EXTENDED ABSTRACT

EVALUATION OF RESISTANT LEVELS OF DIFFERENT RICE BREEDING MATERIALS AGAINST RICE GALL MIDGE (*Orseolia oryzae*)

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Abstract
The rice gall midge (RGM), *Orseolia oryzae* (Diptera: Cecidanyiidae) is one of the major pest of rice in Asia including Sri Lanka. In this study, screening of rice lines and varieties were done against RGM to identify resistant level of selected rice lines for RGM. Total number of hills and the number of galls were recorded and percentages were compared. As infestation ranges, 16%- 17% and 18%-30% were showed for 2020 *Yala* and 2020-21 *Maha* seasons respectively. In 2020 *Yala*, and 2020-21 *Maha*, 1585 and 1098 breeding materials were tested separately. Out of them, 8 were resistance, 50 were resistance/ moderate resistance and 88 were moderately resistance. Furthermore, 4 lines were identified as resistant for RGM through accession lines those that can be used as resistant sources to RGM after identifying their mechanism of resistance. The findings of current study provide better insights for future breeding programs while ensuring sustainability.

Keywords: Accession lines, rice gall midge, screening, infestation

1. Introduction

The rice gall midge (RGM), *Orseolia oryzae* (Diptera:Cecidanyiidae) is a major rice pest in certain regions of Asia including Sri Lanka and occurs in Africa. The RGM was first reported in Bihar, India in 1880 as a rice pest (Fernando, 1971). Major characteristic symptom of gall midge infestation is the production of "silver shoots" which prevents panicle production thus may lead severe crop losses. As a result of feeding and secreting saliva (chemicals in saliva) by the larvae of RGM, the shoot meristem turns into a gall (Chiu- Shin, 1980). Due to suppression of differentiation of leaf primodia at the growth cone and the development of radial ridges from the innermost primodia followed by leaf sheath elongation are the key reasons for gall formation (Perera and Fernando, 1970). Previous studies revealed that the control of gall midge is very difficult. Therefore, it is needed to identify resistant varieties for rice gall midge to manage its infestation up to certain level by enhancing sustainability.

In Sri Lanka development of RGM resistance rice varieties was initiated in 1969 at two locations, Central Agricultural Research Institute, Gannoruwa and Central Rice Breeding Station, Batalagoda (Gunadasa et al., 2000). Initially, the breeding program in Bathalogoda was done using Indian

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breeding lines of Ftb 18 and 13 Eswarakora as donor parents (Weeraratne et al., 1974) and breeding programs are doing up to now. There are several resistant to moderate resistance varieties are recommended by Department of Agriculture against two existing biotypes in Sri Lanka, Biotype I and Biotype II.

Considered about 2019-20 *Maha*, 2020 *Yala* and 2020-21 *Maha*, high infestation of RGM and 50% to 100 % damage severity of above pest were reported in several parts of Sri Lanka especially in Huruluwewa (Mahawali H), Dambulla, Kekirawa and Galewela agrarian service divisions. According to the field observation, the most favorable environmental conditions for RGM prevailed in the above seasons, were major reasons for the widespread and yield losses from RGM attack. Apart from that, farmers' inability to identify the damage of RGM at the correct time at the correct growth stage of rice plants and late application of suitable controlling measures were another main motive for such devastations from RGM. Therefore, cultivation of resistance varieties against RGM is the most suitable method for minimizing the yield losses as well it helps to maintain environmental sustainability and reducing the cost of production by improper application of insecticides to controlling the RGM. In addition to that, new resistance sources can be used in the various breeding programs to get more successful results. For proper classification of biotypes, it is needed to identify resistance genes and to develop isogenic lines. However, effective and efficient control of RGM can be achieved through utilization of the resistant varieties, in combination with chemical, cultural and biological control. The current study was conducted to identify different resistant levels of promising rice lines against the existing biotypes of RGM.

2. Methodology

This screening program was conducted in National Coordinated Rice Varietal Testing (CRVT), Major Yield Trial (MYT) , Preliminary Yield Trial (PYT) and Progeny research plots established in Rice Research and Development Institute RRDI, Batalagoda for 2020 *Yala* and 2020-21 *Maha*. In 2020 *Yala*, 1585 progeny lines were tested in 4 – 4 ½ month, 3 ½ month and 3 month. In 2020-21 *Maha*, 1098 lines were used. Here, Bg94-1 was used as a susceptible check variety and data were collected when susceptible variety showed more than 15% of the plants with infested silver shoots after six weeks of the transplanting. For the transplanted plots in MYT and PYT, data were taken from 200 plants/ replicate for each treatment. When lines and varieties were broadcasted, CRVT data were taken using the quadrant by randomly placing it into each treatment and replicate. Total number of hills and the number of galls were recorded according to the method described by Heinrichs in 1981 and IRRI. Finally, the number of infested galls per hill was taken as a percentage and compared with "range and level of resistance for RGM" values indicated in the Table 1.

Table 1. Range and level of resistance for RGM

Percentage of Infestation	Level of resistance
0 – 1%	R
1 - 3%	R/MR
3 - 5 %	MR
5 - 7%%	MR/MS
7 - 15%	MS
15% <	S

R – Resistance MR – Moderately Resistant MS - Moderately Susceptible S – Susceptible

3. Results and Discussion

When considered about data obtained for 2020 *Yala* and 2020-21 *Maha* field screening against the RGM, it showed 16 % - 17% and 18 % - 30% infestation range according to the susceptible variety Bg94-1in above seasons respectively. Test could be considered as a valid test. In 2020 *Yala*, two lines were (R) resistance to RGM in 4 – 4 ½ month age group out of tested 1585 progeny lines,22 lines were R/MR Resistance/Moderately Resistance and 30 progeny lines were MR Moderately Resistance in above age group. No any Resistance lines were identified in 3 ½ month age category in the same season but 4 R/MR lines and 10 MR lines were identified. In 3 month age group, 10 lines were R/MR and 16 lines were MR while no any completely resistance lines. According to the screening results in 2020-21 *Maha* season, four lines (AC 230 (Sulai), AC 271 (Heen Sulai)), AC 277 (Bw78) and 1344) could be identified as R to RGM from accession lines screening program. In 4 – 4 ¼ month age category, 2 line were R, 2 line were R/MR and 2 line were MR from 423 progenies. By screening of 239 progenies from 3 ½ month age group, two R/MR lines and one MR line were identified. Rice progenies from hybrid rice breeding division, nine R/MR lines and fourteen MR lines were identified out of the 436 progeny lines. Totally forty PYT lines from 4 – 4 ½ month age group, 3 ½ month age group, 3 month age group and 2 ½ month age group were evaluated in 2020 *Yala* season. From them, five MR lines were identified from 4 – 4 ½ month age group and another two MR lines were identified from 2 ½ month age group. All other lines evaluated from 3 month age group and 3 ½ month age group were susceptible to RGM in above seasons. Thirty four MYT lines were evaluated against RGM in 2020 *Yala*. Among them, one R/MR line and two MR lines were identified from 4 -4 ½ month age group. The tested other lines were not perfectly reacted to the RGM. Considered about 2020-21 *Maha* season, fifteen rice lines and varieties were tested for 4 – 4 1/2 month age group and four MR lines were identified from above tested lines and varieties. Although tested lines were not perfectly reacted to RGM in 3 month and 3 ½ month age group, there were 2 lines which identified as MR in 2 ½ month age category.

Table 2. Reactions and Scores for CRVT rice lines in 2020 *Yala* and 2020-21 *Maha* against RGM for 3½ month age group

	2020 Yala		*2020-21 Maha*	
Line/ Variety	Average infested plants percentage	Reaction	Average infested plants percentage	Reaction
Bg16 TC 80	11.97	MS	14.23	MS
Bw14-7-5	7.89	MS	11.40	MS
BwBLB 72-1	7.57	MS	7.49	MS
MA2	9.6	MS	10.00	MS
At362+	13.49	MS	4.23	MR
Bw372+	2.77	R/MR	2.85	MR
Bg366+	13.68	MS	9.36	MS
Bg357+	1.33	R/MR	2.49	R/MR
Bg94-1*	16	S		

Bg94-1 Susceptible Check Variety +- Standard Varieties
R– Resistant MR – Moderately Resistant MS - Moderately Susceptible S – Susceptible

According to an average infested percentage and reactions (Table 2) most tested test lines in 3 ½ month age group were moderately susceptible to RGM. In three month age group, only one line, namely At14-713 responded as R/MR against RGM in both 2020 *Yala* and 2020-21 *Maha* seasons. But the varietal resistance for RGM was reported over a century ago. Apart from that, RGM resistant rice breeding programs were initiated during late 1950s and the first developed RGM resistant rice variety especially through hybridization process was released 1975 for the cultivation. Field evaluation of local rice germ plasm in these two decades identified several sources of resistance such as Eswarakora, Siam29, Ptb10, Ptb18 and several others, which were used in developing new

Table 3. Reactions and Scores for CRVT rice lines in 2020 *Yala* and 2020-21*Maha* against RGM for 3 month age group

	2020 *Yala*		2020 -21*Maha*	
Line/ Variety	Average infested plants percentage	Reaction	Average infested plants percentage	Reaction
Bw15-3-1309	8.02	MS	5.77	MR/MS
At13.-1532	19.69	S	6.57	MR/MS
At14-713	2.57	R/MR	2.05	R/MR
At303+	25.84	S	7.72	MS
Bg300+	13.6	MS	5.72	MR/MS
Bg94-1*	16	S		

Bg94-1 Susceptible Check Variety |+- Standard Varieties
R– Resistant MR – Moderately Resistant MS - Moderately Susceptible S – Susceptible

resistant cultivars (Bentur et al., 2013). According to the Bentur et al., 2013, search for new sources of gall midge resistance has been a continuous endeavor through field screening and greenhouse evaluation. Furthermore, Kogel and Langen, 2005 and Balmer et al., 2013 revealed that majority of research in relation to the defense mechanism have been done for dicotyledonous species such as tobacco and Arabidopsis, whereas in economically important cereal crops like rice, the mechanism of defense against insects is less understood. But Pioneering research has been done on wheat-Hessian fly interactions (Mittapalli et al., 2006, Subramanyam et al., 2013) and now initiated in the case of rice-gall midge (*Orseolia oryzae*) interactions as well. Still RRDI in Sri Lanka, is doing screening programs for RGM as well as other major rice pests. During every rice growing season, such programs are done and reported the data which are obtained through them. Now as an policy, if a variety that have to be released into the commercial market for the cultivation it must be either resistant or moderately resistant to Brown Planthopper (BPH) and RGM. This policy was developed to control the RGM and BPH incidence within the country. Therefore, screening programs are very important to identify the resistant levels of different rice varieties available in Sri Lanka. However, deployment of naturally occurring resistance is probably the most environment friendly way of developing gall midge resistant rice varieties which helps to ensure the sustainable agriculture within the country.

4. Conclusions

During the screening test conducted in 2020-21 *Maha* season four lines (AC 230 (Sulai), AC 271 (Heen Sulai)), AC 277 (Bw78) and 1344) could be identified as R to RGM from accessing lines screening program and those lines can be used as resistant sources to RGM after identifying their mechanism of resistance. Those selected lines were suggested for further breeding program. Emergence of many gall midge bio types has limited the use of resistance genes for resistant varieties. But systematic search for new and effective sources of resistance that are effective against RGM are necessary in future breeding programs.

References

Balmer, D., Planchamp, C., Mauch-Mani, B., 2013. On the move: induced resistance in monocots. *Journal of Experimental Botany* 64: 1249-1261.

Bentur, J.S., Rawat, N., Sinha, D.K., Nagaraju, J., Nair, S., 2013. New genetic avenues for insect pest management in rice as revealed by studies on gall midge, in: Muralidharan, K., Siddiq, E.A., (Eds.), International Dialogue on Perception and Prospects of Designer Rice. *Society for Advancement of Rice Research, Directorate of Rice Research, Hyderabad, India* 185-187.

Fernando, H. E. (1971). 17. Ecological studies on the rice gall midge in Ceylon. In *Proceedings of a Symposium on Tropical Agriculture Researches, 19-24 July, 1971* (No. 5, p. 291).Tropical Agricultural Research Center, Ministry of Agriculture and Forestry.

Gunadasa, A.H. (2000). Development of Gall Midge Resistant Rice Vareities. *ASDA* 2: 101-111.

Heinrichs, E. A. (1981). Reactions of differential varieties to the rice gall midge Orseoliaoryzae in Asia. Report of an international collaborative research project.

Heinrichs, E.A. and Pathak, P.K. (1980).Resistance to the rice gall midge, Orseoliaoryzae in rice. *International Journal of Tropical Insect Science* 1(2): 123-132.

Kogel, K.H., Langen, G., (2005). Induced disease resistance and gene expression in cereals. *Cellular Microbiology* 7: 1555–1564.

Mittapalli, O., Shukle, R., Sardesai, N., Giovanini, M.P., Williams, C.E. (2006). Expression patterns of antibacterial genes in the Hessian fly. *Journal of Insect Physiology* 52: 1143-1152.

Perera, N., & Fernando, H. E. (1970). Infestation of young rice plants by the rice gall midge, Pachy diplosisoryzae (Wood-Mason)(Dipt., Cecidomyiidae), with special reference to shoot morphogenesis. *Bulletin of Entomological Research* 59(4): 605-613.

Shin-Foon, C. (1980).Integrated control of rice insect pests in China. *International Rice Research Institute and Chinese Academy of Agricultural Sciences* 239.

Subramanyam, S., Zheng, C., Shukle, J.T., Christie, E., Williams, C.E. (2013). Hessian fly larval attack triggers elevated expression of disease resistance dirigent-like protein-encoding gene, HfrDrd, in resistant wheat. *Arthropod-Plant Interaction* 7: 389-402.