ppm, where ca. 50% of carboxyl ions in solution were estimated to result in insoluble salts; however, the difference was not significant. Significant decreases in apicidity, and in wetting and spreading ability over waxy surfaces on sprayed leaves were observed at 500 ppm, where ca. 60% of carboxyl ions were estimated to form insoluble salts. Although the washing ability of soap was shown to be reduced by half when dissolved in water with hardness of 150 ppm (YAMANE, 1977), no influence was observed on apicidity in the same water conditions. Therefore, the apicidity of soap is thought to be unaffected by the main factors that govern washing ability. On the other hand, the connection between apicidity and surface tension, which is one of the indices of wetting ability that was proposed to be a key factor for apicidity of soap (IMAI et al., 1995), was shown. Surface tension was also nearly constant over a wide range of water-hardness (0–250 ppm) and rose above 417 ppm.

In Japan, river and underground water is generally not hard: according to Water Supply Statistics (Ministry of Public Welfare, 1994), 1,028 out of 1,029 river and lake water samples (99.90%) and 2,756 out of 2,786 underground water samples (98.92%) revealed that the annual maximum water hardness to be lower than 200 ppm. Therefore, water hardness is not a negative factor for performance of an insecticidal soap, making soap completely suitable for use in almost any region of Japan.

REFERENCES


Adult Emerging Sites of *Thrips palmi* (Thysanoptera: Thripidae) in an Eggplant Field with Mulching Sheet1

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**Key words:** emerging site, mulching sheet, *Thrips palmi*

*Thrips palmi* is one of the most serious pests on eggplant even in low population density (KAWAI, 1986). Recently, the effectiveness of predatory bugs, *Orius* spp., and other agents has been studied to manage the population density of *T. palmi*, because only a few insecticides have been able to regulate its density below the economic injury level (KAJITA, 1988; NAGAI et al., 1988a, b; SAI TO, 1990). Most terembrantian second instar larvae tend to fall on soil and then pupate (LEWIS, 1973). Therefore, information about its distribution pattern in the soil could help us to advance a control program. Findings on the pupating and emerging sites of *T. palmi* in an eggplant field using sticky traps when ridges are mulched with plastic film are presented.

**MATERIALS AND METHODS**

Thirty eggplant seedlings were planted at 1 m intervals on the top of ridges (0.3 m height) in an open field (90 m²) in early May 1991, after mulching the ridges with black-colored plastic film, which is commonly used by farmers to warm the soil temperature (Fig. 1). The surfaces of soil around the stem of eggplant, edge of the ridge and trough were not mulched with the film. Water was supplied to the trough once a day during harvest from mid July to late September. No insecticide was used during the experiment.

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Two types of sticky trap (quadrat trap and can trap) were used. The former was a wooden square frame (100 cm²) to which a transparent vinyl film was set with a sticky substance on the upper surface to catch the adults and larvae falling on the soil. The quadrat traps were placed at three sites per eggplant, i.e., around the stem, on the mulching sheet, and the trough (total 30 quadrat traps per 10 eggplants) with the sticky surface upward 10 cm above the soil horizontally from 9 to 11 and from 17 to 22 September. The latter was a steel can with the top and bottom cut and a sheet of transparent vinyl film (34.2 cm²) attached to the top. The lower surface of the film was coated with sticky substance (Kinryū spray, SDS Biotec Co. Ltd., Japan) to catch adults emerging from the soil. The can traps were inserted into the soil vertically at four sites per eggplant, i.e., around the stem, under the mulching sheet, the edge and the trough (total 36 can traps per 9 eggplants); after uncovering the mulching sheets from 17 to 22 September. The study areas used for the two types of trap did not overlap.

Larvae and adults trapped on the film were counted under a dissecting microscope. Thrips species were identified with the trapped adults and also with adults collected from the eggplant leaves once a week from 1 September to 6 October.

RESULTS AND DISCUSSION

The dominant species of thrips in number was *Thrips palmi*; 43.0 and 53.7% in traps and on-eggplant samples, respectively (Table 1). Three main species,

<table>
<thead>
<tr>
<th>Species</th>
<th>Sticky trap (%)</th>
<th>On eggplant (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Thrips palmi</em></td>
<td>58 (33.7)</td>
<td>422 (43.0)</td>
</tr>
<tr>
<td><em>Myzostethra glycines</em></td>
<td>29 (26.9)</td>
<td>216 (22.0)</td>
</tr>
<tr>
<td><em>Thrips setosus</em></td>
<td>19 (17.6)</td>
<td>244 (24.9)</td>
</tr>
<tr>
<td>Others</td>
<td>2 (1.8)</td>
<td>99 (10.1)</td>
</tr>
</tbody>
</table>

a Total number sampled from 9 to 11 and from 17 to 22 Sep.

b Total number sampled from 1 Sep. to 6 Oct.

*Thrips palmi*, *Myzostethra glycines* and *Thrips setosus* accounted for about 90% of the thrips.

There was no significant difference in the mean number of adults collected among the three quadrat traps sites (Fig. 2). On the other hand, there were significant differences in the mean number of larvae trapped between trap sites except for one case; more larvae tended to be caught at trap sites nearer to the stem. These results suggest that adults fly freely, but larvae fall contagiously on the field, especially near the stem.

The number of adults caught with can traps was significantly larger around the stem than at the other sites (Fig. 3). This result shows that the main emerging site of *Thrips palmi* is around the stem; many larvae seem to fall on sites nearer to the stem, but they could not creep into the soil, the surface of which was mulched. A few and very few thrips emerged from the edge and the trough, respectively. I have not yet ex-
Fig. 2. Mean numbers of adults and larvae caught on quadrat traps during two survey periods (A: from 9 to 11 Sep.; B: from 17 to 22 Sep.). Vertical bars show the standard deviations. Means followed by the same letter were not statistically significant (Scheffe's test, $p < 0.05$).

Fig. 3. Mean number of adults caught with can traps at four sites from 17 to 22 Sep. Vertical bars show the standard deviations. Means followed by the same letter were not statistically significant (Scheffe's test, $p < 0.05$) after the values were transformed by $\sqrt{x + 1/2}$.

amine why very few adults emerged from the latter, but pupae possibly died of water supplied in the trough everyday.

Ikeda et al. (1984) reported that adults of *T. palmi* were caught with sticky traps more frequently when the soil around the stem was mulched with a mass of rice straw instead of plastic film in the musk melon under glasshouse conditions. Rice straw appears to have provided *T. palmi* larvae with a suitable pupation site. Therefore, mulching ridges with plastic film is useful for reducing the pupation sites of *T. palmi*, and will contribute to create an integrated control.
Aerial Infection of Cordyceps militaris Link (Clavicipitales: Clavicipitaceae) against Larvae of Quadriracalifera punctatella (Motschulsky) (Lepidoptera: Notodontidae)

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Keywords: Cordyceps militaris, Quadriracalifera punctatella, larva, aerial infection

Quadriracalifera punctatella is a serious beech tree pest which defoliates beech trees completely every 8 to 11 years in northern Japan (Igarashi and Suzuki, 1980; Yanbe and Igarashi, 1983). Density of the final instar larvae was reported to be 100 to 150/m² during the outbreak (Kamata and Igarashi, 1995), and pupal density was 40 to 50/m² (Igarashi and Suzuki, 1980). Pupae of Q. punctatella overwinter in the litter of Aa horizon (Igarashi, 1982). Since more than 90% of pupae of the outbreak generation in 1981 were killed by Cordyceps militaris in the following spring, this fungus has been considered to be an important natural enemy of Q. punctatella (Yanbe and Igarashi, 1983). Pupae of Q. punctatella were proved to be susceptible to this fungus in the laboratory (Sato et al., 1994). However, it has been speculated that infection of Q. punctatella occurs during the larval stage (Harada, 1994), but there has been no data published to support this. In this report, Q. punctatella larvae were introduced as bait to natural beech forests where epizootic infection by C. militaris had occurred to verify fungal infection during the larval stage.

The experiments were conducted in 1993. Three natural beech forests were selected for introducing larvae; Hachimantai (40°00'N, 140°49'E, 780 m above sea level) (site A), Appi (40°01'N, 140°58'E, 650 m) (site B), and Hakkohda (40°37'N, 140°57'E, 700 m) (site C). All sites were located in the northern part of Honshu, the main island of Japan. Larval density of Q. punctatella was determined by fallen frass collected by 5 traps (1 m x 1 m) deployed on the forest floor (Kamata and Yanbe, 1994; Kamata and Igarashi, 1994 b).

The number of pupae producing fruit bodies of C. militaris was counted from July to August in a quadrat of 60 m² (2 m x 30 m). Fruit bodies were collected in August and observed under a dissecting microscope.

Females of Q. punctatella were put individually into paper bags. Eggs laid inside the bag were used for the experiments. The number of eggs per egg mass was adjusted to 50 by removing eggs by hand. One egg mass of Q. punctatella with 50 eggs was attached to the


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