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INTEGRATED CONTROL OF THE VEGETABLE LEAFMINER (LIRIOMYZA SATIVAE BLANCHARD) DURING THE 1977-78 TOMATO SEASON IN DADE COUNTY, FLORIDA[1]

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Abstract. **Several strategies for the control of insect pests, with particular emphasis on the vegetable leafminer in the Dade County tomato crop, were tested by pilot tomato pest management personnel in cooperation with several commercial producers. Spray applications based on detailed, biological information, treatment at economic threshold values only, and use of insecticides with low toxicity to beneficial insects produced acceptable control of insect pests in commercial-sized fields. Yields for integrated pest management (IPM) plots were comparable to more conventional programs and costs were reduced substantially in several cases.**

The University of Florida integrated pest management (IPM) program on tomatoes in Dade County was initiated in November, 1976. It was the first such program concerned with this commodity in the United States. Scout survey procedures for monitoring disease pathogens, nematodes, insects, and weeds and economic thresholds for selected pests have been outlined (10).

A primary insect pest is one which occurs from season to season and requires a certain number of pesticide applications for maintenance of populations below the economic threshold. Florida tomato growers traditionally have depended on calendar-determined, preventative applications of broad-spectrum insecticides for control of primary insect pests.

Most investigators view the vegetable leafminer (VLM) (*Liriomyza sativae* Blanchard) as a secondary pest, i.e., one that may be adequately controlled by natural agents, when these agents are not killed by insecticides. However, during the 1976-77 season, most growers cited the VLM as their most serious pest problem. It has been shown that repeated applications of broad spectrum insecticides can induce VLM outbreaks (7), and frequent use of broad-spectrum insecticides by Florida tomato growers has been documented (Pohronezny. 1977. Annual summary report, 1976-77, unpublished). Although little change in the growers' approach (almost exclusively chemical) to VLM control was effected in the 1976-77 season, grower cooperators in the 1977-78 season expressed interest in testing an integrated approach to pest control. This paper reports: 1) results of several grower tests of IPM strategies and 2) comparison of use and cost of insecticides among several growers in the IPM program.

Materials and Methods

Unless otherwise stated, the number of 6 ft samples taken by a scout in commercial fields was 1/2-2.5 acres[2]. All scouting procedures have been described previously (10). The economic threshold for VLM was recommended as 25 mines/6 trifoliates with at least 25% of the mines containing live larvae. A "trifoliate" is defined as the 3 distal leaflets of the third or fourth true leaf from the apical end of a stalk. The threshold for lepidopterous larvae (except pinworm) was 1 caterpillar/6 ft of row. Pinworm (*Keiferia lycopersicella* Walsh) threshold was 1 blotch mine/3 top leaves/plant (11).

To assess the effects of various spray programs on parasite populations, live VLM larvae nearing maturity were collected and held in the laboratory (21-25°C) to deter-

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[2]For metric conversions see table at the front of this volume. Ed.

mine the parasitism rate by hymenopterans. Three samples of approximately 15 larvae were taken weekly from each field. Leaflets containing the larvae each were placed on a wire screen shelf inside one quart cardboard ice cream containers. After at least 3 weeks, the number of VLM adults and parasites were counted. Percent parasitism and percent VLM adult emergence were calculated.

Paired-block test-Grower D. One grower participated in a paired block test in the fall of 1977, in which a 1.4 acre section (the IPM block) at the east end of an 80 acre field was treated with insecticides on demand (i.e., when economic thresholds were reached). The rest of the field (designated traditional block) was treated on a calendar basis, predominantly with alternate 4 days applications of 0.45 lbs. active ingredient (a.i.) methomyl and 1.1 lb. a.i. monocrotophos. Due to heavy bacterial spot pressure, the grower did not choose to make any changes in the fungicide (bactericide) program in the test block. All pesticide sprays were applied with a high-pressure, ground spray rig at from 42.8 to 100 gals H_2O/acre.

The grower planted 'Flora-Dade' tomatoes under full-bed plastic mulch culture on 6-ft center beds with drip irrigation (2). An application of 200 lb/geographical acre of Dow-fume MC-33® was made with 3 chisels per bed 14 days prior to planting. Scouting of the IPM block consisted of 5 6-ft samples. This intensive scouting was used in order to gather enough representative data for comparison with the traditional block.

Yield data were taken 110 days after planting. Mature green fruit from 5 12-ft samples randomly selected from within the IPM block were compared to the yields in the 5 randomly-selected 12 ft samples harvested from the 5 acres of the traditionally-sprayed area of the field closest to the IPM block. None of the traditionally sprayed samples was taken from the 2 tomato rows closest to the IPM block. Fruit were graded and sized according to USDA grading standards for fresh-market tomatoes.

Comparison of selective and broad-spectrum insecticide programs—Grower G and Grower H. Many Florida tomato growers have been reluctant to treat fields only on an "as-needed" basis for insect pests. They are concerned particularly with infestations of lepidopterous larvae, especially once fruit has set. Grower G and Grower H planted and harvested the fields reported here at about the same time in the fall of 1977. Grower G used *Bacillis thuringiensis* and endosulfan (usually 3.6 billion international units and 1 lb a.i./100 gals, respectively) on about a 5 days schedule for control of primary pests. These pesticides were chosen for their relatively low toxicity to VLM parasites. Chemical control of VLM was applied on a demand basis. This field was on ground culture. Three lbs a.i. fensulfothion 15 G/acre was broadcast and incorporated before planting, primarily for nematode control. A preemergence application of diphenamid was made in an 18 inch band at a rate of 4 lb a.i./acre. Periodic paraquat application and cultivation were used for post-emergence weed control. All spray applications were made with a high-pressure ground rig at 40 to 100 gals H_2O/acre.

Grower H applied insecticides for control of primary pests and VLM on a regular basis. He made twice-a-week insecticide applications, alternating 1.1 lb a.i. monocrotophos and 0.5-1.0 lb a.i. methamidophos/100 gals. Volume of water applied from a high-pressure ground rig ranged from 25-120 gals H_2O/acre. The land was under full-bed plastic mulch culture, with 200 lb/geographical acre of Dow-fume MC-33® fumigant applied 10 days prior to planting. Both growers used 'Flora-Dade' tomatoes.

Results and Discussion

Paired block test-Grower D. Yields for the tomato IPM block and the traditional program are summarized in Fig. 2. Yields for USDA large and extra large fruit combined were not significantly different at the 5% level (Student's t-test), but the IPM large-fruit yields were significantly higher at the 10% level. The large and extra large yields averaged 186 and 98 30 lb cartons/acre in the IPM and traditional blocks respectively. Yields for medium fruit were 258 and 236 30 lb cartons/acre and 10.2 and 8.3 total tons/acre for IPM and traditional blocks, respectively (non-significant). The traditional block was sprayed an average of 1.8 times a week with insecticide and the IPM block an average of 0.5 times/week. The spray-on-demand schedule used in the IPM block resulted in $52.87/acre savings in the cost of insecticides compared to the traditional strategy (Fig. 1).

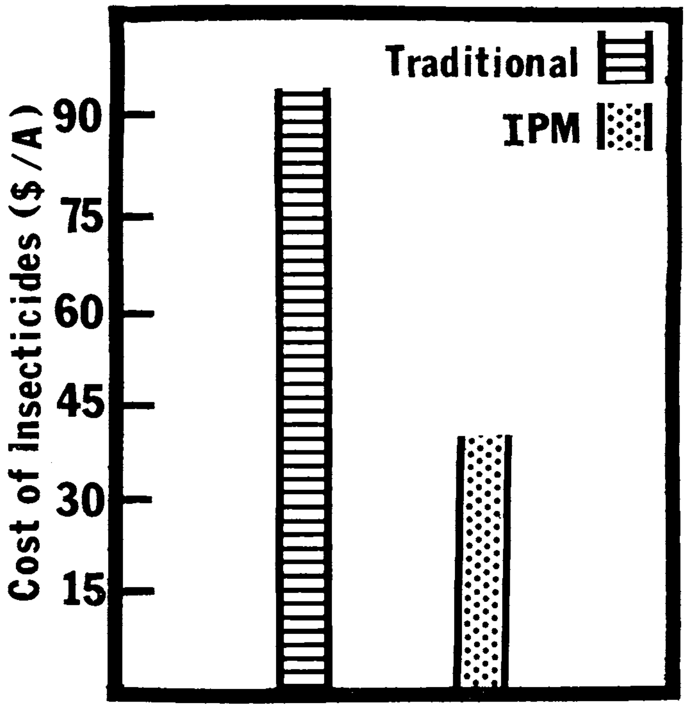

Fig. 1. Cost of insecticides on a per acre basis in contiguous field plots under traditional and IPM spray programs—paired block test.

The traditional block was sprayed 12 times (monocrotophos) for VLM control, whereas the IPM block was never sprayed specifically for VLM. VLM counts remained low (range 1.2-5.6 mines/6 trifoliates) until 2.5 weeks before harvest when 3 weekly counts were 14.2, 22.0, and 21.8; during the same period traditional counts were no higher than 7.0. Yield data indicated that use of the 25 mines/6 trifoliates VLM threshold did not adversely affect production.

The IPM block received 3 insecticide sprays that were requested and 3 additional applications of methomyl at the discretion of the grower, even though lepidopteran counts were not at threshold values. The traditional block received 15 methomyl applications on a preventative basis. Cabbage loopers (*Trichoplusia ni* Hubner) were controlled satisfactorily the last 2 weeks of the test when they reached the threshold of 1 caterpillar/6 ft sample in the traditional block. During the season the IPM block had 2 peaks in cabbage looper populations on August 31, 1977 and October 14, 1977. A reduced rate of methomyl plus *B. thuringiensis* were made on demand after each of these dates.

Looper control was excellent, and none was found in the IPM block during the last 2 weeks of the test.

The yield data (Fig. 2) show that use of insecticides on demand rather than a preventative schedule did not adversely effect yields. Average yields were greater in all size

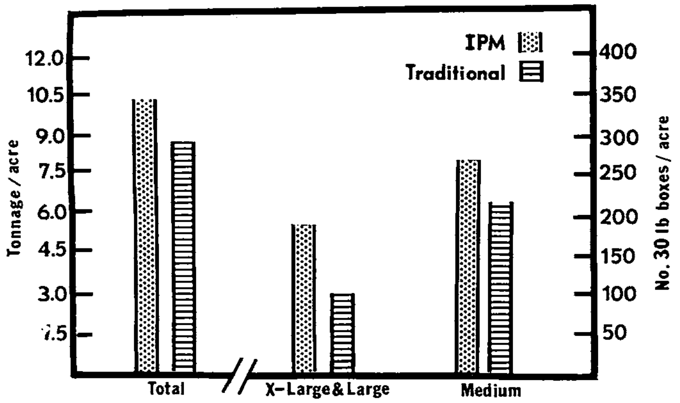

Fig. 2. Comparison of yields in contiguous field plots under traditional and IPM spray programs—paired block test.

classes in the IPM block, especially in large and extra large fruit. Poe et al. (9) also recently reported the yield advantages of using pesticides on a demand basis. The differences observed in fruit yield, especially large sizes, may reflect harmful effects on the crop by insecticide, as has been shown on cotton (3).

Comparison of selective and broad-spectrum insecticide programs—Grower G and Grower H. Table 1 shows the average of the VLM counts in Grower G and Grower H fields during the fall 1977 crop. Grower H (traditional)

Table 1. Vegetable leafminer (VLM) population comparisons in 2 grower fields using different control strategies for insect pests—Fall 1977.

Date 1977	Average VLM counts/six trifoliates	
	Grower G (IPM[z])	Grower H (Traditional[y])
9/12	0.4	0.2
9/26	6.5	0.4
10/6	14.7	0.0
10/17	3.5	0.1
10/25	Naled	
10/31	9.8	1.5
11/16	11.6 (50% live)	2.1
11/16	Methamidophos	
11/23	7.9 (0% live)	2.1

[z]Treatment with *Bacillis thuringiensis* + endosulfan + broad-spectrum insecticides on demand.
[y]Calendar treatments—twice a week, alternating monocrotophos and methamidophos.

had much lower VLM counts than G (IPM, selective insecticides). However, the counts in Grower G's field never exceeded the threshold of 25 mines/6 trifoliates with 25% of the mines containing live larvae. The only specific applications made for VLM were a naled application for a large infestation of adults on October 25 and a methamidophos application on November 16. The latter application was made by the grower in anticipation of possible economically important levels of VLM before the first tomato harvest on November 30 so that this systemic insecticide would be used within the 14 day harvest limit. The post-methamidophos counts show a reduction from 11.6 to 7.9 mines per 6 trifoliates and a complete elimination of live larvae. Parasitism rates were high (Table 2), indicating low toxicity on VLM parasites. Parasitism rates for Grower H are listed in Table 3 for comparison.

Table 2. Percent parasitism and percent adult vegetable leafminer fly emergence from Grower G's selective insecticide—treated field—Fall 1977.

Sample date	% Parasitism	% Fly emergence
9/23	24.4	31.7
9/29	78.6	0
10/3	42.2	0
10/10	59.4	11.4
10/17	33.3	16.7
10/27	80.0	20.0
10/31	68.9	20.0
11/7	25.0	0
11/10	25.0	0
11/16	46.0	6.7
11/23	45.0	23.4
Avg/Field/Season	48.0%	14.7%

Table 3. Percent parasitism and percent adult vegetable leafminer fly emergence from Grower H's broad-spectrum insecticide-treated field—Fall 1977.

Sample date	% Parasitism	% Fly emergence
10/31	33.3	33.3
11/1	33.1	68.9
11/8	4.2	95.8
12/1	53.3	46.7
Avg/Field/Season	31.0%	61.2%

The yields were higher for Grower G, but there are a great many variables that make comparisons between grower yields difficult.

Examination of scouting data was made to identify differences in populations of other pests. No damage by any fruit-invading lepidopterans was recorded from either field. Bacterial spot levels were about the same in both fields throughout the season. Grower G had a higher population of banded cucumber beetle (*Diabrotica balteata* LeConte). Weekly counts from September 26 through November 16 were 0.94, 0.38, 0.0, 0.19, 0.25, 0.25, 0.2, and 0.0 live adult beetles/6 ft sample. Cucumber beetles were recorded in only a few samples in grower H's field on October 10 and October 18.

Despite the calendar applications of broad-spectrum insecticides, Grower H had *higher* armyworm counts than Grower G. On October 11 and October 21, beet armyworm (*Spodoptera exigua* Hubner) counts of 0.56 and 0.71 larvae/6 ft sample were recorded. An additional treatment with 0.45 lb a.i. methomyl/100 gals was necessary to reduce the population to 0. No worms of any kind were found in Grower G's field. These data suggest that the 5 day application schedule with *B. thuringiensis* and endosulfan is a good prophylactic treatment schedule for primary lepidopteran pests. This may be related to the lack of insecticide pressure on predators and parasites of lepidopterous larvae in fields such as Grower G's. The importance of natural enemies in control of beet armyworm has been reported (4). The costs for insecticide sprays for Grower G were $95.41/acre and for Grower H were $165.19/acre.

It is possible that Grower G got significant early-season VLM control with his preplant, granular application of fensulfothion. Phorate (1, 6) and di-syston (1) have been shown to be effective in control of VLM on tomatoes when applied preplant, and excellent control of early season *Liriomyza* infestations with preplant treatments of phorate were found on cotton (8). Fensulfothion has been shown to be an effective systemic, preplant treatment for control of lygus bugs and leafhoppers on beans (5), and would presumably be active against VLM on tomatoes. Florida growers may consider the use of preplant systemic nematicide/insecticide applications for early-season VLM management, since VLM mortality may be obtained without using foliar sprays of insecticides which reduce populations of flying beneficials in the field.

Table 4. Comparison of chemical and biological insecticide use among IPM tomato growers, 1977-78.

Fall crop	Grower				
	A	B	D	G	H
Average percent applications[z] without chemical or biological insecticides	23%	—	22%	30%	0%
Average percent applications with *Bacillis thuringiensis* as only insecticide	23%	—	—	21%	0%
Winter crop					
Average percent applications without chemical or biological insecticides	22%	53%	65%	24%	0%
Average percent applications with *Bacillis thuringiensis* as only insecticide	13%	0%	0%	16%	0%

[z]Applications—number of times pesticide sprayer went over field.

Some major changes in commercial practices among several growers were recorded for the winter/spring crop of 1977-78. This is thought to be at least partially the result of the demonstrated IPM practices already described. Table 4 shows that Grower D omitted an insecticide in 65% of his trips over the field, because of low insect pressure, as determined by the scout. It is estimated that the biological information upon which these decisions were made, enabled him to save between $64 and $128/acre. Grower B left an insecticide out of the tank 53% of the time in his passes over the field. His costs for insecticides were only $45.44/acre, compared to an average cost among cooperating growers of $112.15. The scout's estimates of low insect populations were an important factor in reducing spray costs.

An important measure of grower acceptance of IPM for tomatoes in Dade County is reflected in the financial commitment for scouting. Growers have or have agreed to pay at a future date approximately $17,000 for scouting expenses on 1460 acres. They feel that these costs can be recovered in increased effectiveness of pest control, primarily due to proper and early pest identification, and in savings in costs for pest control materials.

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PROTECTION OF CELERY FROM LEAFMINERS WITH PERMETHRIN[1]

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Abstract. **The synthetic pyrethroid, permethrin, was evaluated for protection of celery from the vegetable leafminer,** Liriomyza sativae **Blanchard, using single and multiple applications of varying concentrations.**

A single application of permethrin resulted in minimal effects on the number of insects reared from sprayed foliage. Used repeatedly, permethrin at all concentrations resulted in significantly fewer mines per leaflet and mines per plant than the control or standard oxamyl treatment. Celery stalk weight and grade were also improved with decreasing levels of leaf mines. The relationship of pesticide concentration to plant weight and to numbers of leafmines was linear. Laboratory tests indicated that leafminer puparia were unaffected by permethrin but that adults were inactivated and prevented from feeding on contact with freshly treated detached leaves.

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Chemical control of *Liriomyza sativae* Blanchard, the vegetable leafminer, has not been satisfactory in Florida vegetables, notably tomatoes and celery, since 1972. Persistent use of ineffective or marginally effective chemicals apparently reduces the natural level of mortality caused by the several species of parasitic Hymenoptera (2) without greatly affecting leafminers. Freed of natural restraints