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Settling behaviour of brown planthopper, *Nilaparvata lugens* (Stål) and whitebacked planthopper *Sogatella furcifera* (Horvath) on selected rice genotypes

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Abstract

The resistance reaction of ten selected rice genotypes to both the brown planthopper (BPH) *Nilaparvata lugens* (Stål) and whitebacked planthopper (WBPH) *Sogatella furcifera* (Horvath) were assessed by mass screening technique. PTB-33 exhibited high resistance (0.8), while RPBio4918-230-S (DS-1.2), BM71 (DS-1.6), and RP2068-18-3-5 (DS-1.9) were resistant. MO1 (DS-5.7), N'Diang Marie (DS-6.2), N22 (DS-7.6), Swarna (DS-9.0), BPT5204 (DS-9.0) and TN1 (DS-9.0) were susceptible. MO1 (1.8), N'Diang Marie (2.0) and N22 (2.6) were resistant to whitebacked planthopper. PTB33 exhibited moderate resistance (DS-4.2) whereas RPBio4918-230-S (DS-5.8), BM-71 (DS-5.6), RP2068-18-3-5 (DS-5.8), Swarna (DS-9.0), BPT5204 (DS-9.0) and TN1 (DS-9.0) were susceptible to WBPH. The settling behaviour of both BPH and WBPH nymphs on the genotypes correlated with the resistance scores. BPH nymphs settled on different genotypes ranged from 5.2% to 19.0%, with TN1 displaying the highest (19.0% nymphs) and PTB33 having the lowest (5.2% nymphs) settling rates. WBPH nymphs settled on different genotypes varied from 4.3 (N22) to 18.3% (TN1) based on the resistance levels. This study underscores genotype-specific responses to planthopper species, with damage scores and settling behaviours as informative indicators of resistance.

Keywords: Brown planthopper, *Nilaparvata lugens* (Stål), whitebacked planthopper *Sogatella furcifera*

1. Introduction

Rice (*Oryza sativa* L.) is indisputably the world's most important staple food that provides nutrition to more than half of the world's burgeoning population. India, as the world's second-largest rice producer, cultivates rice in an area of 43.86 million hectares, yielding 104.80 million tons with a productivity of approximately 2390 kg/ha (Agricultural Statistics at a glance-2015) [1]. Rice, being a crop of extensive cultivation, is susceptible to the attack of numerous insect species, with approximately 100 species identified, among which 20 hold significant economic importance (Atwal and Dhaliwal, 2002) [2]. The primary planthoppers affecting rice cultivation include the Brown Planthopper (BPH) *Nilaparvata lugens* (Stal) (Hemiptera: Delphacidae) and the White Backed Planthopper (WBPH) *Sogatella furcifera* (Horvath) (Hemiptera: Delphacidae) which are the most destructive pests of rice throughout Southeastern and Eastern Asia. Both species often co-occur on the same plant and suck the phloem sap of rice. They share the same habitats throughout most of the rice growing season (Zhao *et al*., 1991) [3]. Each species has the traits of highly aggregated distribution and rapid population growth (Denno *et al*., 1994) [4]. Both the nymphs and adults of this pest are phloem and xylem feeders, extracting nourishment directly from the plant which induces complex plant responses with direct and indirect deleterious effects (Gorman *et al*., 2008) [5]. Serious damage usually occurs during the early stages (WBPH), and maturity stage (BPH) of plant growth with symptoms of hopper burn due to intensive sucking by the insects. Though insecticide application provides immediate control, ill effects like resurgence, secondary pest outbreak and development of resistance to insecticide (Mohan *et al*., 2019 and Reddy *et al*., 2022) [6-7] affect the agro-ecosystem. Host Plant Resistance (HPR) is relatively stable, cheap, environment friendly and generally compatible with other methods of pest management, and has been considered a major control strategy against several pests (Alagar and Suresh, 2008) [8]. Keeping these things in mind, the present study was conducted at ICAR-Indian Institute of Rice Research, Hyderabad during 2022-23 to know resistance reaction in selecting rice genotypes with diverse genetic backgrounds and their antixenosis levels.

2. Material and Methods

Ten rice genotypes *viz*., PTB33, RP2068-18-3-5, RPBio4918-230S, BM71, MO1, N22, N'Diang Marie, Swarna, BPT5204 and TN1were mass screened for their resistance reaction.

2.1. Mass Rearing of BPH and WBPH

BPH and WBPH adults were collected from rice fields of ICAR-IIRR, Rajendranagar, Hyderabad, and the pure colonies were reared and maintained at a temperature of 25 ± 5° C with a relative humidity of 70 ± 5% on 60 days old potted plants of the susceptible variety under glasshouse conditions. Wooden cages of 70 × 62 × 75 cm dimensions with glass-panelled doors on one side and a wire mesh on all the other sides mounted on wooden benches were used for mass rearing. The adult gravid female hoppers were released on pre-cleaned potted plants of susceptible variety and the hatched nymphs were used for screening when they had attained the appropriate age.

2.2. Evaluation of rice genotypes for BPH and WBPH resistance: The standard seedbox screening technique (SSST) (Kalode *et al*., 1975) [9] was used to assess the extent of BPH and WBPH resistance to ten rice genotypes at the seedling stage. The of these test genotypes were sown in trays. Seeds of the 10 genotypes were pre-soaked and pre-germinated seeds were sown in rows of 60 × 45 × 10 cm in seed boxes accommodating 20 seedlings per row during *Kharif* 2022-23 (Figure 1) at the ICAR-Indian Institute of Rice Research, Entomology glasshouse, Hyderabad. Each screening tray had 10 test entries, with the checks being replicated in same tray. The susceptible control, TN1, was sown in two border rows, while PTB33 (Resistant control) was placed in the centre of the box for BPH, and MO1 (Resistant control) was placed in the centre of the box for WBPH. Twelve days after sowing, first-instar nymphs were released on the seedlings at 6–8 nymphs/seedling. The tray was turned 180° when TN1 plants on one side showed symptoms to have even reaction on both sides. The Standard Evaluation System (SES) for rice (IRRI, 2013) [10] was used to rate the damage of the test lines (Table 1) when 90% of the TN1 plants were killed.

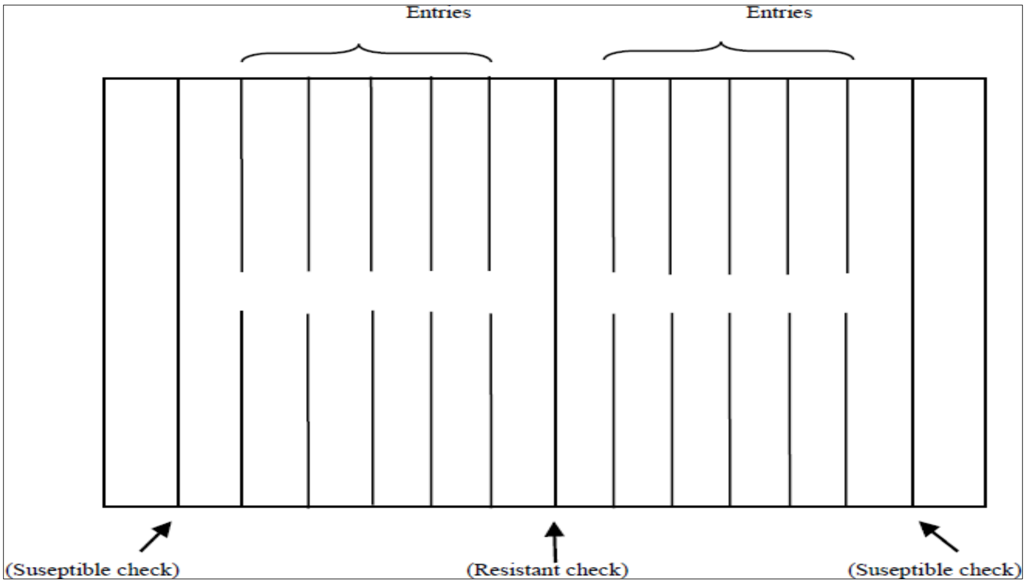

Fig 1: Layout for mass screening test for planthopper resistance in rice culture

2.3. Settling behaviour of BPH and WBPH (Antixenosis studies)

In this experiment, pre-germinated seeds of the test genotypes were randomly planted in rows, spaced 3.5 cm apart, within a seed box measuring 60 cm × 45 cm × 10 cm. Each row comprised 20 seeds. The susceptible control, TN1, was sown in two border rows, while PTB33 (Resistant control) was placed in the centre of the box for BPH, and MO1 (Resistant control) was placed in the centre of the box for WBPH. When the seedlings reached 12-13 days of age, they were infested with 2nd–3rd instar hopper nymphs, with 6–8 nymphs/seedling. To prevent nymphs from escaping, the tray was covered with nylon mesh that allowed light to pass through. The number of nymphs settling on each seedling was counted on days 1, 2, and 3 after the infestation. Following each count, the seedlings were disturbed to reposition the hopper nymphs.

2.4. Statistical analysis

Factorial Completely Randomized Design (FCRD) was followed for the studies on settling behaviour in different rice genotypes. The mean comparison was done by Duncan's Multiple Range Test (DMRT) using Statistix 8.1 software.

Table 1: Classification of resistance based on damage reaction

Plant state	Damage score	Resistance classification
None of the leaves yellow or dead	0	0.0 to 1.0 Highly resistant
One bottom leaf yellow	1	1.1 to 3.0 Resistant
One or two leaves yellow or leaf dried	3	3.1 to 5.0 Moderately resistant
One or two leaves dried or one leaf healthy	5	5.1 to 7.0 Moderately susceptible
All leaves dried or yellow but stem green	7	7.1 to 8.9 Susceptible
Plant dead	9	9.0 Highly susceptible

3. Results

3.1. Resistance reaction in the selected rice genotypes to BPH:

Out of ten selected genotypes, one genotype *viz*., PTB-33 exhibited a damage score of 0.8 and was designated as highly resistant. Three genotypes, *viz*., RPBio4918-230-S (DS-1.2), BM71 (DS-1.6), and RP2068-18-3-5 (DS-1.9) were resistant with a damage score of 1.2 to 1.9. Two genotypes *viz*., MO1 (DS-5.7) and N'Diang Marie (DS-6.2) were moderately susceptible with a damage score of 5.7 to 6.2. The remaining four genotypes *viz*., N22 (DS-7.6), Swarna (DS-9.0), BPT5204 (DS-9.0) and TN1 (DS-9.0) were susceptible to BPH with a damage score of 7.6 to 9.0 (Table 2).

3.2. Resistance reaction in the selected rice genotypes to WBPH

Out of ten screened genotypes, MO1 (1.8), N'Diang Marie (2.0) and N22 (2.6) were resistant to whitebacked planthopper, while PTB33 was moderately resistant with a damage score of 4.2. RPBio4918-230-S (5.8), BM-71 (5.6) and RP2068-18-3-5 (5.8) were classified as moderately susceptible to WBPH, whereas Swarna (9.0), BPT5204 (9.0) and TN1 (9.0) were found to be highly susceptible (Table 2).

Table 2: Damage score (DS) of different rice genotypes to BPH and WBPH

Genotypes	BPH		WBPH	
	DS	R	DS	R
PTB33	0.8	HR	4.2	MR
RP2068-18-3-5	1.9	R	5.8	MS
RPBio4918-230S	1.2	R	5.8	MS
BM71	1.6	R	5.6	MS
MO1	5.7	MS	1.8	R
N22	7.6	S	2.6	R
N'Diang Marie	6.2	MS	2	R
Swarna	9	S	9	S
BPT5204	9	S	9	S
TN1	9	S	9	S

Note: DS- Damage score, R- Reaction, HR- Highly Resistant, R- Resistant, MR- Moderately Resistant, MS- Moderately susceptible, S-Susceptible

3.3. Settling Behaviour of BPH on selected rice genotypes

The settling behaviour of BPH was observed on different genotypes over a period of 24, 48, and 72 hours. On the 1st day, TN1 exhibited the highest BPH nymphs (20.20%), followed by BPT5204 (14.7%), Swarna (12.3%), and N22 (8.9%). PTB33 showed the lowest BPH nymphs (4.9%), followed by RP2068-18-3-5 (5.7%), BM71 (7.4%), and RPBIO4918-230-S (7.5%). On the second day, TN1 had the highest BPH nymphs (18.4%), followed by Swarna (14.3%), BPT-5204 (12.7%) and N22 (11.5%). PTB33 recorded the lowest BPH nymphs (5.5%), along with RPBio4918-230-S (5.6%), BM71 (6.1%), and RP2068-18-3-5 (6.4%). On the third day, TN1 had the highest BPH nymphs (18.5%), followed by BPT5204 (14.4%), Swarna (13.2%), and N22 (10.9%) while PTB33 had the lowest BPH nymphs (4.9%), followed by RP2068-18-3-5 (5.7%), BM71 (5.8%), and RPBio4918-230-S (7.7%). In MO1, BPH nymphs settled decreased over the three days while other genotypes displayed mixed trends of increasing and decreasing nymphs (Table 3 and Figure 2).

The mean number of BPH nymphs settled on different genotypes varied from 5.1% to 19.0%. TN1 recorded the highest BPH nymphs settled (19.0%), followed by BPT5204 (13.9%), Swarna (13.2%) and N22 (10.4%). PTB33 had the lowest nymphs settled (5.1%) followed by RP2068-18-3-5 (5.9%), BM71 (6.4%), and RPBio4918-230-S (6.9%). Resistant genotypes such as PTB33, RPBio4918-230S, RP2068-18-3-5 and BM71 recorded lower settling of BPH nymphs compared to susceptible genotypes (Table 3 and Figure 2).

Table 3: Settling Behaviour of BPH on selected rice genotypes

Genotypes	Nymphs settled (%) on genotypes at different durations			Varietal Mean
	24 h	48 h	72 h	
PTB33	4.9 (12.8)^{j}	5.6 (13.6)^{ij}	4.9 (12.8)^{j}	5.2 (13.1)^{e}
RP2068-18-3-5	5.7 (13.8)$^{h-j}$	6.4 (14.6)$^{g-j}$	5.7 (13.8)$^{h-j}$	5.9 (14.1)^{e}
RPBio4918-230-S	7.5 (15.9)$^{f-j}$	5.6 (13.4)^{ij}	7.7 (16.0)$^{f-j}$	6.9 (15.1)^{de}
BM71	7.4 (15.6)$^{f-j}$	6.1 (14.3)$^{h-j}$	5.8 (13.9)$^{h-j}$	6.4 (14.6)^{de}
MO1	9.8 (18.2)$^{c-h}$	8.6 (16.9)$^{d-j}$	7.9 (16.3)$^{e-j}$	8.8 (17.1)^{cd}
N22	8.9 (17.3)$^{d-i}$	11.5 (19.6)$^{c-f}$	10.9 (19.3)$^{c-f}$	10.5 (18.7)^{c}
N'Diang Marie	8.5 (16.9)$^{d-j}$	10.9 (19.2)$^{c-f}$	10.9 (19.0)$^{c-g}$	10.1 (18.4)^{c}
Swarna	12.3 (20.5)$^{c-e}$	14.3 (22.2)^{bc}	13.2 (21.3)$^{b-d}$	13.3 (21.3)^{d}
BPT5204	14.7 (22.5)$^{a-c}$	12.7 (20.8)^{cd}	14.4 (22.3)$^{a-c}$	13.9 (21.9)^{b}
TN1	20.2 (26.7)^{a}	18.4 (25.4)^{ab}	18.5 (25.5)^{ab}	19.0 (25.8)^{a}
S.Em (±)- hours	0.48	C.D. (0.05)-hours	1.40	
S.Em (±)- genotypes	0.87	C.D. (0.05) -genotypes	2.56	
S.Em (±)-interaction	1.51	C.D. (0.05)- interaction	4.44	
C.V. (%)	12.06			

Note: In a column, means followed by the same letter do not differ significantly from each other by LSD (P=0.05). Figures in parentheses are ARCSINE transformed values.

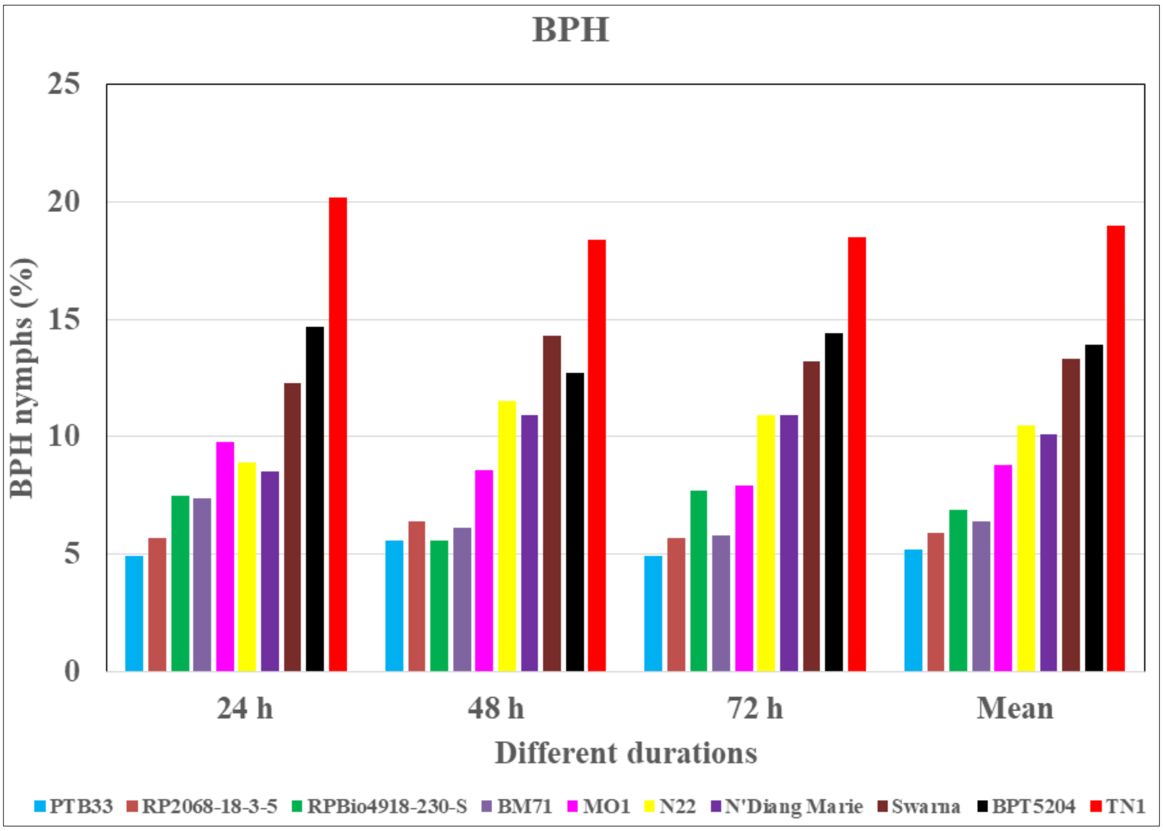

Fig 2: Settling Behaviour of BPH on selected rice genotypes

3.4. Settling Behaviour of WBPH on selected rice genotypes

The settling behaviour of WBPH nymphs was observed at 24hr, 48 hr. and 72 hrs. after the release of nymphs on the selected genotypes. On the first day, WBPH nymphs settled more on TN1 (17.81%) followed by BPT-5204(14.70%), Swarna (14.38%) and RPBio4918-230-S (11.34%). Whereas WBPH nymphs settled less on MO1 (3.94%) followed by N'Diang Marie (4.67%), N22 (4.80%) and BM71 (9.59%). On the second day, more WBPH nymphs settled on TN1 (16.57%) followed by BPT5204 (14.25%), Swarna (12.65%) and N'Diang Marie (10.27%) whereas less number of WBPH preferred N22 (3.81%) followed by RPBIO4918-230-S (7.83%), PTB33 (7.85%) and MO-1 (8.23%). On third day, WBPH nymphs settled more on TN-1 (20.37%) followed by BPT-5204 (15.66%), Swarna (11.29%) and MO-1 (10.88%) while less number settled on N22 (4.18%) followed by PTB33 (6.29%), BM71 (7.03%) and RP2068-18-3-5 (7.87%). The settling behaviour of WBPH on Swarna, BM71 and RP2068-18-3-5 followed a decreasing trend with increasing duration whereas in MO1, an increasing trend was observed (Table 4 and Figure 3).

The mean number of WBPH nymphs settled on different genotypes ranged from 4.26 to 18.25%. In TN1, the highest number of WBPH nymphs settled (18.25%) followed by BPT5204 (14.87%) and Swarna (12.77%) while in N22 WBPH nymphs settled were the lowest (4.26%) followed by PTB-33 (6.55%), MO1 (7.42%) and N'Diang Marie (7.93%). WBPH nymphs settled in less numbers on resistant genotypes compared to susceptible ones (Table 4 and Figure 3).

Table 4: Settling Behaviour of WBPH on selected rice genotypes

Genotype	Nymphs settled (%) on genotypes at different durations			Varietal Mean
	24 hr.	48 hr.	72 hr.	
PTB33	5.5(13.5)$^{h-l}$	7.9(16.2)$^{f-l}$	6.3(14.5)$^{h-l}$	6.3(14.8)^{de}
RP2068-18-3-5	11.3(19.6)$^{b-h}$	9.6(17.9)$^{c-j}$	7.9(16.2)$^{f-l}$	9.6(17.9)^{cd}
RPBio4918-230-S	13.2(21.3)$^{a-f}$	7.8(16.2)$^{f-l}$	8.2(16.6)$^{e-l}$	9.8(18.0)^{cd}
BM71	9.6(18.0)$^{c-j}$	8.9(17.4)$^{d-k}$	7.0(15.0)$^{g-l}$	8.5(16.8)^{d}
MO1	3.9(11.5)^{kl}	8.23(16.52)$^{e-l}$	10.1(17.9)$^{c-j}$	7.4(15.3)^{d}
N22	4.8(12.7)$^{i-l}$	3.81(11.11)^{kl}	4.2(11.2)^{l}	4.3(11.7)^{e}
N'Diang Marie	4.7(12.4) $^{j-l}$	10.3(18.6)$^{c-i}$	8.8(16.9)$^{d-l}$	7.9(15.9)^{d}
Swarna	14.4(22.3)$^{a-f}$	12.7(20.8)$^{a-g}$	11.3(19.6)$^{b-h}$	12.8(20.9)^{bc}
BPT5204	14.7(22.5)$^{a-e}$	14.3(22.2)$^{a-f}$	15.7(23.1)$^{a-d}$	14.9(22.6)^{ab}
TN1	17.8(24.9)^{ab}	16.6(24.1)$^{a-c}$	20.4(26.8)^{a}	18.3(25.3)^{a}
S.Em (±)- hours	0.66	C.D. (0.05) -hours	1.95	
S.Em (±)-genotypes	1.21	C.D. (0.05)-genotypes	3.57	
S.Em (±)-interaction	2.10	C.D. (0.05)-interaction	6.19	
C.V. (%)	16.90			

Note: In a column, means followed by the same letter do not differ significantly from each other by LSD (P=0.05). Figures in parentheses are ARCSINE transformed values.

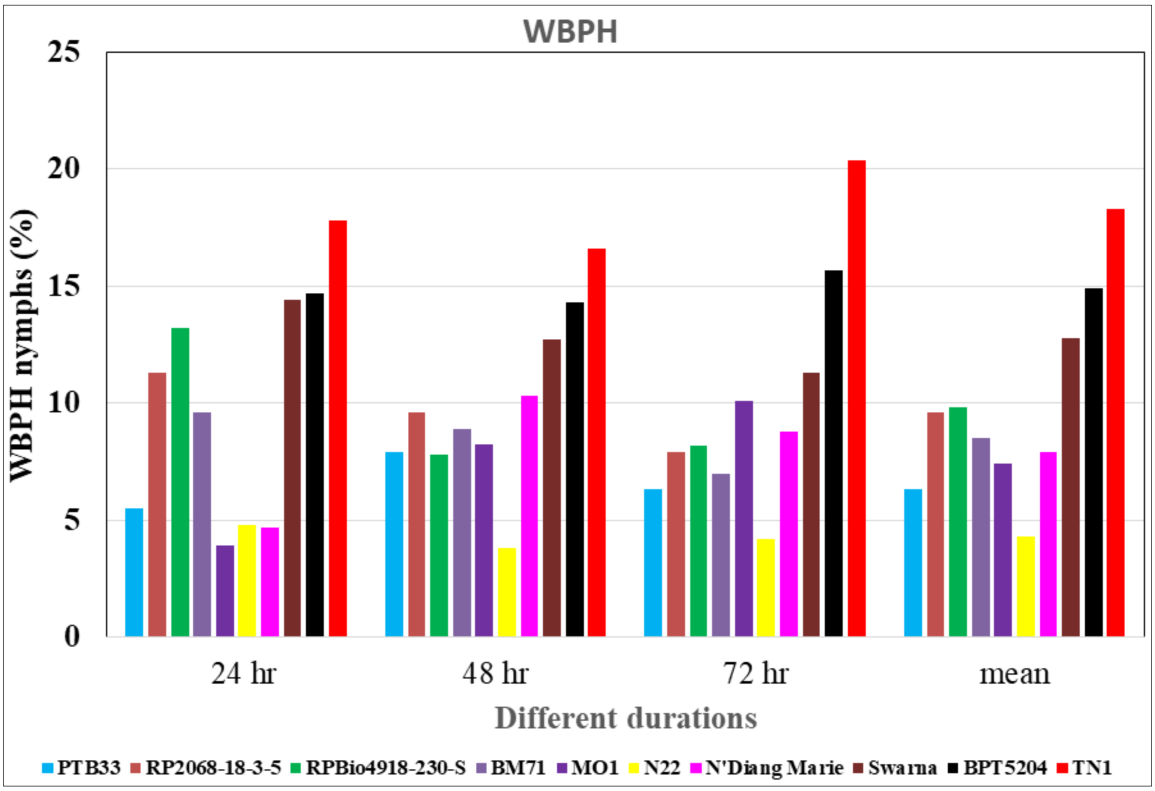

Fig 3: Settling Behaviour of WBPH on selected rice genotypes

4. Discussion

Host plant resistance is the most economical and desirable method for the management of crop pests without affecting non-target organisms adversely. Given the escalating insecticide resistance in BPH and WBPH (Lakshmi *et al.*, 2010) [11], prioritizing host plant resistance and developing resistant varieties becomes imperative. Consequently, thorough screening of new rice entries or germplasm accessions is essential for detecting and deploying novel resistant genes against planthoppers (Horgan *et al.*, 2015) [12].

In India, screening for resistance to BPH and WBPH is a continuous process to identify new sources of resistance. In our screening studies, PTB33, RP2068-18-3-5, RPBio4918-230S, and BM71 displayed resistance to BPH, while the remaining selected genotypes like TN1, BPT5204 and Swarna exhibited susceptibility. These results are in line with Sunil *et al*. (2018) [13] and Naik *et al*. (2018) [14] confirming RP 2068-18-3-5 as resistant. Nagendra Reddy *et al*. (2016) [15], Ramulamma *et al*. (2015) [16] and Dhawande *et al*. (2018) [17] identified PTB 33 as resistant to the brown planthopper. Priyadarshini *et al*. (2021a and b) [18-19] and Dhawande *et al*. (2022) [20] designated TN1 as highly susceptible to BPH. Akanksha *et al*. (2019) [21] observed that RPBio4918-230-S is resistant to BPH while Swarna is susceptible. Anjali *et al*. (2022) [22] reported that N22 and MO1 are susceptible to BPH. Priyadarshini *et al*. (2021a) [18] noted that N'Diang Marie is susceptible, while Bhanu *et al*. (2014) [23] observed that BM71 is resistant to BPH. Our findings revealed that MO1, N22 and N'Diang were resistant and PTB33 was moderately resistant to WBPH, whereas other genotypes such as RP Bio4918-230S, RP 2068-18-3-5, TN1, BPT5204 and Swarna were susceptible. Our results are consistent with those of Meher *et al*. (2020) [24], Anjali *et al*. (2022) [22], and Dhawande *et al*. (2022) [20] who reported MO1 as resistant, N22 and PTB 33 as moderately resistant and TN1 as susceptible to white backed plant hopper. Nymphs settled on the preferred rice genotypes after infestation. TN1 attracted most of the nymphs. More nymphs (3-4 times) settled on the susceptible genotypes than on the resistant ones. The scattered nymphs after a period of time locate the preferred varieties. The nymphs were attracted to different genotypes due to visual or olfactory responses, but they did not settle unless they fed on them (gustatory response) which is an important feature in the preference and non-preference of hoppers to the rice varieties (Pablo, 1977) [25]. The higher number of *N. lugens* settled on susceptible genotypes as compared to resistant ones (Senguttuvan *et al*., 1991; Kim *et al*., 1998; Tenguli *et al*., 2022; Sukumar *et al*., 2022 and Roy *et al*., 2022) [26-30]. The same results were obtained in the case of *S. furcifera* (Shukla, 1984; Bhattal, 1992; Ramesh *et al*., 2014 and Haider *et al*., 2021) [31-34]. Surface waxes and volatile compounds play an important role in insect's preference to rice plants (Horgan, 2009) [35].

5. Conclusion

This study highlights resistance levels of rice genotypes to BPH and WBPH. PTB33, RPbio4918-230S, BM71 and RP2068-18-3-5 exhibited resistance to BPH with low nymphal settling compared to susceptible genotypes. Meanwhile, MO1, N'Diang Marie and N22 were resistant to WBPH with fewer nymphs settled on them compared to susceptible genotypes. The identified resistant genotypes could be used as donors in breeding planthopper-resistant varieties.

6. Acknowledgement

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