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Reaction of gene differential rice varieties against gall midge, *Orseolia oryzae* (Wood-Mason) biotype at Warangal, India

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Abstract
The Asian rice gall midge, *Orseolia oryzae* (Wood-Mason) (Diptera: Cecidomyiidae) is a serious pest of rice (*Oryza sativa* L.) in India. Seven distinct biotypes of the Asian rice gall midge population have been characterized so far from different parts of India. Warangal gall midge population designated as biotype 4M. In order to identify the prevailing rice gall midge biotypes, a study was carried out under natural field conditions at RARS, Warangal. A set of 16 standard rice differentials representing five groups already identified to characterize the prevailing rice gall midge biotypes in the country were evaluated against gall midge population. Based on earlier studies, resistance against biotype 4M confirmed only through the IV group differentials with resistance genes *viz., gm3, Gm4 and Gm8.* The results of present study revealed that the reaction of differential of group I, II, III and V (TN1, Susceptible check) showed susceptibility during both the years *i.e., kharif,* 2011-12 and *kharif,* 2012-13 whereas, reaction of group IV differentials was not stable and changed year after year. Based on this study, it was found that the biotype at RARS, Warangal was not following any prescribed pattern of the seven identified biotypes, indicating a change in the reaction pattern of standard differentials to gall midge biotype 4M with virulence against the resistant group IV rice differentials.

Keywords: rice gall midge, *Orseolia oryzae,* biotypes, rice differentials

Introduction
Rice (*Oryza sativa* L.) is known as "Global Grain" and is the world's most important food crop which is a primary source of carbohydrate for more than half of the world's population. India stands first in rice area with 44.62 million hectares under cultivation and second in rice production by contributing to 26 per cent of global rice production accounting to 161.5 million tonnes (FAO, 2016) [1]. However, many biotic and abiotic stresses often limit rice production. Among the biotic stresses, 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. Gall midge being endophytic, breeding resistant rice varieties has been a viable and ecologically acceptable approach for management of this pest (Heinrichs and Pathak, 1981) [2]. Since 1970 more than 56 high yielding gall midge resistant rice varieties having different genes for resistance have been released for commercial cultivation (Bentur *et al*., 2003) [3]. After the widespread cultivation of high yielding gall midge-resistant rice varieties in farmer fields, different populations or biotypes were observed (Singh, 1996) [4]. But the emergence of new virulent biotypes of gall midge in popular rice varieties is capable of overcoming resistance and this is a cause for concern. So far, seven biotypes (GMB1 to GMB6 and GMB4M) of gall midge and 11 gall midge resistance genes (Gm1, Gm2, gm3, Gm4, Gm5, Gm6, Gm7, Gm8, Gm9, Gm10 and Gm11) have been identified (Vijayalakshmi *et al*., 2006 and Himabindu *et al*., 2010) [5, 6]. At Warangal, Ragolu and Jagtial biotypes GMB4M, GMB4 and GMB3, respectively, have been reported to occur. It has been reported that the resistance genes, gm3, Gm4 and Gm8 confer resistance against gall midge biotypes 1, 2, 3, 4 and 4M (Vijayalakshmi *et al*., 2006; Bentur *et al*., 2009; Dutta *et al*., 2014) [5, 7, 8]. Geographical distribution of these biotypes has been well mapped and is being monitored annually through the national gall midge biotype-monitoring studies under the All India Coordinated Rice Improvement Programme. In many endemic locations of the country, the emergence of new virulent population capable of overcoming resistance has been recorded (Srinivas *et al*., 1994) [9]. Keeping this in view, the present investigation was undertaken.

Material and Methods

A field experiment to identify prevailing rice gall midge biotypes were conducted at Regional Agricultural Research Station, Warangal during *Kharif*, 2011-12 and 2012-13. A set of 16 standard rice differentials (Table 1) representing 5 groups identified to characterize the prevailing gall midge biotypes in the country by Indian Institute of Rice Research (IIRR), Hyderabad under multi location trial of All India coordinated Rice Improvement Programme (AICRIP) were sown, coinciding with the peak incidence of gall midge. Each differential of 20-25 old seedlings were planted in single row consisting 20 hills in each row with spacing of 20x15 cm between rows and plants, respectively. For every ten test entries susceptible check, TN1 were sown. To increase the level of infestation by creating higher relative humidity, constant water level of 5 inches in the field was maintained and 25 per cent excess nitrogenous fertilizer (urea) was applied. All the recommended agronomic practices were followed to raise the crop. No plant protection measures were followed to allow the pest population build up under natural conditions. The test differentials were scored for plant damage at 50 days after transplanting (DAT). Observations on total number of plants, number of damaged plants (with silver shoots), total number of tillers and number of silver shoots were recorded at 30 and 50 days after transplanting (DAT). Per cent damaged plants with silver shoots and per cent silver shoots were calculated as per the following formulae.

$$\text{Per cent Damaged plants (\%DP)} = \frac{\text{Damaged plants}}{\text{Total number of plants}} \times 100$$

$$\text{Per cent Silver shoots (\%SS)} = \frac{\text{Number of silver shoots}}{\text{Total number of tillers}} \times 100$$

Each entry under five groups was rated either resistant (R) (with less than 10% plant damage) or susceptible (S) with higher damage (Kalode and Bentur, 1989). Based on their pattern of resistance or susceptibility, the biotypes at RARS, Warangal are differentiated as biotype 1 (R-R-R-R-S), biotype 2 (S-R-R-R-S), biotype 3 (R-S-R-R-S), biotype 4 (S-S-R-R-S), biotype 4M (S-S-S-R-S), biotype 5 (R-R-R-S-S) and biotype 6 (R-S-S-S-S), (Vijaya Lakshmi *et al*., 2006) [5].

Results

The standard set of 16 differentials, representing five groups carrying all the 11 known resistance genes, unknown genes and susceptible check, TN1 was evaluated at RARS, Warangal during *kharif*, 2011-12 and 2012-13. It was general observation that relatively higher quantum of the incidence of silver shoot (SS%) and plant damage was observed during 2011-12 as compared to that of *kharif*, 2012-13.

During *kharif* 2011-12, the incidence of gall midge was moderate to high. Per cent silver shoot damage among the differentials ranged from 0 to 34.7 and plant damage ranged from 0 to 100 per cent. In susceptible check, TN 1 silver shoot and plant damage recorded was 26.24 and 100.00 per cent, respectively. All the differentials of group I, II, III and V (TN1, Susceptible check) showed susceptibility. However, among the five differentials in group IV, three differentials *viz*., RP 2068-18-3-5, ABHAYA and B95-1 showed susceptibility while the remaining two differentials *viz*., Aganni recorded lowest silver shoot and plant damage of 0.85 and 10 per cent, respectively and INRC 3021 recorded nil damage (Table 1).

During *kharif* 2012-13, the incidence of gall midge was low to moderate. Per cent silver shoot damage among the differentials ranged from 4.5 to 14.1 and plant damage ranged from 40 to 100 per cent. In susceptible check, TN 1 silver shoot and plant damage recorded was 8.6 100.00 per cent, respectively (Table 2). Among 15 differentials and one susceptible check (TN1) screened against gall midge biotype 4M, all 15 differentials and TN1, susceptible check showed susceptibility.

Pooled data of two years revealed the similar trend *i.e.*, all 15 differentials and TN1, susceptible check showed susceptibility (Table 3). The reaction pattern of the different sets of rice differentials against gall midge to determine the biotypes at RARS, Warangal revealed that the reaction of differential of group I, II, III and V (TN1, Susceptible check) showed susceptibility whereas, reaction of group IV differentials was not stable and changing year after year *i.e*., they were resistant one year and susceptible next year. Variations within a resistance group which may have been due to different levels of resistance among the varieties which may be due to sources of resistance from the donor parent.

Warangal gall midge population is designated as biotype 4M. Based on earlier studies, resistance against biotype 4M confirmed only the differentials with resistance genes viz., *gm3, Gm4 and Gm8* (Vijaya Lakshmi *et al*., 2006) [5].

Overall results of the present investigations revealed that the resistance and susceptibility of differentials tested at RARS, Warangal did not exhibited any standard known reaction pattern of biotypes existing in India *i.e.*, biotype 1 (R-R-RR-S), biotype 2 (S-R-R-R-S), biotype 3 (R-S-R-R-S), biotype 4 (S-S-R-R-S), 4M (S-S-S-R-S), biotype 5 (R-R-R-S-S) and biotype 6 (R-S-S-S-S) (Vijaya Lakshmi *et al*., 2006) [5], indicating a change in the reaction pattern of standard differentials to gall midge biotype 4M with virulence against the resistant group IV rice differentials. However, further extensive field and green house studies have to be conducted to find out the biotype existing at RARS, Warangal.

The present results are in conformity with the results of Kumar *et al* (2007) [10] who reported that the reaction of 14 standard differentials, in four groups, during 2004–2006 recorded a progressive change in their reaction pattern against virulent rice gall midge populations at Agricultural Research Station, Mangalore. Similar variable reaction patterns when studied with 14 rice differentials was observed by Anna Diana (2004) [11] where in the differentials in Group II viz., Phalguna (Gm2), ARC 5984 (Gm5), Bhumansan (Gm7 (t)+(Gm8(t)) were found to be resistant and CRMR 1523 of Group III showed susceptibility with an infestation of 10.71 per cent, slightly deviating from the reaction of pattern exhibited by biotype I (R-R-R-S).

In the present study also, among all the rice differentials tested, the differentials in Group IV *viz*., INRC 3021 (*Gm8* gene) was found most promising followed by (Aganni (*Gm8* gene) during *kharif*, 2011-12 whereas these differentials showed susceptibility during *kharif*, 2012-13. Similarly, under gall midge population monitoring trial during 2015 at Warangal, Sakoli and Ragolu revealed that only Aganni (Gm8) holds promise at Sakoli and Ragolu where as other differentials were found to be infested with gall midge. At Warangal, low virulence was observed on Aganni (Gm8) (Progress report, IIRR, 2016) [12]. Similar virulence was observed even during 2016 (Progress report, IIRR, 2017) [13].

Virulence in rice differentials of group IV *viz*., Aganni (*Gm*8)

and INRC 3021(*Gm*8) indicated the necessity of continuous monitoring of virulence pattern of the local gall midge population through field and green house studies to take necessary steps in the resistance breeding programmes or formulate other management strategies.

Table 1: Reaction of differentials to gall midge population at RARS, Warangal during *kharif*, 2011-12

Group	Entry No.	Differential	Gene	2011-12		
				%DP	%SS	R/S
I	1	KAVYA	Gm 1	100	24.3	S
	2	W 1263	Gm 1	100	15.2	S
	3	ARC 6605	(?)	100	18.8	S
II	4	PHALGUNA	Gm 2	100	26.2	S
	5	ARC 5984	Gm 5	80	10.7	S
	6	DUKONG 1	Gm 6	100	26.4	S
	7	RP 2333-156-8	Gm 7	60	10.2	S
	8	MADHURI L 9	Gm 9	100	24.9	S
	9	BG 380-2	Gm 10	100	S	S
III	10	MR 1523	Gm 11	100	20.0	S
IV	11	RP 2068-18-3-5	gm 3	70	9.1	S
	12	ABHAYA	Gm 4	70	9.1	S
	13	INRC 3021	Gm8	0	0.0	R
	14	AGANNI	Gm8	10	0.9	R
	15	B 95-1	none	100	34.7	S
V	16	TN1	none	100	26.2	S

Note: DP – Damaged Plants; SS- Silver Shoots; R- Resistant; S-Susceptible

Table 2: Reaction of differentials to gall midge population at RARS, Warangal during *kharif*, 2012-13

Group	Entry No.	Differential	Gene	2012-13		
				%DP	%SS	R/S
I	1	KAVYA	Gm 1	50	4.5	S
	2	W 1263	Gm 1	60	5.5	S
	3	ARC 6605	(?)	80	8.3	S
II	4	PHALGUNA	Gm 2	80	6.8	S
	5	ARC 5984	Gm 5	70	9.8	S
	6	DUKONG 1	Gm 6	70	7.6	S
	7	RP 2333-156-8	Gm 7	80	6.4	S
	8	MADHURI L 9	Gm 9	90	12.1	S
	9	BG 380-2	Gm 10	100	12.4	S
III	10	MR 1523	Gm 11	60	7.3	S
IV	11	RP 2068-18-3-5	gm 3	60	5.7	S
	12	ABHAYA	Gm 4	60	4.8	S
	13	INRC 3021	Gm8	50	4.8	S
	14	AGANNI	Gm8	40	5.8	S
	15	B 95-1	None	90	14.1	S
V	16	TN1	None	100	8.6	S

Note: DP – Damaged Plants; SS- Silver Shoots; R- Resistant; S-Susceptible

Table 3: Reaction of differentials to gall midge population at RARS, Warangal (Pooled data of two years *i.e. kharif*, 2011-12 and *kharif*, 2012-13)

Group	Entry No.	Differential	Gene	Pooled data		
				%DP	%SS	R/S
I	1	KAVYA	Gm 1	75	14.4	S
	2	W 1263	Gm 1	80	10.35	S
	3	ARC 6605	(?)	90	13.55	S
II	4	PHALGUNA	Gm 2	90	16.5	S
	5	ARC 5984	Gm 5	75	10.25	S
	6	DUKONG 1	Gm 6	85	17	S
	7	RP 2333-156-8	Gm 7	70	8.3	S
	8	MADHURI L 9	Gm 9	95	18.5	S
	9	BG 380-2	Gm 10	100	12.4	S
III	10	MR 1523	Gm 11	80	13.65	S
IV	11	RP 2068-18-3-5	gm 3	65	7.4	S
	12	ABHAYA	Gm 4	65	6.95	S
	13	INRC 3021	Gm8	25	2.4	S
	14	AGANNI	Gm8	25	3.35	S
	15	B 95-1	None	95	24.4	S
V	16	TN1	None	100	17.4	S

Note: DP – Damaged Plants; SS- Silver Shoots; R- Resistant; S-Susceptible

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