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Evaluation of Rice Genotypes for Brown Planthopper Resistance and Implication on Variety Improvement Program in Sri Lanka

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Abstract

Brown planthopper (Nilaparvata lugens) is a major pest of rice, which causes significant yield losses annually in Sri Lanka. Host-plant resistance is an important strategy to manage Brown Planthopper (BPH) damage. Twenty-five rice genotypes including new improved varieties, introductions and traditional rice varieties were evaluated using standard seed box screening technique and honeydew test. During screening Ptb 33 used as resistant check, TN1 and Bg 380 used as susceptible checks. 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 moderately resistant reactions. Two exotic lines, IR 65482-7-216-2 and IR 71033-121-15 showed moderately resistant reaction for the BPH found in Sri Lanka. Among the Traditional rice cultivars, Mudu kiri el, Horana ma wee, Hondarawala and Mada el showed resistant to moderately resistant reactions. Traditional rice cultivars contain inappropriate plant architecture and photoperiod sensitivity. They may be required longer time period to combine BPH resistance with desired commercial traits to improved varieties. According to the present study Bg 379-2 and IR 71033-121-15 would be the better sources for resistance breeding for BPH. Combine use of phenotypic and genotypic evaluation method would be much important to utilize resistant genotypes for rice improvement programs for BPH management.

Keywords: Brown Planthopper, Resistance, Rice genotypes.

Introduction

The brown plant hopper (BPH), *Nilaparvata lugens* (Stal) is one of the most serious insect pests of rice, primarily because of the unpredictability of the infestation and the severity of the damage. 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 and 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. Resistance to BPH been found in a wide range of traditional rice varieties and wild rice species (Pathak and Khush,1979). Some of these resistances have successfully been incorporated into varietal gene-bases and has helped reduce BPH out breaks and increase rice production in many Asian countries (Panda and Khush,1995). Instability of the varietal resistance due to the rapid adaptation of pests to previously resistant varieties requiring replacement with different resistant bases is a major challenge to national rice improvement program 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).

Therefore, identification of new sources of resistance and verification of already reported donors is very important attempt to rice breeding program.

Materials and Method

The experimental materials for BPH reaction consisted of 25 rice accessions along with 6 released varieties. Both standard seed box screening test and honey dew test was performed to evaluate the varietal resistance on BPH. Ptb 33 was used as resistant check while Bg 380 was used as a local susceptible check and TN 1 as universal susceptible check. The experiment was conducted at the BPH screen house of Rice Research & Development Institute, Batalagoda in Maha 2016/17 and Yala 2017.

Standard Seed Box Screening Test (SSST)

Screening was done by using standard seed box technique at the BPH screen house of RRDI, Batalagoda. The dry seeds were sown in galvanized iron trays along with resistant and susceptible check with the two replications. 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 was observed. The genotypes were scored based on scoring system developed by the International Rice Research Institute and each entry was scored according to Table 01. Interpretation of results 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 are designated as resistant, moderately resistant and susceptible respectively.

Table 01: 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)

Source: SES (2014), IRRI, Philippine

Honey Dew Excretion

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% bromocresol 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 petry dish kept at the base of 30 days old plants. A plastic cup was placed over the filter paper and two hoppers which pre-starved for 3-4 hours were released into the feeding chamber using insect aspirator. The BPH were allowed to feed for 24 hours 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.

Results and Discussion

In all 25 rice accessions of rice germplasm including 6 released varieties were evaluated against brown plant hopper (BPH) in screen house by adopting internationally accepted screening technique of IRRI. The rice genotypes were scored when Bg 380 showed hopper burn with a damage score 9. The results of phenotypic response of rice genotypes to BPH screening at seedling stage indicated varied genotypic responses (Table 02).

BPH Resistant Score of Varieties

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 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. The variety Ptb 33 with the score of 3.0 considered as resistant to BPH. Among the genotypes screened majority of the improved varieties and selected traditional varieties were found moderately resistant reactions to BPH. The results of the phenotypic response of rice genotypes to BPH screening at seedling stage revealed that resistant level of different rice varieties to BPH varied based on resistant genes presence.

Honeydew Excretion on Rice Varieties

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 lowest honeydew excretion was measured for BPH adults feeding on Mudukiri el (Ac 783 & 391), Horana mawee (Ac 40 & 41), IR 71033-121-15, Hondarawala (Ac 987), Mada el (Ac 779) Ptb 33 and Bg 379-2. The significantly highest honeydew excreted area was recorded from Bg 380. On the other varieties were recorded honeydew excreted area ranged from 3.67mm^2 to 49.08 mm^2. Apparently, the honeydew excreted area by BPH different among rice varieties with different resistant genes and resistant mechanisms presence.

Table 02: Reactions of different genotypes to Brown Plant Hopper under Standard seed box screening technique and amount of honeydew excretion on rice varieties.

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 seasons	Amount of honeydew in 24h (mm^2)
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}
Bg 379-2	-	4.7	4.7	MR	MR	4.7	3.08^{d}
Bg 450	-	5.7	5.5	MR/MS	MR	5.6	15.17^{bcd}
Bw 367	-	6.0	5.2	MS	MR/MS	5.6	6.33^{d}
IR 65482-7-216-2	-	5.0	5.5	MR	MR	5.25	15.50^{bcd}
IR 71033-121-15	-	3.2	5.5	R/MR	MR	4.35	2.17^{d}
WH 20	-	5.5	6.0	MR/MS	MS	5.75	24.58^{bcd}
WH 48	-	4.5	5.7	MR	MR	5.1	3.75^{d}
ASD 7	BgAc 1075	5.0	5.2	MR	MR/MS	5.1	9.92^{d}
Rathu heenati	BgAc 725	4.7	4.7	MR	MR	4.7	49.08^{bc}
Mudu kiri 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}
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}
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}
Ptb 33	Resistant	3.0	3.0	R	R	3.0	3.08^{d}
TN 1	Susceptible	5.5	4.5	MR/MS	MR	5.0	12.08^{cd}
Bg 380	Susceptible	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.

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 Bg 96-3 *2 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 having 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 Mudukiriel (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 signify that antibiosis tolerance presence. Though, above traditional rice cultivars contain inappropriate plant architecture and photoperiod sensitivity. They may be required longer time period to combine BPH resistance with desired commercial traits to improved varieties.

Molecular markers have become efficient tools for screening of BPH resistance and marker assisted selection (MAS) in rice. Combined use of phenotypic and genotypic evaluation methods can improve the efficiency of MAS and utilization of resistant genotypes for crop improvement by the breeders. To date, 32 BPH resistance genes have been identified in *indica* rice cultivars and related wild species (Han *et al*.,2018). Host plant resistance is a cost-effective and environmentally friendly strategy for BPH management. 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.

Conclusion

The present study revealed that Bg 379-2 and IR 71033-121-15 would be the better sources for resistance breeding for BPH. Resistance observed of these varieties may be due to already identified BPH resistant genes or due to new genes. Therefore, further studies should be carried out with reported molecular markers for verification. Identification of additional BPH resistant genes and exploiting them to widen the genetic base of cultivated rice varieties need to be continued in view of overcoming future BPH outbreaks.

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