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Evaluation of rice breeding lines against gall midge, *Orseolia oryzae* (Wood-Mason), in Warangal, a gall midge-endemic area of Telangana, India

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Abstract

The Asian rice gall midge [*Orseolia oryzae* (Wood-Mason)] is a major endemic pest in the Warangal region of Telangana, India, causing significant yield losses in rice. The present study was conducted during Kharif 2014 at the Regional Agricultural Research Station, Warangal, to evaluate 67 rice breeding lines along with checks for resistance against gall midge using the standard screening method. The entries were assessed based on per cent plant damage (PD) and per cent silver shoot (SS) incidence. The susceptible check TN-1 recorded high infestation levels, with 81.7% PD and 14.2% SS. Among the resistant checks, Aganni (*Gm8* gene) exhibited high resistance, while RP 2068-18-3-5 (*gm3* gene) recorded moderately resistant reaction (score 3), Abhaya (*Gm4* gene) recorded susceptible reaction (score 7) similar to the susceptible check, TN-1, based on silver shoot incidence. Among the breeding lines, JGL 19618 and RP 5332-54-11-8-2-1-B exhibited highly resistant reaction (no damage, score 0), SKL-3-22-19-31-55-11 showed resistant reaction (0.8% SS, score 1) and can serve as potential sources of resistance and could be utilized in breeding programmes for the development of gall midge-resistant rice varieties.

Keywords: Asian rice gall midge, rice breeding lines, resistance screening, silver shoot damage, Standard Evaluation System (SES)

1. Introduction

The Asian rice gall midge *Orseolia oryzae* (Wood-Mason) (Diptera: Cecidomyiidae) is one of the serious pests of rice (*Oryza sativa* L.) and confined to certain endemic pockets in India particularly in Andhra Pradesh, Telangana, Bihar, Kerala, Maharashtra, Odisha, and Tamil Nadu (Pasalu and Katti, 2006) [13]. This insect is essentially a monsoon pest and causes damage wherever high humidity and moderate temperatures prevail (Bentur *et al.*, 2003) [2]. Gall midge infestation induces the formation of characteristic tubular galls known as “silver shoots” or “onion shoots.” These galls inhibit tiller development and prevent panicle emergence, ultimately resulting in yield loss (Hidaka *et al.*, 1974) [6]. Yield loss projections for damage due to 1 per cent gall midge incidence induced silver shoot damage resulted in 3.5 per cent loss (Muralidharan and Pasalu, 2005) [12]. The pest is capable of causing yield losses ranging from 10 to 25% (Prasad and Prasad, 2006) [14] and the severity of damage increases under late planting conditions (Chaudhari *et al.*, 2018) [4]. Considerable efforts have been made to manage gall midge through the development and cultivation of resistant rice varieties using identified donor sources. However, the continuous and widespread cultivation of resistant cultivars has exerted strong selection pressure on gall midge populations, leading to the evolution of new virulent biotypes and the subsequent breakdown of host resistance. So far, at least seven distinct gall midge biotypes have been identified in India. Among them, the Warangal population in Telangana has been characterized as a highly virulent biotype (GMB4M), capable of overcoming resistance genes effective against earlier populations (Vijayalakshmi *et al.*, 2006) [20].

Among the available management strategies, host plant resistance remains the most economical, eco-friendly, and sustainable approach for managing rice gall midge (Bentur *et al.*, 2013) [3]. Systematic screening of rice genotypes in endemic areas is essential for identifying stable and durable sources of resistance. In this context, the present investigation was undertaken to identify

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potential donor lines for resistance to gall midge biotype prevailing in Warangal region of Telangana.

2. Materials and Methods

The present study was conducted in the research farm of Regional Agricultural Research Station (RARS), Warangal under Professor Jayashankar Telangana Agricultural University (PJTU), Telangana, India, during the wet season of 2014. A total of 67 rice breeding lines, along with 6 checks viz., ADT 38, CO 43, Abhaya, Aganni, RP 2068-18-3-5, and TN-1 (susceptible check), were screened for resistance to gall midge. The lines were evaluated under the Gall Midge Screening (GMS) trial as per the technical programme given by the Entomology coordinating centre, ICAR-Indian Institute of Rice Research, Hyderabad under All India Co-ordinated Research Project on Rice.

The experiment was conducted under delayed sowing and transplanting conditions to coincide with pest infestation. The seeds were sown in lines on raised nursery beds during 3rd week of July, 2014 and the nursery was maintained as per the standard agronomic practices (Shaik *et al.*, 2014) [17]. The seedlings were transplanted during 3rd week of August, 2014 at a spacing of 20 x 15 cm. The breeding lines were evaluated in an augmented design with each test line transplanted in a single row consisting of 20 plants. TN-1 was grown as infestor rows (thrice in between the test lines) and also planted as border of the experimental block to facilitate uniform and adequate buildup of gall midge population. All recommended agronomic practices were followed throughout the crop growth period, except for plant protection measures, to allow natural infestation of gall midge.

Observations on gall midge incidence were recorded twice *i.e.*, at 31 days after transplanting (DAT) and 49 DAT. Data were collected on the total number of plants, total number of tillers per plant, number of damaged plants with silver shoots, number of silver shoots/damaged plant. Per cent plant damage (% PD) and per cent silver shoots (% SS) were calculated.

The breeding lines were classified based on their reaction to gall midge using the Standard Evaluation System (SES) for rice (IRRI, 2013) [7], considering both per cent plant damage and per cent silver shoot damage (Table 1). Based on the score of silver shoot damage, the lines were categorized as highly resistant (HR), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S), and highly susceptible (HS). Based on plant damage, the lines were categorized as resistant, and susceptible.

Table 1: Standard Evaluation System scale for scoring the reaction against gall midge

Per cent damage	Score	Reaction
Based on Per cent silver shoots		
0	0	Highly Resistant
<1	1	Resistant
1-5	3	Moderately Resistant
6-10	5	Moderately Susceptible
11-25	7	Susceptible
>25	9	Highly Susceptible
Based on Per cent plant damage		
0-10		Resistant
>10		Susceptible

3. Results and Discussion

Infestations of susceptible rice varieties by the Asian rice gall midge (*Orseolia oryzae* (Wood-Mason)) cause an average

annual yield loss of about US\$80 million in India and US\$500 million in Asia (Bentur *et al.* 2003). This insect is essentially a monsoon pest and causes damage wherever high humidity and moderate temperatures prevail (Bentur *et al.* 2003). Infestations of susceptible rice varieties by the Asian rice gall midge (*Orseolia oryzae* (Wood-Mason)) cause an average annual yield loss of about US\$80 million in India and US\$500 million in Asia (Bentur *et al.* 2003). This insect is essentially a monsoon pest and causes damage wherever high humidity and moderate temperatures prevail (Bentur *et al.* 2003). Infestations of susceptible rice varieties by the Asian rice gall midge (*Orseolia oryzae* (Wood-Mason)) cause an average annual yield loss of about US\$80 million in India and US\$500 million in Asia (Bentur *et al.* 2003). This insect is essentially a monsoon pest and causes damage wherever high humidity and moderate temperatures prevail (Bentur *et al.* 2003).

In the present investigation, all the breeding lines and checks were screened under natural field infestation conditions at Warangal, Telangana, a known hotspot for the highly virulent gall midge biotype GMB4M. At 31 DAT, gall midge damage ranged from 0-35.0% plant damage (PD) and 0-5.4% silver shoots (SS) among the lines as against 11.7% PD and 1.5% SS in TN-1. Since the infestation level was insufficient for reliable differentiation among genotypes, resistance scoring was not performed at this stage.

The lines were assessed based on damage score recorded during the second observation when adequate pest pressure was noticed (Table 2). At 49 DAT, TN-1 recorded 81.7% PD, 14.2% SS while the test lines recorded 0-100% PD, 0-23.3% SS. The resistant check Aganni carrying the *Gm8* gene (Kumar *et al.*, 2000) [9], recorded 'nil' damage by gall midge and showed a highly resistant reaction, indicating its effectiveness against the Warangal gall midge population. Similar observations on the resistance of Aganni to gall midge populations prevailing in Telangana were earlier reported by Anusha *et al.* (2022) [11] and Malathi and Padmakumari (2026) [11]. RP 2068-18-3-5 with *gm3* gene (Sama *et al.*, 2014) [16] recorded moderately resistant reaction (score 3) while Abhaya carrying *Gm4* resistance gene (Shrivastava *et al.*, 1994) [18] recorded susceptible reaction (score 7), based on silver shoot damage. These findings further support earlier reports on the highly virulent nature of the Warangal gall midge population (Vijayalakshmi *et al.*, 2006) [20].

Assessment of the test genotypes based on plant damage showed that the plant damage was 'nil' in JGL 19618, RP 5332-54-11-8-2-1-B and was 5% in SKL-3-22-19-31-55-11 (Table 2). All other breeding lines recorded more than 10% PD. Assessment based on silver shoot damage showed that JGL 19618, RP 5332-54-11-8-2-1-B exhibited highly resistant reaction (no damage, score 0) and the line SKL-3-22-19-31-55-11 showed resistant reaction (0.8% SS, score 1). These lines represent valuable sources of resistance that can be effectively utilized in future gall midge resistance breeding programmes. Only one genotype JGL 21002 (4.5% SS, score 3) was categorized under moderate resistance category. But the plant damage was 35% in this genotype.

An interesting observation in the present study was the contrasting reaction among lines derived from resistant parents. Although Abhaya carrying the *Gm4* gene exhibited susceptible reaction under field conditions, its derivative lines JGL 19618 and SKL-3-22-19-31-55-11 showed highly resistant and resistant reactions, respectively. This suggests that recombination and selection in segregating generations may lead to the accumulation of favourable resistance factors contributing to enhanced resistance expression. Similarly, RP 5332-54-11-8-

2-1-B, which exhibited complete resistance, had *Oryza rufipogon* as one of its parental donors. Wild rice species are recognized as valuable reservoirs of genetic diversity for resistance against major biotic and abiotic stresses. The present findings indicate that *O. rufipogon* accessions can serve as a useful donor source for gall midge resistance breeding. Rajan *et al.*, 2025^[15] also highlighted the importance of *O. rufipogon* in broadening the genetic base of cultivated rice for stress resistance and yield improvement.

Nineteen lines CB 011043, JGL 19621, JGL 20616, JGL 20769, JGL 20779, JGL 21126, JGL 21133, JGL 21828, JGL 23640, JGL 23713, JGL 23714, JGL 23745, KNM 113, KNM 539, KNM 563, R1566-2577-2-1530-1, RNR 15227, RNR 17494, UPR 3413-8-2-1 were categorized as moderately susceptible with silver shoot damage ranging from 5.6 to 9.8% (score 5). Out of 67 breeding lines, 44 lines were susceptible (score 7). This further confirms the highly virulent nature of the Warangal gall midge population, which has previously been identified as a distinct and aggressive biotype (Vijayalakshmi *et al.*, 2006)^[20]. Several breeding lines involving Kavya (*Gm1*) and JGL 3855 as parental sources also exhibited susceptible or moderately susceptible reactions, indicating the ineffectiveness of these resistance sources against GMB4M under the tested environmental conditions. Earlier studies also reported breakdown of resistance in varieties carrying single gall midge resistance genes due to continuous selection pressure imposed by evolving gall midge populations (Lingaraj *et al.*, 2008^[10]; Hari *et al.*, 2022^[5]).

Variability is noticed in the resistance reactions across the different breeding lines derived from same cross combination. Such variation may be attributed to segregation and differential selection of progenies during advancement of generations. Simultaneous fixation of desirable combinations of phenotypic acceptability and resistance becomes difficult under conventional selection. This highlights the importance of integrating molecular markers linked to gall midge resistance

genes in breeding programmes for precise identification and selection of resistant genotypes in elite genetic backgrounds. Variability in resistance expression among rice genotypes was also previously reported. Kalode *et al.* (1993)^[8] evaluated 1295 elite rice breeding lines from Directorate of Rice Research, 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 biotype 4 indicating the variation in virulence of gall midge. Sumathi and Manickam, 2013^[19] tested 17 different rice entries at Rice Research Station, Tirur, Tamil Nadu during 2009 and found that the entries viz., RP 4683-29-2-645, RP 4683-30-1-648, RP 4686-49-1- 943, RP 4687-52-2-1197, RP 4688-53-2-1258, RP 4688-53-2-1259, JGL 17025, JGL 17183, JGL 17187, JGL 17189, Kavya, JGL 17190, JGL 17196, JGL 17198, JGL 17211 and JGL 17221 recorded 'nil' gall midge in field and were promising against gall midge. Out of 145 breeding lines, eight breeding lines - JGL 21854, KNM 1625, RDR 1164, RDR 1166, RDR 1170, RDR 1187, RDR 1188 and RDR 1190 - exhibited moderate resistance based on silver shoot damage (Malathi and Padmakumari, 2026)^[11].

Host plant resistance remains the most economical, environmentally safe, and sustainable strategy for gall midge management. However, cultivation of varieties possessing single resistance genes often results in rapid breakdown of resistance due to emergence of new virulent biotypes. Therefore, identification of stable resistance sources effective against highly virulent populations such as GMB4M is essential for developing durable gall midge-resistant rice cultivars. The highly resistant and resistant lines identified in the present study may serve as valuable donor sources in resistance breeding programmes. Further characterization of these lines using gene-specific molecular markers and pyramiding of multiple resistance genes would help in developing durable gall midge-resistant rice varieties suitable for endemic regions.

Table 2: Reaction of different rice breeding lines against gall midge population of Warangal

S. No.	Designation	Cross	% PD	R*	% SS	DS	R**
1	CB 011043	(CO43*4////Kavya)/ (CO43*4////Abhaya)	38.0	S	6.5	5	MS
2	CB 09022	CO 43/Kavya	65.0	S	10.3	7	S
3	CB 11020	CO 43*3////(B 95-1/Tetep)	75.0	S	13.6	7	S
4	CB 11025	ADT 38/ (B 95-1/Tetep)	80.0	S	20.8	7	S
5	CORG 15	CO 43/Kavya	100.0	S	21.2	7	S
6	CORG 24	CO 43/Kavya	100.0	S	19.3	7	S
7	CR 3606-11-3-2-1-1-1	CR 780-1937-2/Ratna// Panikekoa	100.0	S	12.3	7	S
8	JGL 19618	JGL 11609/Abhaya	0.0	R	0.0	0	HR
9	JGL 19621	JGL 3855/MTU 1010	53.0	S	6.0	5	MS
10	JGL 20122	MTU 1010/JGL 11727	85.0	S	10.9	7	S
11	JGL 20171	MTU 1010/JGL 11470	100.0	S	23.3	7	S
12	JGL 20616	IET 20473/JGL 11118	75.0	S	9.8	5	MS
13	JGL 20621	IET 20473/JGL 11118	80.0	S	20.2	7	S
14	JGL 20624	MTU 1010/JGL 11118	60.0	S	17.6	7	S
15	JGL 20753	MTU 1001/JGL 11470	95.0	S	15.5	7	S
16	JGL 20769	MTU 1001/JGL 13595	50.0	S	5.6	5	MS
17	JGL 20776	MTU 1010/JGL 13595	90.0	S	14.0	7	S
18	JGL 20777	MTU 1010/JGL 13595	55.0	S	13.7	7	S
19	JGL 20779	MTU 1010/JGL 13595	75.0	S	8.3	5	MS
20	JGL 21002	MTU 1010/JGL 11727	35.0	S	4.5	3	MR
21	JGL 21034	MTU 1010/JGL 11727	80.0	S	11.2	7	S
22	JGL 21037	MTU 1010/JGL 11727	75.0	S	10.7	7	S
23	JGL 21041	MTU 1010/JGL 11727	90.0	S	12.6	7	S
24	JGL 21051	MTU 1010/JGL 11727	40.0	S	11.3	7	S
25	JGL 21062	MTU 1010/JGL 11470	50.0	S	14.3	7	S

26	JGL 21066	MTU 1010/JGL 11470	90.0	S	18.8	7	S
27	JGL 21071	MTU 1010/JGL 11470	75.0	S	10.2	7	S
28	JGL 21075	MTU 1010/JGL 11470	65.0	S	12.1	7	S
29	JGL 21078	MTU 1010/JGL 11470	70.0	S	10.3	7	S
30	JGL 21099	MTU 1010/JGL 3844	90.0	S	13.7	7	S
31	JGL 21126	MTU 1010/JGL 3855	40.0	S	7.5	5	MS
32	JGL 21133	MTU 1010/JGL 3855	25.0	S	8.7	5	MS
33	JGL 21136	MTU 1010/JGL 3855	70.0	S	13.5	7	S
34	JGL 21143	MTU 1010/JGL 3855	55.0	S	10.5	7	S
35	JGL 21164	MTU 1010/JGL 384	85.0	S	13.6	7	S
36	JGL 21166	MTU 1010/JGL 384	90.0	S	16.0	7	S
37	JGL 21794	MTU 1010/JGL 11118	85.0	S	15.1	7	S
38	JGL 21820	JGL 13535/JGL 11470	90.0	S	17.7	7	S
39	JGL 21828	JGL 13535/JGL 11470	40.0	S	7.8	5	MS
40	JGL 21851	JGL 11118/JGL 11727	90.0	S	11.9	7	S
41	JGL 21868	MTU 1010/JGL 11727	90.0	S	15.3	7	S
42	JGL 21883	MTU 1010/JGL 11470	90.0	S	16.3	7	S
43	JGL 23634	JGL 11470/VD 62	65.0	S	13.5	7	S
44	JGL 23640	JGL 17204/VD 62	100.0	S	9.9	5	MS
45	JGL 23666	JGL 17204/VD 62	70.0	S	16.8	7	S
46	JGL 23710	JGL 13595/VD 62	65.0	S	14.0	7	S
47	JGL 23713	JGL 13595/VD 62	60.0	S	9.0	5	MS
48	JGL 23714	JGL 13595/VD 62	70.0	S	6.6	5	MS
49	JGL 23740	JGL 11727/VD 82	95.0	S	18.9	7	S
50	JGL 23745	JGL 11727/VD 82	80.0	S	9.0	5	MS
51	JGL 23795	Krishna Hamsa/JGL 3844	85.0	S	11.0	7	S
52	JGL 23842	JGL 3844/VD 62	70.0	S	13.8	7	S
53	KNM 113	MTU 1010/JGL 13595	45.0	S	6.0	5	MS
54	KNM 134	WGL 14377/JGL 3844	70.0	S	16.9	7	S
55	KNM 489	JGL 13535/JGL 11470	100.0	S	21.8	7	S
56	KNM 539	JGL 11727/JGL 11470	80.0	S	6.6	5	MS
57	KNM 557	JGL 13595/JGL 11470	65.0	S	17.0	7	S
58	KNM 563	JGL13595/JGL 11470	50.0	S	8.7	5	MS
59	KNM 637	MTU 1010/JGL 3855	75.0	S	11.7	7	S
60	NP 3113-7	NSPG 1833/NSPG 30	55.0	S	13.2	7	S
61	R1566-2577-2-1530-1	IR 64 /Triguna	40.0	S	9.8	5	MS
62	RNR 17472	Kavya/NLR 34449	50.0	S	17.0	7	S
63	RNR 15227	MTU 4870/JGL 1798	60.0	S	8.8	5	MS
64	RNR 17494	MTU 4870/JGL 1798	60.0	S	9.3	5	MS
65	RP 5332-54-11-8-2-1-B	BPT 5204*2/ <i>Oryza rufipogon</i> (acc.106109-5)	0.0	R	0.0	0	HR
66	SKL-3-22-19-31-55-11	Abhaya /Basmati 370 Narendra 359/IR	5.0	R	0.8	1	R
67	UPR 3413-8-2-1	59656-90-3-1	20.0	S	6.3	5	MS
	Check lines						
68	ADT 38	Check	47.0	S	3.4	3	MR
69	CO 43	Check	80.0	S	9.9	5	MS
70	Abhaya	Resistant check	95.0	S	12.8	7	S
71	Aganni	Resistant check	0.0	R	0.0	0	HR
72	RP 2068-18-3-5	Resistant check	50.0	S	4.1	3	MR
73	TN-1	Susceptible check	81.7	S	14.2	7	S

% PD - Per cent plant damage; % SS - Per cent silver shoots;

DS - Damage score; R-Resistance reaction

* Reaction based on plant damage; ** Reaction based on silver shoot damage

4. Conclusion

Among the 67 rice breeding lines screened against the Warangal gall midge population, JGL 19618 and RP 5332-54-11-8-2-1-B exhibited highly resistant reaction, while SKL-3-22-19-31-55-11 showed resistant reaction under natural field infestation conditions. The study confirmed the highly virulent nature of the Warangal gall midge population (GMB4M), as a majority of the breeding lines and known resistant donor Abhaya exhibited susceptible reactions. The identified resistant lines may serve as valuable donor sources for future gall midge resistance breeding programmes and can be further characterized using molecular markers for effective deployment in gene pyramiding strategies.

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Competing Interests

Authors have declared that no competing interests exist.

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