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Tran, Dang Hoa
Graduate School of Bioresource and Bioenvironmental Science,Kyushu University

Le, Van Hai
College of Agriculture and Forestry, Hue University

Luong, Thi Bich Phuong
Faculty of Agronomy, College of Agriculture and Forestry, Hue University

Takagi, Masami
Faculty of Agriculture,Kyushu University

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Field Evaluation of Cartap, Cyromazine, Permethrin and Phenthoate for Control of the Stone Leek Leafminer *Liriomyza chinensis* (Diptera: Agromyzidae)

Dang Hoa TRAN[1], Van Hai LE[2], Thi Bich Phuong LUONG[3] and Masami TAKAGI*

Laboratory of Insect Natural Enemies, Division of Biological Control, Department of Applied Genetics and Pest Management, Faculty of Agriculture, Kyushu University,
Fukuoka 812–8581, Japan
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The stone leek leafminer, *Liriomyza chinensis* (Kato), has become a serious pest on onioncrops in the whole Vietnam, and it is treated by a wide range of conventional insecticides. Growers apply insecticides early after a few mines on several leaves have been seen, and repeated applications are usually made. Field trial was conducted to evaluate the effects of a single application of four currently and potentially used insecticides on *L. chinensis*. These insecticides were applied at recommended field rates. Leaf samples were used to monitor larval population, and yellow sticky traps were used to monitor adult population. Cyromazine was effective on the larvae, but no effective on the adults. Cartap, permethrin and phenthoate were not or less effective on neither larvae nor adults of the leafminer. These results suggest that cyromazine application provide one potential component of an effective *L. chinensis* control strategy for Vietnamese onion farmers.

INTRODUCTION

The stone leek leafminer, *Liriomyza chinensis* (Kato), has occurred and become a serious pest on *Allium* spp. in China, Japan, Malaysia, Singapore, Thailand (Spencer, 1973, 1990, Chen *et al.*, 2003), Korea (Hwang and Moon, 1995), and Taiwan (Shiao, 2004). Recently, outbreak of the leafminer has been found in onion crops across Vietnam (Andersen *et al.*, 2002, Tran and Takagi, 2005), especially Hue region where Japanese bunching onion (*Allium fistulosum* L.) are mainly produced. Several hectares are planted annually for year–round production.

Liriomyza chinensis is specialist pest on *Allium* spp. Damage caused by *L. chinensis* to onion plants is very similar to other *Liriomyza* species: larvae mine and feed within the leaves, and females produce punctures on the leaves with their ovipositor for the adult's feed and oviposition. Because the quality of onion leave production is directly affected by the damage of the leafminer with its rapid increase and spread in the fields, growers in Vietnam have frequently applied large quantities of broad–spectrum insecticides (Tran and Takagi, 2005). Growers apply insecticides early when they see a few mines on several leaves, and may continue to treat once or twice a week until the end of planting season. Frequent applications of broad–spectrum insecticides, however, adversely affect parasitoid abundance in the vegetable agro–ecosystem (Johnson *et al.*, 1980; Saito *et al.*, 1996; Thang, 1999), can promote the development of pesticide resistance within fly populations (Keil *et al.*, 1985; Johansen *et al.*, 2003) and frequently lead to an increase in leafminer density (Oatman and Kennedy, 1976; Murphy and LaSalle, 1999).

Since laboratory tests on Japanese *L. chinensis* indicated that cartap, cyromazine, permethrin and phenthoate could be effective in controlling the leafminer (Tran and Takagi, 2005), the objective of this study was to observe the effects of a single field application of these insecticides on *L. chinensis* in Hue City, Vietnam. We also consider why potential insecticide application in the fields was ineffective in controlling *L. chinensis*.

MATERIALS AND METHODS

Field preparation and insect monitoring

Field experiment was conducted from March to May 2005 at commercial onion fields in Thuan Loc ward, Hue City, Vietnam. The Japanese bunching onion (*A. fistulosum*) variety was used. Plots consisted of 10 m^2 arranged in randomized complete blocks designs with four replications. The commercial formulations of four insecticides, cartap (Padan 95 SP), cyromazine (Trigard 75 WP), permethrin (Peran 10 EC) and phenthoate (Elsan 50 EC) were diluted with pure water and applied at field rates based on the recommended label dilutions (Table 1). These compounds were selected on the basis of their high efficacy on either larvae or adult bioassays of *L. chinensis* in the laboratory (Tran and Takagi, 2005), and their current and potential use for the management of leafminers affecting vegetable crops in Vietnam. Leafminer–infested plants were sprayed by using power–pack hand sprayers. As a control, pure water was applied in the same as insecticide above. The number of mines and live larvae of the leafminer was

[1] Laboratory of Insect Natural Enemies, Division of Biological Control, Department of Applied Genetics and Pest Management, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, Japan
[2] Department of Plant Protection, Faculty of Agronomy, College of Agriculture and Forestry, Hue University, Vietnam
[3] BVTV35, Faculty of Agronomy, College of Agriculture and Forestry, Hue University, Vietnam
* Corresponding author (E–mail: mtakagi@grt.kyushu–u.ac.jp)

counted on 15 infected leaves of each plot in 1 day before treatment (DBT), and 1, 3, and 7 days after treatment (DAT).

Since yellow sticky board was the most effective in trap capture *Liriomyza* flies (Chaves and Raman, 1987), we used the trap to determine the impact of insecticides on adults of *L. chinensis*. One yellow sticky board (10 cm×20 cm) was placed at 60 cm height using a wooden stake in the middle of each plot at 2 DBT. The sticky paper was replaced at 0, 2, 4 DAT. The trap counts of number of *L. chinensis* adults were made at 48 h after replacing new sticky paper (0 DBT, 2, 4 and 6 DAT).

Data analysis

To examine the effects of insecticide treatment on the number of mine, live larva and adult mean values were computed for each replication plot and one–way ANOVA were undertaken. Means were separated by Tukey–Kramer test (SAS Institute, 1998)

RESULTS

There was no significant difference in mean number of mines made by *L. chinensis* among the treatments ($P>0.05$) (Table 1). Three days after treatment, the mean number of live larvae was significant difference among the treatments (df=3, 16; $F=1.62$; $P<0.05$) (Table 2). The number of live larvae for cyromazine was significantly smaller than that for the control ($P<0.05$). Seven days after treatment, the mean number of live larvae was also significant difference among the treatments (df=3, 16; $F=2.05$; $P<0.05$) (Table 2). The number of live larvae for cyromazine was significantly smaller than that for the control ($P<0.05$). There was no significant difference in mean number of adults among the treatments ($P>0.05$) (Table 3).

DISCUSSION

In Vietnam, cyromazine has been currently registered for leafminer management, but is still not commonly used (Johansen *et al.*, 2003; Tran and Takagi, 2005). The present study has shown that seven days after application of cyromazine, most of *L. chinensis* larvae present in onion leaves were killed (Table 2). This result is consistent with laboratory tests using Japanese *L. chinensis* indicating that cyromazine is highly effective on *L. chinensis* larvae (Tran and Takagi, 2005). Since the translaminar effect of cyromazine enables effective penetration of the leaves that affects leafminer larvae (Weintraub, 2001), application of cyromazine has the potential to provide control of other leafminers such as *L. trifolii* (Burgess), *L.*

Table 1. Effect of insecticides on the number of mines damaged by *L. chinensis* on one infested onion leaf (Mean ±SE)

Treatment	Dilution	1DBT*	1DAT*	3DAT	7DAT
Cyromazine	1000×	8.8±1.6a	8.1±1.1a	5.9±0.6a	10.9±1.3a
Permethrin	2000×	9±1.9a	6.8±1.3a	6.9±0.8a	9.8±0.9a
Phenthoate	1000×	10.7±1.3a	8.2±0.5a	7.5±0.2a	12±1.3a
Cartap	1500×	8.7±0.9a	7.3±1.1a	7.1±1.1a	10.7±1.3a
Water	–	8.5±0.4a	4.9±1.6a	6.3±0.5a	10.8±1.3a

Means with the same letters within the same column are not significantly different by one way ANOVA, P<0.05.
*DBT (days before treatment); DAT (days after treatment)

Table 2. Effect of insecticides on the number of live larvae *L. chinensis* in one infested onion leaf (Mean ±SE)

Treatment	1DBT*	1DAT*	3DAT	7DAT
Cyromazine	5.6±0.9a	4.5±1.3a	4±1a	0.3±0.5a
Permethrin	4.5±1.3a	3.5±1.9a	5.5±0.6ab	2±0.4b
Phenthoate	3±1.4a	3.3±1.4a	4.3±1.5ab	1.3±0.5b
Cartap	3.3±1.4a	3.3±0.9a	4.3±0.5ab	1±0.6b
Water	4±2.2a	4±1.4a	7.8±1.9b	2.3±0.3b

Means with the same letters within the same column are not significantly different by Tukey–Kramer test after one way ANOVA, P<0.05.
*DBT (days before treatment); DAT (days after treatment)

Table 3. Effect of insecticides on the number of adult *L. chinensis* captured by yellow sticky trap (Mean ±SE)

Treatment	0DBT*	2DAT*	4DAT	6DAT
Cyromazine	1.9±0.9a	1.5±0.9a	2.8±0.5a	19.3±0.5a
Permethrin	3.9±1.9a	2.3±0.6a	3.5±0.9a	22±2.4a
Phenthoate	3.1±1.6a	1.8±0.9a	2.8±0.9a	18.8±5.5a
Cartap	4±1.1a	3.3±0.5a	3.3±0.8a	18.2±2.1a
Water	3.3±0.5a	2.3±0.3a	4±1.1a	20±1.9a

Means with the same letters within the same column are not significantly different by one way ANOVA, P<0.5
*DBT (days before treatment); DAT (days after treatment)

huidobrensis (Blanchard), *L. sativae* Blanchard, *L. bryoniae* (Kaltenbach) and *Chromatomya horticola* (Goureau) (Smith, 1986; Weintraub, 1999, 2001; Prijono *et al.*, 2004; Saito, 2004; Tokumaru, 2004; Tokumaru *et al.*, 2005). Generally, growers apply insecticide early after a few mines on several leaves are seen, and multiple applications are usually made. To determine an appropriate timing of insecticide applications, chemical residues left in treated plants should be considered. Weintraub (2001) reported that the cyromazine residues left in potatoes from a single application were sufficient to control larval population of the pea leafminer *L. huidobrensis* until 42 days after treatment. Thus, single application of cyromazine could be effective in suppressing on *L. chinensis* population in the fields.

Formulation of cartap, permethrin and phenthoate are labeled for citrus leafminer management, and are commonly used for management of leafminers on vegetable crops in Vietnam (Tran and Takagi, 2005). Tran and Takagi (2005) reported that these insecticides were highly or moderately effective on either larvae or adults of *L. chinensis* in the laboratory. Conversely, the field evaluation indicated that these insecticides with field recommended doses were less effective on larvae of the leafminer in the fields (Table 2). The number of adult *L. chinensis* captured was not significantly different among the treatments (Table 3). Since the efficacy of traps may vary depending on trap density and wind velocity (Chavez and Raman, 1987), our result could have been influenced by the experimental design with small plots and high trap density.

In Hue City, onion growers apply too–frequent, high concentration, and unnecessary use of insecticides. The widespread and intensive use of insecticides had led to development of resistance of *Liriomyza* leafminers to most of the chemicals registered for control (Parrella, 1983; Parrella and Keil, 1984; Sanderson *et al.*, 1989; Keil and Parrella, 1990; Ferguson, 2004), with some insecticides retaining their effectiveness for only two years after introduction (Ferguson, 2004). Previous studies indicated the development of resistance in L. *trifolii* to several insecticides such as permethrin (Parrella, 1983; Mason *et al.*, 1987; Sanderson *et al.*, 1989; Parrella and Trumble, 1989), spinosad (Ferguson, 2004). Mason *et al.* (1987) reported that resistance to pyrethroids (e.g. permethrin) also has been developed in *L. sativae* on Oahu, Hawaii. Resistance to cypermethrin and profenophos by *L. sativae* larvae has been indicated in populations from three different localities from Hanoi, Vietnam (Johasen *et al.*, 2003). Resistance to insecticides of *L. chinensis* was not investigated in this study. As not effective of cartap, permethrin and phenthoate against *L. chinensis* was found in the field experiments, and Vietnamese growers have claimed control failure from these insecticides over last years, *L. chinensis* in Hue City seems to be resistant to these chemicals. The resistance to these insecticides should be investigated further, and the use of these insecticides against *L. chinensis* should be paused in this area until the resistance situation is clear. Because of different modes of action and no cross resistance between each other (e.g. cyromazine and abamectin (Leibee and Capinera, 1995)), some effective insecticides are available for rotation to manage the development of insecticide resistance within a *Liriomyza* population (Ferguson, 2004). The resistance should be concerned in chemical control of *L. chinensis* only when necessary with a rotation of effective materials (e.g. cyromazine, spinosad, phenthoate, dimethoate, emamectin benzoate, permethrin, and cartap) (Tran and Takagi, 2005).

The effectiveness of insecticides on leafminer management has been dogged by their indiscriminate use, impact on natural enemies and the development of resistance within fly population (Murphy and LaSalle, 1999). Saito *et al.* (1996) reported that application of non–selective insecticides (e.g. permethrin, etofenprox, methomyl and prothiofos) induced outbreak of *L. trifolii* on the gerbera because they were not effective on the leafminer, but were strongly harmful to parasitoids. The finding indicates that insecticides that are effective on leafminer but harmless to parasitoids should be used for suppressing *L. chinensis* population. Prijono *et al.* (2004) reported that cyromazine was relatively safe for *Hemiptarsenus varicornis* (Girault), *Opius* sp., *Gronotoma micromorpha* (Perkins), and *Diglyphus isaea* (Walker), the parasitoids of *L. huidobrensis*. Since these species are common parasitoids of leafmining agromyzid pests (Konishi, 2004; Tran *et al.*, 2005), it would prove to incorporate cyromazine into an integrated pest management (IPM) program of the stone leak leafminer *L. chinensis* in Vietnam.

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