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Evaluation of different rice genotypes against brown planthopper (*Nilaparvata lugens* Stal.) in the glass house

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Abstract

Brown plant hopper, *Nilaparvata lugens* (Stal.), one of the major insect pest in paddy has developed resistance against the majority of insecticides which has created a new challenge for its management. Growing of BPH resistant varieties is an economical, environmentally safe and effective strategy to manage this pest. In the present study, 105 Plant Hopper Screening (PHS) and 25 Multiple Resistant Screening Trial (MRST) of rice genotypes were screened in the glasshouse conditions along with resistant (PTB-33) and susceptible checks Taichung Native-1(TN1). The standard seedbox screening method was used for the bulk screening of entries. The rating scale and level of resistance were adopted from the standard evaluation system for rice but the ranges for percent dead seedling were constructed to facilitate the rating based on percent seedling mortality due to BPH damage. According to observations, entries RP 2068-18-3-5, RP 6121Bphk17-2, IR 73382-80-9-3-13-2-2-1-3-B (HWR-16), IR 77390-6-2-18-2-B (HWR-39), RP 5690-20-6-3-2-1 and PTB-33 showed 15 % to 22.5% seedling mortality, and were moderately resistant.

Keywords: BPH, rice, screening, resistance, standard seedbox method

1. Introduction

Rice (*Oryza sativa* L.) is the staple food for more than half of humanity in the world [1]. Rice constitutes mainly carbohydrates as a source of instant energy which provides up to 50% of the dietary caloric supply and plays a role in maximizing protein intake [2]. The global status of rice production in 2017 was estimated to be 759.6 million tonnes and is expected a rise of 10 million tonnes in 2018 whereas, in India, the estimated production of rice in 2017 was 166.5 million tonnes with a forecasted rise of only 3 million tonnes for 2018 [3]. It is projected that the demand for rice is increasing by 1.1% per year and to meet this demand, the rice production should grow at a rate of 2.9% per year [4]. The world will need about 25% more rice by the year 2030 to meet the estimated demand for an increasing global population [5].

The population of the world is increasing at such a rate that diverting more area to rice production is also impossible. In that case, increasing productivity is the only option left to meet the estimated demand. On the other hand, the limiting factor to rice production is an aggregation of both abiotic and biotic constraints which causes a total loss of 0.8 tons per hectare [6]. The major constraints of rice production are biotic stresses which include several viral, fungal, bacterial and nematode diseases along with numerous insect pests leading to an annual loss of 52% globally [7]. Rice has been documented with a total of 800 insects infesting it [8], but at least 20 insects are reported to cause a serious threat to production and productivity. One of such a destructive monophagous pest is brown plant hopper, *Nilaparvata lugens* [9].

Brown plant hopper is a phloem feeder where both nymph and adult suck the cell sap in rice plants. It causes the reduction in chlorophyll and protein content of leaves which affect the rate of photosynthesis as well as leads to a typical symptom called "Hopper burn". Apart from that, it is also reported to transmit viral diseases such as grassy stunt and ragged stunt. *N. lugens* is distributed all over Asia and it leads to an estimated monetary loss of $300 million annually [7]. Bae and Pathak [10] reported that if we released 100-200 1st instars nymphs to rice plant after 25 days of transplanting it will cause to 40-70% yield loss. In India, *N. lugens* was first reported from Kerala in 1973-74 as a sporadic pest of rice [11]. Over the years, the insect has attained the key pest status which is a consequence of the injudicious and indiscriminate insecticide application for its management. The sub-lethal doses of insecticides caused resurgence in the insect which demanded further increase in insecticide dose as well as more frequent insecticide application to manage the pest. The severe dependence on chemicals to manage the insect has also resulted in the evolution of resistance to numerous insecticides. Secondly, the use of insecticides had its own demerits which include disruption of rice ecosystem balance [12], a decline in natural enemies [13] and cost intensive. This has created a new challenge to find a safer alternative to BPH management.

Growing resistant variety can be one of the safer alternatives which can be helpful in, increasing the rice production to satisfy the ever-enhancing population thereby minimizing the loss caused by insects in a sustainable approach. Growing resistant variety has a constant, specific and cumulative effect on the target pest, thereby providing resistant in a simple and inexpensive way. Furthermore, India being one of the centers of origin of rice has a huge array of germplasm which is genetically still unexplored. On the other hand, the plant itself has several inbuilt mechanisms to interact with the insect, such mechanism is called Host Plant Resistance (HPR). HPR is one of the most important components of IPM but over the years its benefits were ignored. Keeping above facts under consideration, the present study aims at exploring the genotypic and phenotypic resistance of various genotypes against *N. lugens* as a step to satisfy the present demand of high yield and quality rice production with an economic benefit to the farmers.

2. Materials and Methods

2.1 Insect Experiment

The experiment for the screening of rice entries against brown plant hopper *Nilaparvata lugens* (Stal.) were conducted in 2017 in the glass house of the Department of Entomology, GBPUAT, Pantnagar.

2.2 Sources of Entries

One hundred five entries of Plant Hopper Screening Trial (PHS) and twenty-five Multiple Resistance Screening Trial (MRST) received under All India Co-ordinated Rice Improvement Programme (AICRIP) Kharif 2017 were evaluated against brown plant hopper. TN-1 was taken as a susceptible check while PTB-33 and MO-1 were used as resistant check in PHS. In case of MRST, Suraksha and PTB-33 were used as a resistant check while TN-1 as susceptible check.

2.3 Mass rearing of Brown Planthopper

The adults of BPH were mass reared on susceptible cultivar TN-1 grown in pots under glasshouse condition. The stock culture in aluminum rearing cages (1x1.5x1m) fixed with insect-proof nylon net and glass. Approximately 50-60 days old potted plants of TN-1, placed in rearing cages and 10-15 adults on them. After 6-8 days adults were removed and transferred to other pots. The cages were observed regularly for the occurrence of predators and another insect pest. Whenever the predators or other insect species were observed in the cages, they were eliminated immediately to facilitate the better development and growth of BPH population. The seedbed screening method was used for bulk screening of entries. The purpose of the bulk screening was to reject the susceptible ones and to find out entries showing moderate to a high level of resistance against BPH. The entire screening tests were done in plastic trays of size (42cm x 32cm x 7cm) in the glasshouse.

2.4 Germination of Seeds

Fifty seeds of each entry were placed on double layered moist filter papers in plastic Petri dishes with their respective entry numbers. The seeds were soaked for 24 hours by sprinkling a little amount of water after that the Petri dishes were transferred to incubators maintained at 30˚ C to facilitate proper germination. It took 2-3 days for the seeds to germinate.

2.5 Seed sowing and maintenance of test seedlings

The germinated seeds were then sown in trays with the help of forceps and the with their respective entry numbers. Each tray accommodated 13 rows of different entries, of which each row contained 20 germinated seeds. Furthermore, the spacing between the rows and seeds were maintained at 2 x 1cm, respectively. After sowing, standing water of 5 cm depth was maintained for the healthy growth of seedlings.

2.6 Infestation of seedlings with BPH

At 12 days after sowing (DAS), 2^{nd} and 3^{rd} instar nymphs from the stock culture were released on to the trays such that each seedling nurtured 8-10 nymphs per seedling.

2.7 Gradation of test entries

Numbers of dead and surviving plants of each entry were recorded at two days interval till the susceptible check variety (TN-1) was entirely exhausted. The rating was based on the following scoring system (Table 1).

Table 1: The rating scale for scoring level of resistance

Scale	Percent dead seedlings	Level of resistance
0	0	Immune (I)
1	1-5	Highly resistant (HR)
3	6-9	Resistant (R)
5	10-25	Moderately resistant (MR)
7	26-60	Moderately susceptible (MS)
9	61-100	Susceptible(S)

In the above rating scale, the value in "scale" column and level of resistance were taken from Heinrich *et al.*, 1985 [14] but the ranges for percent dead seedlings were organized for ease of rating based on per cent seedling mortality due to BPH damage.

3. Results and Discussion

The screening of 105 entries of PHS and 25 entries of MRST of rice against BPH revealed that a total 18 entries showed some sort of resistance whereas, the rest of all the entries were seen to be susceptible to BPH. After screening of the PHS entries by the standard seedbox screening method concluded that mean seedling mortality varied between 5 to 100 percent (Table-2).

PHS constituted a total of 17 entries showing some sort of resistance to BPH out of which 11 entries namely JGL 24497, JGL 30292, MTU 1211, MTU 1266, MTU 1247, RP 6121Bphk17-1, RP 6121Bphk17-3, RP 6121Bphk17-4, RP 6121Bphk17-6, RP 5995Bphk17-1 and RP 5995Bphk17-5 constituted a range of mean mortality between 30 to 60 percent with damage score 7 and were regarded as moderately susceptible entries. In the above mentioned 11 entries, the entry RP 5995Bphk17-5 (30%) showed a minimum mean mortality percentage. On the other hand, there were 5 PHS entries including RP 2068-18-3-5, RP 6121Bphk17-2, IR 73382-80-9-3-13-2-2-1-3-B (HWR-16), IR 77390-6-2-18-2-B (HWR-39) and RP 5690-20-6-3-2-1 that showed mean mortality range between 15 to 25 percent with the damage score 5 indicating them to be moderately resistant to BPH (Table-2). PTB-33 was found resistant with least damage score 3.The present study indicated that JGL- 24497 & RP5995 BPHK 17-5 were moderately susceptible in reaction whereas, RP6121Bphk17-2, IR 73382-80-9-3-13-2-2-1-3-B (HWR-16), RP5690-20-6-3-2-1, IR77390-6-2-18-2-B(HWR-39), RP 2068-18-3-5 were moderately resistant.

Twenty-five Multiple Resistance Screening Trial (MRST) received under All India Co-ordinate Rice Improvement Programme (AICRIP) when evaluated against brown plant hopper, in Kharif 2017 demonstrated MRST-01 (CR2711-149) to be moderately resistant with 23.33% mean seedlings mortality and MRST-10 (RP 2068-18-3-5) was moderately susceptible with 31.67% mortality, while rest 23 entries were found susceptible (Table-3).

Similar studies were carried out by AICRIP at 5 different location of India which reported JGL-24497 to be moderately susceptible only in the greenhouse study in Mandya (Karnataka) whereas it was found susceptible at all the other location. Similarly, RP5995Bphk 17-5 was found moderately susceptible only at Cuttack which in accordance with the present study whereas; at all the other locations it was found to be susceptible. RP 2068-18-3-5 & IR 73382-80-9-3-13-2-2-1-3-B (HWR-16), were resistant in a reaction as per the experiments conducted by AICRIP while the present study showed that the above-mentioned genotypes to be moderately resistant [16].

In MRST, entry CR2711-149 was observed as resistant at IIRR, Ludhiana, and Mandya while RP 2068-18-3-5 was observed resistant at the 2 other location except for Mandya (AICRIP Centers), during 2017 [16]. Bhatt and Tiwari [17] reported MTU 1121 and RP 2068-18-3-5 to be moderately resistance (score 5) and resistance (score 3) respectively, which partly corroborates to the findings of the present study. Entry CR 2711-149 was found moderately resistant with damage score 12.5 percent, in the screening test done by (Soni, 2013) [18] which accordance with the above study.

Table 2: The reaction of Plant Hopper Screening (PHS) Trial

S. No	Designation	% Seedling Mortality		Mean	Score	Grade
		1st screening	2nd screening			
1	BPT 2411	95	90	92.5	9	S
2	BPT 2571	100	100	100.0	9	S
3	BPT 2595	95	100	97.5	9	S
4	BPT 2600	100	100	100	9	S
5	BPT 2601	90	85	87.5	9	S
6	BPT 2611	90	90	90.0	9	S
7	BPT 2613	100	100	100.0	9	S
8	BPT 2620	90	95	92.5	9	S
9	BPT 2660	100	100	100.0	9	S
10	TN1	95	100	97.5	9	S
11	BPT 2740	85	75	80.0	9	S
12	BPT 2776	100	95	97.5	9	S
13	BPT 2787	100	100	100.0	9	S
14	BPT 2808	100	100	100.0	9	S
15	BPT 2846	100	90	95.0	9	S
16	BPT 3059	95	100	97.5	9	S
17	BPT 3060	90	90	90.0	9	S
18	CB 12 122	100	100	100.0	9	S
19	CB 13 132	100	100	100.0	9	S
20	PTB 33	10	5	7.5	3	R
21	CB 13 168	100	100	100.0	9	S
22	CB 13 529	100	90	95.0	9	S
23	CB 14 156	100	100	100.0	9	S
24	CB 14 161	100	100	100.0	9	S
25	CB 14 502	85	85	85.0	9	S
26	CB 14 536	85	100	92.5	9	S
27	CB 14 811	95	95	95.0	9	S
28	JGL 24497	40	80	60.0	7	MS
29	JGL 24513	100	95	97.5	9	S
30	MO 1	100	100	100.0	9	S
31	JGL 26965	85	100	92.5	9	S
32	JGL 26973	NG	NG	NG	-	-
33	JGL 27371	90	100	95.0	9	S
34	JGL 28454	100	100	100.0	9	S
35	JGL 28461	100	90	95.0	9	S
36	JGL 28540	65	95	80.0	9	S
37	JGL 28545	NG	NG	NG	-	-
38	JGL 28618	85	80	82.5	9	S

39	JGL 28639	NG	NG	NG	-	-
40	RP 2068-18-3-5	10	25	17.5	5	MR
41	JGL 28921	80	100	90.0	9	S
42	JGL 30090	85	100	92.5	9	S
43	JGL 30232	75	100	87.5	9	S
44	JGL 30292	75	40	57.5	7	MS
45	KAU-PTB (Ac-1)	90	80	85.0	9	S
46	MTU 1211	70	50	60.0	7	MS
47	MTU 1266	65	50	57.5	7	MS
48	MTU 1245 (MTU 2139-7-1-1-1)	65	80	72.5	9	S
49	MTU 1247 (MTU 2140-8-1-2-1)	70	45	57.5	7	MS
50	TN1	100	100	100.0	9	S
51	WGL-1151	100	85	92.5	9	S
52	WGL-1153	100	60	80.0	9	S
53	WGL-1156	100	55	77.5	9	S
54	WGL-1157	90	60	75.0	9	S
55	WGL-1161	100	100	100.0	9	S
56	WGL-1162	100	95	97.5	9	S
57	WGL-1164	100	100	100.0	9	S
58	WGL-1167	95	100	97.5	9	S
59	WGL-1175	90	100	95.0	9	S
60	PTB 33	5	10	7.5	3	R
61	WGL-1178	90	100	95.0	9	S
62	WGL-1180	90	100	95.0	9	S
63	WGL-1181	85	100	92.5	9	S
64	WGL-1190	95	100	97.5	9	S
65	WGL-1191	100	100	100.0	9	S
66	WGL-1192	100	100	100.0	9	S
67	WGL-1196	90	100	95.0	9	S
68	WGL-1198	100	100	100.0	9	S
69	WGL-1202	100	100	100.0	9	S
70	MO1	100	100	100.0	9	S
71	RP 6121Bphk17-1	25	90	57.5	7	MS
72	RP 6121Bphk17-2	10	35	22.5	5	MR
73	RP 6121Bphk17-3	50	60	55.0	7	MS
74	RP 6121Bphk17-4	35	75	55.0	7	MS
75	RP 6121Bphk17-5	90	90	90.0	9	S
76	RP 6121Bphk17-6	25	75	50.0	7	MS
77	RP Bio-226	80	90	85.0	9	S
78	RP 2068-18-3-5	10	30	20.0	5	MR
79	RP 5983Bphk17-1	100	60	80.0	9	S
80	RP 2068-18-3-5	35	35	35.0	7	MS
81	RP 5983Bphk17-2	60	90	75.0	9	S
82	RP 5983Bphk17-3	100	90	95.0	9	S
83	RP 5989Bphk17-1	60	70	65.0	9	S
84	RP 5989Bphk17-2	80	75	77.5	9	S
85	RP 5989Bphk17-3	90	40	65.0	9	S
86	RP 5995Bphk17-1	65	45	55.0	7	MS
87	RP 5995Bphk17-2	90	60	75.0	9	S
88	RP 5995Bphk17-3	90	80	85.0	9	S
89	RP 5995Bphk17-4	100	55	77.5	9	S
90	TN1	100	100	100.0	9	S
91	RP 5995Bphk17-5	35	25	30.0	7	MS
92	IR 65482-7-216-1-2-B (HWR-7)	NG	NG	NG	-	-
93	IR 73382-80-9-3-13-2-2-1-3-B (HWR-16)	20	30	25.0	5	MR
94	IR 77390-6-2-18-2-B (HWR-39)	5	25	15.0	5	MR
95	IR 75870-5-8-5-B-5-B (HWR-15)	75	85	80.0	9	S
96	RP 5687-400-80-5-4-2	70	80	75.0	9	S
97	RP 5690-20-6-3-2-1	30	10	20.0	5	MR
98	RP 5694-30-5-1-2	60	65	62.5	9	S
99	RP 5695-121-17-3-2-1	85	90	87.5	9	S
100	PTB 33	10	70	40.0	7	MS
101	RP 5700-68- 44-5-3-2	85	75	80	9	S
102	MSM-TI 3	NG	NG	NG	-	-
103	MSM-TI 13	100	75	87.5	9	S
104	MO1	85	55	70	9	S
105	RP 2068-18-3-5	10	35	22.5	5	MR

Table 3: The reaction of Multiple Resistant Screening Trial (MRST)

S. No.	Designation	% Seedling Mortality			Mean	Score	Grade
		1st screening	2nd screening	3rd screening			
1	CR 2711-149	30	25	15	23.3	5	MR
2	Bahadur	70	65	80	71.7	9	S
3	CO 50	80	80	90	83.3	9	S
4	CR Dhan 701	85	80	95	86.7	9	S
5	TN1	100	100	100	100.0	9	S
6	Dhan Rasi	80	80	80	80.0	9	S
7	DRR Dhan 43	85	95	75	85.0	9	S
8	Govind	95	95	100	96.7	9	S
9	IR 65482-7-216-1-2-B	70	55	75	66.7	9	S
10	RP 2068-18-3-5	30	30	35	31.7	7	MS
11	KNM 113	100	100	100	100.0	9	S
12	NDR 8002	100	100	100	100.0	9	S
13	NP 3113-7	95	100	100	98.3	9	S
14	PR 124	100	100	100	100.0	9	S
15	W1263	100	100	100	100.0	9	S
16	Pushyami	95	95	100	96.7	9	S
17	Ranjeet	90	90	100	93.3	9	S
18	RC Maniphou-11	95	85	100	93.3	9	S
19	RP Bio 226	75	60	100	78.3	9	S
20	Suraksha	65	75	65	68.3	9	S
21	Sahbagidhan	95	100	95	96.67	9	S
22	Saliva Hana	80	95	70	81.7	9	S
23	Shobini	85	95	100	93.3	9	S
24	Swarna Sub 1	100	100	100	100.0	9	S
25	Varalu	85	100	85	90.0	9	S

Identification of new sources of resistance and efficient screening techniques for evaluating breeding lines play a crucial role in identifying and transferring BPH resistant genes into high yielding cultivars. Furthermore, it offers a sustainable way to overcome the frequently occurring new BPH biotypes problem due to extensive cultivation, the effect of insecticide and different environmental factors [19]. A high level of genetic diversity likely reduces the risk of widespread insect epidemics.

4. Conclusion

The results specified that rice germplasms RP 2068-18-3-5, RP 6121Bphk17-2, IR77390-6-218-2-B (HWR-39) and RP 5690-20-6-3-2-1 were moderately resistant in Plant Hopper Screening trial (PHS). Only CR 2711-149 rice germplasm showed promising results against BPH in Multiple resistant screening trial (MRST). These germplasms have appeared as new sources of resistance to *N. lugens* which can be used in the breeding programme to produce BPH resistant rice varieties, as an environment-friendly strategy for BPH management.

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