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# Feeding behaviour of whitebacked planthopper, *Sogatella furcifera* (Horvath), on resistant and susceptible rice varieties

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*Abstract.* Feeding behaviour of the whitebacked planthopper *Sogatella furcifera* (Horvath) was studied on 30-, 45- and 60-day-old plants of seven resistant varieties and one susceptible variety of rice. The preference or otherwise of the hoppers to different varieties was studied in terms of the feeding marks made and the amount of honeydew excreted. The insect made more feeding marks and excreted less honeydew on resistant varieties than on the susceptible TN 1. The number of feeding marks increased with the increase in the plant age of varieties, while the honeydew excretion decreased.

## Introduction

*Sogatella furcifera* (Horvath), the whitebacked planthopper (WBPH) is gradually attaining the status of a major pest of rice in South, South-East and East Asia. Unlike the other leafhoppers and planthoppers infesting rice, it does not transmit any virus or mycoplasma and damage is by direct feeding, leading to hopperburn (Hinckley, 1963; Suenaga, 1963) and ovipositional injury. Studies on host resistance to the WBPH has been stepped-up, both at the International Rice Research Institute (IRRI), Philippines and in many other Asian countries, as certain insecticides have been found to induce resurgence of the WBPH (Nagata, 1979). Measurement of honeydew excretion as a tool in assessing resistance and susceptibility of a variety was demonstrated by Auclair (1958, 1959), with the pea aphid, *Acyrthosiphon pisum* (Harris). Low honeydew excretion was related to the resistance of the rice varieties to the different leafhoppers and planthoppers (Pathak and Saxena, 1980). It has also been demonstrated that the differences in the amount of excretion were related to differences in food intake by the insects on resistant and susceptible varieties. Reported here are the results of experiments to assess the feeding behaviour of WBPH in terms of number of feeding marks made and honeydew excreted on different resistant and susceptible varieties of rice.

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## Materials and methods

In all the experiments, 30-, 45- and 60-day-old plants of seven resistant varieties (ARC 10550, ARC 6650, T 7, IET 5741, IET 6315, IET 6123, IET 6311) and one susceptible variety (TN 1), were used.

### *Number of feeding marks*

The number of stained salivary marks on the plant surface ('feeding marks' or 'feeding punctures'; Sogawa, 1973) as a result of stylet probing was used as a criterion for assessing the feeding behaviour, following the method of Naito (1964). Plants of test varieties were transferred to test tubes (30 × 4 cm) containing culture solution (one tablespoonful of ammonium sulphate fertilizer in 4·54 ℓ of water). A newly emerged female, starved for 10 h was introduced into each tube and confined for 5 h. The feeding marks were stained with 1% aqueous erythrosin solution and examined under a binocular microscope.

### *Honeydew excretion*

*Area measurement.* Honeydew excreted by the WBPH was collected on a filter paper in a feeding chamber previously described (Sogawa and Pathak, 1970). Each variety was replicated five times and five pre-starved 2-day-old brachypterous adult females were allowed to feed inside the feeding chamber for 15 h. The filter papers were then collected and treated with 0·1% ninhydrin in acetone solution. The filter papers were oven dried for 5 min at 100°C and the honeydew spots developed were traced on tracing papers. The area was measured in square millimetres using suitable graph paper.

*Colour intensity measurement.* The ninhydrin-stained purple spots were cut and eluted in a solution mixture of 0·8 ml of 1·2% copper sulphate and 4·2 ml of 85% alcohol and the colour intensity was measured in a Spectral Colorimeter at 475 μm. The quantity of amino acids present in the honeydew was expressed in terms of glutamic acid standard (Moore and Stein, 1948).

## Results

### *Feeding marks*

The number of feeding marks made by the female WBPH on different rice varieties differed significantly (Table 1). In general, the WBPH made more feeding marks on the resistant varieties than on the suceptible check (control), TN 1. The average number of feeding marks on the 30-day-old resistant varieties ranged from 6·8 to 10·2 per plant whereas only 4·6 marks were made on TN 1 of the same age. Among the resistant varieties, more feeding marks were recorded on IET 5741. There was a general increase in the average number of feeding marks on almost all the varieties with increase in age of the plant. Within the plant, more feeding marks were found on the leaf sheath than on the leaf blade.

TABLE 1. Feeding marks of WBPH on rice varieties of different ages

| Varieties | Feeding marks* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS** | | 45 DAS | | 60 DAS | | Mean | |
| | Leaf sheath | Leaf blade | Leaf sheath | Leaf blade | Leaf sheath | Leaf blade | Leaf sheath | Leaf blade |
| ARC 10550 | 5·60ab | 2·80ab | 8·00b | 3·00a | 8·20bc | 2·40a | 7·27c | 2·73abc |
| ARC 6650 | 5·40ab | 3·00ab | 8·00b | 2·20a | 9·40c | 2·00a | 7·60c | 2·40abc |
| T 7 | 5·80b | 2·40ab | 6·00ab | 3·40a | 7·80abc | 2·00a | 6·53bc | 2·60abc |
| IET 5741 | 6·60b | 3·60b | 7·60b | 3·00a | 8·00abc | 3·00a | 7·40c | 3·20c |
| IET 6315 | 4·60ab | 2·20ab | 7·80b | 1·80a | 7·80abc | 2·40a | 6·73bc | 2·13ab |
| IET 6123 | 5·20ab | 3·20b | 7·80b | 2·80a | 7·40abc | 2·60a | 6·80bc | 2·87bc |
| IET 6311 | 5·20ab | 2·60ab | 5·60ab | 2·80a | 6·00ab | 2·80a | 5·60ab | 2·73abc |
| TN 1 | 3·20a | 1·40a | 4·40a | 2·00a | 5·60a | 2·00a | 4·40a | 1·80a |

*Mean of five replications. In a column, varieties followed by the same letter do not differ significantly ($P = 0·05$), Duncan's multiple range test.
**Days after sowing.

*Honeydew excretion*

*Area measurement.* The data on the honeydew excreted on the filter paper by the WBPH fed on different rice varieties, as measured in square millimetres, revealed differences in the rate of honeydew excretion on different resistant and susceptible rice varieties (Table 2). Two to three times less honeydew was excreted when WBPH fed on the resistant varieties than when fed on the 30-day-old plants of TN 1. Honeydew excreted by the WBPH feeding on IET 5741, IET 6315, IET 6123 and IET 6311 was relatively more than that excreted on other resistant varieties. Honeydew excretion was lowest on the resistant check ARC 10550. On the 45-day-old plants of ARC 10550 and ARC 6650, WBPH excreted relatively more honeydew than on 30-day-old plants of the same varieties. However, the feeding rate was low on all other accessions including the susceptible TN 1. Apparent reduction in honeydew excretion was observed in most of the test varieties as the plants aged, and the reduction was more pronounced on 60-day-old plants. However, as in plants of other ages, WBPH excreted significantly more honeydew when they fed on TN 1. The quantity of honeydew excreted was more in 30-day-old plants of each accession except in ARC 6650 where the maximum excretion was on 45-day-old plants.

TABLE 2. Honeydew excretion by WBPH on rice varieties of different ages

| Varieties | Honeydew—area (mm²)* | | | |
|---|---|---|---|---|
| | 30 DAS** | 45 DAS | 60 DAS | Mean |
| ARC 10550 | 1·85a (77·00) | 1·79ab (96·60) | 1·22ab (20·80) | 1·63a (64·80) |
| ARC 6650 | 1·88a (82·60) | 1·97ab (101·00) | 1·00a (12·80) | 1·62a (65·47) |
| T 7 | 1·96ab (94·00) | 1·64a (54·40) | 1·49bc (35·60) | 1·70ab (61·33) |
| IET 5741 | 2·01ab (116·80) | 1·91ab (88·80) | 1·35abc (29·60) | 1·76ab (78·40) |
| IET 6315 | 2·19ab (160·40) | 2·09b (133·40) | 1·93d (110·20) | 2·08cd (134·67) |
| IET 6123 | 2·16ab (152·40) | 1·94ab (121·40) | 1·49bc (78·40) | 1·87bc (117·40) |
| IET 6311 | 2·17ab (153·80) | 2·12b (130·60) | 1·72cd (60·80) | 2·01c (115·07) |
| TN 1 | 2·36b (242·40) | 2·18b (173·60) | 2·18e (161·60) | 2·25d (192·53) |

*Area in Log $x$ values; mean of five replications. In a column, varieties followed by the same letter do not differ significantly ($P$ = 0·05), Duncan's multiple range test. Figures in parentheses represent the area in mm².

**Days after sowing.

*Colour-intensity measurement*

The concentration of amino-acid constituents of honeydew treated with ninhydrin, from different rice varieties, is presented in Table 3. The highest

TABLE 3. Quantity of amino acids in the honeydew excreted by WBPH on rice varieties of different ages

| Varieties | Quantity of amino acids (μg/g dry weight)* | | | |
|---|---|---|---|---|
| | 30 DAS** | 45 DAS | 60 DAS | Mean |
| ARC 10550 | 2·86a | 2·45a | 0·67a | 2·00a |
| ARC 6650 | 3·20a | 2·30a | 1·11ab | 2·20ab |
| T 7 | 3·16a | 2·17a | 1·02ab | 2·12ab |
| IET 5741 | 3·65a | 2·77a | 1·49ab | 2·64bc |
| IET 6315 | 3·73a | 3·00a | 1·85b | 2·86c |
| IET 6123 | 3·60a | 2·66a | 1·49ab | 2·59bc |
| IET 6311 | 3·05a | 2·93a | 1·49ab | 2·49abc |
| TN 1 | 7·41b | 6·49b | 5·81c | 6·57d |

*Mean of five replications. In a column, varieties followed by the same letter do not differ significantly ($P = 0·05$), Duncan's multiple range test.
**Days after sowing.

amount of amino-acid constituents was recorded in the honeydew excreted by WBPH fed on TN 1. The differences in the concentration of amino-acid constituents of the honeydew excreted by WBPH fed on resistant varieties were not significant on 30- and 45-day-old plants. The concentration decreased markedly on old plants of resistant varieties and the decrease was almost gradual on TN 1. The lowest concentration of amino-acid constituents in the honeydew was on 60-day-old plants of ARC 10550.

## Discussion

Although WBPH made feeding marks on both the resistant and suceptible varieties, they made more feeding marks on resistant varieties than on TN 1, despite the lack of sustained feeding on the former. This appears to be attributable to the repeated sap-testing or exploratory probings. Howe and Smith (1957) and McMurty and Stanford (1960) have reported a similar phenomenon in the aphid, *Therioaphis maculata* (Buckton) which, when placed on resistant host plants, was restless and changed feeding sites more frequently. Another species, *Acyrthosiphon pisum*, made more probes on the non-host plants than on the host plants (McLean and Kinsey, 1968). The resistant varieties elicited a feeding response from the insect but could not sustain prolonged feeding, probably because of the presence of certain feeding deterrents or toxic chemicals in their sap. The insect therefore had to make more feeding marks on resistant varieties in an attempt to locate a suitable feeding site. Pablo (1977) made a similar observation: WBPH made more feeding marks on resistant varieties, Colombo, CI 6037-4 and Latighawar than on TN 1. Naito and Masaki (1967) have observed that the green leafhopper (GLH) *Nephotettix cincticeps* Uhler, feeding on a weed, probed more actively than while feeding on rice seedlings. Adult females of the brown planthopper (BPH), *Nilaparvata lugens* (Stål.) made two to three times more feeding marks on resistant Mudgo than on susceptible IR 8 and TN 1 (Sogawa and Pathak, 1970; Sogawa, 1971).

The present study indicated that, at all periods, feeding was lower on all the resistant varieties than on TN 1, and feeding decreased with increase in plant age, being higher on 30- than on 45- and 60-day-old plants, except in ARC 10550 and ARC 6650 where feeding was greater on 45-day-old plants. Waloff (1980) suggested that survival of grassland Auchenorrhyncha populations was to some extent geared to the phenology and the nutritional stage of the host plant.

Our study also revealed that the concentration of amino-acid constituents decreased significantly in the honeydew excreted on resistant varieties, and a higher concentration was recorded at all ages of TN 1. The high feeding rate on 30-day-old plants may have been attributable to the presence of stimulant amino acids at relatively higher concentrations in young plants, causing the insect to ingest larger amounts of sap and consequently to excrete more honeydew. The effects of age of host plant on the performance of pests have already been documented. Growing leaves were more susceptible to colonization by *Myzus persicae* (Sulz.) and *Aphis fabae* Scop. than maturing, mature and dying leaves. The population of aphids was high on young leaves and low on the maturing and mature plants because of the high nitrogen content on young leaves (Kennedy, Ibbotson and Booth, 1950). As soluble nitrogen decreased with plant maturity, the performance of *M. persicae* decreased (van Emden, 1969).

On resistant varieties, honeydew excretion was low, possibly because of the presence either of toxins or of lack of nutrients vital to the WBPH (Pathak and Saxena, 1980). Auclair and Baldos (1982) reported that the rate of honeydew excretion was 267 times less on the resistant variety. WBPH feeding on the susceptible TN 1 plants excreted honeydew containing a significantly higher concentration of amino acids compared with that excreted on resistant varieties. Similar results have been obtained for various ricehoppers, namely WBPH (Rodriguez-Rivera, 1972; Pablo, 1977), GLH (Cheng, 1969) and *Recilia dorsalis* (Pongprasert, 1974). Cheng and Pathak (1972) linked the fecundity of BPH to the total levels of amino acids in the plants. Varieties with a low infestation had amino-acid levels up to 3·7 times lower than those in more favourable varieties, a lower content of asparagine being mainly responsible (Sogawa, 1971; Cagampang, Pathak and Juliano, 1974). The asparagine content of the rice plant is believed to be greatly influenced by the amount of nitrogenous fertilizers applied. Association of leafhopper species with a particular nitrogen concentration in the grasses has already been demonstrated (Prestidge, 1982). Both Hinckley (1963) and Fennah (1969) found a positive correlation between leafhopper fecundity and host-plant soluble nitrogen levels.

Both the methods employed gave satisfactory results, although the procedure of measurement of area is extremely tedious. Measuring the colour intensity of honeydew is the most precise method as it reflected the concentration of amino acids in the honeydew, which again is related to the degree of feeding. However, the method of measuring the area of honeydew on filter papers could be satisfactorily employed by less well-equipped laboratories (Paguia, Pathak and Heinrichs, 1980). Auclair and Baldos (1982) remarked that the method of estimating pH, amino-acid and sugar concentrations in honeydew would appear to be a more accurate method for monitoring feeding sites by plant-sucking insects than that based on determining the frequency of salivary sheath distribution in plant tissues, the latter giving exact information on the frequency of probing but not necessarily on that of actual feeding.

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