Efficacy of Acetamiprid 2% Granule against Diamondback Moth on Cabbage by Soil Treatment

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INTRODUCTION

Insect pests on crucifers, especially the diamondback moth, have become serious problem in recent years as resistance to many insecticides has developed. As the insect has a short life cycle and shows several generations in a year, damages by the insect result in heavy reduction of the harvest. The insect is commonly controlled by granular application at transplanting, and by the succeeding interval sprays in Japan. For the granular application, acephate or benfuracarb has been used for the control of the insect. Acetamiprid, (E)-N1-[(6-chloro-3-pyridyl)methyl]-N2-cyano-N1-methylacetamidine, invented by Nippon Soda Co., Ltd., possesses a high activity against Hemiptera, Thysanoptera and Coleoptera as other neonicotinoid compounds, and it shows good activity against Lepidoptera as well. Moreover it shows excellent systemic activity. In order to find out the suitable way of application for acetamiprid property, we investigated the efficacy against the diamondback moth by the soil application. In this report the planting hole application was mainly studied using 2% granules.

MATERIALS AND METHODS

1. Chemical

Acetamiprid was synthesized and 2% granule was formulated at Odawara Research Center of Nippon Soda Co., Ltd. Release controlled formulation and uncontrolled one were designed. Benfuracarb 5% granule and acephate 5% granule were purchased by commercial source.

2. Determination of Released Active Ingredient Percent from Granule

One gram of each granule was added into 3 liters of water in a beaker. Twenty milliliters of the solution was sampled periodically and 20 ml of water was supplemented to the beaker. After adding inner standard solution to the sampled solution, the mixed solution was filtered through filter paper. Concentration of the released acetamiprid in the filtrate was analyzed using HPLC and released percent was determined. From the results, candidate formulations were selected for the biological evaluations.

3. Insects

Hiratsuka-strain, the insecticides-susceptible one, of the diamondback moth was used for the laboratory experiments and pot test in greenhouse. The insects were reared in a room regulated at 25°C, 65% relative humidity and 16L–8D photoperiod. For the field study, naturally occurred insects in our Haibara Agricultural...
Research Laboratory were tested.

4. **Activity by Soil Drench Test**

Five- to six-leaf stage seedlings of cabbage planted in 9 cm diameter plastic pot were prepared for the experiment. The compound was dissolved by dimethylformamide, and diluted to each concentration by water. Forty milliliters of chemical solution was drenched on the surface of the soil. The pots were maintained in greenhouse. The third instar larvae of the diamondback moth were inoculated on the cabbage 10 days after treatment. The experiment was replicated 3 times. Mortality was investigated 1 day and 3 days after inoculation.

5. **Efficacy by Planting Hole Application in the Field**

5.1 The 5- to 6-leaf stage seedlings of cabbage were used. The seedlings were raised in 9 cm diameter plastic pots and with Fujisawa soil, which is clay loam involving 7.2% organic matter, and Kannami soil, which is sandy loam involving 0.1% organic matter, in greenhouse. The seedlings raised with Fujisawa soil were transplanted to the Fujisawa soil field and those with Kannami soil were to Kannami one, respectively. At transplanting, a hole of about 10 cm diameter and 5 cm deep was dug. After treating the granule into the holes, the seedlings were transplanted there. Larvae of the diamondback moth infested on 10 plants per plot were counted at 10, 15, 22 and 28 days after treatment. Each plot was replicated 3 times. Following trials in field were designed in the same scale. The experiment was conducted at Haibara Agricultural Research Laboratory of Nippon Soda Co., Ltd., in May, 1991.

5.2 Seedlings of cabbage were raised using 128-hole paper pots with Fujisawa soil and Kannami one. The 3- to 4-leaf stage seedlings were used for the experiment. Granule was applied at the planting hole by the same way with the test 5.1. Evaluation of the biological efficacy was made at 10, 13, 21 and 28 days after treatment. The experiment was conducted at Haibara Agricultural Research Laboratory in May, 1993.

5.3 The seedlings of the cabbage were raised using 128-hole paper pots. The 3-leaf stage seedlings were used for the experiment. Granule was applied by the same way with the test 5.1. Efficacy of the granules was evaluated 7, 14, 21, 28 and 35 days after treatment. The experiment was conducted at Haibara laboratory in May, 1995.

6. **Efficacy by Planting Hole Application by Greenhouse Pot Test**

The 4.5-leaf stage cabbage seedlings were used for the experiment. The seedlings of cabbage were raised in greenhouse. Granule of the compound was applied into the holes, that were 5 cm diameter and 8 cm deep, made in the center of a plastic pot of 30 cm diameter. Thereafter the cabbage seedling was transplanted into the hole. The pot was maintained in greenhouse with watering by the volume exhibited in Fig. 5.

Biological activity was evaluated by the artificial infestation with the first instar larvae of the diamondback moth. Fifteen insects per plot were infested and each plot was replicated 3 times. Three days after infestation alive larvae were counted and the insects were removed. Lasting activity was evaluated by the interval infestations.

7. **Nursery Box Application**

The seedlings of cabbage were raised using 128 hole paper pot and Fujisawa soil in the greenhouse. At the 3- to 4-leaf stage of seedling, granule was treated on the plant and the soil uniformly. The plant was transplanted accompanied with soil and granule in the field. The experiment was conducted at Haibara Agricultural Research Laboratory in 1992.

### RESULTS AND DISCUSSION

1. **Activity by Soil Drench Treatment**

As previously reported, acetamiprid possesses excellent systemic activity against larvae of the diamondback moth. The LC50 value of acetamiprid in the plot where roots were dipped into the chemical solution for 24 and 72 hr was 0.73 and 0.31 ppm, respectively. And the efficacy was superior to that of the commercial insecticide acephate and benfuracarb.

Therefore, the activity by soil drench treatment was investigated using larvae of the diamondback moth. Acetamiprid showed 100% mortality at the dosage of 5 mg/plant. The activity of acetamiprid was superior to that of benfuracarb and inferior to acephate. Although acetamiprid was inferior to acephate in this treatment, we inferred the compound had the potential for the soil treatment insecticide (Table 1).

The characteristics of acetamiprid compared to other neonicotinoid insecticides are that it possesses the activity

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Table 1 The efficacy of acetamiprid against larvae of the diamondback moth by soil drench.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Dosage (mg/plant)</th>
<th>% Mortality (Moribund)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 hr</td>
<td>48 hr</td>
</tr>
<tr>
<td>Acetamiprid</td>
<td>20</td>
<td>60(40)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>40(60)</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>0(20)</td>
</tr>
<tr>
<td>Acephate</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>100</td>
</tr>
<tr>
<td>Benfuracarb</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0(40)</td>
</tr>
<tr>
<td></td>
<td>1.25</td>
<td>0</td>
</tr>
<tr>
<td>Untreated control</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
against the lepidopterous insects. Acetamiprid showed a high activity against larvae of the diamondback moth especially in the case of the first instar. The chemical showed a high systemic activity against the insect.\(^1\) Besides, it was elucidated that the chemical was efficacious by soil drench. On the other hand, as vapor pressure of acetamiprid is very low,\(^1\) it is not expected to control the soil insect pests by its vapor action. To find the applicable insects and the suitable way of application in practical control by taking into consideration the property of acetamiprid, we subsequently examined the efficacy of acetamiprid in the soil treatment by the field trials and by the pot test in greenhouse. Two percent granules were formulated for the tests.

2. Determination of Released Active Ingredient from Granule

Several kinds of formulations were designed and released percent was determined. Some controlled release formulations were tested biologically by greenhouse pot tests and by field trials. From the evaluations, the most excellent granule was selected for the field trials. The released percent of the selected release controlled formulation was 30.7 and 54.7\% in 24 and 72 hr after application into water, respectively. On the other hand, that of the uncontrolled granular reached 100\% within 3 hr (Fig. 1).

3. Efficacy by Planting Hole Application in the Field

3.1 Acetamiprid suppressed the diamondback moth for 2–3 weeks after treatment in the plot of Fujisawa soil. The efficacy was comparable to that of benfuracarb and superior to that of acephate. In the plot of Kannami soil, acetamiprid provided suppression of the insect also for 2–3 weeks, but the efficacy was inferior to that of benfuracarb. The precipitation for the period of the experiment was not so heavy. These results suggested the efficacy of acetamiprid fluctuate depending on the soil type and not enough for practicability in soil treatment (Fig. 2). It was presumed that the efficacy of granule changed according to the precipitation, stage of seedling at transplanting, soil type, etc. On the other hand, the damage by the insect was initially observed about 7–10 days after transplanting. After planting, an adult female lay eggs on the surface of the cabbage leaf and the eggs hatch in 5 to 6 days at 20°C.\(^2,3\) To prevent the damage, chemicals should control eggs or larvae in planting hole treatment. The reason why there was difference between the efficacy of acetamiprid in Kannami soil and that in Fujisawa soil was supposed to be that the active ingredient was released too fast and was decomposed in the soil. It has been ascertained that the half time of acetamiprid in the soil was from 1 to 2 days.\(^4\) Active ingredient released to Fujisawa soil, which is clay loam involving 7.2\% organic matter, and Kannami soil, which is sandy loam involving 0.1\% organic matter, was possibly affected by the difference of the soil type. For the efficacy in the field, it is wasteful that active ingredient is released from granule for a short period. It is ideal that the concentration of the compound in the plant is constant to get enough mortality. Solubility in water of acetamiprid is 4250 ppm\(^1\) which may be a little too high for exhibiting sufficient lasting efficacy. Therefore we designed release controlled granule that seemed not to be affected by the difference of soil types.

3.2 In the next test, the efficacy of release controlled
formulation against the diamondback moth was evaluated. Acetamiprid 2% granule suppressed the diamondback moth for 28 days after application. The efficacy was superior to that of benfuracarb. These compounds were tested in two different soil type fields. Acetamiprid provided good control in both types, and it exhibited a higher activity in Fujisawa soil than in Kannami one (Fig. 3).

3.3 In the third experiment, the efficacy of the release controlled formulation and the uncontrolled one was investigated in Fujisawa soil field and Kannami one. In Fujisawa soil, the release controlled one showed efficacy for 3-4 weeks and was superior to the release uncontrolled formulation in every evaluations. In Kannami soil, the release uncontrolled one showed a higher activity at 21 days after treatment and the order of efficacy by the two formulations was adverse thereafter. The reason why the number of insects of untreated control in Kannami soil declined at 35 days after treatment was due to severe damage on cabbage by the insect (Fig. 4).

From results of the field trials, influence of precipitation on the efficacy of acetamiprid is discussed below.

In test 3.1, total precipitation in 10 days after treatment was 12.5 and 89 mm in 10-20 days. The precipitation in 10-20 days was larger than that in the first 10 days. Although the precipitation seems not so heavy, the efficacy of acetamiprid was inferior to that of benfuracarb in Kannami soil plot. In order to improve the efficacy...
of acetamiprid, release controlled formulation was formulated.

In tests 3.2 and 3.3, release controlled formulation was tested. In test 3.2, the precipitation in 10 days was 60.5 and 12.5 mm in 10–20 days. And in test 3.3, precipitation was 30 mm for 10 days after treatment and 114 mm in 10–20 days. In test 3.2, much precipitation was in the first 10 days and in test 3.3 it was in the next 10 days.

In tests 3.2 and 3.3, the release controlled formulation exhibited an excellent efficacy against the diamondback moth. Although the precipitation was not so heavy in both tests, it was presumed the efficacy of the release controlled formulation was not affected by common rainfall. In the field trials, the influence of rainfall is not evaluated accurately as the conditions other than precipitation are different. Therefore, influence of rainfall was examined by pot test in greenhouse.

4. Efficacy by Planting Hole Application by Pot Test

In this experiment, the influence of rainfall on the efficacy against the diamondback moth by planting hole application was investigated (Fig. 5). Residual activity was assessed by the greenhouse pot test. The precipitation was regulated to be at 24 and 55 mm/week with watering pot.

In the plot of 24 mm/week, acetamiprid showed a high activity even at 32 days after treatment. The activity was superior to that of benfuracarb and acephate. In the plot of 55 mm/week, acetamiprid exhibited a high activity at 23 days after treatment. The activity was superior to that of acephate and a little inferior to that of benfuracarb. The efficacy of the standard insecticide acephate was better in the plot of 24 mm/week precipitation and that of benfuracarb was better in 55 mm/week plot. There was the tendency that acephate showed a higher activity in small precipitation and in case of benfuracarb heavier precipitation was proper in these experimental conditions. It seemed that the efficacy of acetamiprid was stable and was not affected by rainfall in comparing with these two insecticides.

From the test results of the planting hole treatment, it was confirmed that the efficacy of acetamiprid granule against the diamondback moth surpassed that of the commercial insecticide benfuracarb and acephate in two soil types. We examined the efficacy by the planting hole application as the elemental way of application of granule. The planting hole application is not practical for labor-saving way for transplanting. In the next step, the efficacy by nursery box application was tested for the basis of practical application.

5. Nursery Box Application

Acetamiprid was highly effective for 26–35 days after treatment at the dosage of 0.5 and 0.25 g/plant. The efficacy was almost the same with that of benfuracarb 5% G 1 g/plant. Although the test was conducted only in Fujisawa soil, the efficacy of acetamiprid was outstanding. **Release controlled formulation.**
ing. It was confirmed that acetamiprid showed an excellent efficacy by the application (Fig. 6).

For the study of practical uses of insecticides, we should investigate many kinds of application and find a suitable way for acetamiprid and labor-saving method. The products would be published in the near future.

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REFERENCES

4) M. Tokieda, M. Ozawa, S. Kobayashi, K. Gomyou & M.

Takeda: J. Pesticide Sci., in contribution

要 約

アセタミプリド2%粒剤の土壌施用によるキャベツのコナガに対する殺虫効力

高橋英光，満井順，村橋一彦，浅井真，山田富夫

Acetamipridは、鱗翅目昆虫に対する殺虫活性及び浸透移行殺虫力に特長を有する新規殺虫剤であるが、その特長を生かすための実用的な処理方法を探索するに当たり、粒剤の土壌処理による効力を検討した。植え付け処理を土壌処理における基本的処理方法と位置付け、本処理法を中心に圃場におけるコナガ幼虫に対する殺虫効力を調べた。その結果、acetamipridは、普通粒剤でも対照薬剤並の効果を示すが、散布性粒剤にすることにより土壌や降雨などに影響を受けにくい安定した効力を得ることができた。さらに、育苗箱株元処理（ペーパーボット処理）でも高い効力を示すことが分かり、土壌処理用粒剤として使用するのが適当であると判断された。