

RESEARCH ARTICLE : **Evaluation of rice pre-breeding lines for gall midge resistance**

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ARTICLE CHRONICLE :

Received :
15.07.2017;

Accepted :
30.07.2017

SUMMARY : Pre-breeding lines with known source of gall midge resistance through *Gm1* gene in the elite backgrounds were evaluated in a replicated trial under greenhouse conditions at IIRR, Rajendranagar, Hyderabad against biotype 1 and in field at Jagtial and Warangal against biotype 3 and 4, respectively. Screening of 15 day old seedlings of the test lines against gall midge biotype 1 was carried out by releasing gall midge adults. Field screening for biotype 3 and 4M was carried out under natural infestation in endemic areas. Scoring for damage was done when at least 50% of the susceptible check plants exhibited damage symptoms as silver shoots. Data on total number of plants and number of plants with silver shoots were taken. Per cent plant damage and silver shoots was calculated. Among 38 pre-breeding lines, chosen with phenotypic acceptability, 12 lines showed nil damage from four crosses against biotype 1 and 6 lines against biotype 3. Of these RNR17927-1 (Tellahamsa X JGL11690) and RNR19872, RNR19875, RNR19880, RNR19881 and RNR19883 (MTU1010/JGL3855) were found resistant against both biotype 1 and 3 but susceptible to biotype 4M.

KEY WORDS :

Gall midge, Pre-breeding lines, Resistance

How to cite this article : Anusha, Ch., Padmakumari, A.P., Maheswari, T. Uma, Malathi, S., Prakash, S. Om and Raju, Ch. Damodar (2017). Evaluation of rice pre-breeding lines for gall midge resistance. *Agric. Update*, 12(TECHSEAR-5) : 1300-1307; DOI: 10.15740/HAS/AU/12.TECHSEAR(5)2017/1300-1307.

BACKGROUND AND OBJECTIVES

The Asian rice gall midge *Orseolia oryzae* (Wood- Mason) (Diptera: Cecidomyiidae) is a serious pest of rice (*Oryza sativa* L.) in India, causing an average annual yield loss of about US \$80 million (Bentur *et al.*, 2003). The estimated loss due to gall midge was about 0.8% of total yield or approximately US\$ 80.00 million in South India (Bentur *et al.*, 2003). Yield loss projections for damage due to 1% gall midge induced silver shoot damage was 3.5% loss (Muralidharan

and Pasalu, 2005).

Except for granular formulations, most of the spray formulations are ineffective in control of gall midge. The best logical approach to overcome this problem is to breed new cultivars with high resistance to rice gall midge (Thippeswamy *et al.*, 2014). So far, 11 gall midge resistance genes have been characterized in rice (Himabindu *et al.*, 2007) and seven biotypes of the pest were reported (Vijayalakshmi *et al.*, 2006). Interestingly, none of the identified genes confers resistance

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to all the gall midge biotypes, while none of the gall midge biotypes is virulent against all the resistance genes. So there's always a need to evaluate and identify new sources of resistance. The present study reports the performance of elite pre-breeding lines against gall midge biotype (GMB) 1, 3 and 4M. The resistant lines do not produce any silver shoots (galls) as the maggots are found dead at the base of the tiller. However, the phenotypic reaction of a resistant line could be either be associated with hypersensitive reaction (HR+) where tissue necrosis is observed or without HR where there's no tissue necrosis (Bentur, 2004).

RESOURCES AND METHODS

Greenhouse screening :

A total of 38 pre-breeding lines developed from six crosses (Table A) and phenotypically acceptable were screened at the Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad, against GMB1 as per the standard procedure (Vijaya Lakshmi *et al.*, 2006) along with Kavya and W 1263 as resistant checks. Gall midge culture maintained on the susceptible variety TN1 was used for the evaluation of the lines. Test genotypes recording nil plant damage were rated as resistant. Data collected included total no. of plants and number of silver shoots. The lines with nil damage were considered as resistant. Resistant lines were re-evaluated and the lines were dissected out at the point of larval entry and observed for the HR reaction (Bentur, 2004).

Field screening for gall midge resistance :

From the earlier studies it is evident that the gall midge population at Jagtial has been characterized as biotype 3 (Srinivas, 1999) and Warangal as biotype 4M (Vijayalakshmi *et al.*, 2006). Field evaluation of all the test material was done against GMB3 (RARS, Jagtial) and GMB4M (RARS, Warangal) *Kharif* 2014 and 2015. The seeds were sown in lines on raised nursery beds and the nursery was maintained as per the standard agronomic practice. Time of sowing was adjusted so that the vegetative phase of the pest coincides with the occurrence of the pest in the field. The pre-breeding lines were transplanted (21 days old rice seedlings) in Randomized Block Design (RBD) @ single seedling per hill in two replications @ 20 plants per replicate. The crop geometry adopted was 20 x 10 cm. All the cultural practices were followed as per the standard agronomic

Table A : List of pre-breeding lines evaluated in the study

Sr. No.	Entries		
	Tellahamsa/JGL 11690	26.	RNR17852
1.	RNR17923	27.	RNR17853
2.	RNR17927-1	28.	RNR17854
3.	RNR17927-2	29.	RNR17855
4.	RNR 17927-3	30.	RNR17856-1
5.	RNR17928	31.	RNR17856-2
6.	RNR17931-1		MTU1075/Kavya
7.	RNR17931-2	32.	RNR21225
8.	RNR 17932	33.	RNR21226
9.	RNR17933-1	34.	RNR21228
10.	RNR17933-2	35.	RNR21223
11.	RNR17935	36.	RNR21237
	MTU1010/JGL3855	37.	RNR21224
12.	RNR19868		RNRC36/JGL11690
13.	RNR 19872	38.	RNR17937
14.	RNR 19875		
15.	RNR 19880		Parents
16.	RNR19881		
17.	RNR 19883	39.	JGL 3855
18.	RNR19884	40.	Tellahamsa
19.	RNR 19886	41.	MTU1010
	MTU1081/JGL11690	42.	MTU1081
20.	RNR17791	43.	IR64
21.	RNR17802		
22.	RNR17803		Check lines
23.	RNR17804	44.	Kavya (R.check)
	JGL11690/IR 64	45.	W1263 (R.check)
24.	RNR17850	46.	TN1 (S. check)
25.	RNR17851		

practices (Shaik *et al.*, 2014). No insecticidal spray was given. The test entries were scored for plant damage at 30 DAT and 50 DAT. Data collected included total number of plants, total no. of tillers/plant, damaged plants (with silver shoots), number of silver shoots/damaged plant. Per cent plant damage (DP) and per cent silver shoots (SS) were calculated and analysis was done by using Repeated measures ANOVA (Gomez and Gomez, 1984). Scoring was done as per the SES standard procedure (Anonymous, 2002).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Greenhouse evaluation of pre-breeding lines against GMB1 :

The plant damage in the lines varied from 0 to 100% with a mean damage of 45.8% DP. Resistant checks, Kavya, W1263 showed nil damage; JGL3855, the source of resistance also showed nil damage whereas MTU1010, IR64, Tellahamsa, MTU1081 and TN1 showed susceptible reaction with > 10% DP (Table 1).

Table 1 : Summary of the evaluation of the pre-breeding rice lines against gall midge biotype1 under greenhouse conditions

Entries with nil damage	Entries	DP(%)
Tellahamsa/JGL 11690	Parents and check lines	
RNR17927-1		
RNR17931-2		
RNR17933-1	JGL 3855	0.0
MTU1010/JGL3855	Tellahamsa	100.0
RNR19868	MTU1010	60.0
RNR 19872	MTU1081	100.0
RNR 19875	IR64	71.4
RNR 19880	Kavya (R.check)	0.0
RNR19881	W1263 (R.check)	0.0
RNR 19883	TN1	100.0
JGL11690/IR 64	Mean damage in the trial	45.8
RNR17852	Maximum damage in the trial	100.0
MTU1075/Kavya	Minimum damage in the trial	0.0
RNR21225	No. of test lines with nil damage	12
RNR21226		

Tellahamsa/JGL 11690 :

Of the 11 lines tested in this cross, RNR17927-1, RNR17931-2 and RNR17933-1 did not record any damage and showed HR-reaction. All the other lines were susceptible. In this cross we could also identify contrasting lines (the most resistant lines and susceptible lines) for gall midge damage.

MTU1010/JGL3855 :

RNR19868, RNR19872, RNR19875, RNR19880, RNR19881 and RNR19883 showed nil gall midge damage with HR- reaction; Of these, two phenotypically contrasting lines -RNR 19880 as the resistant line and RNR 19886, the most susceptible line were identified.

MTU1081/JGL11690 :

All the four lines RNR17804 viz., RNR17803, RNR17802 and RNR17791 chosen in this cross were found susceptible to GMB1.

JGL11690/IR 64 :

RNR17852 recorded nil gall midge damage with HR-reaction. All the seven lines RNR17855 RNR17853, RNR17854, RNR17850, RNR17851 RNR17856-1 and RNR17856-2 were susceptible.

MTU1075/Kavya :

RNR21225 and RNR21226 had nil damage with HR- reaction.

RNRC36/JGL11690 :

One line, RNR 17937 screened from this cross, was susceptible.

Out of 38 pre-breeding lines, 12 lines showed nil damage from four crosses viz., Tellahamsa/JGL 11690, MTU1010/JGL3855, JGL11690/IR 64 and MTU1075/Kavya. As Kavya is one of the parent for JGL11690, which is a resistant source of *Gm1*, these lines could be found resistant against GMB1. Evaluation of the eight pre-breeding lines derived from MTU1010/JGL3855, in two *Kharif* seasons of 2014 and 2015 identified RNR19868, RNR19872, RNR19875, RNR19880, RNR19881 and RNR19883 as resistant, whereas RNR19884 and RNR19886 as susceptible. These lines displayed HR-reaction, where, no tissue necrosis was observed at the basal portion of the stem but dead maggots were observed. Though all these lines were derived from JGL3855 (Sambamahsuri/ARC5984//Kavya) which is the source of resistance and the resistance could have been transferred from either Kavya (*Gm1* gene) or ARC5984 (*Gm5* gene) or both which are parents for JGL3855. Three rice cultivars viz., Erramallelu (Sabarmati/W12708), Kavya (developed from WGL 27120, WGL 17672, Mahsuri and Surekha) and Orugallu (OBS 677/IR 2070-423-2-5) were reported to be highly resistant against gall midge biotype1 (Reddy *et al.*, 1997). Present results are in agreement with the report of DRR, Screening nurseries, 2005, in which JGL3855 identified as resistant against GMB3 and JGL11690 identified as resistant against GMB1 and 3 (DRR, Screening nurseries, 2006). The present study suggests that, though Kavya is one of the parents for source of resistance, not all the resistant progeny are resistant to gall midge.

Phenotyping of pre-breeding lines at Jagtial against biotype3 :

A total of 38 pre-breeding lines from six crosses

Table 2 : Summary of field reaction of rice pre breeding lines to GMB3 at Jagtial

Plant damage(%)	<i>Kharif</i> 2014	<i>Kharif</i> 2015	Plant damage(%)	<i>Kharif</i> 2014	<i>Kharif</i> 2015
	Tellahamsa/JGL11690			MTU1081/JGL11690	
0-9.9	RNR 17927-1	RNR17927-1 RNR17931-1	0-9.9	-	-
10-19.9	RNR17923 RNR17931-2	RNR17923 RNR17933-2	10-19.9	-	-
20-29.9	RNR17931-1 RNR17933-1 RNR17935	RNR17933-1 RNR17935 RNR17933-2	20-29.9	-	-
30-39.9	RNR17927-2		30-39.9	-	-
40-49.9	RNR17928 RNR17933-2	RNR17927-3 RNR17928	40-49.9	-	-
50-59.9	RNR17932	RNR17927-2 RNR17932	50-59.9	-	RNR17802
60-69.9	RNR17927-3	-	60-69.9	RNR17804 RNR17791	RNR17791 RNR17803
70-79.9	-	-	70-79.9	RNR17803	RNR17804
80-89.9	-	-	80-89.9	RNR17802	-
90-100	-	-	90-100		-
	MTU1010/JGL3855			JGL11690/ IR 64	
0-9.9	RNR 19868 RNR 19872 RNR 19875 RNR 19880 RNR 19881 RNR 19883 RNR 19884	RNR 19872 RNR 19875 RNR 19880 RNR 19881 RNR 19883	0-9.9		-
10-19.9	-	RNR19868 RNR19884 RNR19886	10-19.9	-	RNR17852
20-29.9	-	-	20-29.9	-	-
30-39.9	-	-	30-39.9	RNR17853	-
40-49.9	-	-	40-49.9	RNR17850	-
50-59.9	-	-	50-59.9	-	RNR17850 RNR17856-2
60-69.9	RNR 19886	-	60-69.9	RNR17852	RNR17853 RNR17854 RNR17855
70-79.9	-	-	70-79.9	-	RNR17851 RNR17856-1
80-89.9	-	-	80-89.9	RNR17851 RNR17854	-
90-100	-	-	90-100	RNR17855 RNR178856-1 RNR17856-2	-
	MTU1075/Kavya			RNRC36/JGL11690	
0-9.9	-	RNR21226	0-9.9	-	RNR17937

Table 2 contd...

Table 2 contd...

	30 DAT		50 DAT	
	DP(%)	SS(%)	DP (%)	SS(%)
<i>Kharif 2014</i>				
TN1(S.check)	55.0±0.5 (47.9)	14.8±0.3 (22.6)	79.0±0.6 (62.7)	18.3±55.0 (25.4)
Mean damage in the trial	8.1±0.8 (11.2)	8.9±1.0 (10.0)	47.2± 0.9 (42.2)	10.4±0.3 (16.4)
F val	6.78	30.30	27.38	4.65
Sig.	0.01	0.00	0.00	0.03
<i>Kharif 2015</i>				
TN1(S.check)	55.0±1.5 (47.9)	9.0±0.4 (17.5)	70.0±0.6 (56.8)	15.8±1.0 (23.4)
Mean damage in the trial	24.3±1.2 (17.7)	2.4±0.4 (6.5)	43.9±0.9 (31.0)	9.2±0.5 (14.3)
F val	0.90	0.40	0.71	0.48
Sig.	0.34	0.52	0.40	0.48

Figures in parentheses are arcsine transformed values

were screened in a replicated trial against GMB3 under field conditions during *Kharif* 2014 and 2015.

Phenotyping of pre-breeding lines during *Kharif* 2014 :

The pest infestation data of the evaluations are presented in Table 2. The susceptible check, TN1 recorded 79% DP with 18.3% SS at 50 DAT. Mean damage at 30 DAT observed was 8.1% DP and 8.9% SS and at 50 DAT, 47.2% DP and 10.4% SS. At 30 DAT and 50 DAT both DP(%) and SS(%) were statistically significant across the varieties.

Tellahamsa/JGL 11690 :

At 50 DAT, RNR17927-1 recorded 7.5% DP. RNR17923, RNR17931-2, RNR17931-1, RNR17933-1, RNR17935, RNR17927-2, RNR17928 and RNR17933-2, RNR17932 and RNR 17927-3 were susceptible.

MTU1010/JGL3855 :

Seven pre-breeding lines viz., RNR19868, RNR19872, RNR19875, RNR19880, RNR 19881,

RNR19883 and RNR19884 recorded 0.0-7.5% DP and RNR19886 was susceptible.

MTU1081/JGL11690 :

All pre-breeding lines were susceptible.

JGL11690/IR 64 :

All pre-breeding lines were susceptible.

MTU1075/Kavya :

One pre-breeding line, RNR21225 showed 10% DP. RNR21226, RNR21224 RNR21228, RNR21223 and RNR21237 were susceptible.

RNRC36/JGL11690 :

One pre-breeding line, RNR17937 was screened from this cross, which showed about 32.5% DP.

Phenotyping of pre-breeding lines during *Kharif* 2015 :

In this field trial, at 30 DAT and 50 DAT both DP(%) and SS(%) were statistically not significant across the

pre-breeding lines tested (Table 2). Mean damage at 30 DAT observed were 24.3% DP and 2.4% SS and at 50 DAT, 43.9% DP and 9.2% SS. Resistant checks *viz.*, Kavya and Aganni recorded nil damage for gall midge. W1263, Abhaya, RP2068-18-3-5 showed 5.0% DP, 25% DP and 40% DP, respectively and the susceptible check, TN1 recorded 70% DP with 15.8 per cent silver shoots. The reaction of the test lines are discussed cross wise:

Tellahamsa/JGL 11690 :

At 50DAT, three pre-breeding lines, RNR17923, RNR17927-1 and RNR17931-1, showed 5-10% DP. All other lines were susceptible.

MTU1010/JGL3855 :

Seven pre-breeding lines *viz.*, RNR19872, RNR19875, RNR 19880, RNR19881, RNR19883, RNR19868 and RNR19884 recorded 0-10% DP. RNR19886 was susceptible.

MTU1081/JGL11690 :

All pre-breeding lines were susceptible.

JGL11690/IR 64 :

One pre-breeding line, RNR17852 showed 10% DP. All other lines were susceptible.

MTU1075/Kavya :

One pre-breeding line, RNR21226 showed nil gall midge damage. All other lines were susceptible.

RNRC36/JGL11690 :

One pre-breeding line, RNR 17937 was screened from this cross which showed 5.0 % DP.

Evaluation of the eight pre-breeding lines derived from MTU1010/JGL3855, in two *Kharif* seasons of 2014 and 2015 identified RNR19872, RNR19875, RNR19880, RNR19881 and RNR19883 as resistant, whereas RNR19868, RNR19884 and RNR19886 found susceptible from the cross *MTU1010/JGL3855*. Though all these lines were derived from JGL3855 (Sambamahsuri/ARC5984//Kavya) which is the source of resistance and the resistance could have been transferred from Kavya (*Gm1* gene) which is parent for JGL3855. Present results are in confirmation with the report of screening nursery (DRR, 2000), in which JGL3855 was identified as resistant against GMB3.

Evaluation of the 11 pre-breeding lines derived from Tellahamsa/JGL11690, in two *Kharif* seasons of 2014 and 2015 identified RNR17927-1 and RNR17923 as resistant, whereas RNR17927-2, RNR 17927-3, RNR17928, RNR17931-2, RNR17933-1, RNR17932, RNR17931-1, RNR17933-2 and RNR17935 were found susceptible. Evaluation of 13 pre-breeding lines from four crosses with JGL11690 (derived from Kavya) as one of the parents identified all the lines as susceptible, though from the earlier studies JGL11690 was identified as resistant against biotype 1 and 3 (DRR, Screening nurseries, 2006). Similarly, all the four lines from MTU1075/Kavya were found susceptible for GMB3. This could be due to the fact that only a few pre-breeding lines from each cross which were phenotypically acceptable were chosen for this study.

Phenotyping of pre-breeding lines at Warangal against GMB4M :

A total of 38 pre-breeding lines from six crosses were screened against GMB4M under field conditions in a replicated trial during *Kharif* 2014 and 2015.

Phenotyping of pre-breeding lines during *Kharif* 2014 :

In this field trial, mean damage observed at 30 DAT was 22.0% DP and 3.1% SS and at 50 DAT, mean DP(%) increased to 49.9% and SS to 12.6% SS. At 30 DAT and 50 DAT both DP(%) and SS(%) were not statistically significant across the varieties tested (Table 3). At 50 DAT, resistant checks *viz.*, Kavya, RP2068-18-3-5, Abhaya, Aganni and W1263 recorded 23.7, 13.2, 22.9, 8.2 and 13.7% DP, respectively, whereas the susceptible check, TN1 showed 75.0% DP with 27.1% SS. All the pre-breeding lines from the selected crosses were susceptible to GMB4M.

Phenotyping of pre-breeding lines during *Kharif* 2015 :

In this field trial, mean damage at 30 DAT observed was 25.6% DP and 2.4% SS and at 50 DAT 85.2% DP and 18.4% SS. At 30 DAT and 50 DAT both DP(%) and SS(%) were statistically not significant across the varieties (Table 3). At 50 DAT, resistant checks *viz.*, Kavya, RP 2068-18-3-5, Abhaya, Aganni and W1263 17.7, 17.5, 12.5, 13.5 and 11.0 %DP, where the susceptible check, TN1 recorded 90.3% DP. All pre-

Table 3 : Summary of field reaction of rice pre breeding lines to GMB4M

Kharif 2014	30 DAT		50 DAT	
	DP(%)	SS(%)	DP (%)	SS(%)
TN1 (S.check)	50.0±1.0 (45.0)	8.3±0.2 (16.7)	75.0±0.8 (60.0)	27.1±0.8 (31.4)
Mean damage in the trial	22.0±1.3 (29.3)	3.1±0.0 (12.3)	49.9±1.4 (44.8)	12.6±0.8 (16.4)
F val	2.5	0.24	0.42	2.7
Sig.	0.11	0.62	0.51	0.09
<i>Kharif 2015</i>				
TN1 (S.check)	51.4±2.0 (45.8)	5.1±1.2 (13.1)	90.3±1.0 (71.9)	22.8±0.5 (28.5)
Mean damage in the trial	25.6±0.9 (29.3)	2.4±0.2 (8.3)	85.2±1.1 (70.0)	18.4±0.3 (25.0)
F val	0.07	2.4	0.28	1.7
Sig.	0.70	0.12	0.59	0.19

Figures in parentheses are arcsine transformed values

breeding lines from the selected crosses were susceptible to GMB4M.

Though JGL11690, JGL3855, Kavya are the resistant sources of *Gm1* gene, none of the lines from these cross combinations were found resistant against GMB4M even though 12 lines and three lines were identified as resistant against GMB1 and GMB3, respectively suggesting a differential biotype reaction for the pre-breeding lines tested. Srinivas (1999) reported the range of plant damage in W1263, ARC6605, Phalguna and ARC5984 at Warangal over years fluctuated from 0 to 40%.

Reaction of pre-breeding lines across biotypes :

Evaluation of the pre-breeding lines for gall midge biotypes suggested that the frequency distribution for all the biotypes is continuous and damage varied from 0-100% (Table 1 and 2). Though 12 lines were found

resistant against biotype1 from four crosses (Tellahamsa/JGL 11690, MTU1010/JGL3855, JGL11690/IR 64 and MTU1075/Kavya), one line from MTU1010/JGL3855 and three lines from Tellahamsa/JGL 11690, were found resistant against biotype 3, none of the lines were resistant against biotype4M. Among 38 pre-breeding lines, chosen with phenotypic acceptability, 12 lines showed nil damage from four crosses against biotype1 and 6 lines against biotype 3. Of these RNR17927-1 (Tellahamsa X JGL11690) and RNR19872, RNR19875, RNR19880, RNR19881 and RNR19883 (MTU1010/JGL3855) were found resistant against both biotype 1 and 3 (DRR, Screening nurseries 2005 and 2006) but susceptible to biotype 4M (Table 4). The study once again affirms that the resistance material differs in their reaction to the three designated biotypes suggesting the variation in the virulence of gall midge populations. Kalode *et al.* (1993) evaluated 1295 elite rice breeding lines from DRR, Hyderabad both under field and greenhouse conditions against gall midge biotypes 1 and 4. Nine of the resistant lines were derivatives of Siam 29, which, like its derivative Phalguna are resistant to biotype1, but susceptible to biotype4 indicating the variation in virulence of gall midge. The study identifies the drawback of the conventional breeding, wherein all the progeny would not have the resistance to the level as expected though one of the parents is a donor for resistance. Moreover resistance coupled with phenotypic acceptability is a rare chance. This suggests the utility of trait specific markers to identify resistance in elite background.

Table 4 : List of resistant lines identified as resistant across two seasons of evaluation

Sr. No.	Cross	Reaction against	
		GMB1	GMB3
1.	Tellahamsa/JGL11690	RNR17927-1	RNR17927-1
		RNR17931-2	
		RNR17933-1	
2.	MTU1010/JGL 3855	RNR19868	RNR19872
		RNR19872	RNR19875
		RNR19875	RNR19880
		RNR19880	RNR19881
		RNR19881	RNR19883
		RNR19883	
3.	MTU1075/Kavya	RNR21225	-
		RNR21226	
4.	JGL11690/IR 64	RNR17852	-

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