Res. Crop. **23** (4) : 827-831 (2022) DOI : 10.31830/2348-7542.2022.ROC-878
Printed in India

Susceptibility of the vegetable leafminer, *Liriomyza sativae* (Blanchard) (Diptera: Agromyzidae) to lambda-cyhalothrin, abamectin, cypermethrin and clothianidin

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(Received : September 24, 2022/Accepted : November 14, 2022)

ABSTRACT

The vegetable leaf miner, *Liriomyza sativae* (Blanchard) is a serious insect pest on vegetable and ornamental crops in the whole of Vietnam. It was controlled by a wide range of conventional insecticides. Since there is a limited recommendation on insecticide application, growers continue to use whatever is available. This study was carried out at Entomology Laboratory, Faculty of Agronomy, University of Agriculture and Forestry, Hue University, Vietnam during 2021-22 to determine the susceptibility of larval and adult stages of *L. sativae* to four insecticides (*e.g.,* lambda-cyhalothrin, abamectin, cypermethrin and clothianidin) currently used for the management of the leaf miner. Among four tested insecticides, abamectin was highly effective on larvae and moderately effective on adults of *L. satiave*. Lambda-cyhalothrin and cypermethrin were moderately effective on either larvae and adults of the leaf miner. Clothianidin was least effective against the leaf miner. These results suggest that abamectin, lambda-cyhalothrin and cypermethrin can be rotationally used for the management of *L. sativae*.

Key words : Efficacy, insecticide, leaf miner, *Liriomyza sativae*, vegetable crops

INTRODUCTION

The vegetable leaf miner, *Liriomyza sativae* (Blanchard) (Diptera: Agromyzidae) is an economically important pest of vegetable and ornamental crops worldwide (Murphy and LaShalle, 1999). Native to North America, *L. sativae* is widespread in many countries of the world (Murphy and LaSalle, 1999; Askari-Saryazdi *et al.*, 2015; Fourouzan and Farrokh-Eslamlu, 2017; Dnyaneshwar *et al.*, 2018).

Liriomyza sativae is also the dominant *Liriomyza* species found on various vegetables in the of whole Vietnam (Tran *et al.*, 2005; Tran, 2009). Recently, the outbreak of the leaf miner has been found in many crops, and it was controlled by a wide range of conventional insecticides, which were ineffective. Since there is a very limited recommendation on insecticide application, farmers continue to use whatever is available without considering its effectiveness. Growers apply insecticides very early when they see a few miners on several leaves and may continue to treat them once or twice a week until the end of the season (Sabbour and Abd El-Aziz, 2022). Applications of broad-spectrum insecticides have resulted in a decline in parasitism and the development of resistance within a fly population followed by an increase in leaf miner density (Tran *et al.*, 2004; Tran *et al.*, 2007; Tran and Ueno, 2012). Information regarding the specific action of a given insecticide against the various stages of *L. sativae* is necessary to incorporate the insecticide into integrated pest management (IPM) program (Tran *et al.*, 2006; Fourouzan and Farrokh-Eslamlu, 2017; Balikai and Pushpalatha, 2018; Hirekurubar and Tatagar, 2018). The objective of this study was to determine the efficacy of four insecticides currently used for the management of leaf miners (*L. sativae*) affecting vegetable crops in Vietnam. The susceptibility of larval and adult stages of *L. sativae* to these insecticides was evaluated by laboratory assay.

MATERIALS AND METHODS

Insect Rearing

Liriomyza sativae used for the present study originated from a culture reared by Entomology Laboratory, Faculty of Agronomy, University of Agriculture and Forestry, Hue University, Vietnam. *Liriomyza sativae* was reared on the kidney bean, *Phaseolus vulgaris* L. A single seed of this plant was sown in a plastic pot (7.5 cm in diameter) and kept in the condition of 25 °C and 60–70 % humidity under constant light. One week after germination, a tray (32 cm x 44 cm x 6 cm) containing 24 potted plants was placed on a shelf covered with a fine nylon mesh. Leaf miner adults were released into the shelf and allowed to oviposit on the plants for 24 h. Thereafter, the potted plants were maintained under the same condition until all leaf miner larvae feeding on the plants reached the last instars. The leaves containing final-instar larvae were cut off and kept in a PET bottle (1.5 l in volume) to gain adults of leaf miners.

Insecticides

The commercial formulations of four insecticides were diluted with distilled water and applied at field rates based on the recommended label dilutions (Table 1). These compounds were selected on the basis of their current use for the management of leaf miners affecting vegetable crops in Vietnam.

Larval Leaf miner Bioassay

Bioassays were conducted in the Laboratory of Entomology, Hue University, Vietnam during 2021-22. The potted plants were caged and exposed to 50 mixed-sex *L. sativae* adults in a plastic cage (45 cm × 30 cm × 25 cm) covered with a fine nylon mesh for an oviposition access period of 2 – 4 h. After the oviposition access period, the plants were removed and held in an incubator (SANYO MIR-253, Japan) at 25 °C and 16L: 8D photoperiod. After 4 days, the number of first instars (visible mine) on each plant was counted, and the diluted insecticides were sprayed on the leaves until runoff (approximately 3 ml/plant) by using a hand sprayer of 0.5 litre volume. No surfactants were added to the insecticides. As a control, distilled water was applied to host-infested plants in the same way as the insecticides above. Treated plants were maintained in an environmental chamber at a constant temperature of 25 °C and a photoperiod of 16L: 8D. Six plants infested with more than 100 larvae in total were used for each insecticide. Mortality was determined 12, 24, 36, and 48 hours after treatment.

Adult Leaf miner Bioassay

The diluted insecticides were sprayed on the leaves of the potted plants until runoff (approximately 5 ml/plant). Two hours after spraying, each plant was exposed to 10 mixed-sex *L. sativae* adults (12–24 hours old) in a plastic cage (35 cm × 20 cm × 25 cm) covered with a fine nylon mesh and maintained in an environmental chamber at a constant temperature of 25 °C and a photoperiod of 16L: 8D. Honey was not provided to the flies. Mortality was recorded 24 hours from the onset of exposure. Distilled water was used as a control, and trials were replicated five times.

Data Analysis

Since natural mortality occurred in the control plants, the efficacy of the insecticide was judged after Henderson and Tilton (1955) correction of data. The percentages of the efficacy were arsine-transformed and then analyzed by one-way ANOVA. Means were separated by the Tukey-Kramer test by using STATISTICA 10.0 software.

Table 1. Efficacy (%) of insecticides on *L. sativae* adults at 24 hours after treatment.

Common name	Trade name	Dilution	Efficacy (Mean ± SE) (%)
Lamda-cyhalothrin	Karate 2.5 EC	400x	61.2±5.01ab
Abamectin	Catex 1.8 EC	1000x	71.3 ±1.50a
Cypermethrin	Visher 10 EW	1000x	57.4±2.22b
Clothianidin	Dantotsu 50 WG	350x	55.2±1.22b

Means ± SE with the same letters within the same column are not significantly different by one-way ANOVA, P <0.05.

RESULTS AND DISCUSSION

The efficacy of chemicals frequently varies between different stages of the target pest (Muhammad *et al.*, 2017), and according to the evaluation time (Tran and Ueno, 2012). The efficacy of four tested insecticides (*e.g.*, lambda-cyhalothrin, abamectin, cypermethrin and clothianidin) at recommended rates in the adult stage of *L. sativae* was moderate and recorded at a range of 55.2 - 71.3% (Table 1). Efficacy was highest in abamectin reaching 71.3%. Efficacy among lambda-cyhalothrin, clothianidin and cypermethrin were not statistically different (*P*>0.05). The efficacy of clothianidin was the lowest (55.2%).

Table 2 shows the efficacy of lambda-cyhalothrin, abamectin, cypermethrin and clothianidin at recommended dilutions on first instar larvae of *L. sativae*. After 12 hours after treatment, the efficacy of abamectin and cypermethrin against first instars of *L. sativae* was 14.6% and 16.7%, respectively, were significantly higher than those of lambda-cyhalothrin and clothianidin (0%) (*P*<0.01). After 24 hours after treatment, the efficacy of abamectin and cypermethrin reached 49.9% and 43.7% which were significantly different compared to those of lambda-cyhalothrin (27.1%), clothianidin (13.4%) (*P*<0.01). There was no significant difference in the efficacy between abamectin and cypermethrin, and between lambda-cyhalothrin and clothianidin (*P*>0.05). The efficacy at 36 hours after treatment increased in all insecticides, in which the highest of 70.8% was found in abamectin, a significant difference compared with lambda-cyhalothrin and clothianidin of 52.1% and 26.6%, respectively (*P*<0.01). Efficacy between abamectin and cypermethrin was not statistically different (*P*>0.05). After 48 hours after treatment, the efficacy continued to increase, ranging from 26.6 to 88.4%. The efficacy was highest in abamectin reaching 84.4%. The efficacy of cypermethrin, lambda-cyhalothrin and clothianidin was 77.0, 56.2 and 26.6%, respectively.

Among four tested insecticides commonly used in Vietnam for controlling vegetable leaf miners, only one insecticide, abamectin, is registered for use for leaf miner management in vegetable crops. The present study has shown that abamectin was highly effective on the larvae of *L. sativae* (Table 2). This result is consistent with previous studies indicating that abamectin has high efficacy against *L. sativae* larvae (Arfan *et al.*, 2020; Silva *et al.*, 2022; Damasceno *et al.*, 2022). Although there was very limited research on the effectiveness of abamectin on adults of *L. sativae*, this study also indicated that abamectin showed higher efficacy (Table 1) against the adults.

Formulation of lambda-cyhalothrin, cypermethrin, clothianidin are labeled for other insect pests (*e.g.*, caterpillar, aphid, thrip) management in Vietnam. The laboratory tests indicated lambda-cyhalothrin and cypermethrin were also moderately effective on either larvae or adults of *L. sativae*. Previous studies indicated that insecticide susceptibility varied among species of *Liriomyza* (Mason *et al.*, 1987; Macdonald, 1991). Our result was consistent with research on insecticide tests indicating a moderate efficacy of cypermethrin on either larvae and adults of the stone leek leaf miner, *L. chinensis*, and less efficacy of clothianidin on the larvae of *L. chinensis* (Tran and Takagi, 2005). Recently, Matsuda (2022) reported that clothianidin appeared to have caused a decrease in the insecticide susceptibility of *L. trifolii* and low insecticide susceptibility for all strains of the leaf miner in Japan. This study also indicated clothianidin was least effective on the larvae of *L. sativae*. Therefore, the exact efficacy of each insecticide on a target species needs to be investigated.

Table 2. Efficacy (%) of insecticides on *L. sativae* larvae.

Common name	12HAT	24HAT	36HAT	48HAT
Lamda-Cyhalothrin	0.0b	27.1±3.29bc	52.1±2.55b	56.2± 6.06c
Abamectin	14.6±3.89a	49.9±3.89a	70.8± 3.91a	88.4±2.54a
Cypermethrin	16.7±4.65a	43.7±2.55ab	66.6±3.91a	77.0±2.18b
Clothianidin	0.0b	13.4±4.69c	22.1±2.6c	26.6±2.08d

Means ± SE with the same letters within the same column are not significantly different by one-way ANOVA, P <0.05; HAT: Hours after treatment.

The widespread use of insecticides had led to the development of resistance of *Liriomyza* leaf miners to most of the chemicals registered for control (Ferguson, 2004; Damasceno *et al.*, 2022; Matsuda, 2022), with some insecticides retaining their effectiveness for only two years after introduction (Ferguson, 2004). Previous studies indicated the development of resistance in *L. sativae* to several insecticides such as abamectin, cyromazine, cyantraniliprole, spinetoram (Damasceno *et al.*, 2022; Silva *et al.*, 2022), chlorpyrifos (Askari-Saryazdi *et al.*, 2015). Since insecticides have 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 *Liriomyza* leaf miners (Ferguson, 2004). Thus, the resistance should be managed with the chemical control of *L. sativae* only when necessary, with a rotation of effective materials (*e.g.*, abamectin, lambda-cyhalothrin, and cypermethrin).

CONCLUSION

It is concluded that among four tested insecticides, abamectin was highly effective on larvae and adults of *L. sativae*. Lamda-cyhalothrin and cypermethrin were moderately effective on either larvae or adults of the leaf miner. Clothianidin was least effective on the leaf miner. On the basis of these results it may be recommended that abamectin, lambda-cyhalothrin and cypermethrin can be rotationally used and not to use clothianidin for *L. sativae* management.

ACKNOWLEDGMENTS

This work was partially supported by Hue University, Vietnam under the Core Research Program, Grant No. NCM.DHH.2020.14.

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