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https://doi.org/10.5109/4651

出版情報：九州大学大学院農学研究院紀要. 50 (2), pp.383-390, 2005-10-01. Faculty of Agriculture, Kyushu University

J. Fac. Agr., Kyushu Univ., **50** (2), 383–390 (2005)

Susceptibility of the Stone Leek Leafminer *Liriomyza chinensis* (Diptera: Agromyzidae) to Insecticides

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(Received June 15, 2005 and accepted July 26, 2005)

The stone leek leafminer, *Liriomyza chinensis* (Kato), has become a serious pest on onion in the whole Vietnam, and it was controlled by a wide range of conventional insecticides. Because there is no recommendation on insecticide application, growers continue to use whatever is available without considering the effectiveness. The susceptibility of larva and adult *L. chinensis* to several insecticides currently and potentially used for the management of leafminers was investigated in the laboratory. Among 10 insecticides available in Vietnam, dimethoate, phenthoate, permethrin, and cartap were highly or moderately effective on either larvae or adults of *L. chinensis*, but ethofenprox was ineffective. Of the seven insecticides labeled for leafminer control in Japan, cyromazine, emamectin benzoate, cartap, and spinosad were highly effective, but thiamethoxam, flufenoxuron, and chlothianidin were less or no effective on *L. chinensis* at their field recommended dilutions. While dimethoate was effective on both the larvae and adults, cyromazine was only highly effective on the larvae and spinosad, and phenthoate were only found highly effective on the adults. These results suggest that dimethoate, cyromazine, spinosad, phenthoate, and cartap can be rotationally used for *L. chinensis* control.

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), Vietnam (Andersen *et al.*, 2002), and Taiwan (Shiao, 2004). Recently, outbreak of the leafminer has been found in onion crops across Vietnam, and it was controlled by a wide range of conventional insecticides, which were ineffective. Because there is no recommendation on insecticide application, farmers continue to use whatever is available without considering the effectiveness. 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 season. 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 leafminer density (Oatman and Kennedy, 1976; Murphy and LaSalle, 1999; Tran *et al.* 2004). Information regarding the specific action of a given insecticide against the various stages of *Liriomyza* leafminers is necessary to incorporate the insecticide into an integrated

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pest management (IPM) program (Schuster and Everett, 1983)

The objective of this study was to determine efficacy of several insecticides currently and potentially used for the management of leafminers affecting vegetable crops in Vietnam and Japan on controlling *L. chinensis*. We evaluated susceptibility of various life stage of the leafminer to these insecticides by laboratory assay.

MATERIALS AND METHODS

Insect pest

Liriomyza chinensis used for the present study was originated from a culture reared by the Fukuoka Agricultural Research Center, Fukuoka, Japan. *Liriomyza chinensis* was reared on Japanese bunching onion, *Allium fistulosum* L. Seeds of this plant were sown in a tray (20 cm × 60 cm × 15 cm). Two months after germination, a single plant was transplanted in a plastic pot (9 cm in diameter). A tray (32 cm × 44 cm × 6 cm) containing 15 potted plants was placed in a small greenhouse at 20 ± 5 °C and 60 ± 10% humidity.

Six potted plants with 2–3 leaves were exposed to 50 mixed sex *L. chinensis* adults in a plastic cage (45 cm × 30 cm × 25 cm) covered with a fine nylon mesh. After exposure for 12h, the flies were removed and these plants were maintained in an environmental chamber at a constant temperature of 25 °C and a photoperiod of 16L: 8D until all leafminer larvae reach pupae. Before incubation, the upper opening of each pot was covered with a piece of reversed funnel-shaped filter paper (11 cm in diameter), which prevented leafminer larvae from pupating in the soil. The pupae were immediately transferred to petri dishes (9 cm in diameter) containing damp soil and maintained at the same condition to gain adult leafminers.

Insecticides

The commercial formulations of several 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 and potential use for the management of leafminers affecting vegetable crops in Vietnam and Japan.

Larval leafminer bioassay

The bioassay technique used was similar to the methods described by Cox *et al.* (1995) and Ferguson (2004). The potted plants were caged and exposed to 50 mixed sex *L. chinensis* 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 oviposition access period, the plants were removed and held in an incubator 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 power-pack aerosol hand sprayer (Hand Spray Nozzle, Takeda Engei Co., Japan). No surfactants were added to either insecticide. As a control, distilled water was applied to host infested plants in the same way as insecticides above. Treated plants were maintained in an environmental chamber at a constant temperature of 25 °C and a photoperiod of 16L: 8D. Five days after spraying, the number of normal individuals pupated on the plants was counted. Six plants infested with more than 120 larvae in total were used for each insecticide.

Adult leafminer bioassay

The diluted insecticides were sprayed on the leaves of the potted plants until runoff (approximately 3 *ml*/plant). Two hours after spraying, each plant was exposed to 10 mixed sex *L. chinensis* adults (12–24 h 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 48 h from the onset of exposure. Distilled water was used as a control, and trials were replicated five times.

Data analysis

The mortality calculation used was similar to the methods described by Ferguson (2004). Larval mortality was calculated from the number of first instars and normal pupated pupae (i.e. larvae failed to survive successfully to the pupal stage). Because natural mortality occurred in the control plants, the number of collected pupae, and number of alive adults were used for Abbott's (1925) correction.

RESULTS

Table 1 shows the efficacy of 17 insecticides at recommended dilutions on larvae of *L. chinensis*. While mortality was high in cyromazine (94.9%), dimethoate (93.2%), emamectin benzoate (87%), permethrin (81.8%), and trichlorfon (79.1%), the mortalities were very low in chlothianidin (1.2%), fenitrothion (2.2%), and ethofenprox (4.7%). Mortality in flufenoxuron, acetamipid, thiamethoxam, spinosad, fenobucarb, cypermethrin, phenthoate, cartap, and nitenpyram was uneven, ranging from 21.9% to 68.4%, respectively.

The efficacy of several insecticides to the adult stage of *L. chinensis* was high. Total (100%) mortality was observed for treatments of dimethoate and phenthoate. Cartap, spinosad, and emamectin benzoate produced a high mortality at 90%, 91%, 75%, respectively. However, mortality in the other insecticides was low or moderate recorded at range of 30–62.5% (Table 2). Table 2 also shows separately mortalities of males and females of the leafminer. Dimethoate, phenthoate, emamectin benzoate, and spinosad produced a completely mortality (100%) of the females, while dimethoate, phenthoate, and cartap gave 100% mortality for the males.

DISCUSSION

Among 10 insecticides commonly used in Vietnam for controlling vegetable leafminers, 2 insecticides, fenitrothion and trichlorfon, are registered for using in leafminer management in vegetable crops. However, the present study has shown that fenitrothion was not effective on *L. chinensis* (Table 1, 2). This result is consistent with research in Japan indicating that the insecticide is not effective in controlling *Liriomyza trifolii* (Burgess) (Saito *et al.*, 1992), and *Chromatomyia horticola* (Goureau) (Saito,

Table 1. Efficacy of insecticides on *L. chinensis* larvae.

Common name	Trade name	Dilution	N	Percent mortality (Mean±SE)
Organophotsphates				
Dimethoate[1]	Dimethoate 43 EC	1000x	256	93.2±1.9
Fenitrothion[1]	Sumithion 50 EC	1000x	122	2.2±11.7
Phenthoate[1]	Elsan 50 EC	1000x	271	60.9±11
Trichlorfon[1]	Dipterex 50EC	1000x	192	79.1±6.9
Cacbamates				
Fenobucarb[1]	Bassa 50 EC	2000x	239	41.7±6
Pyrethroids				
Permethrin[1]	Adion 20 EC	2000x	159	81.8±2.3
Ethofenprox[1]	Trebon 20 EC	1000x	192	4.7±12.2
Cypermethrin[1]	Agrothrin 6 EC	2000x	157	58±9.4
Chloronicotinyls				
Nitenpyram[2]	Bestgard 10 SP	1000x	218	68.4± 9.1
Acetamipid[2]	Mospilan 20 SP	2000x	136	22.8±7.8
Thiamethoxam[1,2]	Actara 10 SG	2000x	212	28.3±6.3
Chlothianidin[2]	Dantotsu 16 SP	2000x	163	1.2±14.2
Macrorides				
Emamectin benzoate[2]	Affirm 1 EC	2000x	220	87±6.2
Nereistoxins				
Cartap[1,2]	Padan 75 SG	1500x	183	65.4±5.8
IGRs				
Cyromazine[2]	Trigard 8.3 L	1000x	319	94.9±3.7
Spinosad[2]	Spinoace 25 SG	2500x	211	31.2±13.6
Flufenoxuron[2]	Cascade 10 EC	2000x	236	21.9±6.4

[1] commonly used in Vietnam
[2] commonly used in Japan

2004). As results, fenitrothion does not have the potential to provide control of *Liriomyza* leafminers. Although Saito *et al.* (1992) and Saito (2004) reported that trichlorfon was not effective to *L. trifolii* and *C. horticola*, our finding indicated the superiority of the insecticide in controlling larval *L. chinensis*, but was not totally effective.

Formulation of dimethoate, phenthoate, permethrin, cartap, and ethofenprox are labeled for citrus leafminer management in Vietnam. The laboratory tests with these insecticides indicated that while dimethoate, phenthoate, permethrin, and cartap were also effective on either larvae or adults of *L. chinensis*, ethofenprox was ineffective. This result was consistent with research on insecticide tests with leaf dripping method indicating a high efficacy of captap and less efficacy of ethofenprox on *L. chinensis* (Tokumaru, 2004; Tokumaru and Okadome, 2004). Saito *et al.* (1992) reported that cartap was also highly effective, while dimethoate, phenthoate, and permethrin were not or less effective on *L. trifolii*. Previous studies indicated that insecticide susceptibility varied among species of *Liriomyza* (Mason *et al.*, 1987; Macdonald, 1991). Therefore, the exact efficacy of each insecticide on a target species needs to be investigated.

Seven tested insecticides commonly used in Japan are labeled for vegetable leafminer

Table 2. Efficacy of insecticides on *L. chinensis* adults.

Common name	Trade name	Percent mortality (Mean±SE)		
		Male	Female	Total
Organophotsphates				
Dimethoate[1]	Dimethoate 43 EC	100	100	100
Fenitrothion[1]	Sumithion 50 EC	60±40	40±6.3	43.3±8.5
Phenthoate[1]	Elsan 50 EC	100	100	100
Trichlorfon[1]	Dipterex 50EC	50±7.9	24±7.5	35.6±4.2
Cacbamates				
Fenobucarb[1]	Bassa 50 EC	50	44±9.8	45.7±6.9
Pyrethroids				
Permethrin[1]	Adion 20 EC	46.7±13.3	70±9.4	60±9.5
Ethofenprox[1]	Trebon 20 EC	66.7±10.5	50±9.8	60±8.3
Cypermethrin[1]	Agrothrin 6 EC	75±7.9	50±13.7	62.5±10.5
Chloronicotinyls				
Nitenpyram[2]	Bestgard 10 SP	40±24.5	46.7±16.9	45±16.6
Acetamipid[2]	Mospilan 20 SP	60±24.5	15±10	30±13.3
Thiamethoxam[1,2]	Actara 10 SG	95±5	24±4	55.6±3.5
Chlothianidin[2]	Dantotsu 16 SP	80±9.4	32±13.6	53.3±9.5
Macrorides				
Emamectin benzoate[2]	Affirm 1 EC	33.3±18.3	100	75±6.8
Nereistoxins				
Cartap[1,2]	Padan 75 SG	100	80±20	90±6.1
IGRs				
Cyromazine[2]	Trigard 8.3 L	20±37.4	40±6.1	36±11.7
Spinosad[2]	Spinoace 25 SG	70±12.3	100	91±3.5
Flufenoxuron[2]	Cascade 10 EC	0	44±13.3	36.7±9.7

[1] commonly used in Vietnam
[2] commonly used in Japan

management, including cyromazine, emamectin benzoate, cartap, spinosad, thiamethoxam, flufenoxuron, and chlothianidin. However, our tests indicated that the last three insecticides were not or less effective on neither larvae nor adults of *L. chinensis* (Table 1, 2). Thiamethoxam was only an insecticide labeled for *L. chinensis* control. However, the laboratory assay revealed that the insecticide was not highly effective on the leafminer (Tokumaru, 2004; Tokumaru and Okadome, 2004). Saito (2004) has recently reported that *C. horticola* populations collected in Shizuoka and Kagoshima, Japan had less susceptibility to thiamethoxam. These findings indicate that thiamethoxam may have been less effective on leafminers on vegetable crops. According to several authors, the application of cyromazine, spinosad and cartap has the potential to provide control of leafminers such as *L. trifolii* (Smith, 1986), *L. huidobrensis* (Weintraub, 1999; Weintraub, 2001; Prijono *et al.*, 2004), and *C. horticola* (Saito, 2004). However, the efficacy of these insecticides on the leafminers was examined mortality of the larval stage; adult mortality was overlooked. The present study indicated a difference in the response to tested insecticides between larvae and adults of *L. chinensis* (Table 1, 2). Cyromazine was highly effective on the larvae, but not effective on the adults. Conversely, spinosad and phenthoate were found highly effective on *L. chinensis* adults, but proved low in effective on the larvae. This result was consistent with research on these insecticides for controlling *L. trifolii* (Saito *et* al., 1992) and *L. chinensis* (Tokumaru, 2004; Tokumaru and Okadome, 2004). The successful control of leafminer populations requires treatments to be targeted against all the developmental stages (Head *et al.* 2002). Among 17 tested insecticides, therefore, dimethoate, emamectin benzoate, permethrin, and cartap seem to have good protection to *L. chinensis*, because these insecticides have highly or moderately effective on both the larval and adult stages.

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), and cyromazine (Leibee and Capinera, 1995; Ferguson, 2004). Mason *et al.* (1987) reported that some resistance to pyrethroids (e. g. permethrin) also has developed in *L. sativae* on Oahu, Hawaii. 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* leafminers (Ferguson, 2004). Although there are no studies on the development of insecticide resistance in *L. chinensis*, the resistance should be concerned in chemical control of the leafminer only when necessary with a rotation of effective materials (e.g. cyromazine, spinosad, phenthoate, dimethoate, emamectin benzoate, permethrin, and cartap).

The effectiveness of insecticides on leafminer management has been dogged by their impact on natural enemies (Murphy and LaSalle, 1999). Saito *et al.* (1996) reported that application of non–selective insecticides (e.g. permethrin, ethofenprox, methomyl and prothiofos) induced outbreak of *L. trifolii* on the gerbera because they were less effective on the leafminer, but strongly affected its parasitoids. The finding indicates that insecticides that are effective on leafminer but harmless to parasitoids should be used for suppressing *L. chinensis* population. While there was no studies on effects of spinosad, phenthoate, dimethoate, emamectin benzoate, and cartap on parasitoids of *Liriomyza* leafminers, 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), it would prove to incorporate cyromazine into a biological control program of onion leafminer, *L. chinensis*.

ACKNOWLEDGMENT

We thank Mr. H. Takemoto (Fukuoka Agricultural Research Centre) for providing *L. chinensis* and his suggestion on tested insecticides used in Japan. This work was supported in part by a Grand–in–Aid from the Japanese Society for the Promotion of Science and Technology (No. 15208007).

REFERENCES

Abbott, W. S. 1925 A method of computing the effectiveness of an insecticide. *J. Econ. Entomol.*, **18**: 265–267

Andersen, A., E. Nordhus., V. T. Thang., T. T. T. An., H. Q. Hung and T. Hofsvang 2002 Polyphagous *Liriomyza* species (Diptera: Agromyzidae) in vegetables in Vietnam. *Trop. Agric. (Trinidad)*, **79**: 241–246

Chen, X. X., X. Y. Lang., Z. H. Xu., J. H. He and Y. Ma 2003 The occurrence of leafminers and their parasitoids on vegetables and weeds in Hangzhou area, Southeast China. *BioControl*, **48**: 515–527

Cox, D. L., M. D. Remick, J. A. Lasota, and R. A. Dybas 1995 Toxicity of avermectins to *Liriomyza trifolii* (Diptera: Agromyzidae) larvae and adults. *J. Econ. Entomol.*, **88**: 1415–1419

Ferguson, J. S. 2004 Development and stability of insecticide resistance in the leafminer *Liriomyza trifolii* (Diptera: Agromyzidae) to cyromazine, abamectin, and spinosad. *J. Econ. Entomol.*, **97**: 112–119

Head, J., K. F. A. Walters and S. Langton 2002 Utilisation of morphological features in life table studies of *Liriomyza huidobrensis* (Dipt., Agromyzidae) developing in lettuce. *J. Appl. Ent.*, **126**: 349–354

Hwang, C. Y. and H. C. Moon 1995 Effect of temperature on the development and fecundity of *Liriomyza chinensis* (Diptera: Agromyzidae). *Korean J. Appl. Entomol.*, **34**: 65–69 (in Korean with English summary)

Keil, C. B. and M. P. Parrella 1990 Characterization of insecticide resistance in two colonies of *Liriomyza trifolii* (Diptera: Agromyzidae). *J. Econ. Entomol.*, **83**: 18–26

Konishi, K. 2004 An illustrated to the species of hymenopterous parasitoids of leafmining agromyzid pests. *In* "Proceedings of 2004 Asian science seminar on biological control of agricultural pests in Asia –Theory and Practice". JASS' 04, Fukuoka, Japan, pp: 40–56

Leibee, G. L. and J. L. Capinera 1995 Pesticide resistance in Florida insects limits management options. *Florida Entomol.*, **78**: 386–399

Macdonald, O. C. 1991 Responses of the alien leaf miners *Liriomyza trifolii* and *Liriomyza huidobrensis* (Diptera: Agromyzidae) to some pesticides schedules for their control in the UK. *Crop Prot.*, **10**: 509–513

Mason, G. A., W. J. Marshall and B. E. Tabashnik 1987 Susceptibility of *Liriomyza sativae* and *L. trifolii* (Diptera: Agromyzidae) to permethrin and fenvalerate. *J. Econ. Entomol.*, **80**: 1262–1266

Murphy, S. T. and J. LaSalle 1999 Balancing biological control strategies in the IPM of New World invasive *Liriomyza* leafminers in field vegetable crops. *Biocontrol News and Information*, **20**: 91–104

Oatman, E. R. and G. G. Kennedy 1976 Methomyl induced outbreak of *Liriomyza sativae* on tomato. *J. Econ. Entomol.*, **69**: 667–668

Parrella, M. P. 1983 Evaluations of selected insecticides for control of permethrin-resistant *Liriomyza trifolii* (Diptera: Agromyzidae) on Chrysanthemum. *J. Econ. Entomol.*, **76**: 1460–1464

Parrella, M. P. and J. T. Trumble 1989 Decline of resistance in *Liriomyza trifolii* (Diptera: Agromyzidae) in the absence of insecticide selection pressure. *J. Econ. Entomol.*, **82**: 365–368

Parrella, M. P., and C. B. Keil 1984 Insect pest management: the lesson of *Liriomyza*. *Bull. Entomol. Soc. Am.*, **30**: 22–25

Prijono, D., M. Robinson, A. Rauf, T. Bjorksten and A. A. Hoffmann 2004 Toxicity of chemicals commonly used in Indonesian vegetable crops to *Liriomyza huidobrensis* population and the Indonesian parasitoids *Hemiptarsenus varicornis*, *Opius* sp., and *Gronotoma micromorpha*, as well as the Australian parasitoids *Hemiptarsenus varicornis* and *Diglyphus isaea*. *J. Econ. Entomol.*, **97**: 1191–1197

Saito, T. 2004 Insecticide susceptibility of leafminer, *Chromatomyia horticola* (Goureau) (Diptera: Agromyzidae). *Appl. Entomol. Zool.*, **39**: 203–208

Saito, T., F. Ikeda and A. Ozama 1996 Effect of pesticides on parasitoid complex of serpentine leafminer *Liriomyza trifolii* (Burgess) in Shizuoka Prefecture. *Jpn. J. Appl. Entomol. Zool.*, **40**: 127–133 (in Japanese with English summary)

Saito, T., T. Oishi, F. Ikeda and T. Sawaki 1992 Effect of insecticides on the serpentine laefminer, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae). *Jpn. J. Appl. Entomol. Zool.*, **36**: 183–191 (in Japanese with English summary)

Sanderson, J. P., M. P. Parrella, and J. T. Trumble 1989 Monitoring insecticide resistance in *Liriomyza trifolii* (Diptera: Agromyzidae) with yellow sticky cards. *J. Econ. Entomol.*, **82**: 1011–1018

Schuster, D. J. and P. H. Everett 1983 Response of *Liriomyza trifolii* (Diptera: Agromyzidae) to insecticides on tomato. *J. Econ. Entomol.*, **76**: 1170–1174

Shiao S. F 2004 Morphological diagnosis of six *Liriomyza* species (Diptera: Agromyzidae) of quarantine importance in Taiwan. *Appl. Entomol. Zool.*, **39**: 27–39

Smith, R. F. 1986 Efficacy of selective insecticides against *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae), a leafminer of chrysanthemum. *Can. Ent.*, **118**: 761–766

Spencer, K. A. 1990 *Host specialization in the world Agromyzidae (Diptera)*. Series Entomologica. Kluwer Ac. Pub. Dordrecht.

Spencer, K.A. 1973 *Agromyzidae (Diptera) of economic importance*. Dr. W. Junk B. V., Publishers, The Hague.

Tokumaru, S. and K. Okadome 2004 Insecticide susceptibility of the stone leek leafminer, *Liriomyza chinensis* Kato (Deptera: Agromyzidae). *Ann. Rept. Kansai Pl. Prot.*, **46**: 23–27 (in Japanese with English summary)

Tokuruma, S. 2004 Developmental ecology and insecticide susceptibility of the stone leek leafminer, *Liriomyza chinensis* Kato (Deptera: Agromyzidae). *Jpn. Agri. Tech.* **48**: 12–16 (in Japanese)

Tran, D. H., M. Takagi and K. Takasu 2004 Effects of selective insecticides on host searching and oviposition behavior of *Neochrysocharis formosa* (Westwood) (Hymenoptera: Eulophidae), a parasitoid of the American serpentine leafminer. *Appl. Entomol. Zool.*, **39**: 435–441

Weintraub, P. G. 1999 Effects of cyromazine and abamectin on the leafminer, *Liriomyza huidobrensis* and its parasitoid, *Diglyphus isaea* in celery. *Ann. Appl. Biol.*, **135**: 547–554

Weintraub, P. G. 2001 Effects of cyromazine and abamectin on the leafminer, *Liriomyza huidobrensis* and its parasitoid, *Diglyphus isaea* (Hymenoptera: Eulophidae) in potatoes. *Crop Prot.*, **20**: 207–213