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Feeding behavior of whitebacked planthopper, *Sogatella furcifera* (Horvath) on selected Rice Genotypes

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Abstract
The present investigation was carried out under glass house conditions to study the feeding behaviour of whitebacked planthopper (WBPH) *Sogatella furcifera* (H) on selected rice genotypes. Feeding marks and feeding rate were used as reliable parameters to evaluate the resistance nature of the genotypes against insect pests. Low honeydew excretion and higher feeding marks was related to resistance of rice genotypes against WBPH. The maximum number of feeding marks observed 30 days-old plant in leaf sheath PTB 41 (10.67) followed by IR 72 (10.33). In 45 days old plants also maximum number of feeding marks present in PTB 41 (13.33) followed by IR 64 (11.67). In leaf blade 30 days old plants was maximum PTB 41 (5.33) followed by CO 43 (4.67). On 45 days-old plants, the feeding marks on the leaf blade were maximum in CB 08-504 and IR 64 (4.67) followed by IR 72 (4.33) when compared to TN 1 (3.00). The feeding rate WBPH was assessed in terms of the amount of honeydew excreted is directly propositional to the amount of the sap sucked by WBPH. CO 43 recorded 24 hours the lowest feeding rate (0.08 cm^2) followed by IR 64 (0.12 cm^2). Likewise at 48 hours feeding rate (0.20 cm^2) followed by (0.25 cm^2).

Keywords: *Sogatella furcifera*, genotypes, feeding marks, honeydew

Introduction
Whitebacked planthopper (WBPH), *S. furcifera* (Horvath) is one of the major pests of rice. It damages the plants by sucking the sap leading to hopper burn and transmitting the black streck duarf virus (SRBSDV) has rabidly spread in China and Northern Vietnam [1]. Outbreaks of *S. furcifera* have been recently reported in many Asian countries [2, 3] due to the misuse of insecticides and due to the large scale cultivation of hybrid rice. Both the nymphs and adults of this monophagous pest are phloem and xylem feeders, extracting nourishment directly from the plant which induces complex plant responses with direct and indirect deleterious effects [4]. Serious damage usually occurs during the early stages of plant growth with symptoms of hopper burns 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 affect the agro ecosystem. Host Plant Resistance (HPR) is relatively stable, cheap environment friendly and generally compatible with other methods methods of pest management, has been considered as a major control strategy against several pests [5]. Measurement of honeydew excretion and number of feeding marks made by WBPH is used as a tool to assess the resistance and susceptibility of a genotype. The present study was carried out with set of selected rice genotypes against the feeding behavior of *S. furcifera*.

Materials and Methods
Studies on the identification of new sources of resistance in rice genotypes against whitebacked planthopper (WBPH), *Sogatella furcifera* (Horvath) based on Feeding marks and Feeding rate – filter paper method at Paddy Breeding Station (Department of Rice), Agricultural College and Research Institute, Coimbatore, Tamil Nadu, May, 2012. The details of methodologies adopted in the laboratory and glass house are described in this chapter.

Maintenance of insect culture
S. furcifera was mass cultured in the glass house on the susceptible rice variety Taichung Native 1 (TN1). Initial WBPH population was collected from unsprayed rice fields at Paddy

Breeding Station, Tamil Nadu Agricultural University, Coimbatore. The adults were confined on 30 day old potted plants of TN1 placed in oviposition cages (45x45x60 cm) having wooden frames, glass top and door and wire-mesh side walls. The ovipositing insects were removed three days later and plants with eggs were taken out of cages, placed in separate cages for the nymphs to emerge. The emerged nymphs were then transferred to 10 to 15 day old TN1 seedlings raised in 10 cm diameter clay pots placed in galvanized iron trays (64x47x15cm) containing 10 cm depth of water and permitted to feed for 3-4 days and the resulting second and third instar nymphs were used either for seedling screening or for varietal resistance studies. The remaining second and third instar nymphs were used for further multiplication on grown up TN1 plants.

Using this technique, a continuous pure culture of the *S. furcifera* was maintained in the glasshouse during the period of study. The temperature and relative humidity in the glasshouse ranged from 29º to 38 ºC and 42-80 percent, respectively. The plants were observed periodically and the natural enemies if any were removed regularly along with the dried leaves.

Collection of rice genotypes

A set of 11 rice accessions including both cultivated varieties and local landraces collected from Paddy Breeding Station, Coimbatore, Tamil Nadu Rice Research Institute, Aduthurai, Agricultural College and Research Institute, Killikulam, Agricultural Research Station, Ramnad and Hybrid Rice Evaluation Centre, Gudalore were used to assess the level of resistance to *S. furcifera* at seedling stage.

Feeding marks

Three numbers of ten day old seedlings in each genotype were planted in 10 cm diameter clay pots, maintaining three replications for each genotype. The potted plants were covered with a polyester film cage (90 cm height x 10 cm diameter) in Complete Randomized Design. The temperature and relative humidity in the glasshouse ranged from 29 ºC to 38 ºC and 62-80 percent, respectively. The feeding marks counted were used as a parameter to assess the feeding behaviour following the method [6]. Three newly emerged females starved for 24 h were confined on 30 and 45 day old plants of each genotype, grown in 10 cm diameter clay pot and covered with polyester film cages. The feeding marks were stained with 0.1 percent safranine dye for 15 minutes. The number of stained stylet probes was counted for each genotype under microscope.

Feeding rate – filter paper method

Feeding was indirectly assessed by quantifying the area of honeydew droplets in the filter paper after 24 and 48 hours of confinement of *S. furcifera* on test accessions. Insects were allowed to feed in a feeding chamber designed by IRRI [7]. The feeding chamber consisted of an inverted transparent plastic cup placed over a filter paper resting on a plastic lid. Five freshly emerged brachypterous females of *S. furcifera* starved for four hours were placed into the chamber through a hole at the top of the cup. A piece of cotton wad was then placed in the hole to prevent insect escape and the above experiment was conducted with four replications. The insects were allowed to feed for 24 and 48 h. The filter paper, which absorbed the honeydew, was then sprayed with 0.1 percent ninhydrin in acetone solution. Then, the filter papers were oven dried for 5 minutes at 100 ºC. The honeydew stains appeared as violet spots due to the presence of amino acids. The area of the honeydew spots was traced on a tracing paper and the area measured using a millimeter square graph paper. Area of the honeydew spots was assessed with 45 day old plants of the test genotypes.

Statistical analysis

Completely randomized design (CRD) was followed for the studies on feeding marks and honeydew excretion in different rice genotypes. The mean comparison was done by Duncan's Multiple Range Test (DMRT) using IRRISTAT and AGRES statistical software.

Results and Discussion

Feeding marks on leaf sheath were found to be more on the resistant than the susceptible genotypes (Table 1). On 30 day old plants, the feeding marks over the leaf sheath were maximum on PTB 41 (10.67) compared to TN1 (4.67). Among the other genotypes, the feeding marks on the leaf sheath was more on IR 72 (10.33) followed by IR 64 (9.33). On 45 day old plants, the feeding marks on the leaf sheath was maximum on PTB 41 (13.33), IR 64 (11.67), IR 72 (11.33), CO 43 (11.33) and CB 06 535 (11.33) compared to TN1 (6.33).

On 30 day old plants, the feeding mark on the leaf blade was maximum on

PTB 41 (5.33) followed by CO 43 (4.67), CB 06 535, IR 72 and IR 64 (4.33) compared to TN1 (3.00). On 45 day old plants, the feeding marks on the leaf blade were maximum on CB 08 504 and IR 64 (4.67) followed by IR 72 (4.33) and CB 06 535 (4.33) compared to TN1 (3.00).

The overall mean indicated that number of feeding marks on leaf blade was significantly higher in PTB 41 (4.67) followed by IR 64 (4.50) compared to TN1 (3.00) and number of feeding marks on leaf sheath was significantly higher in PTB 41 (12.00) followed by IR 72 (10.83) compared to TN1 (5.50). The feeding marks of leaf blade were significantly lower in 45 day old plants (3.76) compared to 30 day old plants (4.21). Similar observations were recorded in leaf sheath also, where the number of feeding marks was more (9.91) in 45 DAP compared to 30 DAP (7.64).

Feeding marks were found more on leaf sheath of resistant genotypes than on leaf blade. Irrespective of the genotypes studied, TN1 recorded minimum feeding punctures on leaf blade and leaf sheath, compared to other genotypes. PTB 41 recorded maximum feeding punctures in both leaf blade and leaf sheath. Similar findings were also reported regarding the feeding marks [8, 9].

The resistant genotypes elicited feeding response from the insect but could not sustain prolonged feeding probably because of the presence of the certain feeding deterrents like gallic acid in the sap [5]. The presence of oxalic acid and soluble silicic acid acting as feeding deterrent to *N. lugens* was reported [10], while aromatic phenyl alanine and tyrosine produced marked sucking inhibition. The amounts of amino acids like aspartic acid, tyrosine, isoleusine and alanine were lower in resistant genotypes and higher in susceptible genotypes. Therefore, the insect had to make more feeding mark on resistant genotypes to locate the suitable feeding site. The minimum feeding marks on resistant varieties compared to susceptible check, TN1 for *N. lugens* [11, 5].

Extracted epicuticular waxes from IR 22 (susceptible), IR 46 and IR 62 and manipulated plants by switching wax applications between varieties [12]. They found wax composition to affect feeding; specifically, they suggest that a

high ratio of long to short carbon-chain compounds in IR 46 and the presence of shorter chain hydrocarbons in IR 22 largely determined planthopper feeding responses. Plant-surface effects were also suggested from a study comparing planthopper feeding on resistant variety B5 and susceptible variety MH 63 [13]. They found more saliva on the upper part of stems of B5 plants, whereas those left in

MH 63 plants were mainly on the lower part of the stems. However, varying amounts of "general inhibitors" such as silicic acid can also determine the location of sucking sites [14]. *Nilaparvata lugens* can break down after previous attack by planthoppers of a different species. In experiments with *N. lugens* and *S. furcifera*, the effects of feeding by one species increased fitness of the second species feeding on the same plant [15]. This was not observed after feeding by a single planthopper species on the same plant. Amino acids (some of which act as feeding stimulants) and secondary chemicals (many of which are anti-feedants) determine feeding responses [16] (Fig 1).

It has been generally accepted that host selection by planthoppers is due to phloem chemistry and likely involves the lack of particular feeding stimulants [17]. Silicic and oxalic acids deter *N. lugens* feeding on resistant rice [10, 18]. Phenolic acids in resistant varieties appear to be related to the inability of *N. lugens* to find and ingest phloem [19]. On the other hand, *N. lugens* is more likely to reject rice varieties with low levels of essential amino acids in the phloem [20]. Sterols acted as sucking inhibitors for *N. lugens*, whereas asparagines stimulated sucking [21]. However, the results of studies in Korea suggest that *N. lugens* can thrive on resistant rice with *Bph 1* or *bph2* genes despite its difficulty in ingesting the phloem sap of resistant plants [22]. Amino acids interfere with the salicylic acid signaling pathway and induces callose deposition in phloem cells and trypsin inhibitor production after planthopper infestation, thereby reducing the feeding of *N. lugens* [23].

The amount of honeydew excreted by *S. furcifera* feeding on rice genotypes of 30 day old plants was studied in terms of the area of honeydew droplets absorbed by the filter paper (Table 2). Significant difference in the area of honeydew droplets absorbed by filter paper was observed in 24 h and it was maximum in TN1 (0.93 cm^2) and minimum in CO 43 and PTB 41 (0.08 cm^2). Likewise at 48 h, it was maximum in TN1 (2.60 cm^2) and minimum in IR 64 (0.20 cm^2).

Overall mean indicated that the honey dew excretion was significantly low in CO 43 and IR 64 (0.16 cm^2) compared to TN1 (1.76 cm^2). The honeydew excretion was significantly higher on 48 h (0.81 cm^2) compared to 24 h (0.31 cm^2) irrespective of the genotypes tested. The amount of honey dew excreted is directly proportional to the quantity of food ingested by the insect. Very low amount of honey dew excretion was recorded in Co 43, PTB 41, IR 64, IR 72 and CB 06 535 at 24 and 48 hours after release as compared to TN1. IET 15423 recorded lower honeydew area (91.7 percent) than TN1 [6]. That resistant varieties obtained minimum feeding rate compared to susceptible check, TN1 for *N. lugens* [24, 11, 12, 5]. Similar reports were also made in *S. furcifera* [25], *N. virescens* [26] and *Recilia dorsalis* Mot. [27] As the age of the plant increased, the rate of feeding was reduced [25]. This might be due to the presence of feeding stimulant in higher concentration in young plants, leading to larger amount of sap ingestion and consequently excreting more amount of honey dew (Fig 2).

The amino acids were very high in susceptible genotypes and lower in resistant genotypes. So it reduced feeding and the feeding rate also was very low in resistant varieties. Some amino acids *viz.,* serine and leucine were not present in resistant check, PTB 33. In the resistant genotypes, presence of low quantity of amino acids *viz.,* alanine, asparagine, aspartic acid, glutamic acid and valine stimulated the feeding on the *N. lugens* resistant rice genotypes [29].

A close positive correlation between the amount of honey dew excreted by *S. furcifera* and immigrant females in the CJ-06/ TN1 DH lines [30]. *S. furcifera* was smaller and its honeydew excretion was lower than that of *N. lugens* and sucking rate was less than that of *N. lugens* because *S. furcifera* had lower biomass [31].

Table 1: Plant age on the number of feeding marks of *S. furcifera* in rice genotypes

Genotypes	Number of feeding marks/ plant*					
	Leaf blade			Leaf sheath		
	30 DAP	45 DAP	Mean	30 DAP	45 DAP	Mean
CB 06 535	4.33 (2.08)^{abc}	4.33 (2.08)^{ab}	4.33	5.67 (2.38)^{b}	11.33 (3.37)^{b}	8.50
BPT 5204	3.00 (1.73)^{c}	3.00 (1.73)^{ab}	3.00	5.67 (2.38)^{b}	8.00 (2.83)^{c}	6.83
CB 08 504	4.00 (2.00)^{abc}	4.67 (2.16)^{a}	4.33	9.00 (3.00)^{a}	11.00 (3.32)^{b}	10.00
CO 43	4.67 (2.16)^{ab}	4.00 (2.00)^{ab}	4.33	8.67 (2.94)^{a}	11.33 (3.37)^{b}	10.00
ADT 47	3.33 (1.83)^{bc}	3.33 (1.83)^{ab}	3.33	5.00 (2.24)^{b}	6.33 (2.52)^{c}	5.67
Veeradangan	4.67 (2.16)^{ab}	3.33 (1.83)^{ab}	4.00	5.67 (2.38)^{b}	6.67 (2.58)^{c}	6.17
PTB 41	5.33 (2.31)^{a}	4.00 (2.00)^{ab}	4.67	10.67 (3.27)^{a}	13.33 (3.65)^{a}	12.00
IR 72	4.33 (2.08)^{abc}	4.33 (2.08)^{ab}	4.33	10.33 (3.21)^{a}	11.33 (3.37)^{b}	10.83
IR 64	4.33 (2.08)^{abc}	4.67 (2.16)^{a}	4.50	9.33 (3.06)^{a}	11.67 (3.42)^{ab}	10.50
TN1	3.00 (1.73)^{c}	3.00 (1.73)^{ab}	3.00	4.67 (2.16)^{b}	6.33 (2.52)^{c}	5.50
PTB 33	5.33 (2.31)^{a}	2.67 (1.63)^{b}	4.00	9.33 (3.06)^{a}	11.67 (3.42)^{ab}	10.50
Mean	4.21	3.76	3.99	7.64	9.91	8.78

*Mean of three replications

Figures in parentheses are square root transformed values; In a column, mean followed by a common letter are not significantly different by DMRT at 5 percent level

Table 2: Honeydew excretion by *S. furcifera* in rice genotypes

Genotypes	Honeydew (Area in cm^2)*		
	24h	48h	Mean
CB 06 535	0.15 (0.39)^{ab}	0.29 (0.54)^{ab}	0.22
BPT 5204	0.38 (0.61)^{c}	0.59 (0.77)^{c}	0.48
CB 08 504	0.78 (0.88)^{d}	0.33 (0.57)^{b}	0.55
CO 43	0.08 (0.28)^{a}	0.25 (0.50)^{ab}	0.16
ADT 47	0.43 (0.65)^{c}	1.94 (1.39)^{e}	1.18
Veeradangan	0.24 (0.49)^{b}	1.27 (1.13)^{d}	0.76
PTB 41	0.08 (0.29)^{a}	0.58 (0.76)^{c}	0.33
IR 72	0.13 (0.36)^{ab}	0.35 (0.59)^{b}	0.24
IR 64	0.12 (0.35)^{a}	0.20 (0.44)^{a}	0.16
TN1	0.93 (0.96)^{e}	2.60 (1.61)^{f}	1.76
PTB 33	0.12 (0.35)^{a}	0.54 (0.74)^{c}	0.33
Mean	0.31	0.81	0.56

*Mean of three replications

Figures in parentheses are square root transformed values; In a column, mean followed by a common letter are not significantly different by DMRT at 5 percent level

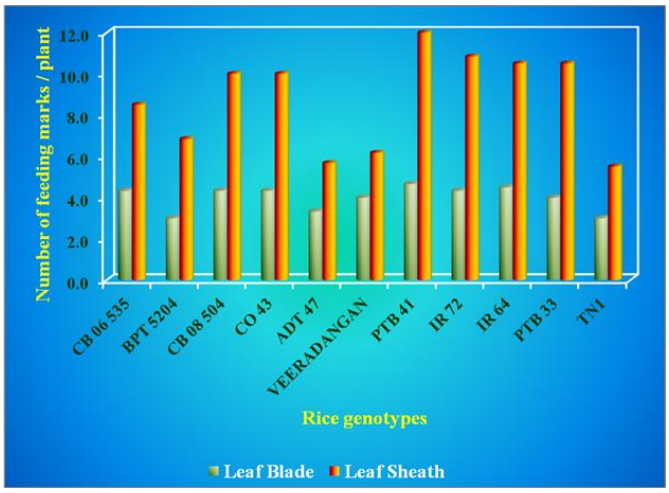

Fig 1: Feeding marks of *S. furcifera* in rice genotypes

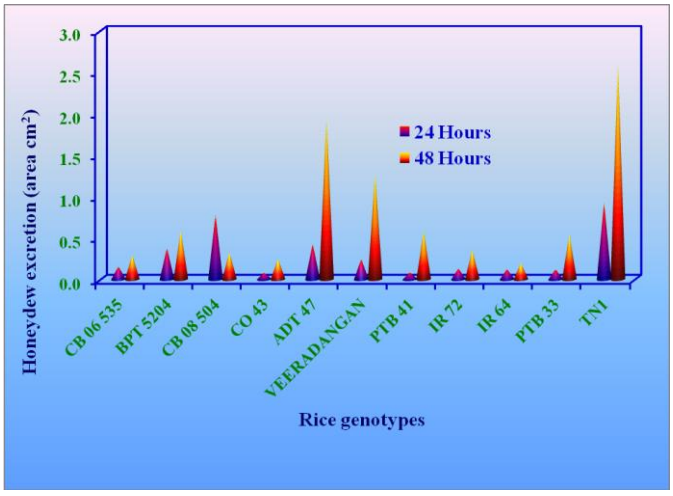

Fig 2: Honeydew excretion of *S. furcifera* in rice genotypes

Conclusion

Feeding punctures on leaf sheath and leaf blade were found to be more on resistant than on the susceptible genotypes. The 45 day old plants had more feeding punctures than the 30 day-old plants. They were maximum on PTB 41 (12.00).The honeydew excretion was the lowest in IR 64 which was on par with CO 43 which was 90.90 percent lower than TN1 followed by CB 06 535 (87.5 percent) and IR 72 (86.36 percent).

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