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Sucking Inhibitory Action of Aromatic Amines for the Rice Plant- and Leafhoppers (Homoptera: Delphacidae, Deltocephalidae)

Shinji KURATA[1] and Kazushige SŌGAWA[2]

Laboratory of Applied Entomology and Nematology, Faculty of Agriculture, Nagoya University, Chikusa, Nagoya 464, Japan

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A laboratory bioassay was conducted to evaluate three kinds of aromatic amines, phenethylamine hydrochloride, tyramine hydrochloride and hordenine sulfate, as sucking deterrents for the rice plant- and leafhopper, *Nilaparvata lugens*, *Sogatella furcifera*, *Laodelphax striatellus*, and *Nephotettix cincticeps*. These aromatic amines reduced the insect sucking on 5% sucrose solution by 80–90% at 100 ppm, and about 50% at 10–50 ppm.

INTRODUCTION

In the preliminary screening tests on the sucking deterrent properties of various amino acid derivatives when administrated to the brown planthopper, *Nilaparvata lugens*, it has been found out that such aromatic amines as phenethylamine, tyramine and hordenine drastically reduce the excretion of honeydew and increase the probing frequency to an abnormally high level (SŌGAWA, 1971). This has indicated that these chemicals act as gustatory stimuli to interrupt the normal processes of the insect feeding.

In the present study, the effect of the aromatic amines as sucking deterrents were further tested with the four species of rice plant- and leafhoppers.

MATERIALS AND METHODS

Insects: Female adults of the three species of planthoppers, *Nilaparvata lugens*, *Sogatella furcifera*, and *Laodelphax striatellus*, and a species of leafhopper, *Nephotettix cincticeps*, were used taking from their stock colonies reared successively on rice seedlings in the laboratory.

Preparation of test solutions: The following three kinds of aromatic amines were tested; phenethylamine hydrochloride ($C_6H_5CH_2CH_2NH_2$–HCl), tyramine hydrochloride ($HOC_6H_4CH_2CH_2NH_2$–HCl), and hordenine sulfate ($[HOC_6H_4CH_2CH_2N(CH_3)_2]_2$–$H_2SO_4 \cdot 2H_2O$). Each of them was dissolved in 5% sucrose solution at concentrations of 10, 50, 100, 500, and 1000 ppm. Naphthol yellow S (2,4-dinitro-

[1] Present address: 2277 Akasaka, Iijima, Kamiina, Nagano 399-37, Japan.

[2] Present address: Tropical Agriculture Research Center, Kitanakazuma, Yatabe, Ibaraki 300-21, Japan.

1-naphthol-7-sulfonic acid) was added to the test solutions at 0.02% as a color indicator to measure colorimetrically the amount of insect sucking. The sucrose solution containing no test chemicals was used as a control.

Bioassay: The bioassay was conducted using a sucking apparatus made of glass ring (25 mm in inner diameter, 20 mm in hieght). The one open end of the ring was covered by tetoron gauze remaining a small opening at the center which was closed with a cotton plug. A certain volume of each test solution was encapsulated between two sheets of stretched parafilm membranes (parafilm sachet) covering the opening of the sucking apparatus. The volumes of each test solutions enclosed in the parafilm sachet were 0.02, 0.04, and 0.25 ml for *S. furcifera* and *L. striatellus*, *N. lugens*, and *N. cincticeps*, respectively. Five female adults of each species were introduced into the apparatus through the small opening of tetron gauze and allowed to ingest the test solution for 22 hr at 25°C under the continuous lighting. In bioassay with the planthoppers, the apparatus was placed the side of parafilm sachet down, while the apparatus enclosing the leafhoppers was placed reversely. At the end of the test period, the insects were removed from the apparatus, and the test solution remaining in the parafilm sachet was carefully transferred into glass tube with a capillary pipette after dilution with 0.3 ml of distilled water for *S. furcifera* and *L. striatellus*, or 0.6 ml for *N. lugens*. The absorbance of the collected solutions was measured at 430 nm with spectrophotometer, Shimazu Spectronic 20, and the amount of imbibition was calculated by the following formula:—

$$x=y(y+z)\frac{A-B}{A(y+z)-By}$$

where x=amount of insect imbibition,
y=amount of test solution enclosed in the parafilm sachet,
z=amount of distilled water used for dilution,
A=absorbance before the insect sucking,
and B=absorbance after the insect sucking.

In the case of *N. cincticeps*, the test solution remained in the parafilm sachet was diluted to 5 ml with distilled water and submitted to the spectrophotometric assay. The amount imbibition was calculated from the calibration curve. The bioassays for each chemicals were repeated five times, and the results obtained were averaged.

The insect mortalities on the test solutions and by starvation were also recorded after 22 hours.

RESULTS

The results obtained were assembled in Tables 1 to 4. The three kinds of aromatic amines similarly deterred the sucking of all the four species of plant- and leafhoppers. Generally, 80 to 90% inhibition in the insect imbibition was obtained at 1000 ppm, and about 50% inhibition at 10 to 50 ppm, although appreciable variations were recognized in the effect of each chemical to the different insect species. The insect mortality, especially in *N. lugens*, tended to increase with the increase of amine concentrations in the dietary solutions. It was usually as high as that induced by starvation when the fluid imbibition was suppressed to about one-tenth.

Table 1. Effect of the Aromatic Amines on the Sucking of *N. lugens*

Compound	Conc. (ppm)	Imbibition (μl)[a]	Inhibition (%)[b]	Mortality (%)
Phenethylamine hydrochloride	1000	2.4	90	50
	500	6.0	75	38
	100	10.7	55	29
	50	11.3	51	0
	10	14.5	39	25
Tyramine hydrochloride	1000	3.4	86	33
	500	4.7	80	25
	100	6.5	73	8
	50	9.8	59	17
	10	17.2	27	0
Hordenine sulfate	1000	2.5	89	75
	500	5.4	77	46
	100	6.5	73	29
	50	7.9	67	17
	10	11.5	51	13
Control		23.7	0	0
Starvation[c]		—	—	58

[a] μl/five insects/22 hours.

[b] $\frac{\text{Imbibition on control} - \text{Imbibition on amine}}{\text{Imbibition on control}} \times 100(\%)$

[c] The insects were kept in the apparatus without dietary solution.

Table 2. Effect of the Aromatic Amines on the Sucking of *S. furcifera*

Compound	Conc. (ppm)	Imbibition (μl)[a]	Inhibition (%)[b]	Mortality (%)
Phenethylamine hydrochloride	1000	0.8	94	0
	100	3.6	71	0
	10	5.6	55	0
Tyramine hydrochloride	1000	2.2	82	41
	100	4.6	63	0
	10	8.1	35	0
Hordenine sulfate	1000	1.7	86	41
	100	5.1	59	0
	10	6.0	52	0
Control		12.4	0	0
Starvation[c]		—	—	71

[a,b,c] See Table 1.

DISCUSSION

Though the aromatic amines have been known to occur widely in plants (Smith, 1971), they do not appear to have been previously reported as feeding inhibitors for phytophagous insects excepting hordenine sulfate against the grasshopper, *Melanoplus*

Table 3. EFFECT OF AROMATIC AMINES ON THE SUCKING OF *L. striatellus*

Compound	Conc. (ppm)	Imbibition (μl)[a]	Inhibition (%)[b]	Mortality (%)
Phenethylamine hydrochloride	1000	2.7	76	45
	100	5.3	53	5
	10	6.6	41	0
Tyramine hydrochloride	1000	2.2	80	0
	100	3.3	71	0
	10	5.2	54	0
Hordenine sulfate	1000	0.8	93	0
	100	1.2	89	0
	10	4.8	57	0
Control		11.2	0	0
Starvation[c]		—	—	60

[a,b,c] See Table 1.

Table 4. EFFECT OF AROMATIC AMINES ON THE SUCKING OF *N. cincticeps*

Compound	Conc. (ppm)	Imbibition (μl)[a]	Inhibition (%)[a]	Mortality (%)
Phenethylamine hydrochloride	1000	2.3	97	55
	500	9.3	88	0
	100	16.3	77	25
	50	32.5	55	0
	10	38.3	47	25
Tyramine hydrochloride	1000	2.3	97	35
	500	11.5	84	40
	100	16.3	77	5
	50	25.5	64	0
	10	41.8	42	0
Hordenine sulfate	1000	12.5	83	25
	500	20.5	71	0
	100	22.6	69	35
	50	34.2	52	0
	10	43.6	39	0
Control		71.8	0	0
Starvation[c]		—	—	55

[a,b,c] See Table 1.

bivittatus (MARLEY and THORSTEINSON, 1967). However, it has been indicated that several kinds of aromatic amines function as sucking deterrents for the planthopper, *N. lugens*, because the honeydew excretion by *N. lugens* sucking on sucrose solution containing the amines is markedly reduced in spite of intensive trials of the stylet probing (SŌGAWA, 1971). The present study further demonstrated by the direct measurements of insect sucking that phenethylamine, tyramine and hordenine effectively suppressed the fluid intake of the four species of plant- and leafhoppers at the concentrations above 10 ppm. The mortality in *N. lugens* on the test solutions was

Table 5. Correlation Coefficeients between the Amounts of Fluid Imbibed by *N. lugens*[a] and the Insect Mortality[b] (A), and between the Amounts of Aromatic Amines Ingested by *N. lugens*[a] and the Insect Mortality[b] (B)

Compound	A	B
Phenethylamine hydrochloride	−0.82* (d.f.=5)	0.57 (d.f.=4)
Tyramine hydrochloride	−0.95**(d.f.=5)	0.94*(d.f.=4)
Hordenine sulfate	−0.94**(d.f.=5)	0.87 (d.f.=4)
Total[c]	−0.62* (d.f.=15)	0.21 (d.f.=14)

[a] Transformed to logarithmic values.

[b] Actual numbers of the dead insects.

[c] The data for the three kinds of test compounds were considered to belong to the same population.

considered to be induced by starvation or desiccation as a results of strong inhibition of the fluid imbibition rather than the toxic effects of the amines, because the insect mortality was more closely correlated with the amount of imbibition than with the amount of amines absorbed by the insects (Table 5). From the above discussion, it is concluded that the aromatic amines probably deter the continuous sucking of the plant- and leafhoppers through the gustatory responses.

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