SHORT COMMUNICATIONS

Studies on the Mode of Action of Buprofezin I. Nymphcidal and Ovicidal Activities on the Brown Rice Planthopper, *Nilaparvata lugens* Stål (Homoptera: Delphacidae)[1]

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Buprofezin (2-*tert*-butylimino-3-isopropyl-5-phenylperhydro-1, 3, 5-thiadiazin-4-one; Applaud®, NNI-750) is a new insecticide being developed for control of hemipterous and coleopterous insect pests. Kanno et al. (1981) and Kajihara et al. (1982) reported that buprofezin efficiently controlled the brown rice planthopper, *Nilaparvata lugens* Stål, in field trials. In their reports, third instar nymphs of *N. lugens* were highly susceptible to buprofezin and the number of progenies was drastically reduced in spite of the low mortality of adults which were inoculated on rice plants treated with the substance. However, it is not known which nymphal instars are most susceptible to buprofezin and why such a drastic reduction occurred in the number of progenies. It is the purpose of this paper to reveal the level of susceptibility of each instar nymph and ovicidal activity in relation to the reduction of progeny.

N. lugens was reared on rice seedling (Kinmaze cultivar) in an air-conditioned cabinet (25±1°C; 60–70% R. H.; 16–8 hr light-dark).

Buprofezin was synthesized and formulated at the Chemical Research Center of our company. Throughout the experiments, the buprofezin used was a 25% wettable powder. *m*-Tolyl *N*-methylcarbamate (MIMC 50% E. C.), *o*-*sec*-butylphenyl *N*-methylcarbamate (BPMC 50% E. C.), propaphos (50% E. C.) and diazinon (50% E. C.) were used as reference insecticides.

The test suspensions (150 m*l* each) were sprayed on rice plants (Kinmaze cultivar, 6–7 leaf stage) with a spray gun at 2×760 mmHg. After drying, the rice stems were cut at the bottom and the stem inserted into a glass tube (18 cm in height×1.8 cm in diameter) with 1 m*l* of distilled water. Five of first, second, third, fourth and fifth instar nymphs of *N. lugens* were exposed on one rice stem per glass tube, respectively. Mortality was recorded five days after exposure, which corresponds to the dying-time (Kanno et al., 1981; Kajihara et al., 1982). Abbot's formula (Abott, 1925) was used to correct the mortality percentage. Three replicate experiments were made. The LC-50 and LC-95 values of buprofezin for each instar nymph of *N. lugens* are shown in Table 1 as the concentration sprayed on the plants. The LC-50 value for second instar was about 1.15 times higher than that for first instar. These values for third, fourth and fifth instar were respectively 1.75, 2.93 and 3.98 times higher than for first instar. Though its nymphcidal activity declined with the nymphal stage process, efficient activity was found even at as low a concentration as less than 1 ppm. Buprofezin was 20–80 times as active as BPMC and propaphos on third instar nymphs of *N. lugens* (Kanno et al., 1981; Kajihara et al., 1982). Thus its high killing activity was elucidated against every instar nymph of *N. lugens* and this nymphcidal activity is considered to be an efficient control of *N. lugens*.

Figure 1 shows a characteristic death symptom when a third instar nymph of *N. lugens* was exposed to a rice stem treated with 1 ppm of buprofezin. The nymph was incapable of casting its exuvie and died in a typical moulting position accompanied by loss of moisture and blackening. This phenomenon was usually observed when nymphs of any instar were treated with this insecticide. A similar phenomenon of nymphal death has been seen in insect growth regulators such as chitin synthesis inhibitors, juvenile hormone mimics and thiosemicarbazones (Mulder and Gijswift, 1973; Staal, 1982 a,b; Bowers, 1982; Kelly et al., 1982).

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Table 1. Toxicity of buprofezin on instar nymphs of *N. lugens*

Instar	Regression equation	n[b]	LC-50[a] (ppm)	LC-95[a] (ppm)	Pr
1	$Y=5+2.497\ (X+0.875)$	6	0.133 a	0.608 a	$0.990<\mathrm{Pr}<0.995$
2	$Y=5+1.773\ (X+0.815)$	6	0.153 a,b	1.296 b	$0.950<\mathrm{Pr}<0.975$
3	$Y=5+1.484\ (X+0.633)$	6	0.233 c	2.088 c	$\mathrm{Pr}>0.995$
4	$Y=5+1.960\ (X+0.410)$	6	0.389 d	2.687 c	$0.990<\mathrm{Pr}<0.995$
5	$Y=5+0.968\ (X+0.311)$	6	0.489 d	24.450 d	$0.975<\mathrm{Pr}<0.990$

[a] LC-50 and LC-95 values were computed from mortality of nymphs examined five days after treatment. Means followed by a common letter in a column are not significantly different at the 5% level.
[b] Number of dosages.

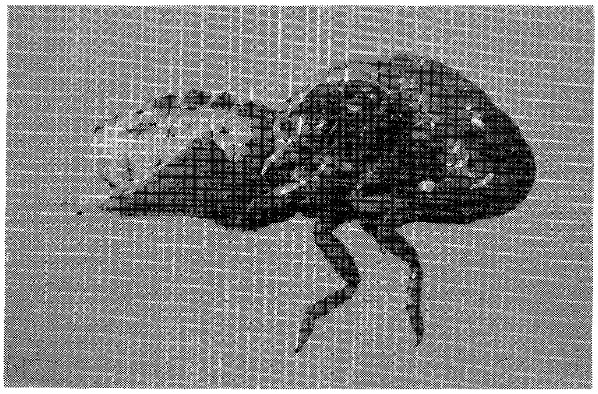

Fig. 1. A third instar nymph of *N. lugens* exposed to a rice stem sprayed with buprofezin, has unsuccessfully tried to wriggle out of its exuvie.

Test liquids (150 m*l* each) were sprayed on rice plants (Kinmaze cultivar, 6–7 leaf stage) which had been oviposited by female adults of *N. lugens* for twenty-four hours. After counting the number of hatched nymphs, the number of unhatched eggs was counted by dissecting the oviposited rice stem under a binocular microscope.

Table 2 shows the effect of buprofezin and four other insecticides on *N. lugens* egg hatchability deposited during a twenty-four hour period. The hatchability of eggs directly treated with buprofezin was 43.3 and 9.7% corrected hatchability at 250 and 1,000 ppm, respectively. This was a little higher than the effect of the other four insecticides which showed 60–100% corrected hatchability at 250 ppm. But this level of buprofezin ovicidal activity could not explain the more than 96% suppression of the hatched nymphs when adults of *N. lugens* were inoculated on rice plants sprayed with 250 ppm (Kanno et al., 1981; Kajihara et al., 1982). To explain this suppression, a second effect of buprofezin, its sterilizing effect on adults, must be studied. This sterilizing effect has been well documented in precocene on milkyweedbug (Bowers, 1976) and dimilin on housefly (Wright and Spates, 1976).

It is suggested that the symptoms of buprofezin death may be similar to that of dimilin, described above. Yet to be clarified, however, is whether buprofezin acts by the same mechanism as dimilin, which interferes with synthesis and the formation of a new cuticle (Sowa and Marks, 1975; Hajjar and Casida, 1979). Future multilateral studies using histological and biochemical approaches will be needed to resolve this question.

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Table 2. Effect of buprofezin and four other insecticides on hatchability of eggs of *N. lugens*

Compound	Concentration (ppm)	Number of eggs used	Number of hatched nymphs	Hatchability (%)	Corrected hatchability (%)
Buprofezin	250	446	166	37.2	43.3
	1,000	423	35	8.3	9.7
BPMC	250	318	188	59.4	68.7
MIMC	250	470	352	74.7	87.1
Propaphos	250	304	163	53.6	62.3
Diazinon	250	300	263	87.7	100
Control	0	464	399	85.9	100

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Indican as a Feeding Stimulant to the Strawberry Leaf Beetle, *Galerucella vittaticollis* BALY Attacking Polygonaceous Plants[1]

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In previous papers, the role of plant chemicals in the host selection of Polygonaceae-feeding leaf beetles has been reported. The strawberry leaf beetle, *Galerucella vittaticollis* BALY, which feeds on plants of the family Polygonaceae and strawberry, *Fragaria chiloensis*, was stimulated to feed by some nutrient chemicals such as sugars and amino acids as well as flavonoids and esters of higher alcohols (MATSUDA and MATSUMOTO, 1974; MATSUDA, 1976; MATSUDA and SUGAWARA, 1978). The feeding of another beetle, *Gastrophysa atrocyanea* MOTSCHULSKY with a host range restricted to polygonaceous plants was stimulated by nutrient chemicals, flavonoids and organic acids (MATSUDA, 1981, 1976; MATSUDA and MATSUMOTO, 1975). The other two beetles, *Gallerucida nigromaculata* BALY and *G. bifasciata* MOTSCHULSKY, both feeding only on Polygonaceae were stimulated to feed by flavonoids, organic acids and esters of higher alcohols (MATSUDA, 1976; MATSUDA and MATSUMOTO, 1975; MATSUDA and SUGAWARA, 1978). In the present study, the feeding stimulations of indican present in *Polygonum tinctorium* and related compounds were examined as the next step in understanding the host plant selection in Polygonaceae-feeding leaf beetles. The distribution of indican in Polygonaceae and *F. chiloensis* was also investigated.

MATERIALS AND METHOD

Insects. *Gal. vittaticollis* and *Galler. nigromaculata* used in the experiments were selected from laboratory colonies maintained on *Rumex obtusifolius*. Larvae of *Gastr. atrocyanea* were collected from *R. obtusifolius* and reared on the same plant to adults. Adults *Galler. bifasciata* were gathered from *Polygonum sachalinense* and reared on the same plant.

Chemicals. Indican, 3-indoxylsulfuric acid potassium salt and indoxyl acetate (Tokyo Kasei Kogyô Co., Ltd.) and 3-indole acetic acid, indigo, indole and isatin (Wako Pure Chemical Ind. Co., Ltd.) were used for the experiments. The first compound was recrystallized from methanol prior to use to remove contaminants.

Bioassay. The effects of indican and related compounds on the feeding of adult leaf beetles were examined in the choice trial test. Adult beetles were

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