Andhra Pradesh, India. International Journal of Tropical Insect Science. 26: 3, 207-211.

Leenakumary S and Mahadevappa M 1997 Fertility restoration in WA and MD 577A cytoplasmic male sterile (CMS) lines in rice. Oryza 34 (4) : 385-387.

Leenakumary S 1994 Studies on cytoplasmic male sterility, fertility restoration and its inheritance and heterosis in rice (Oryza sativa L.). Ph. D. thesis submitted to University of Agricultural Sciences, Bangalore.

Lewis 1954 Gene-environment interactions; A relationship between dominance, heterosis, phenotypic stability and variability. Heredity 8: 333-356.

Li GuiYong Yuan PingRong Yang TianMei Qiu ChongLi Li ZhengYou Lu YiXuan Li BenXun Yang CongDang 2010 Analysis of combining ability and heritability in yield and yield components characters of Dian-type japonica hybrid rice.[Chinese] Southwest China Journal of Agricultural Sciences. 2010. 23: 6, 1784-1789.

Li Y C and Yuan L P 1986 Genetic analysis of fertility restoration in male sterile lines of rice. Rice Genetics IRRI Manila Philippines pp 617-632.

Lingaraju S 1997 Combining ability studies in hybrid rice (Oryza sativa L.). M. Sc. (Ag.) thesis submitted to University of Agricultural Sciences, Bangalore.

Lohithaswa H C, Bhushana H O, Basavarajaiah D, Prasanna H C and Kulkarni R S 1999 Stability analysis of rice (Oryza sativa L.) hybrids. Karnataka Journal of Agricultural Sciences 12 (1) : 48-54.

Lokaprakash R, Shivashankar G, Mahadevappa M, Shankaregowda B T and Kulkarni R S 1992 Heterosis in rice. Oryza 29 : 293-297.

Lokaprakash R, Shivashankar G, Mahadevappa M, Shankaregowda B T and Kulkarni R S 1991 Combining ability for yield and its components in rice. Oryza 28 : 319-322.

Malarvizhi D, Thiyagrajan K, Manonmani S and Deepa Sankar P 2003 Fertility restoration behaviour of promising CMSD lines in rice (Oryza sativa L.). Indian Journal of Agricultural Science 37 (4) : 259-263.

Mandal R K and Saha V N and Saran S 1990 Fertility restoration in a male sterile line of rice. Oryza 27 : 319-321.

Manonmani S and Ranganathan T B 1998 Genetic analysis in early lines of indica rice. Oryza 35 (4): 358-360.

Math B C V, Sardana A R, Zaman F U and Siddiq E A 1990 Genetics of fertility restoration in rice. In expanded summary proceedings International Symposium- Rice Research-New Frontiers, Nov 15-18, 1990 held at Directorate of Rice Research, Hyderabad,India p.98.

Meenakshi T and Devarathinam A A 1999 Combining ability for yield and physiological characters in semi dry rice. Oryza 36(2): 111-113.

Mishra M and Pandey M P 1998 Heterosis breeding in rice for irrigated sub-humid tropics in north India. Oryza 35(1) : 8-14.

Mishra G P, Singh R K, Mohapatra T, Singh A K, Prabhu K V, Zaman F U and Sharma R K 2003 Molecular mapping of a gene for fertility restoration of wild abortive (WA) cytoplasmic male sterility using a basmati rice restorer line. Journal of Plant Biochemistry and Biotechnology 12: 37-42.

Motiramani, N. K. Kumar, A. Bose, P.1999 Genetics of resistance against biotype 1 of rice gall midge in some rice cultivars. Oryza. 36: 4, 396-397. 5 ref.

Narasimman R, Thirugnanakumar S, Eswarn R, Praveen C, Sampath Kumar and Anandan A 2007. Combining ability and heterosis for grain yield and its component characters in rice (Oryza sativa L.). Crop Improvement 34(1): 16-18.

Narsimha Reddy V 2005 Heterosis, combining ability and stability analysis for yield and yield components in hybrid rice (Oryza sativa L). Ph.D thesis, Acharya N.G. Ranga Agricultural University, Hyderabad

Naikebawane, S. B. Thorat, A. S. 2008 Arvind Kumar Genetics of gall midge (Orseolia oryzae Wood Mason) resistance in some new donors of rice (Oryza sativa L.).nternational Journal of Plant Sciences (Muzaffarnagar).3: 2, 518-521.

Oudhia, P. Pandey, N. Ganguli, R. N. Tripathi, R. S. 1999 Reaction of hybrid rice varieties to gall midge (Orseolia oryzae). Insect Environment. 4: 4, 134.

Padmavathi N, Mahadevappa M and Reddy O U K 1997 Restorers and maintainers for W A and 577A cytomplasm. Oryza 34 (3) : 264-266.

Pande K, Ratho S N, Patnaik R N and Jachuk P J 1990 Fertility restoration in cytoplasmic male sterile lines in rice. Oryza 27 : 232-238.

Pande K, Ratho S N, Patnaik R N and Jachuk P J 1990 Fertility restoration in cytoplasmic male sterile lines in rice. Oryza 27: 232-238.

Pandey M P, Singh J P and Singh H 1995 Heterosis breeding for grain yield and other agronomic characters in rice (Oryza sativa L.). Indian Journal of Genetics and Plant Breeding 55 (4) : 438-445.

Pandey M P, Rongbai L, Gupta S, Singh P N and Singh J P 2001 Inter and intra-subspecific heterosis from two line hybrids using thermo-sensitive genetic male sterility system in rice. Oryza 38(3&4): 102-105.

Pani, J. Sahu, S. C. 2000 Inheritance of resistance against biotype 2 of the Asian rice gall midge, Orseolia oryzae. Entomologia Experimentalis et Applicata. 95: 1, 15-19.

Panwar L L 2005 Line x Tester analysis of combining ability in rice (Oryza sativa L.). Indian Journal of Genetics and Plant Breeding 65 (1) : 51-52.

Panwar D V S, Rakeshkumar, Singh A and Mehla B S 2002 Studies on heterosis in hybrid rice. Oryza 39 : 54-55.

Panwar D V S, Rakeshkumar, Singh A and Mehla B S 2002 Studies on heterosis in hybrid rice. Oryza 39: 54-55.

Panwar L L, Joshi V N and Ali M 2008 Genotype x Environment interaction in scented rice. Oryza 45(1): 103-109.

Paroda R S 1998 Rice research and development status and future direction in inaugural address 33rd All India Rice Group Meeting held at Punjab Agricultural University Ludhiana on 16-4-1998.

Pasalu, I. C. Huang Bing Chao Zang Yang Tan YuJuan 1998 New approaches to gall midge resistance in rice, Proceedings of the International Workshop, Hyderabad, India, 22-24 November, . 2004. 131-138.

Pathak A R, Singh B and Kumadia M U 1993 Heterosis in sunflower. Gujarat Agricultural University Journal 9: 62-66.

Patil D V, Thiyagarajan K and Kamble P 2003 Combining ability of parents for yield and yield contributing traits in two line hybrid rice (Oryza sativa L.). Crop Research 25 (3) : 520-524.

Patil R S 1993 Evaluation of induced mutants for different reaction to environment for pollen sterility in rice (Oryza sativa L.) and estimation of standard heterosis in experimental hybrids. M. Sc. (Ag.) thesis submitted to University of Agricultural Sciences, Bangalore.

Patnaik R N, Pande K, Ratho S N and Jachuck P J 1990 Heterosis in rice hybrids. Euphytica 49: 43-47.

Peng J Y and Virmani S S 1990 Combining ability for yield and yield related traits in relation to breeding in rice. Oryza 27: 1-10.

Peng J Y and Virmani S S 1991 Heterosis in some inter-varietal crosses of rice.Oryza 28:31-36.

Perkins J M and Jinks J L 1968 Environment and genotype-environment components of variability in multiple lines and crosses. Heredity 23: 339-356.

Pradan S K, Bose L K and Mani S C 2006 Basmathi type restorers and maintainers for two cytosterile lines of rice (Oryza sativa). Indian Jounal of Genetics 66 (4): 335-336.

Pradhan S B and Jachuk P J 1999 Genetics of fertility restoration of elite lines for different cytoplasmic male sterile sources in rice. Oryza 36(4): 374-376.

Pradhan S K and Singh S 2008 Combining ability and gene action analysis for morphological and quality traits in basmati rice. Oryza 45: 193-197.

Prakash N, Mishra C H, Giri S P and Dixit S 2003 Combining ability analysis for yield and other yield contributing traits in rice (Oryza sativa L.) using CMS system. Annals of Agricultural research 24 (3): 552-558.

Radhakrishna R M 1992 Heterosis in widely contrasting rice (Oryza sativa L.) genotypes. M. Sc. (Ag.) thesis submitted to University of Agricultural Sciences, Bangalore.

Raju Ch S, Rao M V B and Sudarshanam A 2006 Heterosis and genetic studies on yield and associated physiological traits in rice (Oryza sativa L.). Oryza 43 (4): 264-273.

Ram T, Singh J and Singh R M 1998 Combining ability for yield and its components in rice. Oryza 35 (3) : 237-241.

Ramya K and Senthilkumar N 2008 Genotype x environment interaction for yield and its component traits in rice (Oryza sativa L.). Crop Improvement 35(1): 11-15.

Ramalingam J, Nadarajan N and Vannirajan C 1992 Genetic analysis of fertility restoration in hybrid rice (Oryza sativa L.). Annals of Agricultural Research 13(3): 221-223.

Ramalingam J Nadarajan N and Vanniarajan C 2000 Heterotic ability involving cytoplasmic male sterile lines in rice. Madras Agricultural Journal 87 : 140-141.

Ramalingam J, Vivekanandan P and Subramanian M 1993 Combining ability in rice. Oryza 30: 33-37.

Ramalingam J, Nadarajan N, Vanniarajan C and Rangasamy P 1997 Combining ability studies involving CMS lines in rice. Oryza 34: 4-7.

Rao, U. P. Roy, J. K. Pasalu, I. C. Krishnaiah, K. 1998 Genetics and breeding for gall midge resistance in India. New approaches to gall midge resistance in rice, Proceedings of the International Workshop, Hyderabad, India, 22-24 November, 2004. 99-110.

Reddy J N 2002 Combining ability for grain yield and its components in lowland rice (Oryza sativa L.). Indian Journal of Genetics and Plant Breeding 62(3): 251-252.

Reddy C D R and Nerkar Y S 1995 Heterosis and inbreeding depression in upland rice crosses. Indian Journal of Genetics and Plant Breeding 55 (1): 94-97.

Ren C Y and Hao R L 1984 A preliminary analysis of restoring genes in restoring line IR 24 of rice. Acta Agronomica Sinica 10 (2) : 81-86.

Rogbell J E and Subbaraman 1997 Line x tester analysis for combining ability in saline rice cultivars. Madras Agricultural Journal 84 (1): 22-25.

Rosamma C A and Vijaya Kumar N K 2007. Variation in quantitative characters and heterosis in F1 rice (Oryza sativa L.) hybrids as affected by male sterile cytoplasm. Indian Journal of Genetics and Plant Breeding 67(1): 23-27.

Roy B and Mandal A B 2001 Combining ability of some quantitative traits in rice. Indian Journal of Genetics and Plant Breeding 61 (2) : 162-164.

Roy S K, Senapathi B K, Sinhamahapatra S P and Sarkar K K 2009 Heterosis for yield and quality traits in rice. Oryza 46(2): 87-93.

Sahai V N and Chaudhary R C 1991 A study of commercial exploitation of heterosis in rice. Oryza 28 : 27-30.

Saidaiah P 2008 Genetic divergence, combining ability and stability for yield and yield contributing traits in hybrid rice (Oryza sativa L). Ph.D thesis, Acharya N.G. Ranga Agricultural University, Hyderabad

Salgotra R K, Katoch P C and Kaushik R P 2002 Identification of restorers and maintainers for cytoplasmic genic male sterile lines of rice. Oryza 39 : 55-57.

Salgotra R K, Katoch P C and Sood M 2005 Performance of rice hybrids for yield and quality traits in mid hills of Himachal Pradesh, India. Crop Improvement 42 (2) : 93-96.

Salgotra R K, Gupta B B and Singh P 2009 Combining ability studies for yield and yield components in Basmati rice. Oryza 46: 12-18.

Sanjeevkumar, Singh H B and Sharma J K 2007 Combining ability analysis for grain yield and other associated traits in rice. Oryza 44(2): 108-114.

Saravanan K, Anbanandan V and Sateesh kumar P 2006 Heterosis for yield and yield components in rice (Oryza sativa L.). Crop Research 31(2): 242-244.

Sarial A K and Singh V P 2000 Identification of restorers and maintainers for developing basmati and non-basmati hybrids in rice (Oryza sativa). Plant Breeding 119 : 243-247.

Sarial A K, Savial Sindhu S and Singh N P 2007. Combining ability of new basmati fertility restorers for grain yield and its components in rice (Oryza sativa L.). Indian Journal of Genetics and Plant Breeding 67 (2): 156-160.

Sarkar C K G, Fu Z and Singh A K 2002 Genetics of fertility restoration of WA based cytoplasmic male sterility system in rice (Oryza sativa L.) using basmati restorer lines. Indian Journal of Genetics 62(4): 305-308.

Sarkar C K G, Zaman F U and Singh A K 2003 Stability analysis for fertility restoration, grain yield and other traits in hybrid rice (O. sativa L.). SABRAO Journal of Breeding and Genetics 35 (2): 113-122.

Sarma M K, Sharma A K, Agrawal R K and Richharia A K 2007 Combining ability and gene action for yield and quality traits in Ahu rices of Assam. Indian Journal of Genetics and Plant Breeding 67(3): 278-280.

Sathya A, Kandasamy G and Ramalingam J 1999 Heterosis in hybrid rice. Crop Research 18 (2): 243-246.

Sattari, Kathiresan A, Gregorio G B and Viramani S S 2008 Comparative genetic analysis and molecular mapping of fertility restoration genes for WA, Dissi and Gambiaca cytoplasmic male sterility systems in rice. Euphytica 160: 305-315.

Satyanarayana P V, Reddy M S S, Ish Kumar and Madhuri J 2000 Combining ability studies on yield and yield components in rice. Oryza 37(1): 22-25.

Sawant D S, Kunkerkar R L , Shetye V N and Srirdhankar M M 2006 Inheritance of fertility restoration of five sources of cytoplasmic male sterility in (Oryza sativa).Annals of Agricultural Research New Series 27 (2):133-138.

Shalini Tiwari Bentur, J. S. Mishra, B. Kumar, A. A. Kole, C. 2005 Reaction of gene differential rice varieties against gall midge Orseolia oryzae (Wood-Mason) biotypes in the greenhouse. Indian Journal of Genetics and Plant Breeding. 65: 4, 313-314.

Shanmuganathan M and Ibrahim S M 2005 Stability analysis for yield and its components in hybrid rice (Oryza sativa L.). Crop Research 30(1): 40-45.

Shanthala J, Latha J and Hittalmani S 2006 Heterosis of rice (Oryza sativa L.) hybrids for growth and yield components. Research on Crops 7(1): 143-146.

Shanthi P, Shanmugasundaram P and Nagarajan 2003 Combining ability analysis in rice. Oryza 40 (1&2) : 11-13.

Shanthi P, Shanmugasundaram P, Jebaraj S and Nagarajan P 2004 Combining ability analysis in three line rice hybrids. Madras Agriculture Journal 91 (7-12): 511-514.

Sharma A.K, and Sharma R.N 2007 Genetic variability and character association in early maturing rice. Oryza 44 (4): 300-303.

Sharma J P and Mani S C 1990 A study of heterosis by utilizing male sterility-restoration system in rice (Oryza sativa L.). Oryza 27 : 202-204.

Sharma R K and Mani S C 1996 Comparative efficiency of diallel, partial diallel and line x tester analysis in the study of gene action in rice. Oryza 33: 157-162.

Sharma R K and Mani S C 2008 Analysis of gene action and combining ability for yield and its component characters in rice. Oryza 45: 94-97.

Sharma V K and Singh V P 2003 Genetics of fertility restoration of cytoplasmic male sterility in rice. National Journal of Plant Improvement 5 (1): 7-9.

Sharma V K, Singh V P, Singh A K and Zaman F U 2001 Inheritance pattern of spikelet fertility restoration in hybrid rice. Indian Journal of Genetics and Plant Breeding 61 (2) : 160-161.

Sharma S K, Pandey M P, Dwivedi D K and Shukla S K 2006. Combining ability and heterosis among elite bacterial blight resistant lines in rice (Oryza sativa L.). Oryza 43 (4) : 315-317.

Sharma V K, Singh V P and Singh A K 2005 Differential fertility restoration of restorer genes to WA- cytoplasmic male sterility system in rice (Oryza sativa) Indian Journal of Genetics 65 (3): 207-208.

Sheeba N K, Viraktamath B C, Sivaramakrishnan S, Gangashetti M G, Pawan K and Sundaram R M 2009 Validation of molecular markers linked to fertility restorer gene(s) for WA-CMS lines for rice. Euphytica 167: 217-227.

Shen Y, Cai Q, Gao M and Wang X 1996 Isolation and genetic characterization of a fertility-restoring revertant induced from cytoplasmic male sterile rice. Euphytica 90 : 17-23.

Shinjyo C and Omura T 1966 Cytoplasmic male sterility in cultivated rice, Oryza sativa L. 1 Fertilities of F1, F2 and offsprings obtained from their mutant reciprocal back crosses and segregation of completely male sterile plants. Japan Journal of Breeding 16: 179-180.

Shukla S K and Pandey M P 2008 Combining ability and heterosis over environments for yield and yield components in two line hybrids involving thermosensitive genic male sterile lines in rice (Oryza sativa L.). Plant Breeding 127: 28-32.

Siddiq E A 1996 Current status, future outlook for hybrid rice technology in India. "Hybrid Rice Technology", Directorate of Rice Research pp 1-26.

Singh R K, Singh Omkar and Prasad B K 2006. Heterosis in long grain aromatic rice for yield and quality components. Annals of Agricultural Research 27 (2): 128-132.

Singh N K, Singh S, Singh A K, Sharma C L, Singh P K and Singh O N 2007 Study of heterosis in rice (Oryza sativa L.) using line x tester mating system. Oryza 44(3): 260-263.

Singh R K 2005 Heterosis breeding in aromatic rice (Oryza sativa) for yield and quality characters. Indian Journal of Genetics 65 (3): 176-179.

Singh S K and Haque M F 1999 Heterosis for yield and yield components in rice (Oryza sativa L.). Indian Journal of Genetics and Plant Breeding 59(2) : 237-238.

Singh M and Maurya D M 1999 Heterosis and inbreeding depression in rice for yield and yield components using CMS system. Oryza 36(1): 24-27.

Singh, M. P. 1990 Reaction of rice varieties to gall midge (GM). International Rice Research Newsletter.

Singh M R K and Sinha P K 1988 Genetics of fertility restoration for cytosterile line V 20A. Oryza 25 (2) : 194-185.

Singh A K, Maurya D M and Giri S P 1992 Estimation of heterosis in rice. Oryza 29: 259-261.

Singh R V, Verma O P, Dwivedi J L and Singh R K 2006b. Heterosis studies in rice hybrids using CMS systems. Oryza 43 (2): 154-156.

Singh N K, Singh S, Singh A K, Sharma C L, Singh P K and Singh O N 2007 Study of heterosis in rice (Oryza sativa L.) using line x tester mating system. Oryza 44 (3): 260-263.

Singh P K, Thakur R and Chaudhary V K 1994 Genetics of fertility restoration of WA-CMS lines in rice. International Rice Research Notes 19 (1) : 5.

Singh P K, Thakur R, Chaudhary V K and Singh N B 1996 Identification of maintainers and restorers for three CMS lines in rice. Crop Research 11 (1) : 131-132.

Singh N B, Singh H G and Singh P 2005 Heterosis and combining ability for quality components in rice. Indian Journal of Agricultural Sciences 37: 347 -352.

Sohu V S and Phul P S 1995 Inheritance of fertility restoration of three sources of cytoplasmic male sterility in rice. Journal of Genetics and Breeding 49 (1) : 24-28.

Sota Fujii and Kinya Toriyama 2005 Molecular mapping of the fertility restorer genes for ms-CW-type cytoplasmic male sterility of rice. Theoritical and Applied Genetics 111: 696-701.

Sprague G F and Federer W T 1951 A comparision of variance components in corn yield traits. II. Error. Year X variety, location x variety and variety components. Agronomy Journal 43: 535-544.

Sreedhar S 2010 Identification of heterotic and stable hybrids using three line system in rice (*Oryza sativa* L.). Ph.D thesis, Acharya N.G. Ranga Agricultural University, Hyderabad-30

Sreedhar M and Kulkarni N 1993 Heterosis in rice. Journal of Research APAU 21(3):138-141.

Sridhara S Vidhyachandra B, Kulkarni R S, Prasanna H C and Shetty U 1998 Genetics of fertility restoration of CMS lines in rice (Oryza sativa L.). Mysore Journal of Agricultural Sciences 32 : 107-110.

Srinivas C, Reddy V N, Rao P S and Ramesh P 1994 Rice gall midge Orseolia oryzae (Wood-Mason) biotype in Karimnagar District, Andhra Pradesh, India. International Rice Research Notes. . 19: 2, 14-15.

Sudarshan M R 1999 Identification of gall midge resistant restorers for WA CMS lines and combining ability analysis over environments in hybrid rice (Oryza sativa L). Ph.D thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Swain B, Acharya B and Pande K 2003 Combining ability analysis for yield and yield components in low land rice. Oryza 40 (3&4): 70-72.

Tan Y P, Li S Q, Wang L, Liu G, Hu J and Zhu Y G 2008 Genetic analysis of fertility-restorer genes in rice. Biologia Plantarum 52(3): 469-474.

Tiwari D K, Pandey P, Giri S P and Dwivedi J L 2011 Heterosis studies for yield and its components in rice hybrids using CMS system. Asian Journal of Plant Sciences. 2011. 10: 1, 29-42.

Tiwari V N, and Sarathe M L 2000 Heterosis and inbreeding depression in direct seeded rainfed rice. Oryza 37(2): 37-38.

Tu shihang, Zhang Shuijin , Dong Ruixia,Yang Dong, Xie Hongguang and Zheng Jiatuan 2008 Analysis of combining ability and heritability of the major agronomic characters in some parents of three-line indica hybrid rice. Journal of Fujian Agriculture and Forestry University 37(3): 230-234.

Udayashetty 1999 Identification of maintainers and restorers for CMS lines from three different sources in rice (Oryza sativa L.). M.Sc. (Ag.) thesis submitted to University of Agricultural Sciences, Bangalore.

Vanaja T and Babu L C 2004 Heterosis for yield and yield components in rice (Oryza sativa L.). Journal of Tropical Agriculture 42(1-2): 43-44.

Venkatesan M, Anbuselvam Y, Elangaimannan R and Karthikeyan P 2007 Combining ability for yield and physical characters in rice. Crop Improvement 44(4): 296-299.

Verma R S, Yadav R D S, Singh R S, Giri S P and Dwivedi J L 2004 Studies on heterosis and inbreeding depression in rice (Oryza sativa L.). Oryza 41(3&4): 131-132.

Vidyachandra B 1991 Studies on hybrid rice (Oryza sativa L.). Ph.D. thesis submitted to University of Agricultural Sciences, Bangalore.

Vijay Kumar R, Raju P R K and Sreerama Reddi N 1991 Identification of maintainers and restorers for different CMS lines in rice. The Andhra Agricultural Journal 38 (2&3) : 302-303.

Vijaya Kumar R, Subbarao M, Satyanarayana P V and Sitadevi B 1997 Reaction of elite rice lines for restoring or maintaining ability for eight CMS lines. Annals of Agricultural Research 18 (4) : 547-549.

Vijaya lakshmi B , Vinay kumar M , Srinivas B and Seetharamaiah K V 2008 Line x tester analysis of combining ability studies in rice (Oryza sativa L.). Research on Crops 9(3): 640 - 643.

Vijayakumar S B, Kulkarni R S and Murthy N 1994 Line x tester analysis for combining ability in ratooned F1 rice. Oryza 31: 8-11.

Vijaykumar R Subbarao M, Satyanarayana P V, Sitadevi B and Annapurna R 1998 Interaction of elite rice lines with two different cytosterilities with respect to hybrid fertility. Journal of Research ANGRAU 26 (3 & 4) : 50-52.

Viraktamath B C, Ilyas Ahmed M and Ramesha M S 2006 Current status and future prospects of hybrid rice in India. Journal of Rice Research 1(1): 52-60.

Virmani S S Govindaraj K Casal C Dalmacio R D and Aurin P A 1986 Current knowledge of and outlook on cytoplasmic-genetic male sterility and fertility restoration in rice. In Rice Genetics, IRRI, Manila, Philippines pp 633-647.

Virmani S S Viraktamath B C Casa C L Toledo R S Lopez M T and Manalo J O 1997 Hybrid rice breeding manual,IRRI, Phlippines pp 20.

Virmani S S, Aquino R O and Khush G S 1982 Heterosis breeding in rice (Oryza sativa L.). Theoretical and Applied Genetics 63:373-380.

Virmani S S Viraktamath B C Casal C L Toledo R S Lopez M T and Manalo J O 1997 Hybrid rice breeding manual. International Rice Research Institute, Manila, Philippines.

Virmani S S 1994 Heterosis and hybrid rice breeding. Monograph on Theoretical and Applied Genetics. Vol. 22 Springer-Verlag, Berlin/Heidelberg.

Vishwakarma D N, Maurya D M, Mishra S K, Verma G P and Rakesh Kumar 1998 Heterosis studies in rice using CMS system. Annals of Agricultural Research 19(4): 370-374.

Wilfred Manuel W and Prasad M N 1992 Combining ability and heterosis in rice (Oryza sativa L.). Oryza 29 : 15-18.

Wilfred Manuel W and Rangaswamy M 1994 Stability performance of hybrid rice. Oryza 31: 16-21.

Yadav L S, Maurya D M, Giri S P and Singh S B 2004 Nature and magnitude of heterosis for growth, yield and yield components in hybrid rice. Oryza 41 (1&2) : 1-3.

Yadav S S Maurya D M and Yadav D S 1997 Identification of restorers for some CMS in rice. Crop Research 13 (1) : 225-226.

Yadav L S, Maurya D M, Giri S P and Singh S B 2004 Nature and magnitude of heterosis for growth, yield and yield components in hybrid rice. Oryza 41(1&2): 1-3.

Yadav H N, Agarwal R K and Singh S P 2007 Inheritance of qualitative and quantitative traits in rice (Oryza sativa L.) employing partial diallel analysis over years. Crop Improvement 34 (2): 149-152.

Yang Z, Han P and Shen G 1993 A preliminary study on the genetic stability of wild abortive sterile cytoplasm. Journal of Fjian Agricultural College 12:14-21.

Yao F Y, Xu C G, Yu S B, Li J X, Gao Y J, Li X H and Zhang Q 1997 Mapping and genetic analysis of two fertility restorer loci in the wild abortive cytoplasmic male sterility system of rice (Oryza sativa L.). Euphytica 98: 183.

Yates F and Cockhran W G 1938 The analysis of group of experiments. Journal of Agricultural Sciences 28: 556-580.

Yograj Pandey M P and Dwivedi D K 2002 Genetics of fertility restoration of cytoplasmic male sterility lines in rice. Oryza 39:9-11.

Yolanda and Vijendradas L D 1995 Study on heterosis in hybrid rice. Oryza 32(2): 109-110.

Young J B and Virmani S S 1984 Inheritance of fertility restoration in a rice cross. Rice Genetic News letter 1: 102-103.

Young J B and Virmani S S 1990 Stability analysis of agronomic traits in rice hybrids and their parents. Oryza 27: 109-121.

Zhou T L, Shen J Heterosis and Ye F C 1983 A genetic analysis of the fertility of Shan type hybrid rice with wild rice cytoplasm. Acta Agron Sin 9 (4) : 241-247.

APPENDIX

L.B Ratios of Lines, Testers, Checks and Hybrids					
			Grain Length mm	**Grain Breadth mm**	**L. B Ratio.**
Testers					
IR 68897 B			8.59	2.09	4.11
APMS 8 B			7.83	1.99	3.93
APMS 6 B			7.85	1.95	4.03
CMS 16 B			7.74	1.97	3.93
IR 58025 B			8.73	2.07	4.22
Lines					
JGL 11110-2			7.55	2.07	3.65
JGL 11110-1			7.11	2.08	3.42
JGL 17211			7.06	2.09	3.38
JGL 16284			7.36	2.07	3.56
JGL 13515			6.86	2.13	3.22
JGL 11160			7.5	2.09	3.59
JGL 11118			7.03	1.91	3.68
JGL 11111			7.34	2	3.67
JGL 8605			7.01	2.01	3.49
JGL 8292			7.01	2.16	3.25
JGL 3855			7.07	1.97	3.59
JGL 3844			7.1	2.1	3.38
JGL 1798			7.2	2.1	3.43
Hybrids					
IR 68897A	X	JGL 11110-2	7.43	2.16	3.44
IR 68897A	X	JGL 11110-1	8.26	2.02	4.09
IR 68897A	X	JGL 17211	7.55	2.11	3.58
IR 68897A	X	JGL 16284	7.62	2.25	3.39
IR 68897A	X	JGL 13515	7.62	2.25	3.39
IR 68897A	X	JGL 11160	7.29	2.15	3.39
IR 68897A	X	JGL 11118	8.07	2.18	3.7
IR 68897A	X	JGL 11111	8.11	2.25	3.6
IR 68897A	X	JGL 8605	7.55	2.18	3.46
IR 68897A	X	JGL 8292	7.51	2.18	3.44
IR 68897A	X	JGL 3855	7.65	2.2	3.48
IR 68897A	X	JGL 3844	7.54	2.07	3.64
IR 68897A	X	JGL 1798	7.82	2.16	3.62
APMS 8A	X	JGL 11110-2	7.52	1.97	3.82
APMS 8A	X	JGL 11110-1	7.54	2.09	3.61
APMS 8A	X	JGL 17211	7.54	1.95	3.87
APMS 8A	X	JGL 16284	7.43	2.21	3.36
APMS 8A	X	JGL 13515	7.62	2.12	3.59
APMS 8A	X	JGL 11160	7.05	2.22	3.18
APMS 8A	X	JGL 11118	7.12	2.12	3.36
APMS 8A	X	JGL 11111	7.32	2.08	3.52
APMS 8A	X	JGL 8605	7	2.13	3.29
APMS 8A	X	JGL 8292	6.88	2.05	3.36
APMS 8A	X	JGL 3855	7.66	2.15	3.56
APMS 8A	X	JGL 3844	7.66	2.26	3.39
APMS 8A	X	JGL 1798	7.8	2.2	3.55

CMS 16A X JGL 11110-2	8.15	2.21	3.69
CMS 16A X JGL 11110-1	7.16	2.02	3.54
CMS 16A X JGL 17211	8.28	2.12	3.91
CMS 16A X JGL 16284	7.65	2.13	3.59
CMS 16A X JGL 13515	7.55	2.01	3.76
CMS 16A X JGL 11160	7.19	2.11	3.41
CMS 16A X JGL 11118	7.08	2.12	3.34
CMS 16A X JGL 11111	6.74	2.13	3.16
CMS 16A X JGL 8605	6.45	2.08	3.1
CMS 16A X JGL 8292	8.3	1.92	4.32
CMS 16A X JGL 3855	6.6	2.11	3.13
CMS 16A X JGL 3844	7.88	2.15	3.67
CMS 16A X JGL 1798	7.04	2.16	3.26
APMS 6A X JGL 11110-2	6.67	2.23	2.99
APMS 6A X JGL 11110-1	7.42	2.14	3.47
APMS 6A X JGL 17211	7.58	2.08	3.64
APMS 6A X JGL 16284	7.46	2.14	3.49
APMS 6A X JGL 13515	7.04	2.13	3.31
APMS 6A X JGL 11160	8.23	2.13	3.86
APMS 6A X JGL 11118	8.32	2.19	3.8
APMS 6A X JGL 11111	7.71	2.1	3.67
APMS 6A X JGL 8605	7.47	2.22	3.36
APMS 6A X JGL 8292	6.89	2.11	3.27
APMS 6A X JGL 3855	7.32	2.01	3.64
APMS 6A X JGL 3844	7.72	2.08	3.71
APMS 6A X JGL 1798	7.21	2.16	3.34
IR 58025A X JGL 11110-2	7.67	2.19	3.5
IR 58025A X JGL 11110-1	7.2	2.16	3.33
IR 58025A X JGL 17211	6.44	2.03	3.17
IR 58025A X JGL 16284	8.15	2.07	3.94
IR 58025A X JGL 13515	7.6	1.91	3.98
IR 58025A X JGL 11160	7.42	1.54	4.82
IR 58025A X JGL 11118	8.12	1.90	4.27
IR 58025A X JGL 11111	7.49	2.16	3.47
IR 58025A X JGL 8605	8.15	2.12	3.84
IR 58025A X JGL 8292	6.88	1.95	3.53
IR 58025A X JGL 3855	7.34	2.15	3.41
IR 58025A X JGL 3844	7.43	2.16	3.44
IR 58025A X JGL 1798	7.7	2.17	3.55
Checks			
KRH - 2	8.26	1.67	4.95
DRRH - 2	7.55	1.93	3.91
PA 6201	8.14	2.11	3.86
JAYA	7.36	2.74	2.69
IR - 64	8.69	2.27	3.83