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INSECTICIDE AND GROWTH REGULATOR EFFECTS ON THE LEAFMINER, *LIRIOMYZA TRIFOLII* (DIPTERA: AGROMYZIDAE), IN CELERY AND OBSERVATIONS ON PARASITISM

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ABSTRACT

The effects of different insecticides were compared on survival and development of the leafminer, *L. trifolii,* in celery in Michigan and parasitism was assessed in this non-resident population. Avermectin, thiocyclam, and cyromazine effectively controlled *L. trifolii* larvae or prevented successful emergence as adults. Moderate to high levels of resistance to permethrin and chlorpyrifos were present. Avermectin caused high mortality of all larval stages and no adults successfully emerged. Thiocyclam caused high mortality to all larval stages, but did not affect adult emergence from the surviving larvae. Cyromazine acted most strongly against early stage larvae before visible mines were present, caused little direct mortality of larger larvae, but prevented successful adult emergence. No parasitoids emerged from 2029 larvae collected and reared, in contrast to studies in sites where *L. trifolii* is a year-round resident.

The leafminer, *Liriomyza trifolii* (Burgess), is a severe pest of a variety of greenhouse crops and attacks vegetable crops grown in the southern and southwestern U.S. Host crops include: snap beans, celery, cucurbits, lettuce, peppers, tomatoes, and chrysanthemums (Parella et al. 1981, Johnson 1987, Bethke et al. 1987, Hanna et al. 1987). Cosmetic injury may occur at low population levels and severe stunting and yield losses occur at higher populations (Trumble 1985, Chandler and Gilstrap 1987). Insecticide resistance in *L. trifolii* has reached extreme levels in many greenhouses and field situations (Parella 1983, Schuster and Everett 1983, Parella and Keil 1984, Keil et al. 1985, Trumble 1985).

Liriomyza trifolii apparently does not overwinter in Michigan except in greenhouses. Field infestations are generally below economic levels, occur infrequently, and can usually be traced to importation of infested plant material, such as transplants, greenhouse plants, or celery for packing and shipping. Initial introductions to California, Canada, Colombia, and England are also thought to be the result of imported plant material (Parella et al. 1981, Lindquist 1983). Since infestations in Michigan celery fields are not common, no information is available on the susceptibility or resistance to insecticides of the presumably-imported *L. trifolii* or parasitoids associated with it.

The objective of this study was to compare effectiveness and action of experimental and registered materials against *L. trifolii* in Michigan celery. The interactions between pesticide applications, pesticide resistance in the pest, and biological control are important for management of *Liriomyza* (Oatman and Kennedy 1976). However, the importance of parasitism in non-resident populations of *L. trifolii* is unknown. Therefore, a secondary objective of the study was a preliminary assessment of parasitoids attacking the leafminers and evaluation of the effects of treatment on parasitism.

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MATERIALS AND METHODS

Trials were conducted in a severely infested celery field near Hudsonville MI (Ottawa County). Initial leafminer populations had apparently been introduced from chrysanthemums discarded from a nearby greenhouse. Adult density was >500 per 100 sweeps and flies were present on nearly every new leaf. Estimated defoliation exceeded 80% and only new growth was free of visible mines. Plots were 3 rows by 25 ft., arranged linearly along the eastern border of the field with three replications per treatment, arranged in a randomized complete block design. Plots were numbered randomly within each block and all sampling and evaluations were done without knowledge of which treatment had been applied. Treatments were applied to the center row of each plot on 10 Sept. and 17 Sept. 1985 with a single nozzle CO_2 hand sprayer at 467 l/ha (50 gpa) and 2.11 kg/cm^2 (30 psi). The following materials were selected to give a broad range of insecticide types and modes of action: (1) a standard organophosphate (chlorpyrifos), (2) a pyrethroid (permethrin), (3) an insect growth regulator (cyromazine), (4) a microbial product (avermectin), and (5) a new type of insecticide (thiocyclam). Rates were: avermectin, 0.17 kg ai/ha (kg active ingredient/ha); thiocyclam, 0.56 kg ai/ha; cyromazine, 0.84 kg ai/ha; chlorpyrifos, 1.87 kg ai/ha; and permethrin 0.19 kg ai/ha.

Ten leaflets from the new growth were collected at random from each plot after the first treatment, as soon as the spray had dried. The leaflets were too new to have visible mines, but numerous feeding and oviposition punctures were present on each leaflet. Leaflets from each plot were placed in plastic bags, returned to the laboratory and kept at room temperature (20–25°C). Larvae that emerged in the plastic bags were counted 9 and 13 days after collection and were retained in screen-covered vials. Adult emergence was assessed 22 days after collection. Observations for parasitoids were made when emerged larvae were transferred to vials and again when adult emergence was assessed.

Ten older leaflets with visible mines from each plot were also randomly collected immediately after treatment and returned to the laboratory for evaluation. Because of the growth habit of celery (leaves and stalks produced on alternating sides of the plant), leaflets of approximately the same age could be selected from each plant. The third or fourth oldest leaflets from randomly-selected plants were chosen for sampling. Mature larvae began emerging from these leaflets within 24h of collection. Leaflets were retained in plastic bags and larvae and pupae were counted 6 days after collection and retained in vials. Numbers of adults emerged from new and old leaflets were recorded 20 days after collection. Plastic bags and vials were also checked for the presence of emerged parasitoids. Percent successful adult emergence was defined as: 100 × (# adults ÷ # larvae emerging from the respective leaflet).

On 25 Sept., 8 days after the second application, 3 plants were randomly selected from each plot. The terminal leaflet from each of the newest 3 stalks was collected from each plant and the number of visible mines recorded. The oldest of these 3 stalks was generally the same age as stalks sampled as "new growth without mines" at the beginning of the study. Leaflets were retained as before and the numbers of larvae emerging were recorded. Adult emergence was recorded and observations for parasitoid emergence were made 22 days after collection.

RESULTS AND DISCUSSION

Survival and development. Dead adults were observed on foliage in all treatments immediately after spraying on 10 Sept. However, chlorpyrifos and permethrin were not effective in controlling the larvae or reducing new infestations. Chlorpyrifos is moderately effective in controlling *L. trifolii* in greenhouses in Michigan and Ohio (Smitley, Michigan State Univ., Pers. Comm.; Lindquist 1985), but had little or no effect on *L. trifolii* in studies in California (Parella et al. 1982b). In this study, avermectin, thiocyclam, and cyromazine reduced the number of larvae emerging from the new growth almost to zero (Figure 1a). Chlorpyrifos treatment after visible mines were present reduced the numbers of larvae, but levels were still much higher than in either avermectin or thiocyclam treatments (Figure 1b). Avermectin and thiocyclam were highly effective even on the larger larvae present in older leaves with visible mines (Figure 1b). Cyromazine treatment only moderately reduced the numbers of larvae emerging to pupate from the older leaves, but surviving larvae did not successfully emerge as adults. Permethrin had little or no effect on larval or adult numbers from leaflets with no visible mines or leaflets with visible mines. This was similar to results reported by Parella et al. (1982b) for oxamyl and methomyl. Cyromazine may not be effective in reducing larval activity if larvae are already partially grown but will kill early instars and will prevent adult emergence. In contrast, in studies by Parella et al. (1982a) and Parella (1983) on chrysanthemum, cyromazine was as effective on third instars as on newly-eclosed larvae. These results contradict data from the present study. Differences may be due to variations in maturity of larvae, higher trans-cuticular movement of the chemical in chrysanthemum, differences in application rates, or other factors. Differences in tolerance to cyromazine may also exist between populations. Cyromazine resistance has recently been reported in house flies, *Musca domestica* L. (Bloomcamp et al. 1987) and the Michigan population was tested after the registration of cyromazine for *L. trifolii* control in Florida.

Numbers of new mines 15 days after initial treatment were significantly reduced by avermectin, thiocyclam and cyromazine, even under the extreme pressure of the small plot design (Table 1). However, the numbers of larvae that emerged from leaflets collected at the end of the experiment were significantly higher in the thiocyclam treatment than in either avermectin or cyromazine treatments. Numbers of adults emerged from the thiocyclam-treated leaflets were not significantly lower than from permethrin-treated or untreated leaflets. The intervals between treatments and between the last treatment and final sampling were perhaps too long for thiocyclam to be effective.

Cyromazine appeared to interfere with the pupation process and showed a clear effect on percent successful adult emergence (Table 2). High numbers of larvae emerged from cyromazine-treated leaves with visible mines (Fig. 1b), but most failed to pupate and none emerged as adults (Table 2). Avermectin treatment may have also affected pupation and adult emergence. The few larvae that did emerge from avermectin-treated leaflets did not mature to adults. Permethrin, chlorpyrifos, and thiocyclam had little or no effect on percent successful adult emergence from surviving larvae (Table 2). No assessment of adult fecundity was made.

Parasitism. Although 2029 larvae were collected from all treatments (including 783 from untreated plots) and 784 were reared to adults, there was no indication of parasitism. This complete lack of parasitoids was in marked contrast to results reported from other locations. In California, Trumble and Nakakihara (1983) reported at least 7 species of parasitoids from *Liriomyza sativae* Blanchard and *L. trifolii* and Oatman and Kennedy (1976) reported 9 species of parasitoids with up to 100% parasitism of *L. sativae*. Johnson (1987) reported more than 15 species of parasitoids and as much as 96% parasitism of *L. trifolii* and *L. sativae* in Hawaii.

In contrast to the populations studied previously, *L. trifolii* is not known to overwinter in Michigan and the study population was presumably introduced within a few weeks or months of the study. The lack of parasitism may be the result of: (1) few or no native parasitoids (perhaps attacking native agromyzids) in nearby crops or weeds, (2) few or no parasitoids introduced with the original pest population, (3) parasitoids eliminated by heavy insecticide applications in the greenhouse before escape or release, (4) parasitoids eliminated by the intensive treatment of the celery field before initiation of the experiments, or (5) insufficient time allowed or unsuitable conditions for parasitoid development and emergence after collection. The latter is unlikely, since samples were held in plastic bags and then in vials for a total of 20 to 22 days and at least some of the parasitoids would have been nearly mature at the time of collection and would have emerged, regardless of conditions. Also, the ca. 50% successful emergence of *L. trifolii* indicates that conditions were probably adequate. Smitley (Michigan State Univ., Pers. Comm.) has observed no significant parasitism in commercial greenhouses in Michigan. Intensive insecticide treatments in the greenhouse and in the field, perhaps combined with

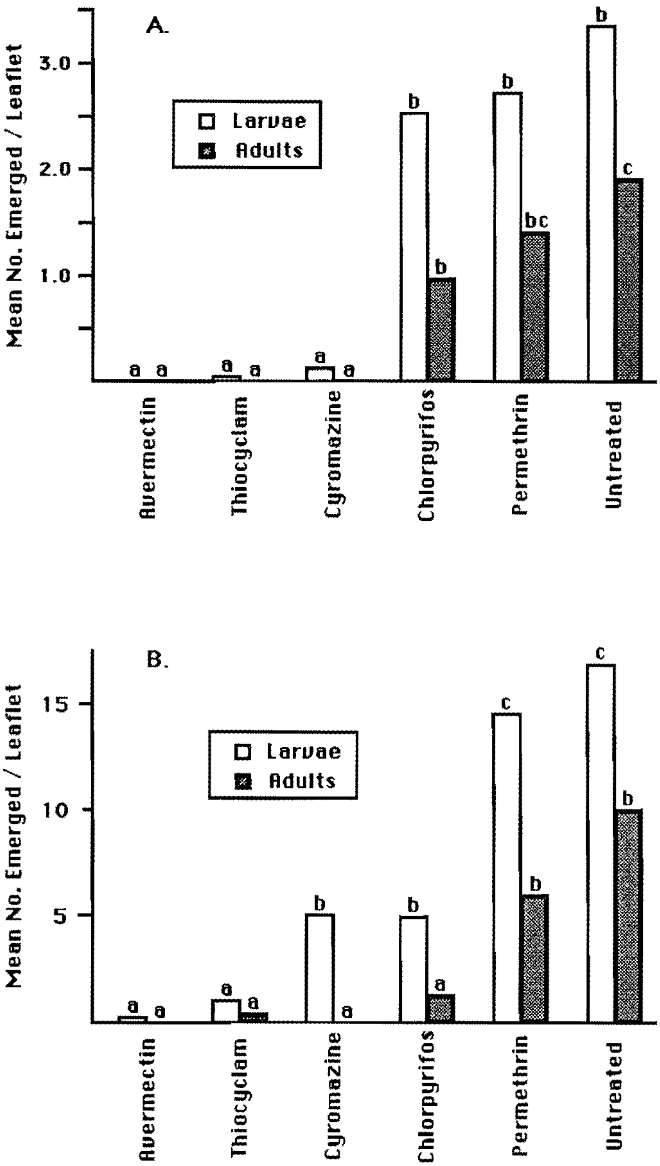

Fig. 1. Larval emergence and subsequent adult success from leaflets collected immediately after initial treatment. **A.** Leaflets without visible mines at the time of collection. **B.** Leaflets with visible mines at the time of collection. Larval or adult numbers with different letters are significantly different (ANOVA, SNK test, $p < .05$).

Table 1. Number of visible mines, larval emergence, and adults from leaflets collected at the end of the study (15 days after initial treatment).

	Visible mines per leaflet*	Mean no. larvae emerged per leaflet*	Mean no. adults per leaflet*
Avermectin 0.15 SC 0.17 kg ai/ha	1.59 a	0.11 a	0.00 a
Thiocyclam 50 SP 0.56 kg ai/ha	1.81 a	2.30 b	0.74 ab
Cyromazine 75 WP 0.84 kg ai/ha	2.63 ab	0.04 a	0.00 a
Chlorpyrifos 4 E 1.87 kg ai/ha	3.96 bc	3.96 c	1.52 b
Permethrin 2 EC 0.19 kg ai/ha	3.19 abc	2.96 b	0.93 ab
Untreated	4.33 c	4.93 d	1.30 ab

*Means followed by different letters are significantly different (SNK test, $p < .05$).

Table 2. Percent successful adult emergence from larvae reared from leaflets collected immediately after the first treatment or at the end of the study (8 days after the 2nd treatment).

	Leaflets collected immediately after 1st treatment		Leaflets collected 8 days after 2nd treatment
	without visible mines (% success)**	with visible mines (% success)**	(% success)**
Avermectin 0.15 SC 0.17 kg/ha	—[x]	—[x]	—[x]
Thiocyclam 50 SP 0.56 kg ai/ha	—[x]	34.3 b	39.7 b
Cyromazine 75 WP 0.84 kg ai/ha	—[x]	0.0 a	—[x]
Chlorpyrifos 4 E 1.87 kg ai/ha	30.0	25.7 b	36.0
Permethrin 2 EC 0.19 kg ai/ha	40.7	42.7 bc	31.0
Untreated	51.0 n.s.	50.0 c	39.7 n.s.

**% success = 100 × (No. adults/No. larvae emerged from each leaflet). Means followed by different letters are significantly different (SNK test, $p < 0.05$).

[x]Excluded from analysis. Less than 5 larvae emerged/treatment (see Fig. 1 and Table 1).

a low rate of parasitoid introduction and low endemic levels, were therefore the most probable causes of the lack of parasitism.

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LITERATURE CITED

Bethke, J. A., M. P. Parella, J. T. Trumble, and N. C. Toscano. 1987. Effect of tomato cultivar and fertilizer regime on the survival of *Liriomyza trifolii* (Diptera: Agromyzidae). J. Econ. Entomol. 80: 200–203.

Bloomcamp, C. L., R. S. Patterson, and P. G. Koehler. 1987. Cyromazine resistance in the house fly (Diptera: Muscidae). J. Econ. Entomol. 80: 352–357.

Chandler, L. D. and F. E. Gilstrap. 1987. Seasonal fluctuations and age structure of *Liriomyza trifolii* (Diptera: Agromyzidae) larval populations on bell peppers. J. Econ. Entomol. 80: 102–106.

Hanna, H. Y., R. N. Story and A. J. Adams. 1987. Influence of cultivar, nitrogen, and frequency of insecticide application on vegetable leafminer (Diptera: Agromyzidae) population density and dispersion on snap beans. J. Econ. Entomol. 80: 107–110.

Johnson, M. W. 1987. Parasitism of *Liriomyza* spp. (Diptera: Agromyzidae) infesting commercial watermelon plantings in Hawaii. J. Econ. Entomol. 80: 56–61.

Keil, C. B., M. P. Parella, and J. G. Morse. 1985. Method for monitoring and establishing baseline data for resistance to permethrin by *Liriomyza trifolii* (Burgess). J. Econ. Entomol. 78: 419–422.

Lindquist, R. K. 1983. New greenhouse pests with particular reference to the leafminer, *Liriomyza trifolii*. Proc. 10th Int. Congr. Plant Prot., Brighton, England. 3: 1087–1094.

______. 1985. Evaluation of pesticides for leafminer and green peach aphid control on potted greenhouse chrysanthemum. Ohio Florists' Assoc. Bull. No. 669: 4–5.

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

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

Parella, M. P., M. W. Allen, and P. Morishita. 1981. Leafminer species causes California mum growers new problems. California Agric. Sept.–Oct: 28–31.

Parella, M. P., G. D. Christie, K. L. Robb, and J. A. Bethke. 1982a. Control of *Liriomyza trifolii* with biological agents and insect growth regulators. California Agric. Nov.–Dec: 17–19.

Parella, M. P., K. L. Robb, and P. Morishita. 1982b. Response of *Liriomyza trifolii* (Diptera: Agromyzidae) larvae to insecticides with notes about efficacy testing. J. Econ. Entomol. 75: 1104–1108.

Parella, M. P. and C. B. Keil. 1984. Insect pest management: The lesson of *Liriomyza*. Bulletin Entomol. Soc. Amer. 3: 22–25.

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

Trumble, J. T. 1985. Planning ahead for leafminer control. California Agric. Jul.–Aug: 8–9.

Trumble, J. T. and H. Nakakihara. 1983. Occurrence, parasitization, and sampling of *Liriomyza* species (Diptera: Agromyzidae) infesting celery in California. Environ. Entomol. 12: 810–814.