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Studies on Combining Ability and Panicle Mite Resistance in Hybrid Rice (*Oryza sativa* L.)

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A B S T R A C T

Studies were conducted on the combining ability and relative resistance of rice hybrids against panicle mite (*Steneotarsonemus spinki*) during *Kharif*, 2017. Six cytoplasmic male sterile lines were crossed to seven testers in Line X Tester mating design to produce 42 hybrids. The parents and hybrids along with two checks were evaluated. The analysis of variance for combining ability showed that mean sum of square due to lines, testers and the interaction between lines and testers was significant for most of the characters under study. The result revealed that peak incidence of mite occurred at the ripening stage but significantly higher number of mite population and damage symptoms in all plants were observed at the panicle emerging to ripening stage. Out of 42 rice hybrids and 13 parental lines evaluated, based on GCA and SCA effects two parental lines *viz.*, JMS 20B and JR 80 and fifteen hybrids were of good yield potential and resistant against panicle mite with no damage symptoms. The results on categorization of resistance revealed that, five parental lines and eleven hybrids contribute for moderate resistance. Six parents and sixteen hybrids were found susceptible against *Steneotarsonemus spinki.*

Introduction

Rice (*Oryza sativa* L.) is the major source of calories for a large portion of the world's population, particularly in Asia, where more than 90 per cent of all rice is grown and consumed by about 60 per cent of the world's population. India is number one in area with approximately 44.5 million hectares of rice and it ranks second in production with approximately159.02 million tones. But the productivity of 3570 kg per hectare (IRRI, 2017) is far below the world's average productivity. India ranks approximately15th or still lower with regard to per hectare yield or productivity. Development of new varieties with high yield and quality parameters is the prime objective of all rice breeders. The first step in a successful breeding program is to select appropriate parents. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis (Sarker *et al.*, 2002; Muhammad *et al.*, 2007). Traditionally, insect pests, diseases and weeds are the triple evils responsible for low yields of rice in India. Introduction and wide adoption of high yielding varieties has led to severe incidence of different insect pests. Of late, mites are also assuming major pest status. Among different species of mites associated with rice crop, the sheath mite or panicle mite and the leaf mite are most important. The sheath mite, *Steneotarsonemus spinki* in association with the sheath rot fungus, *Acrocylindrium oryzae* causes grain discolouration, ill-filled and chaffy grains and often inflicts heavy losses in rice, in almost all Asian countries.

Sheath mite, *Steneotarsonemus spinki* and leaf mite, *Oligonychus oryzae* are the two most important mite species damaging rice crop. *S. spinki* remains in the leaf-sheath below epidermis and during the reproductive phase of the crop growth, *S. spinki* migrate to the developing grains in milky stage and cause spikelet sterility and also partially filled and ill filled grains (Sogawa, 1977). Deformed panicles and inflorescences, lesions on the inner surface of leaf sheaths and browning of rice hulls are also caused by this mite (Cho *et al.,* 1999). Mite population in the leaf sheath and grain has a positive correlation with grain sterility and negative correlation with grain weight confirming that *S. spinki* is responsible for these symptoms (Lo and Ho, 1977). Reduction in panicle size, length of panicle neck, panicle weight occurred as a result of damage by *S. spinki*a long with sheath rot fungus (Ghosh *et al.,* 1997).

Some information on these mite pests is available from other Asian countries but the information available from India is scarce. Therefore, it is very essential to initiate some research programmes in India on these mites. This investigation was conducted to determine the level of resistance against *Steneotarsonemus spinki* and also to find out the resistant or tolerant rice hybrids. The identification of resistant or tolerant rice hybrids will help breeders for future use in developing resistant new breeding rice lines.

Materials and Methods

To generate information on combining ability and resistance to panicle mite, 42 rice hybrids and 13 parental lines along with two highly susceptible checks BPT 5204 and JGL-3855 were evaluated under natural field conditions at RARS, Polasa, Jagtial. The experiment was laid out in RB D (Randomized Block Design) having 2 replications. Each entry was planted in two rows of four meters length with a spacing of 20 x 15 cm. Irrigation, fertilizers and intercultivation operations were taken up at regular intervals. Data was collected from an average of five plants from each entry in each replication on the following traits: Days to 50 per cent flowering, plant height (cm), panicle length (cm), number of productive tillers per plant, number of grains per panicle, spikelet fertility percentage, 1000- grain weight (g), grain yield per plant (g), hulling percentage, milling percentage, head rice recovery, kernel length, kernel breadth, kernel L/B ratio, paddy length, paddy breadth and paddy L/B ratio. Analysis of variance for grain yield and other traits were performed using the model described by (Kempthorne 1957). The entries were screened for rice panicle mite based on the preliminary or composite scale, developed at Rice Research Centre, ARI, Rajendranagar after the check entries showed panicle mite incidence on leaf sheath and more than 50 per cent grain discolouration. Observations were recorded from 5 hills (Table 1 and 2).

Results and Discussion

Combining ability studies

The analysis of variance for combining ability of all the traits under study has been presented in the Table 3. The variance due to treatments was highly significant for all the characters under study. The parents exhibited significant differences for all the traits studied except for spikelet fertility, grain yield per plant, kernel breadth and paddy L/B ratio. The variance due to crosses was found highly significant for all the characters. The variance due to parent *vs.* crosses was also found highly significant for most of the characters except number of productive tillers per plant. The variance due to lines was found significant for all the traits except number of productive tillers per plant, spikelet fertility, number of grains per panicle, grain yield per plant, kernel breadth and paddy L/B ratio, whereas the variance due to testers was found non-significant for spikelet fertility and paddy L/B ratio. When the effects of crosses was partitioned into lines, testers and line x tester effects, the interaction effects (lines x testers) were found to be significant for all the traits under study. This suggested that sufficient variability is available in the material used for study.

Similar works have been reported by Shukla and Panday (2008) for lines and line x tester interaction, Nadali and Nadali (2010) for crosses, lines and line x tester interaction, Srikrishna Latha *et al.,* (2013) for treatments, hybrids, testers and line x tester and Gaurav Dharwal *et al.,* (2017) for treatments, lines and line x tester. The results pertaining to the estimate of combining ability revealed that mean *sca* variance was relatively greater in magnitude than *gca* variance for all the traits except panicle length, 1000- grain weight, kernel breadth and paddy length indicating that these traits were predominantly under the control of non-additive gene action.

Genetic analysis of data showed that twelve parents had significant GCA estimates of line and testers for plant height with four lines being positive and one negative, three testers being positive and one negative. Nine parents were significantly different for days to 50 per cent flowering; three were negative and six were positive. Nine parents were significant for panicle length with two lines and one tester being negative while three lines and three testers were positive. Only one tester was positively significant for number of productive tillers per plant. Nine parents displayed significant 1000- seeds weight differences; one line and two testers were negative while two lines and three testers were positive. Eight parents exhibited significance for number of grains per panicle; two lines and three testers were negative and one line and two testers were positive. Four parents were significantly different for spikelet fertility, one line and one tester being positive while one line and one tester were positive. Ten parents exhibited significance for grain yield per plant, two lines and four testers were negative and two lines and two testers were positive while, two lines and three testers had positive and significant GCA effect four lines and two testers were positively significant for hulling percentage. Nine parents were significant for milling percentage with three lines and two testers being negative while two lines and two testers were positive.

All the parents displayed significant head rice recovery percentage differences; three lines and four testers were negative while three lines and three testers were positive. Two lines and three testers were positively significant for kernel length. Eight parents were significantly different for kernel breadth, among which three lines and two testers were positively significant. Seven parents were significantly different for kernel L/B ratio, three were negative and four were positive. One line and two testers for paddy length, one line and one tester for paddy breadth and two lines and three testers for paddy L/B ratio exhibited a positive significant GCA effects (Table 4). In this study negative *gca* effects of the days to 50 per cent flowering, plant height were desirable. While positive *gca* effects for other characters are needed. The perusal of the results revealed that the line JMS 20B was good combiner for days to 50 per cent flowering, panicle length, 1000 - grain weight and kernel length. Line JMS 21B was good combiner for number of grains per panicle, spikelet fertility, grain yield per plant, hulling percentage, milling percentage, head rice recovery, kernel breadth and paddy breadth, while line JMS 19B performed well for spikelet fertility, kernel L/B ratio, paddy length and paddy L/B ratio. The tester, JBR 6 was good general combiner for number of productive tillers per plant and grain yield per plant. Whereas, JMBR 44 for days to 50 per cent flowering, plant height and kernel breadth. Tester JR 85 was also good general combiner for most of the quality traits. Hence, these good general combiners of males and females may be extensively used in future hybrid rice breeding programme.

Twenty seven crosses were significant for days to 50 per cent flowering, CMS 64A x JMBR 31 (-9.98) had high negative *sca* and CMS 64A X JR 83 (15.01) had high positive *sca*. For plant height; thirteen crosses had negative and thirteen had positive *sca* effects. The highest negative *sca* was recorded by JMS 20A X JBR 6 (-19.97) and the lowest recorded by JMS 11A X JR 83 (-3.81)**.** JMS 19A X JMBR 44 (-1.79) had high negative and significant *sca* for panicle length while JMS 11A X JBR 6 (2.90) showed positive and significant *sca* effect. Only three crosses *viz*., JMS 11A X JBR 6 (2.13), JMS 20A X JMBR 44 (1.81) and CMS 64A X JR 85 (1.79) recorded positive significant *sca* effect for number of productive tillers per plant. The highest positive *sca* for 1000- grain weight was recorded for the cross CMS 64A X JMBR 31 (3.06) while the highest negative *sca* was recorded by JMS 11A X JMBR 31 (-1.25). Nine crosses were significant for number of grains per panicle JMS 21A X JR 67 (62.60) had high positive *sca* effect. JMS 11A X JBR 6 (-9.80) had high negative and significant *sca* for spikelet fertility while CMS 52A X JBR 6 (13.10) showed positive and significant *sca* effect. Sixteen crosses exhibited significant *sca* effect for grains yield per plant. The highest positive *sca* was recorded by the cross JMS 20A X JMBR 44 (13.33) and the lowest was recorded by the cross JMS 11A X JR 83 (5.37). The cross JMS 21A X JBR 6 (-4.88) recorded the highest negative *sca* effect for grain yield per plant while the lowest was recorded by the cross JMS 21A X JR 85 (-15.51). Out of 42 crosses, sixteen crosses recorded significant positive *sca* effects for hulling percentage with a range from -7.74 (CMS 64A X JMBR 31) to 4.54 (CMS 64A X JR83). *sca* effects ranged from -11.91 (CMS 64A X JMBR 31) to 10.31 (CMS 52A X JMBR 31) for milling percentage. Seventeen crosses were found with highly positive and significant *sca* effects and registered as best specific combiners for the trait. The range of *sca* effects for head rice recovery varied from -14.62 (CMS 64A X JMBR 31) to 9.53 (CMS 52A X JMBR 31). Out of 42 hybrids, twenty hybrids recorded positive significant *sca* effect. The best specific combiners for this trait are CMS 52A X JMBR 31 (9.53), CMS 64A X JBR 6 (7.91) and CMS 52A X JR 67 (6.65). Fifteen hybrids expressed significant positive *sca* effects for kernel length. The cross, JMS 11A X JR 80 (0.42) recorded highest positive *sca* effect followed by JMS 19A X JR 67 (0.41) and JMS 21A X JBR 6 (0.39). One cross recorded significant positive *sca* effect and two crosses registered significant negative *sca* effects with a range from -0.22 (JMS 21A X JR 80) to 0.15 (JMS 21A X JR 85) for kernel breadth. A range of -0.35 (JMS 21A X JR 85) to 0.35 (JMS 11A X JR 83) was recorded for *sca* effects with regard to kernel L/B ratio. Three crosses exhibited negative significant *sca* effect, among which JMS 21A X JR 85 (-3.55) recorded low significant *sca* effect and the cross JMS 11A X JR 83 (0.35) recorded high significant *sca* effect. The best specific combiners identified for this trait are JMS 11A X JR 83 (0.35), JMS 19A X JBR 6 (0.33) and CMS 52A X JMBR 44 (0.28). Out of 42 crosses, seven crosses recorded significant positive *sca* effects for paddy length with a range from –1.49 (CMS 52A X JR 83) to 0.95 (CMS 64A X JR83). The best specific crosses for this trait are JMS 11A X JR 83 (0.95), CMS 52A X JR 80 (0.89) and JMS 11A X JBR 6 (0.74). The range of *sca* effects for paddy breadth varied from -0.35 (JMS 21A X JMBR 44) to 0.42 (JMS 11A X JMBR 44). Out of 42 hybrids, nine hybrids recorded positive significant *sca* effects. The best specific combiners identified for this trait are JMS 11A X JMBR 44 (0.42), CMS 52A X JR 85 (0.21) and CMS 64A X JR 67 (0.20). Among the crosses, eighteen crosses recorded significant *sca* effects, where nine crosses showed positive *sca* effects and nine crosses showed negative *sca* effects. The cross JMS 11A X JBR 6 (0.71), CMS 64A X JR 85 (0.61) and JMS 20A X JR 85 (0.57) were identified as best specific combiners for this trait (Table 5).

The crosses CMS 64A X JMBR 31 and JMS 20A X JR 85 were identified as good specific combiners for days to 50 per cent flowering, JMS 20A X JBR 6 and CMS 64A X JR 80 were good specific combiners for plant height, CMS 64A X JMBR 31 and JMS 11A X JR 80 for 1000- grain weight, JMS 21A X JR 67 and JMS 19A X JR 85 for number of grains per panicle CMS 52A X JBR 6 and CMS 52A X JR 67 for spikelet fertility while, JMS 11A X JBR 6 was good specific combiner for panicle length and number of productive tillers per plant. CMS 64A X JR 83 for hulling percentage and paddy length, CMS 52A X JMBR 31 for milling percentage and head rice recovery were the potential hybrids with high *sca* effects. Many authors reported similar results in rice Ghara *et al.,* (2012), Hasan *et al.,* (2013), Savita Bhatti *et al.,* (2015), Gaurav Dharwal *et al.,* (2017) and Rumanti *et al.,* (2017).

The lines JMS 21B, JMS 20B, JMS 19B and testers JBR 6, JR 67 were recorded significant *gca* effects for grain yield per plant. These parents resulted in the production of best single crosses JMS 21A X JR 85, JMS 20A X JMBR 44, CMS 52A X JBR 6, JMS 11A X JBR 6, JMS 19A X JR 80 and JMS 11A X JBR 6 with positive *sca* effects for grain yield indicating the possibility of production of desirable crosses, with high *sca* effects from low yielding parents. The superior crosses identified with high x high *gca* effects can be exploited through pedigree breeding method and the better crosses with high x low and low x low *gca e*ffects can be improved through biparental mating and recurrent selection methods.

Specific combining ability (SCA) effects of hybrids alone has limited value for choosing parents in a breeding program, and must be used in combination with other parameters such as GCA of the respective parents and actual performance of the hybrids (Marilia *et al.,* 2001). However, SCA is important to identify parents of opposite heterotic types which should be improved within and not across heterotic groups. The hybrid combinations with significant mean performance, significant and desirable heterosis and significant desirable SCA estimates and which involve at least one of the parents with high GCA would likely enhance the concentration of favorable alleles and this is what a breeder desires to improve a trait (Kenga *et al.,* 2004). However, enhancing favorable alleles should be done separately on opposite sides of heterotic groups in this investigation; good specific combiners were identified based on *sca* effects of the crosses and *gca* effects of the parents involved in the cross.

Panicle mite resistance studies

Thirteen parents and their forty two rice hybrids were screened and categorized based on the preliminary composite scale developed at Rice Section, Agricultural Research Institute, Rajendranagar. The check varieties *viz.,* JGL 3855and BPT 5204 were highly susceptible for panicle mite. Based on the screening, the entries were categorized as highly susceptible, moderately susceptible, susceptible, moderately resistant and resistant as presented in Table 6.

Among the 13 parental lines evaluated 5 lines *viz*., CMS 64B, JMS 11B, JMS 19B, JR 83 and JR 85 were moderately resistant while two lines JMS 20Band JR 80 were found to be completely resistant. Six lines *viz*., CMS 52B, JMS 21B, JMBR 44, JMBR 31, JR 67 and JBR 6 were susceptible. Out of 42 hybrids screened 15 hybrids *viz.,* JMS 11A X JR 80, JMS 11A X JMBR 31, JMS 19A X JR 80, JMS 19A X JMBR 44, JMS 19A X JR 67, CMS 52A X JR 83, CMS 52A X JR 80, CMS 52A X JMBR 31, CMS 52A X JR 67, JMS 21A X JR 80, JMS 21A X JMBR 31, JMS 21A X JR 67, JMS 20A X JR 85, JMS 20A X JMBR 31 and JMS 20A X JR 67 were completely resistant. Eleven hybrids JMS 11A X JR 83, JMS 11A X JMBR 44, JMS 11A X JR 67, JMS 11A X JBR 6, JMS 19A X JR 85, JMS 19A X JMBR 31, CMS 52A X JMBR 44, JMS 21A X JR 83, JMS 20A X JR 83, JMS 20A X JR 80 and JMS 20A X JBR 6 were moderately resistant while, CMS 64A X JR 83, CMS 64A X JR 85, CMS 64A X JR 80, CMS 64A X JMBR 44, CMS 64A X JMBR 31, CMS 64A X JR 67, CMS 64A X JBR 6, JMS 11A X JR 85, JMS 19A X JR 83, JMS 19A X JBR 6, CMS 52A X JR 85, CMS 52A X JBR 6, JMS 21A X JR 85, JMS 21A X JMBR 44, JMS 21A X JBR 6 and JMS 20A X JMBR 44 were found to be susceptible.

Table.1 Composite scale for screening against rice panicle mite

1st scale based on damage symptom of panicle mite on leaf midrib		**2nd scale based on grain discolouration (GD)**		**3rd scale Based on damage symptom on leaf sheath below boot leaf**	
No incidence	0	No grain discolouration	0	No Symptoms	0
1 – 20%	1	< 5% GD	1	Up to 1cm	1
21 – 40%	3	5.1 – 10%	3	1.1 – 3cm	3
41 – 60%	5	10.1 – 30%	5	3.1 – 6cm	5
61 – 80%	7	30.1 – 50%	7	6.1 – 8cm	7
81 – 100%	9	50.1 – 100%	9	>8cm	9

Table.2 Categorization of rice entries based on composite scale as follows

HS: Highly Susceptible	**All three scores between 7-9**	**9 9 9 or 7 9 9, 7 7 9 or 7 7 7 etc.,**
MS: Moderately Susceptible	Two scores between 7-9 and one between 1-5	7 7 5 or 9 9 5 or 7 9 5 or 5 5 9 etc.,
S: Susceptible	Two scores between 7-9 and one score between 1-3	9 3 9 or 9 3 7 or 9 3 5 or 7 3 7 or 7 3 5 or 5 7 5 or 5 5 5 or 3 9 3 or 9 1 9 etc.,
MR: Moderately Resistant	All three scores 3 or at least two scores 3/5 and one score 5 or two scores 5 and one score 1/3	3 3 3 or 3 5 5 or 3 3 5 or 5 1 7 or 5 1 5 etc.,
R: Resistant	Two scores 3, one score 1 or 0	3 3 1 or 3 3 0 or 1 1 0 or 1 1 3 or 0 1 0 etc.,

Table.3 Analysis of variance for combining ability (Line x Tester) for yield and quality traits in rice

Source of variation	d.f	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	No. of productive tillers per plant	1000-grain weight (g)	No. of grains per panicle	Spikelet fertility (%)	Grain yield per plant (g)
Replicates	1	0.03	4.85	0.38	5.68*	1.57	440.00	62.02	30.22
Treatments	54	86.17**	226.31**	7.34**	3.16**	16.01**	4420.20**	126.02**	136.23**
Parents	12	57.78**	170.97**	4.27**	3.12*	15.22**	2917.96*	71.32	20.04
Parents (Lines)	5	31.20**	140.94**	3.95*	2.28	9.63**	1770.13	58.99	14.44
Parents (Testers)	6	82.83**	217.92**	5.01*	4.31*	15.77**	4205.11**	85.18	25.62*
Parents (L *vs* T)	1	40.38**	39.50*	1.43	0.26	39.83**	934.15	49.71	14.49
Parents *vs* Crosses	1	17.08**	104.01**	10.49*	0.22	16.05**	7594.43*	859.99**	72.34*
Crosses	41	96.17**	245.49**	8.16**	3.24**	16.25**	4782.47**	124.13**	171.80**
Line effect	5	66.72	533.90*	30.07**	1.86	45.80**	10574.88*	226.24	501.30*
Tester effect	6	324.46**	672.23**	12.37*	3.94	42.48**	9301.44*	207.48	185.60
Line x Tester effect	30	55.42**	112.08**	3.66**	3.33**	6.07**	2913.27*	90.44*	114.12**
Error	54	0.88	3.89	1.15	1.20	0.52	875.50	45.28	11.25
Total	109	43.13	114.09	4.21	2.21	8.21	2627.59	85.43	73.34

Table 3 (Cont.)

Source of variation	d.f	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Paddy length (mm)	Paddy breadth (mm)	Paddy L/B ratio
Replicates	1	34.00**	6.08**	1.93	0.02*	0.00	0.00	0.00	0.02*	0.08
Treatments	54	13.54**	29.43**	89.71**	0.37**	0.04**	0.16**	1.18**	0.05**	0.38**
Parents	12	9.28**	10.32**	36.46**	0.29**	0.01	0.12**	0.44*	0.03**	0.03
Parents (Lines)	5	0.57**	8.50**	22.20**	0.34**	0.01	0.08*	0.36*	0.02*	0.01
Parents (Testers)	6	14.35**	12.32**	35.56**	0.28**	0.02*	0.17**	0.41*	0.03**	0.06
Parents (L *vs* T)	1	22.41**	7.46**	113.16**	0.08**	0.00	0.01	1.07*	0.06**	0.00
Parents *vs* Crosses	1	0.61*	22.53**	14.26**	0.53**	0.09*	0.88**	4.82**	0.09**	2.32**
Crosses	41	15.10**	35.19**	107.14**	0.39**	0.04**	0.16**	1.31**	0.06**	0.43**
Line effect	5	46.41*	50.14	396.62*	1.44**	0.19**	0.35*	2.34	0.04	0.95*
Tester effect	6	9.08	6.86	32.14	0.62*	0.05*	0.29*	1.73	0.09	0.75*
Line x Tester effect	30	11.08**	38.36**	73.89**	0.17**	0.01*	0.10**	1.05**	0.05**	0.28**
Error	54	0.07	0.41	0.52	0.00	0.01	0.03	0.13	0.00	0.03
Total	109	7.05	14.84	44.72	0.18	0.02	0.10	0.65	0.03	0.21

* Significant at 5 per cent level ** Significant at 1 percent level

Table.4 Estimates of general combining ability (*gca*) effects for lines and testers for yield and quality traits in rice

Source	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	No. of productive tillers per plant	1000 - grain weight (g)	No. of grains per panicle	Spikelet fertility (%)	Grain yield per plant (g)
PARENTS								
LINES								
CMS 64B	-0.01	-12.26**	-2.30**	-0.29	-3.39**	-24.75**	-3.52	-8.45**
JMS 11B	2.77**	3.79**	-1.08**	0.20	0.07	-20.32*	3.24	-3.90**
JMS 19B	-0.29	4.25**	1.09**	0.41	0.39	15.32	-3.04	4.42**
CMS 52B	0.48	2.35**	0.05	-0.44	1.38**	-8.67	-3.36	-0.42
JMS 21B	0.91**	1.46*	0.59*	0.34	-0.11	48.39**	6.08*	8.52**
JMS 20B	-3.86**	0.39	1.64**	-0.22	1.66**	-9.96	0.60	-0.16
TESTERS								
JR 83	-10.72**	-11.94**	1.64**	-0.54	-1.47**	-35.0**	4.68*	-4.60**
JR 85	3.27**	9.70**	0.85*	0.20	1.79**	15.91	-5.57*	3.23
JR 80	2.94**	5.27**	1.38**	-0.21	0.30	27.50*	-0.90	-3.13*
JMBR 44	-2.39**	-4.81**	-0.33	0.61	1.72**	-28.75*	-5.47*	-2.10*
JMBR 31	0.27	-4.92**	0.00	-0.54	-0.82**	4.58	1.90	-2.40*
JR 67	3.44**	2.48**	-0.71*	-0.38	-3.10**	34.75**	1.70	3.98**
JBR 6	3.19**	4.22**	0.45	0.86*	1.57**	-19.00*	3.66	5.03**
CD 95% GCA (Line)	0.50	1.06	0.57	0.59	0.39	15.97	3.63	1.81
CD 95% GCA (Tester)	0.54	1.15	0.62	0.63	0.42	17.25	3.92	1.95

Table 4 (Cont.)

Source	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Paddy length (mm)	Paddy breadth (mm)	Paddy L/B ratio
PARENTS									
LINES									
CMS 64B	-3.52**	-0.71**	-1.54**	-0.51**	-0.11**	-0.06	0.14	-0.07**	0.20**
JMS 11B	-0.29**	1.87**	3.46**	-0.06*	-0.08*	0.10*	0.10	0.00	0.04
JMS 19B	1.19**	-0.23	-4.30**	-0.09**	-0.09**	0.12*	0.39**	-0.05*	0.25**
CMS 52B	0.45**	-1.53**	3.77**	0.31**	0.05	0.05	0.09	0.03	-0.04
JMS 21B	1.25**	2.68**	6.14**	-0.02	0.17**	-0.29**	-0.80**	0.08**	-0.48**
JMS 20B	0.91**	-2.06**	-7.53**	0.38**	0.07*	0.06	0.06	0.00	0.015
TESTERS									
JR 83	1.74**	-0.26	-1.56**	-0.01	-0.07*	0.13**	0.01	-0.15**	0.27**
JR 85	0.49**	1.24**	2.49**	0.33**	-0.03	0.26**	0.48**	0.01	0.20*
JR 80	-0.09	0.72**	-0.57*	0.17**	0.03	0.00	0.43**	-0.01	0.21**
JMBR 44	-0.51**	0.10	0.92**	-0.07**	0.08*	-0.18*	-0.01	0.03	-0.06
JMBR 31	-0.62**	-0.96**	1.45**	-0.11**	0.04	-0.14*	-0.16	0.13**	-0.29**
JR 67	-0.27**	-0.37	-1.80**	-0.37**	0.08*	-0.06	-0.62**	0.03	-0.34**
JBR 6	-0.72**	-0.46*	-0.93**	0.07*	0.03	-0.00	-0.13	-0.04*	0.01
CD 95% GCA (Line)	0.14	0.35	0.39	0.04	0.05	0.10	0.19	0.03	0.10
CD 95% GCA (Tester)	0.15	0.37	0.42	0.04	0.05	0.10	0.21	0.04	0.11

* Significant at 5 per cent level ** Significant at 1 percent level

Table.5 Estimates of specific combining ability (*sca)* effects for yield and quality traits in rice

S.No.	Crosses	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	No. of productive tillers per plant	1000-grain weight (g)	No. of grains per Panicle	Spikelet fertility (%)	Grain yield per plant (g)
1	CMS 64A X JR 83	15.01**	4.54*	0.61	0.54	1.77*	34.50	-7.55	3.51
2	CMS 64A X JR 85	-3.48**	-4.10*	0.61	1.79*	-2.76**	-37.91	-1.09	-4.11
3	CMS 64A X JR 80	4.84**	-11.27**	-1.41	-786.00	-3.53**	32.50	7.42	1.25
4	CMS 64A X JMBR 44	-5.82**	0.31	1.00	-0.11	1.86**	-27.25	-3.39	0.01
5	CMS 64A X JMBR 31	-9.98**	-7.17**	-0.23	-1.45	3.06**	-28.58	-0.92	-2.48
6	CMS 64A X JR 67	-4.65**	3.41*	-0.61	0.38	-1.84**	-5.75	4.02	-2.86
7	CMS 64A X JBR 6	4.09**	14.27**	0.01	0.36	1.45*	32.50	1.51	4.68
8	JMS 11A X JR 83	-5.77**	-3.81*	-0.49	1.04	-1.80*	48.07*	2.03	5.37*
9	JMS 11A X JR 85	9.22**	4.43*	-1.39	-0.70	0.54	-31.84	4.58	-9.66**
10	JMS 11A X JR 80	-1.94*	10.27**	2.27*	-0.78	2.33**	-8.92	0.36	-0.89
11	JMS 11A X JMBR 44	-3.60**	-6.74**	-1.11	-0.61	0.37	-16.67	6.03	-0.52
12	JMS 11A X JMBR 31	0.22	-4.82*	-0.74	0.04	-1.25*	-36.01	2.31	-0.62
13	JMS 11A X JR 67	3.06**	-0.54	-1.42	-1.11	-0.87	11.82	-5.53	-4.21
14	JMS 11A X JBR 6	-1.19	1.22	2.90**	2.13*	0.67	33.57	-9.80*	10.54**
15	JMS 19A X JR 83	-2.70**	-2.66	0.71	-0.16	-0.33	-14.07	-2.48	4.24
16	JMS 19A X JR 85	1.29	-1.61	0.71	0.08	0.35	55.01*	-4.17	0.81
17	JMS 19A X JR 80	0.63	0.61	-0.11	1.50	-0.15	0.42	1.35	10.57**
18	JMS 19A X JMBR 44	2.46**	-5.20**	-1.79*	-1.33	0.05	3.17	8.77	0.94
19	JMS 19A X JMBR 31	-0.70	11.31**	0.76	-0.66	-2.04**	21.34	-6.25	-6.75*
20	JMS 19A X JR 67	-0.86	-5.00**	-0.11	-0.33	1.14*	-45.82*	-3.15	1.36
21	JMS 19A X JBR 6	-0.11	2.56	-0.18	0.91	0.97	-20.07	5.93	-11.18**
22	CMS 52A X JR 83	-3.48**	-2.56	-0.03	-1.31	-0.86	-25.57	0.13	-6.51*
23	CMS 52A X JR 85	3.01**	2.38	0.96	-0.06	0.97	-1.98	-2.30	1.05
24	CMS 52A X JR 80	-1.65*	7.31**	-2.77**	-0.64	0.79	-15.07	-9.92*	-3.97
25	CMS 52A X JMBR 44	1.17	1.99	0.84	0.02	-0.18	-7.32	-10.85*	-3.61
26	CMS 52A X JMBR 31	2.51**	-5.88**	-0.28	1.19	0.96	43.34*	1.02	4.08
27	CMS 52A X JR 67	-1.15	-0.20	1.02	0.52	0.73	-41.32	8.82	-2.69
28	CMS 52A X JBR 6	-0.40	-3.03*	0.26	0.27	-2.41**	47.92*	13.10*	11.65**
29	JMS 21A X JR 83	-3.91**	-5.88**	0.01	-1.09	0.40	17.35	1.14	-4.25
30	JMS 21A X JR 85	-0.91	-2.33	-0.28	-0.34	0.87	0.44	5.50	15.51**
31	JMS 21A X JR 80	-1.58*	-0.40	-0.01	0.57	-0.69	-10.14	1.52	-8.52**
32	JMS 21A X JMBR 44	2.25*	5.58**	-0.09	0.23	-1.65*	3.10	-5.59	-10.15**
33	JMS 21A X JMBR 31	1.08	0.40	0.36	0.40	-1.39*	11.27	4.92	6.34*
34	JMS 21A X JR 67	0.91	-2.31	0.18	-0.76	0.40	62.60*	3.47	5.96*
35	JMS 21A X JBR 6	2.16*	4.95**	-0.18	0.98	2.06**	-84.64**	-10.98*	-4.88*
36	JMS 20A X JR 83	0.86	10.38**	-0.82	0.97	0.82	-60.28*	6.72	-2.36
37	JMS 20A X JR 85	-9.13**	1.23	-0.62	-0.77	0.02	16.29	-2.51	-3.60
38	JMS 20A X JR 80	-0.29	-6.52**	2.04*	0.14	1.26*	1.21	-0.74	1.56
39	JMS 20A X JMBR 44	3.53**	4.05*	1.16	1.81*	-0.44	44.96*	5.03	13.33**
40	JMS 20A X JMBR 31	6.86**	6.17**	0.12	0.47	0.66	-11.369	-1.09	-0.56
41	JMS 20A X JR 67	2.70**	4.65*	0.94	1.31	0.43	18.46	-7.64	2.44
42	JMS 20A X JBR 6	-4.54**	-19.97**	-2.82**	-3.94	-2.76**	-9.28	0.24	-10.80**
43	CD 95 % SCA	1.34	2.81	1.53	1.56	1.03	42.25	9.61	4.79

Table 5 (cont.)

S.No.	Crosses	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Paddy length (mm)	Paddy breadth (mm)	Paddy L/B ratio
1	CMS 64A X JR 83	4.54**	7.41**	6.29**	0.36**	0.01	0.23	0.95**	0.19**	0.05
2	CMS 64A X JR 85	2.13**	-0.03	-6.76**	0.01	-0.15*	0.33*	0.58*	-0.17*	0.61**
3	CMS 64A X JR 80	-1.12**	-1.03*	5.15**	-0.12*	0.06	-0.18	-0.01	-0.08	0.16
4	CMS 64A X JMBR 44	3.92**	3.69**	2.65**	-0.12*	0.01	-0.12	-0.56*	-0.08	-0.11
5	CMS 64A X JMBR 31	-7.74**	-11.91	-14.62**	0.06	0.11	-0.17	-1.06**	-0.08	-0.35*
6	CMS 64A X JR 67	0.00	1.12*	-0.61	-0.27**	-0.10	0.01	0.10	0.20**	-0.30*
7	CMS 64A X JBR 6	-1.74**	0.75	7.91**	0.07	0.07	-0.09	0.00	0.03	-0.08
8	JMS 11A X JR 83	-1.51**	0.93*	3.54**	0.41**	-0.05	0.35*	0.29	0.09	0.31*
9	JMS 11A X JR 85	-2.10**	-0.50	5.23**	-0.13*	0.05	-0.20	-1.07**	0.04	-0.58**
10	JMS 11A X JR 80	1.44**	5.44**	1.35*	0.42**	0.08	0.07	0.07	0.17*	-0.29*
11	JMS 11A X JMBR 44	-0.80**	-3.63**	-2.09**	-0.42**	-0.01	-0.19	0.42	0.42**	-0.48*
12	JMS 11A X JMBR 31	0.96**	-1.89**	5.72**	0.01	-0.07	0.13	-0.42	-0.17*	0.07
13	JMS 11A X JR 67	-0.17	-2.82**	-5.31**	-0.02	0.00	-0.02	-0.05	-0.18**	0.25
14	JMS 11A X JBR 6	2.18**	2.48**	-8.44**	-0.27**	-0.00	-0.14	0.74*	-0.19**	0.71**
15	JMS 19A X JR 83	-0.82**	-0.20	-0.04	-0.35**	0.06	-0.33*	0.51	-0.03	0.35*
16	JMS 19A X JR 85	0.66*	0.87	3.94**	-0.10	-0.07	0.09	-0.15	0.00	-0.09
17	JMS 19A X JR 80	-1.14**	-2.86**	-6.98**	-0.03	-0.00	-0.01	-1.20**	-0.16*	-0.22
18	JMS 19A X JMBR 44	-1.44	-0.95*	-3.82**	0.16*	-0.00	0.05	-0.15	-0.01	-0.05
19	JMS 19A X JMBR 31	1.04**	-0.80	-2.00**	-0.14*	0.08	-0.24	0.49	0.08	0.05
20	JMS 19A X JR 67	-0.87**	1.97**	6.22**	0.41**	0.07	0.11	0.35	-0.02	0.17
21	JMS 19A X JBR 6	2.58**	1.98**	2.68**	0.06	-0.11	0.33*	0.16	0.15*	-0.22
22	CMS 52A X JR 83	-0.76**	-10.56**	-11.72**	-0.06	0.01	-0.05	-1.49**	-0.11	-0.47*
23	CMS 52A X JR 85	0.10	1.36*	-2.08**	0.18*	0.07	-0.05	0.34	0.21**	-0.22
24	CMS 52A X JR 80	0.79**	1.57*	0.10	0.25**	0.09	-0.01	0.89*	-0.05	0.49**
25	CMS 52A X JMBR 44	0.06	-0.97*	3.71**	0.20**	-0.10	0.28*	0.24	0.09	-0.05
26	CMS 52A X JMBR 31	2.57**	10.31**	9.53**	-0.55**	-0.11	-0.08	0.49	0.09	0.07
27	CMS 52A X JR 67	0.97**	1.57*	6.65**	-0.19**	0.02	-0.13	0.35	-0.11*	0.34*
28	CMS 52A X JBR 6	-3.74**	-3.28**	-6.20**	0.15**	0.00	0.06	-0.84*	-0.12*	-0.15
29	JMS 21A X JR 83	-0.03	1.69**	-2.34**	-0.32**	-0.00	-0.18	0.30	-0.06	0.21
30	JMS 21A X JR 85	-0.79**	-1.453*	1.94**	-0.17*	0.15*	-0.35*	-0.36	0.06	-0.28*
31	JMS 21A X JR 80	0.19	1.00*	1.83**	-0.30**	-0.22*	0.20	-0.26	0.04	-0.209
32	JMS 21A X JMBR 44	-1.01**	0.2	-0.40	0.04	0.12	-0.11	-0.36	-0.35**	0.39*
33	JMS 21A X JMBR 31	1.44**	1.86**	1.75*	0.23**	0.06	0.03	-0.11	0.04	-0.07
34	JMS 21A X JR 67	0.42*	-0.68	-3.98**	0.14*	-0.09	0.22	0.66*	0.13*	0.09
35	JMS 21A X JBR 6	-0.22	-2.70**	1.19*	0.39**	-0.01	0.20	0.15	0.12*	-0.13
36	JMS 20A X JR 83	-1.40**	0.74	4.28**	-0.03	-0.00	-0.01	-0.56*	0.11*	-0.45*
37	JMS 20A X JR 85	-0.00	-0.22	-2.27**	0.21**	-0.04	0.18	0.66*	-0.15*	0.57**
38	JMS 20A X JR 80	-0.17	-4.12**	-1.45*	-0.21**	-0.02	-0.06	0.51	0.08	0.07
39	JMS 20A X JMBR 44	-0.71**	1.59*	-0.04	0.13*	-0.02	0.10	0.41	-0.067	0.29*
40	JMS 20A X JMBR 31	1.71**	2.43**	-0.38	0.37**	-0.08	0.33*	0.61*	0.03	0.21
41	JMS 20A X JR 67	-0.35	-1.17*	-2.96**	-0.06	0.10	-0.19	-1.42**	-0.025	-0.57**
42	JMS 20A X JBR 6	0.94**	0.75	2.85**	-0.41**	0.08	-0.35*	-0.21	0.00	-0.11
43	CD 95 % SCA	0.38	0.92	1.03	0.10	0.14	0.26	0.52	0.10	0.28

* Significant at 5 per cent level ** Significant at 1 percent level

Table.6 Screening of rice entries against panicle mite and their categorization

S.No	Name of entry	Scale I	Scale II	Scale III	Category
1	CMS 64B	1	5	7	Moderately Resistant
2	JMS 11B	1	5	7	Moderately Resistant
3	JMS 19B	3	3	5	ModeratelyResistant
4	CMS 52B	3	7	7	Susceptible
5	JMS 21B	3	3	9	Susceptible
6	JMS 20B	1	3	3	Resistant
7	JR 83	1	5	7	Moderately Resistant
8	JR 85	3	3	3	Moderately Resistant
9	JR 80	1	3	3	Resistant
10	JMBR 44	3	3	9	Susceptible
11	JMBR 31	3	3	9	Susceptible
12	JR 67	3	7	7	Susceptible
13	JBR 6	3	9	7	Susceptible
14	CMS 64A X JR 83	3	5	9	Susceptible
15	CMS 64A X JR 85	3	7	9	Susceptible
16	CMS 64A X JR 80	3	3	9	Susceptible
17	CMS 64A X JMBR 44	3	3	9	Susceptible
18	CMS 64A X JMBR 31	3	3	9	Susceptible
19	CMS 64A X JR 67	3	5	9	Susceptible
20	CMS 64A X JBR 6	3	9	7	Susceptible
21	JMS 11A X JR 83	3	3	5	Moderately Resistant
22	JMS 11A X JR 85	3	9	9	Susceptible
23	JMS 11A X JR 80	1	3	1	Resistant
24	JMS 11A X JMBR 44	3	3	5	Moderately Resistant
25	JMS 11A X JMBR 31	1	3	3	Resistant
26	JMS 11A X JR 67	3	3	5	Moderately Resistant
27	JMS 11A X JBR 6	1	5	7	Moderately Resistant
28	JMS 19A X JR 83	3	3	9	Susceptible
29	JMS 19A X JR 85	3	3	5	Moderately Resistant
30	JMS 19A X JR 80	1	0	1	Resistant
31	JMS 19A X JMBR 44	1	3	3	Resistant
32	JMS 19A X JMBR 31	3	3	3	Moderately Resistant
33	JMS 19A X JR 67	1	1	0	Resistant
34	JMS 19A X JBR 6	3	3	5	Susceptible
35	CMS 52A X JR 83	1	1	3	Resistant
S.No	**Name of entry**	**Scale I**	**Scale II**	**Scale III**	**Category**
36	CMS 52A X JR 85	3	3	9	Susceptible
37	CMS 52A X JR 80	1	3	3	Resistant
38	CMS 52A X JMBR 44	3	3	5	Moderately Resistant
39	CMS 52A X JMBR 31	1	3	3	Resistant
40	CMS 52A X JR 67	1	1	3	Resistant
41	CMS 52A X JBR 6	3	7	7	Susceptible
42	JMS 21A X JR 83	3	3	5	Moderately Resistant
43	JMS 21A X JR 85	3	3	9	Susceptible
44	JMS 21A X JR 80	1	1	3	Resistant
45	JMS 21A X JMBR 44	3	3	9	Susceptible
46	JMS 21A X JMBR 31	1	1	3	Resistant
47	JMS 21A X JR 67	1	1	3	Resistant
48	JMS 21A X JBR 6	3	5	9	Susceptible
49	JMS 20A X JR 83	3	3	5	Moderately Resistant
50	JMS 20A X JR 85	1	1	3	Resistant
51	JMS 20A X JR 80	3	3	5	Moderately Resistant
52	JMS 20A X JMBR 44	3	3	9	Susceptible
53	JMS 20A X JMBR 31	1	3	3	Resistant
54	JMS 20A X JR 67	1	3	3	Resistant
55	JMS 20A X JBR 6	3	5	3	Moderately Resistant
C_1	BPT 5204	7	7	9	Susceptible
C_2	JGL 3855	7	7	7	Susceptible

Scale 1:Based on damage symptom of panicle mite on leaf midrib; Scale 2:Based on per cent grain discolouration
Scale 3:Based on damage symptoms on leaf sheath; C_1: check variety 1and C2: check variety 2

Fig.1 Rice panicle mite damage symptom on Rice panicle mite damage symptoms on grains leaf sheath

Fig.2 Rice panicle mite damage symptoms on leaf midrib

The incidence of panicle mite was observed to be relatively very low in rice entries with well exerted panicles (2 - 4 cm above the boot leaf) in comparison to incompletely exerted panicles. A relation was also observed between duration of the crop and incidence of panicle mite indicating that some genotypes escaped from the incidence. Overall, the panicle mite incidence was observed to be more in early duration cultures than late duration cultures with few exceptions. However, these results need to be investigated across locations. The results obtained in the present study were compared with those reported by the earlier workers. Some such reports are as follows:

Rao *et al.,* (2000) while working on rice sheath mite reported the cultivars MTU-1001, MTU-2067, MTU-2077, MTU 7029, BPT-5204 andPLA-1000 being most susceptible to rice sheath mite. According to Lee (1980), the cultivars Kaohsiung Selection No. 1, Hsinchu-57, Chinung-shenyu-19, Nanshen-yu-42 and Kaohsiung-shen-yu-194 were the most resistant in Taiwan. Chandrasena *et al.,* (2016) while conducting studies on rice panicle mite, reported *Cyperusrotundus, Leptochloachinensis, Echinocloacrus-galli, Paspalumscrobiculatum, Imperatacylindrica* etc. as the alternate hosts of this mite. Thuy *et al.,* (2012) evaluated the effect of panicle rice mite (PRM) population on the agronomic characters of dominant rice cultivar IR 50404 by artificial inoculation and reported that the periods of PRM introduction affected the yield loss but these effects were only significantly smaller when the initial number of mites released was small (1-2 mites per tiller). Mukhopadhyay *et al.,* (2017) performed varietal screening in relation to morphological characters of leaf sheath in respect of 29 rice cultivars reported variety IR-72 and JKRH-2082 were best and length of flag leaf lamina was not affected due to infestation of *Steneotarsonemus spinki* and regarding chaffy grain, among 10 late paddy cultivars tested, the variety Mandira was the best among all showing the minimum % of chaffy grain.

It is concluded, based on *gca* and *sca* effects, some lines and crosses have been identified with resistance to panicle mite as well as other desirable yield related characters. Based on the screening studies, promising hybrids *viz.,* JMS 11A X JR 80, JMS 11A X JMBR 31, JMS 19A X JR 80, JMS 19A X JMBR 44, JMS 19A X JR 67, CMS 52A X JR 83, CMS 52A X JR 80, CMS 52A X JMBR 31, CMS 52A X JR 67, JMS 21A X JR 80, JMS 21A X JMBR 31, JMS 21A X JR 67, JMS 20A X JR 85, JMS 20A X JMBR 31 and JMS 20A X JR 67 or parental lines *viz.*, JMS 20B and JR 80can be used in future breeding programmes to develop rice hybrids with less panicle mite damage as well as grain discolouration. The major criterion for panicle mite resistance was observed to be panicle exertion and crop duration. Complementary studies should be conducted to explain how much of the observed yield reduction was exclusively due to the rice panicle mite and how much to other causes, as for example the different prevailing climatic and disease conditions.

References

Cho Myoung-Rae. 1999. A new record of tarsonemid mite, *Steneotarsonemus spinki* (Acari: Tarsonemidae), and its damage on rice in Korea. Korean Journal of Applied Entomology. 38(2): 157–164.

Gaurav Dharwal, Verma, O.P., and Verma, G.P. 2017.Combining ability analysis for grain yield and other associated traits in rice. International Journal of Pure and Applied Bioscience.5 (2):96-100.

Ghara, A.G., Nematzadeh, G., Bagheri, N., Ebrahimi, A., and Oladi, M. 2012. Evaluation of general and specific combining ability in parental lines of hybrid rice. IJRR.2 (4): 455-460.

Ghosh, S. K., Rao, J., and Prakash, A. 1997. Effect of tarsonemid mites, *Steneotarsonemus spinki* Smiley on the growth of rice plants. Journal of Applied Zoological Research.8(2): 123-124.

Hasan, M.J., Kulsum, U.K., Lipi, L.F., and Shamsuddin, A.K.M. 2013.Combining ability studies for developing new rice hybrids in Bangladesh. Bangladesh Journal of Botany.42(2): 215-222.

IRRI, 2017. http://ricestat.irri.org:8080/ wrsv3/entrypoint.htm.

Kenga, R., Albani, S.O., and Gupta, S.C. 2004. Combining ability studies in tropical sorghum [*Sorghum bicolor* L. (Meonch)]. Field Crop Research.88: 251-260.

Lee, H.C. 1980. Screening for varietal resistance to sterility of rice caused by tarsonemid mite. Plant Protection Bulletin. Taiwan. 22: 91-100.

Lo, K. C., and Ho, C. C. 1977. Preliminary studies on rice tarsonemid mite *Steneotarsonemus spinki smiley* (Acarina: Tarsonemidae). Natural Sciences Council Monthly.5(4): 274-284.

Marilia, C.F., Servio, T.C., Vatter, O.R., Clibas, V., and Siu, T.M. 2001.

Combining ability for nodulation in common bean (*Phaseolus vulgaris* L.) genotype from Andean and middle American gene pools. *Euphytica*. 118: 265-270.
Muhammad, R., Cheema, A.A., and Muhammad, A. 2007. Line X tester analysis in Basmati rice. Pakistan Journal of Botany. 39(6): 2035-2042.
Mukhopadhyay, S., Kinkar, S., and Gupta, S.K. 2017. Varietal screening of rice Panicle mite in relation to morphological characters of leaf sheath and population in 5 major rice growing districts of West Bengal. Biological Forum – An International Journal. 9(1): 162-168.
Nadali, B., and Nadali, B.J. 2010. Heterosis and combining ability analysis for yield and yield related traits in hybrid rice. I J B. 2 (2): 222-231.
Rao, P.R.M., Bhavani, T.R.M., Rao, T.R.M., and Reddy, P.R.2000. Spikelet sterility/ grain discolouration in Andhra Pradesh, India. International Rice Research Notes. 25, 40. Notes from the fields.
Rumanti, I.A., Purwoko, B.S., Dewi, I.S., Aswidinnoor, H., and Widyastuti, Y. 2017. Combining ability for yield and agronomic traits in hybrid rice derived from wild abortive, gambiaca and kalinga cytoplasmic male sterile lines. SABRAO J BREED GENET. 49(1): 69-76.
Sarker, U., Biswas, P.S., Prasad, B., and Khaleque, M.M.A. 2002. Heterosis and genetic analysis in rice hybrid. Pakistan Journal of Biological Science. 5(1): 1-5.
Savita Bhatti., Pandey, D.P., and Dhirendra Singh.2015. Combining ability and heterosis for yield and its component traits in rice (*Oryza sativa* L.). EJPB. 6(1): 12-18.
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.
SriKrishna Latha., Deepak Sharma., Gulzar., and Sanghera, S. 2013. Combining ability and heterosis for grain yield and its component traits in rice (*Oryza sativa* L.). Not Sci Biol. 5(1): 90-97.
Sogawa K. 1977. Occurrence of the rice tarsonenmid mite at IRRI. International Rice Research Newsletter. 2(5): 17.
Thuy, L.D., Tung, N.D., and Dinh, N.V. 2012. Population intensity of panicle rice mite *Steneotarsonemus spinki smiley* (acari: tarsonemidae) influencing rice yield in Vietnam. Journal of International Society for Southeast Asian Agricultural Sciences. 18(2): 62-69.

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