RESEARCH ARTICLE

Evaluation of rice genotypes for brown planthopper resistance

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ABSTRACT

Brown planthopper (Nilaparvata lugens) (BPH) is a major pest of rice in Sri Lanka. Identification of new resistance sources has immense important in varietal improvement programme. Therefore, twenty-five rice genotypes including new improved, exotic and traditional varieties were evaluated for BPH resistance using standard seed box screening technique and honeydew test to identify resistant varieties. During screening Ptb 33 was used as resistant variety. TN1 and Bg 380 were used as susceptible varieties. Bg 380 showed highly susceptible reaction. Ptb 33 had the highest level of BPH resistance with lowest damage score of 3.0. Bg 300, Bg 352, Bg 379-2, Bg 450 and Bw 367 which are popular varieties recorded damage score of 4.7 to 5.6 which categorized as moderately resistant reactions. Similarly, two exotic lines, IR 65482-7-216-2 and IR 71033-121-15 showed moderately resistant reaction too. Among the traditional rice cultivars, Mudukiri el, Horana ma wee, Hondarawala and Mada el showed resistant to moderately resistant reactions. According to the present study, Bg 379-2 and IR 71033-121-15 were the better donor parents for BPH resistance since those varieties having good plant architecture and yield.

Keywords: *Brown planthopper, pest, resistant, honeydew test*

INTRODUCTION

Brown planthopper (BPH), *Nilaparvata lugens* (Stal) is one of the most serious insect pests of rice, and it causes severe damage and frequent outbreaks. It causes huge yield losses every year in rice grown throughout tropical, subtropical and temperate areas in Asia (Park *et al*., 2008). An average of 5-10% of rice lands of the Sri Lanka is affected annually due to BPH damage (Nugaliyadde *et al*., 2001). At high pest density, it's feeding damage causes "hopper burn" or complete wilting and drying of the rice plant. In addition to direct damage, BPH also act as a vector for ragged stunt virus and grassy stunt virus (Park *et al*., 2008; Jena *et al.,* 2006).

Development of resistant rice cultivars through host plant resistance is generally considered to be the most economic and effective way for controlling BPH damage. Pathak and Kush (1979) reported that most traditional rice varieties and wild rice species were resistance to BPH. Some of these resistances have successfully been incorporated into varietal gene-bases and helped reduce BPH out breaks and increase rice production in many Asian countries (Panda and Khush, 1995). Break down of varietal resistance due to rapid adaptation of pests to previously resistance varieties requiring replacement of new sources of resistance. This is a major challenge to national rice improvement programme in Sri Lanka (Nugaliyadde *et al.*, 2000).

The long-term stability of the resistant varieties is threatening because of the evolution of prolific bio types of BPH which can destroy these varieties (Roderick, 1994). Among the different chemical and biological control methods available, utilization of host resistance has been recognized as one of the most economic and effective measures for BPH management (Chao *et al.,* 2006).

This study was conducted with the objective of identification of new sources of resistance and verification of already reported donors to improve the effectiveness in rice breeding programs.

MATERIALS AND METHODS

The experimental materials for BPH reaction consisted of 25 rice accessions along with 6 released varieties. Ptb 33 was used as resistant variety while Bg 380 was used as a local susceptible variety and TN 1 as universal susceptible variety. The experiment was conducted at Rice Research & Development Institute, Batalagoda in *Maha* 2016/17 and *Yala* 2017.

Screening for BPH resistance

Standard seed box screening test (SSST)

Table 1: Standard evaluation system for rating damage by brown planthopper (BPH), *Nilaparvata lugens.*

Scale value	Symptoms	Reaction
0	No damage	Immune (I)
1	Slight yellowing of few plants	Highly resistant (HR)
3	First and 2^{nd} leaves of most plants partially yellowing	Resistant(R)
5	pronounced yellowing and stunting or about 10-25% of the plants wilting or dead and remaining plants severely stunted or dying	Moderately resistant(MR)
7	more than half of the plants wilting or dead	Moderately susceptible(MS)
9	all plants dead	Highly susceptible(HS)

Screening was done by using standard seed box technique (Anon, 1988) at the BPH screen house of RRDI, Batalagoda. The dry seeds at the rate of 40-50 were sown in galvanized iron trays along with resistant and susceptible check with the two replications as randomized manner. Ten-day old seedlings were infested with fifth nymphal stage at the rate of eight to ten hoppers per seedlings.

Approximately, one week after infestation, "hopperburn" symptoms were observed (Table 1). The genotypes were scored based on scoring system developed by the International Rice Research Institute and each entry was scored according to Table 1 (IRRI, 2014). Average of two scores was considered in interpreting results and it was based on standard evaluation system where the families with a mean rating of 0 to 3, 3.1 to 6.9 and 7 to 9 were designated as resistant, moderately resistant and susceptible, respectively.

Feeding rate

The preference of BPH for each selected rice varieties was assessed by estimating the amount of honeydew excreted by the adult hoppers as an indication of the feeding preference. Whatman no.1 filter paper was dipped in a 0.02% bromo-cresol green solution in ethanol and allowed to dry for one hour and dipped again till the filter paper turned yellowish orange. The treated paper was then placed on the plastic petri dish kept at the base of 30 d old plants. A plastic cup was placed over the filter paper and two hoppers which pre-starved for 3-4 h were released into the feeding chamber using insect aspirator. The BPH were allowed to feed for 24 h at the base of the stem. The honeydew droplets excreted by the hoppers when came in contact with the filter paper turned into blue spots. The area of blue spots appeared on filter paper as a result of honey dew excretion was measured by graph method. The antibiosis effect on feeding among the rice varieties were determined by comparing the average area of honeydew excreted in mm^2.

Statistical analysis

The honeydew test data were analyzed using the procedure of ANOVA and mean separation was done following Duncan Multiple Range Test using SAS computer software package version 9.1.

RESULTS AND DISCUSSION

The results of phenotypic response of rice genotypes to BPH screening at seedling stage indicated varied genotypic responses (Table 2).

Resistant reaction of the varieties in seedling screening

The 25 rice varieties were scored as 3.0 to 6.1 in standard seed box screening test with varying resistant to moderately susceptible. Among the genotypes screened some of the improved varieties (Bg 300, Bg 352, Bg 379-2) and selected traditional varieties (*Rathuheenati*, *Mudukiri el*, *Horana ma wee*, *Hondarawala*, *Hathi el*, *Mada el*, *Murungakayan*) were found moderately resistant reactions to BPH (Table 2). Among the rice varieties Bg 380, Bg 450, Bw 367 and WH 20 showing moderately susceptible reactions which recorded average damage score ranged from 5.6 to 6.1 (Table 2). The variety Ptb 33 with the score of 3.0 considered as resistant to BPH.

Table 2: Reactions of different genotypes to Brown Plant Hopper under Standard seed box screening technique and amount of honeydew excretion.

Variety name	Accession Number	Damage Score 2016/17 *Maha*	Damage Score 2017 *Yala*	Reaction 2016/17 *Maha*	Reaction 2017 *Yala*	Average Damage score over 2 season	Amount of honeydew in 24 h (mm^2)
Resistant variety							
Ptb 33	-	3.0	3.0	R	R	3.0	3.08^{d}
Improved/Exotic varieties							
IR 71033-121-15	-	3.2	5.5	R/MR	MR	4.35	2.17^{d}
Bg 379-2	-	4.7	4.7	MR	MR	4.7	3.08^{d}
WH 48	-	4.5	5.7	MR	MR	5.1	3.75^{d}
Bg 300	-	5.0	5.7	MR	MR	5.35	8.25^{d}
Bg 352	-	4.7	5.0	MR	MR	4.85	7.58^{d}
IR 65482-7-216-2	-	5.0	5.5	MR	MR	5.25	15.50^{bcd}
ASD 7	BgAc 1075	5.0	5.2	MR	MR/MS	5.1	9.92^{d}
Bg 450	-	5.7	5.5	MR/MS	MR	5.6	15.17^{bcd}
WH 20	-	5.5	6.0	MR/MS	MS	5.75	24.58^{bcd}
Bw 367	-	6.0	5.2	MS	MR/MS	5.6	6.33^{d}
Traditional varieties							
Horana Ma wee	*BgAc 40*	*4.5*	*3.2*	*MR*	*R/MR*	*3.85*	1.08^{d}
	BgAc 41	*3.2*	*5.7*	*R/MR*	*MR*	*4.45*	1.00^{d}

Hondarawala	*BgAc 284*	*3.2*	*3.3*	*R/MR*	*R/MR*	*3.25*	*4.58*[d]
	BgAc 987	*3.2*	*3.2*	*R/MR*	*R/MR*	*3.2*	*2.17*[d]
Rathuheenati	*BgAc 725*	*4.7*	*4.7*	*MR*	*MR*	*4.7*	*49.08*[bc]
Mudukiri el	*BgAc 783*	*4.5*	*4.5*	*MR*	*MR*	*4.5*	*0.83*[d]
	BgAc 391	*4.5*	*3.2*	*MR*	*R/MR*	*3.85*	*2.83*[d]
Hathi El	*BgAc 35*	*4.7*	*4.5*	*MR*	*MR*	*4.6*	*17.58*[bcd]
Mada El	*BgAc 779*	*5.0*	*4.5*	*MR*	*MR*	*4.75*	*2.92*[d]
Murungakayan	*BgAc 395*	*4.7*	*5.0*	*MR*	*MR*	*4.85*	*13.33*[cd]
Sinnakaruppan	BgAc 479	5.2	4.7	MR/MS	MR	4.95	6.00[d]
Baba wee	BgAc 206	5.5	4.7	MR/MS	MR	5.1	19.5[bcd]
Susceptible varieties							
TN 1	-	5.5	4.5	MR/MS	MR	5.0	12.08[cd]
Bg 380	-	6.2	6.0	MS	MS	6.1	173.08[a]
F test							Sig
CV (%)							130.2

Note: R - Resistant, MR - Moderately resistant, MS - Moderately susceptible, S - Susceptible
Means with the same letters are in the final column not significantly different at $P = 0.01$

Resistant reaction of the varieties based on honeydew excretion

Honeydew excretion measured by colour area ranged from 3.08 mm^2 on resistant check, Ptb 33 to 173.08 mm^2 on susceptible check, Bg 380. Among the rice varieties, significantly (P<0.05) lowest honeydew excretion was measured for BPH adults feeding on *Mudukiri el* (Ac 783 & 391), *Horanamawee* (Ac 40 & 41), IR 71033-121-15, *Hondarawala* (Ac 987), *Mada el* (Ac 779) Ptb 33 and Bg 379-2. The significantly (P<0.05) highest honeydew excreted area was recorded from Bg 380 (Table 2). On the other varieties were recorded honeydew excreted area ranged from 3.67 to 49.08 mm^2. It indicated that the honeydew excreted area by BPH was different among rice varieties with resistant genes and resistant mechanisms presence. Similar study was conducted by Bhanu *et al.* (2014) and reported that levels of antibiosis that reduces feeding activity of insect.

Among the several BPH resistant donors used in rice varietal improvement programme in Sri Lanka only the BPH resistance of Ptb 33 has successfully been incorporated into high yielding varieties (Nugaliyadde *et al.*, 2000). In the present investigation rice varieties Bg 379-2 and IR 71033-121-15 were the improved rice varieties that having resistant to moderately resistant reaction at seedling screening. Bg 379-2 is a derived variety of the cross between advanced line Bg 96-3 and Ptb 33. Khush (1979) reported that one dominant and one recessive gene responsible for BPH resistance in Ptb 33 based on the reaction to Philippine-stain of BPH biotype 1. A similar study conducted with BPH population from Sri Lanka indicated the presence of a single dominant gene in Ptb 33 (Nugaliyadde *et al.*, 2004). Therefore, the resistance of the Bg 379-2 might be acquired from the Ptb 33. IR 71033-121-15 is a rice line developed at IRRI which has Bph 20 and 21 genes and it shows resistant reaction to the BPH biotypes found in Korea (Rahman *et al.*, 2009).

Among the tested traditional rice cultivars *Mudukiri el* (Ac 783 and 391), *Horana ma wee* (Ac 40 and 41), *Hondarawala* (Ac 987) and *Madael* (Ac 779) were recorded resistant to moderately resistant reaction and lower honeydew excreted area which signifies antibiosis tolerance presence. However, those traditional rice cultivars contain inappropriate plant architecture and long duration for maturity. Therefore, they may be required longer time period to combine BPH resistance with desired commercial traits to improved varieties through conventional breeding. Marker assisted backcrossing (MABC) is one of the most promising approach in rice breeding which use molecular markers to identify and select genes controlling varietal resistance (Muhammad *et al.*, 2015).

Host plant resistance is a cost-effective and environmentally friendly strategy for BPH management. To date, 32 BPH resistance genes have been identified in *indica* rice cultivars and related wild species (Han *et al.*, 2018). Therefore, identifying new BPH-resistant germplasms and determining the associated resistance types are continuously needed. However, few BPH-resistant rice varieties are widely cultivated due to the ability of BPH to rapidly overcome plant resistance and a lack of sufficient resistance resources. Therefore, rice varieties with durable resistant to BPH are timely needed.

CONCLUSIONS

The present study revealed that Bg 379-2 and IR 71033-121-15 would be the better sources for BPH resistance among the varieties tested. *Mudukiri el* (Ac 783 and 391), *Horana ma wee* (Ac 40 and 41), *Hondarawala* (Ac 987) and *Mada el* (Ac 779) showed resistant reaction for BPH. Thus, those varieties require longer duration for improvement due to traditional plant architecture. Resistance observed in these varieties may be due to already identified BPH resistant genes or due to new genes. Therefore, further studies should be carried out with molecular markers for verification. Identification of additional BPH resistant genes from different sources and exploiting them to widen the genetic base of cultivated rice varieties need to be continued in view of overcoming future BPH outbreaks.

REFERENCES

Anonymous (1988). Screening manual for rice in Sri Lanka, Research Division, Department of Agriculture, Peradeniya, Sri Lanka pp 14-18.

Bhanu, K.V., Laksmi, V.J., Katti, G. and Reddy, A.V. (2014). Antibiosis and tolerance mechanisms of resistance in rice varieties carrying brown planthopper resistance genes. Asian J. Biol. Life Sci.3(2),108-113.

Chao, C.S.U, Zhai, H.Q., Wang, C.M., Sun, L.H. and Min, W.A.N.J. (2006). SSR mapping of brown planthopper resistance gene Bph9 in kaharamana, an indica rice (*Oryza sativa L*) Acta.Genet.Sin.33(3), 262-268.

Han, Y., Wu, C., Yang, L., Zhang, D. and Xiao, Y. (2018). Resistance to *Nilaparvata lugens* in rice lines introgressed with the resistance genes *Bph14* and *Bph15* and related resistance types. Availablefrom:www.https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0198630 (Accessed on 12.11.2018).

IRRI (International Rice Research Institute) (2014). Standard evaluation system for rice (SES). 5th edition. Los Banos (Philippines): International Rice Research Institute. Pp. 51.

Jena, K.K., Jeung, J.U., Lee J.H, Choi, H. C. and Brar, D.S. (2006). High-resolution mapping of a new brown planthopper (BPH) resistance gene, *Bph (18) (t),* and marker–assisted selection for BPH resistance in rice (*Oryza sativa* L.). Theor. Appl. Genet.112, 288-297.

Khush, G.S. (1979). Genetics and breeding for resistance to brown planthopper. In brown planthopper: threat to rice production of Asia. Eds. IRRI. pp 321: 332. International Rice Research Institute, Los Banos, Phillipine.

Muhammad, M.H., Mohd, Y.R., Mohd, R.I., Maziah, M., Harun, A.R., Mohd, A.A., Sadegh, A., Mohd, A.M. and Mohammad, A.L. (2015). Marker-assisted backcrossing: a useful method for rice improvement. Biotechnology and

Biotechnological Equipment. 29:2,237-254. Available from: www.http://doi.org/10.1080/13102818.2014.995920 (Accessed on 09.11.2018).

Nugaliyadde, L., Dissanayake, N. and Mithrasena, J. (2000). Advances of pest and disease management of rice in Sri Lanka: Annual symposium of the department of Agriculture, Sri Lanka. pp 409-422.

Nugaliyadda, L., Amarasinghe, A.A. and Hidaka, T. (2001). The rice brown plant hopper outbreak in 1997/1998 Maha season. Strategies to improve rice pest management in Sri Lanka. Annals of the Sri Lanka Department of Agriculture*,* 185-194.

Nugaliyadde, L, Abeysiriwardene, D.S.Z., Samanmalee, L.G.A., Pathirana, R. and Wilkins, R.M. (2004). Inheritance of resistance in rice to brown planthopper: its implication on rice varietal improvement in Sri Lanka. Vol 3. Available from: www.http://ag.udel.edu/delpha/7674.pdf (Accessed on 12.11.2018).

Panda, N. and Kush, G.S. (1995). Host plant resistance to insects. Wallingford (UK): CAB International, 431.

Park, D.S., Song, M.Y., Park, S.K., Lee, S.K. and Lee, J.H. (2008). Molecular tagging of the Bph locus for resistance to brown planthopper (*Nilaparvata lugens* Stal) through representational divergence analysis. Mol. Genet. Genom. 280, 163-172.

Pathak, M.D. and Khush, G.S. (1979). Studies of varietal resistance in rice to the brown planthopper at the International Rice Research Institute. In: Brown Planthopper threat to rice production in Asia. Pp. 285-301. International Rice Research Institute, Philippines.

Rahman, M.L., Jiang, W., Chu, S.H., Qiao, Y., Ham, T.H., Woo, M.O., Lee, J., Khanam, S.K., Chin, J.H., Jeung, J.U., Brar, D.S., Jena, K.K. and Koh, H.J. (2009). High-resolution mapping of two rice brown planthopper resistance genes, Bph20(t) and Bph21(t), originating from *Oryza minuta*. Theor. Appl. Genet. 119, 1237-1246.

Roderick, G.K. (1994). Genetics of host plant adaptation in delphacid plant hoppers. Planthoppers: Their ecology and management. pp 551-570. Eds. Denno, R.F., Perfect John R. Chapman and Hall, London.