Long-Term Suppressive Effect of Buprofezin on Population Growth of the Greenhouse Whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae)\(^1\)

Michihiro Yasui,\(^2\) Tetsuyosi Nishimatsu, Minoru Fukada\(^3\) and Sadafumi Maekawa\(^4\)

*Biological Research Center, Nihon Nohyaku Co., Ltd., Honda-cho, Kawanishi-ku, Osaka 550, Japan*

(Received April 25, 1990)  (Accepted October 16, 1990)

**Key words**: buprofezin, greenhouse whitefly, long-term effect, population growth, IGR

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), has high reproductive potential in favorable conditions such as greenhouse and vinylhouse environments (Naba et al., 1978; Yamada et al., 1979; Iheagwan, 1980; Yano, 1989). An insect growth regulator (IGR), buprofezin (2-tert-butylinino-3-isopropyl-5-phenylpyrroliodine-1,3,5-thiadiazin-4-one, Applaud\(^8\)) has molting-inhibiting action on each *T. vaporariorum* instar and suppresses hatching and activity of hatched larvae through adult treatment, but adulticidal and ovicidal actions are weak (Yasui et al., 1985, 1987). These actions seem to have some long term effect on *T. vaporariorum* in vinylhouses (Naba et al., 1983; Sugihara, 1984; Takahashi, 1984), but constitutional changes of the insect stage and the reproductive rate are poorly understood. In this paper we analyzed the long-term suppressive effect of buprofezin.

**MATERIALS AND METHODS**

Buprofezin was synthesized and formulated to 25% wettable powder (W.P.) at the Chemical Research Center of Nihon Nohyaku Co. Methidathion 36% W.P. was used as a reference insecticide. Each formulation was diluted with water mixed with 0.03% of spreader (Rinoh\(^\circledast\), Nihon Nohyaku Co.). *T. vaporariorum* were reared on potted tomato plant (cultivar: Ponderosa) in a greenhouse. Tomato plants (cultivar: Satan) were cultivated in a vinylhouse (5.8 m \(\times\) 2.7 m) partitioned by plastic sheets. Four rows of tomato seedlings of 6.5 leaf stage were planted with four plants each for each plot on May 12th. Topping was done at six cluster-flowering stage on July 6th. Eight *T. vaporariorum* adults were released per pot in the nursery pots on April 27th. Twelve and 2.5 *T. vaporariorum* adults/plant were released after planting in the vinylhouse on May 13th and 24th, respectively. Buprofezin at 250 ppm and methidathion at 360 ppm were sprayed at 18 leaf stage on June 8th in each plot. One each of the buprofezin and methidathion plots were sprayed again at 24 leaf stage 14 days after the first spray. Air temperature ranged from 12 to 37\(^\circ\)C during the experiment. The number of adults in the eight plants/plot was directly counted prior to spraying, two days after spray and at intervals of seven days thereafter. The number of eggs, larvae, pupae and puparia was counted under a binocular microscope in 61.8 cm leaf discs sampled by a cork borer from upper, middle and lower leaf positions of seedlings from 16 plants/plot at 14 day intervals after spray. The intrinsic rates of natural increase \(r\) of *T. vaporariorum* adults were calculated as an

![Fig. 1. Population changes of *Trialeurodes vaporariorum* adults on tomato plants in a vinylhouse.](image)

- Buprofezin at 250 ppm, single treatment, O: Buprofezin at 250 ppm, double treatment, Δ: Methidathion at 360 ppm, double treatment, ×: Control, ◀: Spray application.

---

2. Present address: Planning & Coordination Department, Nihon Nohyaku Co., Ltd., Tsukuba 5-chome, Nishiyodo-gawa-ku, Osaka 535, Japan
3. Present address: Saga Plant, Nihon Nohyaku Co., Ltd., Kamine-cho, Miyaki-gun, Saga 849–01, Japan
4. Present address: Developmental Department, Nihon Nohyaku Co., Ltd., Nihonbashi, Chuo-ku, Tokyo 103, Japan
Table 1. Changes in the number of eggs, larvae, pupae and puparia of *T. vaporarium*
on tomato leaves after buprofezin applications in a vinylhouse.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Conc. (ppm)</th>
<th>No. of treatment</th>
<th>No. of eggs$^a$</th>
<th>No. of larvae$^b$</th>
<th>No. of pupae$^a$</th>
<th>No. of puparia$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0$^b$</td>
<td>14</td>
<td>28</td>
<td>42</td>
</tr>
<tr>
<td>Buprofezin</td>
<td>250</td>
<td>1</td>
<td>0.69</td>
<td>1.81</td>
<td>0.13</td>
<td>0.50</td>
</tr>
<tr>
<td>Buprofezin</td>
<td>250</td>
<td>2</td>
<td>3.06*</td>
<td>2.25</td>
<td>1.06</td>
<td>2.38</td>
</tr>
<tr>
<td>Methidathion</td>
<td>360</td>
<td>2</td>
<td>0.63</td>
<td>0</td>
<td>0.82</td>
<td>1.42</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0.50</td>
<td>1.50</td>
<td>54.76</td>
<td>47.17</td>
</tr>
</tbody>
</table>

$^a$ Average number/one leaf disc (φ1.8 cm).
$^b$ Days after first spray. Second spraying was applied 14 days after the first spraying.
* Aggregated eggs were observed in circles.
index of population growth for some limited periods after IGR treatment by fitting to the population growth formula, \( N_t = N_0 e^{rt} \) (\( N_t \): no. of adults \( t \) days after the treatment, \( N_0 \): initial number of adults just prior to the treatment), namely \( \ln(N_t/N_0)=rt \), used by NABA et al. (1978), NAKAZAWA et al. (1979) and YAMADA et al. (1979).

RESULTS AND DISCUSSION

The number of adults just prior to the first spray were 35.6, 48.5, 38.1 and 25.8 adults/plant in single and double buprofezin treatment plots, the methidation plot and the control plot, respectively. The number of adults in the control plot increased exponentially (Fig. 1). For 28 days after the first spray, the number of adults gradually decreased in single and double treatments of 250 ppm buprofezin. For days 28–56 after the first spray, the number of adults increased exponentially in both single and double treatments. Adult density was suppressed to levels below the threshold of the tolerable pest density (TPD, 400 adults/plant, NABA et al., 1978; NAKAZAWA et al., 1979; NAKAZAWA, 1981) for 56 days in single and double treatments of buprofezin. The number of adults in the double and single treatment of 360 ppm methidation drastically decreased two days after the first spray, but then gradually increased until the second spray. The number of adults depressed by the second spray increased rapidly between the 16th and 56th days.

The number of eggs, larvae, pupae and puparia on tomato leaves was counted to evaluate the residual effects of buprofezin on each developmental stage at 14 day intervals by leaf disc sampling (Table 1). In the control plot, rapid increase was observed in eggs between the 14th and 28th days, in larvae between the 14th and 42nd days and in pupae between the 42nd and 56th days. Leaves were fully damaged on the 56th day after the start of the experiment. In single treatment buprofezin plots, few eggs but no larvae developed during the experiment between the 14th and 28th days. In double treatment buprofezin plots, there were also a few eggs present during the experiment but no larvae for days 14–42 and a few larvae on day 56. No pupae were seen in buprofezin plots during days 14–42 nor were puparia seen in days 28–42 after the first spray. These results demonstrate the long-term suppressive action of buprofezin on *T. vaporariorum*. The action was slightly stronger in double treatments. The \( r \) of the adult in single and double buprofezin-treated plots was \(-0.0542\) and \(-0.0594\) for 28 days after the first spray and \(0.1276\) and \(0.0708\) for days 28–56, respectively (Table 2). Between days 28 and 56 days after the first spray, the \( r \) in the double buprofezin treated plot was slightly smaller than the \( r \) in the single buprofezin treated plot and the control plot. In the methidation plot, no eggs were observed on day 14 and no pupae on day 28 after the first spray but eggs and larvae increased gradually in days 28–56 (Table 1). The \( r \) in the methidation plot was 0.1884 for days 16–56 after the first spray and a little larger than the \( r \) in the control plot.

The long-term suppressive effects of buprofezin are observed for more than 40–60 days in applied control of pest insects such as the brown rice planthopper *Nilaparvata lugens* Stål in paddy fields (ASSA et al., 1984), the sweet potato whitefly, *Bemisia tabaci* (Gennadius) under field conditions (ISHII et al., 1988), and the California red scale, *Aonidiella aurantii* (Maskell) in outdoor conditions (YARM et al., 1988). The suppressive effect on *T. vaporariorum* lasted for about 60 days in the vineyard.

Table 2. Intrinsic rate of natural increase (\( r \)) of *T. vaporariorum* calculated from adult population growth on tomato plants in a vineyard

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Conc. (ppm)</th>
<th>No. of treatment</th>
<th>Periods after the first spray (days)</th>
<th>( r^a )</th>
<th>Relative coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buprofezin</td>
<td>250</td>
<td>1</td>
<td>0–28</td>
<td>-0.0542</td>
<td>-0.910</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>2</td>
<td>28–56</td>
<td>0.1276</td>
<td>0.987</td>
</tr>
<tr>
<td>Methidation</td>
<td>360</td>
<td>2</td>
<td>16–56</td>
<td>0.1884</td>
<td>0.980</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>0</td>
<td>0–49</td>
<td>0.1314</td>
<td>0.994</td>
</tr>
</tbody>
</table>

\(^a\) Calculated by \( \ln(N_t/N_0)=-rt \). \( t \)=days after the first application in Fig. 1.
The long-term effect of buprofezin probably depended not only on the stability of the compound as seen in rice plants (Asai et al., 1984) and tomato plants (Yasui et al., unpublished) but also on the low value of median effective concentration (EC₅₀) on each instar larva and the effect on eggs through adult (Yasui et al., 1985, 1987). The r of *T. vaporariorum* adults is 0.048–0.086 on glasshouse cucumbers planted between February and April (Yamada et al., 1979). The r on tomato plants is 0.079–0.102 from April to August in vinylhouses (Nakazawa et al., 1979), 0.079 at 25°C (Heagwan, 1980) and 0.0844–0.0932 at high temperature (Yano, 1989). The higher r in the control plot of this experiment (Table 2), 0.1314, might be due to more favorable reproductive conditions in the vinylhouse from June to July. Single and double buprofezin treatment brought about negative r for 28 days after the first spray (Table 2), which appears to be due to low adult emergence caused by the larvicidal effect of the compound (Table 1) and suppression of adult longevity (Yasui et al., 1985).

*T. vaporariorum* adults emerged on old mature leaves fly to new ones, and deposit eggs on their lower surfaces (Nakazawa and Hayashi, 1975; Yamada et al., 1979). Emergent adults on treated leaves seemed to absorb buprofezin by sucking fluid containing it or being in direct contact with it. Eggs laid on new leaves seldom hatched if adults were treated. Furthermore, if hatched, young larvae have low viability and hardly survive (Yasui et al., 1987). A few adults freshly emerged on the treated leaves seem to die gradually (Yasui et al., 1985). Consequently, the number of ovi- posited eggs seemed to decrease with adult reduction (Table 1) and the population growth was depressed. The recovery of population growth seemed to be retarded and suppressed due to effects on adults through treated leaves (Table 2). Thus, one or several treatments of buprofezin per cultivation can keep *T. vaporariorum* populations below TPD for long periods.

ACKNOWLEDGEMENT

We wish to express our sincere thanks to Dr. F. ARAKI, the manager of the Biological Research Center of Nihon Nobyaku Co., Ltd. for his helpful suggestions and critical reading of manuscript. Thanks are also due to Mr. T. TAKASHIMA of the Biological Research Center, for his computational program.

REFERENCES


