Proc. Fla. State Hort. Soc. 94:137-140. 1981.

INTEGRATED MANAGEMENT OF PESTS OF SNAP BEAN IN FLORIDA[1,2]

KEN POHRONEZNY, R. MCSORLEY, AND VAN H. WADDILL
University of Florida, IFAS,
Agricultural Research and Education Center,
18905 SW 280 St., Homestead, FL 30031

Additional index words. Phaseolus vulgaris, Liromyza sativae, Urbanus proteus, Anticarsia gemmatalis, Nezara viridula, Heliothis zea, Pythium spp., *Helicotylenchus dihystera, Quinisulcius acutus, Rotylenchulus reniformis.*

Abstract. **Insects, diseases, and nematodes were monitored in several experiments in Homestead area snap bean fields. Traditional management (TM) plots were compared with adjacent integrated pest management (IPM) plots. Although low levels of insect defoliators, such as banded cucumber beetle (Diabrotica balteata Le Conte) and cabbage looper (Trichoplusia ni Hubner), were present, in addition to moderate levels of the vegetable leafminer (Liriomyza sativae Blanchard), levels of defoliation in the IPM plots did not exceed action thresholds of 20% and 10% for prebloom and postbloom, respectively. Extension recommendations were developed for an insecticide spray at the pinpod stage, based on monitoring of crop phenology. There were substantial savings in insecticide costs in the IPM plots compared to the TM plots, ranging from 48% to 83%, with no demonstrable reduction in yield or quality. In 2 of 3 large-plot demonstration tests, there was significant insecticide-induced buildups of vegetable leafminer populations in the TM plots. A Pythium crown rot was identified during the course of one of the demonstration experiments, and appropriate alternatives in the fungicide spray program were initiated. Yields of snap beans were negatively correlated with populations of Rotylenchulus reniformis Linford and Oliveira at harvest, but not with populations of Quinisulcius acutus (Allen) Siddiqi or Helicotylenchus dihystera (Cobb) Sher at anytime in crop development. In several experiments in commercial fields, growers did not experience sufficient nematode populations to significantly affect yield.**

The concept of integrated pest management (IPM) for high-cash-value vegetable crops was introduced into the Homestead area through a pilot program for tomatoes (10, 11, 12) and subsequently extended to Hillsborough/Manatee area (13). During the pilot phase, university-employed scouts helped developed the techniques and data base that demonstrated the feasibility and usefulness of IPM for fresh-market tomatoes. As the tomato IPM acreage increased and growers assumed full costs for field scouting through private pest management advisory services, interest in IPM developed among producers of other vegetable crops.

Bush-type snap bean (*Phaselous vulgaris* L.) production for once-over mechanical harvest has been increasing in the Homestead area (W. M. Stall, *personal communication*). Florida snap bean growers traditionally have relied on routine preventative applications of pesticides to prevent economic crop damage. It is likely that this bean spray practice accounts in part for observations that tomato IPM strategies for polyphagous pests are not as effective in tomato fields adjacent to snap beans, as they are in isolated tomato fields. Therefore, the Homestead IPM program was extended to snap beans to evaluate the applicability of IPM in multicrop systems and to meet the informational needs of an expanding bean industry. Specific experimental objectives were to: 1. develop and validate sampling procedures for insects, nematodes, and diseases affecting snap bean; 2. test empirically-derived action thresholds as criteria for management decisions; 3. examine the scouting program economics; and 4. relate observed pest populations (especially nematodes) to crop damage.

Materials and Methods

A cooperating grower planted a large snap bean IPM demonstration experiment on 3 October 1979. The experimental site was a 4.05 hectare (10 acre) field of Rockdale soil, seeded to cv. Sprite with rows on 0.9 m (3 ft) centers and approximately 4 cm (1.6 inches) between plants in a row. One half of the field was sprayed according to a normal, calendar-based traditional management program (TM) and the other half according to IPM dictates. The sampling procedures were essentially the same as those previously reported (17) for other large demonstration experiments, except that live vegetable leafminer (VLM) (*Liriomyza sativae* Blanchard) larvae rather than total VLM mines were counted.

Plots were monitored twice a week to assess disease and insect levels. Sample sites were selected at random each field visit, with one sample every 0.4 ha (1 acre), for a total of 5 samples for each treatment (TM and IPM). Sampling sites were spread evenly throughout plots, so that all areas were represented in the composite data. Each sampling site consisted of 0.94 m (3 ft) of a single row. Plant phenology was recorded. The Horsfall-Barratt rating system (5) was used to make an estimate of total defoliation (including abiotic factors) for all plants in each sample, followed by individual Horsfall-Barratt ratings for disease, total insect, and VLM defoliation. Action thresholds of 20% prebloom and 10% postbloom were used for treatment decision-making, based on conservative interpretations of previous Florida work (3, 4). When the plant growth stage ranged from cotyledons to 2 true leaves, specific counts were made of live VLM larvae, aphids, and bean leafroller [*Urbanus proteus* (L.)] on 3 whole plants selected at random from within the sample. These same specific counts were made on 3 trifoliate leaves per sample, when the plant growth stage was 3 true leaves to maturity. Other insects were counted by using the ground-cloth method (1). Intact bean plants were bent and shaken over a 0.94 m^2 white cloth placed adjacent to the sample. All insects deposited on the cloth were counted. Whole plant loss due to diseases and insects was recorded as a percentage of the stand.

Plots were harvested on 21 November 1979. Five 2 m (6 ft) single-row plots were randomly selected from TM and IPM areas, and all pods were removed and the marketable ones counted and weighed. Cull beans also were counted and weighed and placed in one of several cull categories.

The relative effect of IPM and TM strategies on populations of beneficial parasites of VLM were assessed by collecting leaves with mature, live VLM larvae and holding them in the laboratory for adult VLM and parasite emergence from puparia. Three samples of 15 larvae each

[1]Florida Agricultural Experiment Station Journal Series No. 3380.
[2]The authors wish to thank E. Renee Fischer, Joyce Francis, Steve Williams, and Jorge Parrado for technical assistance.

were taken weekly from each of the 2 treatment areas. Leaflets containing the larvae were placed on wire screens inside 1 liter ice cream cartons and incubated on a lab bench (21-25°C). After 4-5 weeks the number of emerged VLM adults and hymenopterous parasites were counted. Percentage parasitism and percentage VLM adult emergence were calculated.

Treatment decisions for nematodes must be based on preplant counts. Therefore, efforts were made to incorporate nematode management into snap bean IPM programs through experiments designed to relate nematode populations to crop damage. Four such experiments were carried out between October 1978 and April 1979, both in small plots at Homestead AREC and in large demonstration experiments in growers' fields. Test strips consisted of 4 replications of 3.66 m (12 ft) (growers' fields) or 76.2 m (250 ft) (AREC) sections of bean row treated with 2.24 kg a.i./ha (2.0 lb/acre) of carbofuran applied preplant, paired with adjacent untreated rows. Nematode samples were collected from all test strips prior to planting and periodically throughout the crop until harvest. Each sample consisted of approximately 500 cm^3 of soil collected to a depth of 15 cm (5.9 inches) from 10 locations along a row. The soil was passed through a 4 mm (0.16 inch) screen to remove stones. A composite 100 cm^3 subsample was processed by decanting and sieving, followed by suspension of the residues in modified Baermann funnels (2). The extracted nematodes were killed by heating at 55-60°C for 10 minutes and preserved in 5% formalin for counting. Cobb metal slide mounts (15) were prepared for nematode indentification. Detailed harvest data were gathered for each experiment by picking 1.83 m (6 ft) of each of the test strips.

Results

VLM was the most common defoliating pest in the large demonstration experiment. Bean leafroller, banded cucumber beetle (*Diabrotica balteata* Le Conte), cabbage looper [*Trichoplusia ni* (Hubner)], and corn earworm [*Heliothis zea* (Boddie)] and other insect defoliators were encountered occasionally, but levels of these pests were lower than those encountered in other tests (17). Previous work (17) also had shown that velvetbean caterpillar *Anticarsia gemmatalis* Hubner can be a significant foliage-feeding insect early in the fall snap bean crop in Dade County, but it was not observed in the Fall 1979 demonstration experiment. Total defoliation levels were generally higher for the IPM plots (Fig. 1) reaching a maximum mean Horsfall-Barratt rating of 3.4 on 31 October 1979 (approximately 10 days before pinpod stage). The defoliation in both TM and IPM plots was due primarily to VLM mining. Total defoliation levels were similar to those observed in Fall 1978 (Fig. 2).

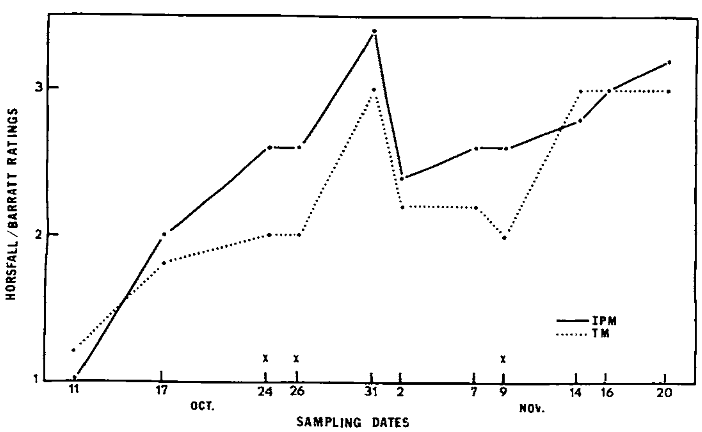

Fig. 1. Mean Horsfall-Barratt defoliation ratings for Fall 1979 demonstration experiment. X above a date denotes significant difference on that date ($P \leq 0.05$).

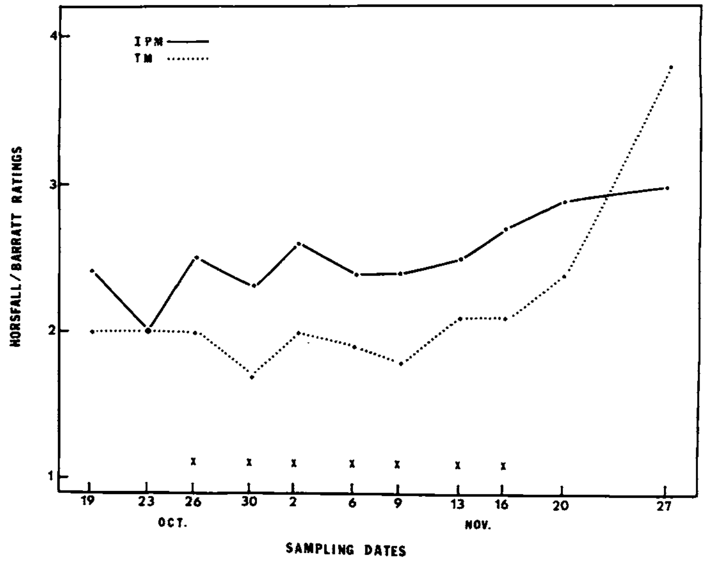

Fig. 2. Mean Horsfall-Barrett defoliation ratings for Fall 1978 demonstration experiment. X above denotes significant difference on that date ($P \leq 0.05$) (copyright Trop. Agric. (Trinidad) Vol. 58:163, used with permission of IPC Sciences and Technology Press Ltd., Guildford, England).

The live VLM larval counts fluctuated considerably in both treatments. The routine weekly applications of dimethoate (7 per crop) in the TM plots, primarily for control of VIM, did not result in any significant reduction in levels of this pest, and, indeed, a significantly higher population of live VLM was found in the TM plot on 14 November 1979 (Fig. 3). This apparent insecticide-induced VLM build-up also has been observed in other experiments (9, 17) (see Fig. 4 for comparison).

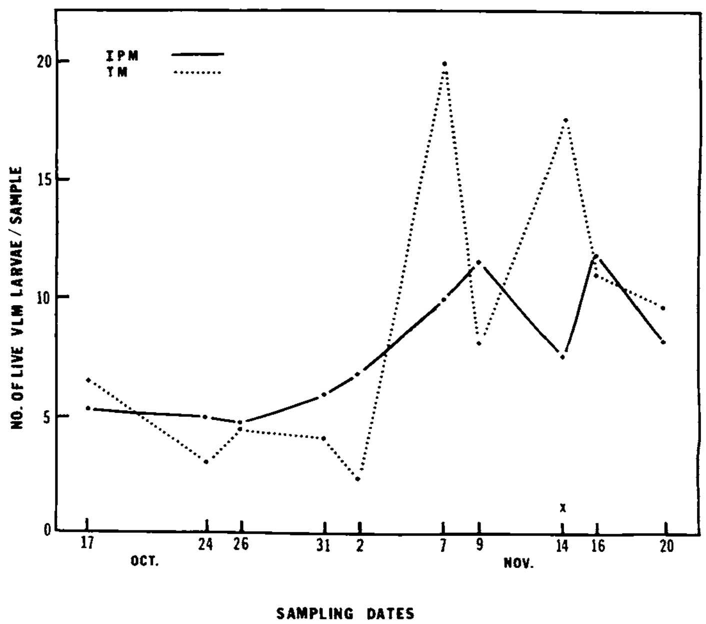

Fig. 3. Mean vegetable leafminer larval counts for Fall 1979 demonstration experiment. X above date denotes significant difference on that date ($P \leq 0.05$). IPM plot sprayed on 10 November 1979 with acephate and 17 November 1979 with *Bacillus thuringiensis*. TM plot was sprayed weekly with dimethoate and/or methomyl.

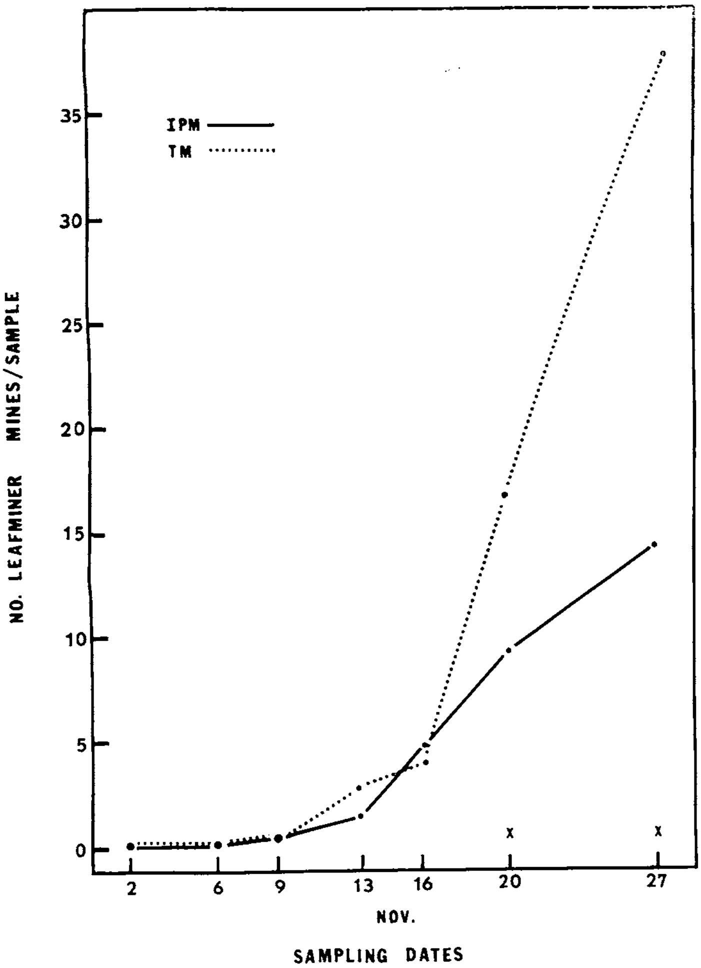

Fig. 4. Mean number of total vegetable leafminer mines per sample for Fall 1978 demonstration experiment. X above a date denotes significant difference between counts on that date ($P \leq 0.05$) (copyright Trop. Agric. (Trinidad) Vol. 58:102, used with permission of IPC Science and Technology Press Ltd, Guildford, England.)

An acephate spray was made on the IPM plot at the pinpod stage, (10 November 1979) followed by an application of *Bacillus thuringiensis* 1 week later, for control of *Heliothis,* cabbage loopers, and stink bugs (*Nezara viridula* L.). This was deemed necessary due to lack of information on action thresholds for such pod feeders, once pods appear.

Foliar diseases were kept under control by routine fungicide applications which were the same for both treatments. During whole plant inspection from first true leaf to flowering, a disease was observed at the crown area, causing hypocotyl decay, plant wilting and death. At times, a white, fungal growth was seen on lower stems of affected plants. The problem resembled *Sclerotinia* disease and was so diagnosed by the grower and others in these experimental plots and in similarly-affected fields in Dade County.

Samples of diseased plants were brought to the IPM laboratory at AREC Homestead for analysis. Coenocytic mycelium was observed, microscopically suggesting an Oomycete as the causal agent. Specimens were washed thoroughly in running tap H_2O for 30 minutes and blotted dry. Some lower stem cylinders were incubated in a damp chamber overnight; others were cut into several cross sections, and the pieces plated on acidified potato glucose agar and PVP medium (7, 16), selective for pythiaceous fungi. The PVP medium consisted of 17 g corn meal agar, 5 ppm pimaricin (Sigma Chemical Co., St. Louis, MO 63178), and 300 ppm vancomycin (Eli Lilly & Co., Indianapolis, IN 46206), in 1 liter of distilled H_2O.

Pythium spp. (14) were consistently isolated from the diseased bean plants. Benomyl applications to both TM and IPM plots for a misdiagnosed *Sclerotinia* problem were subsequently curtailed.

No significant differences in yield or quality of beans were found between IPM and TM plots (Table 1). Also, there were no differences in percent by weight of the total harvest in any of the 5 established cull categories (*Rhizoctonia* tip rot, *Heliothis,* stink bug, cabbage looper, or physiogenic and mechanical damage).

Table 1. Harvest data (g/1.8 m plot) in large IPM and TM snap bean plots—Fall 1979.[z]

Treatment	Total mkt. yield	No. plants	No. mkt. beans	Cull wt	No. cull beans
TM	740	51	290	166.4	44.2
IPM	872	46	321	158.7	37.8

[z]No comparisons were significantly different at the 5% level by student's t-test ($P \leq 0.05$).

Nine more insecticide applications at an additional cost of $103.25/ha ($41.80/acre) were made to the TM plot (Table 2). Based on the harvest data, the extra pesticide expenditures were deemed unnecessary.

Table 2. Insecticide use and cost of material per hectare on IPM and TM large snap bean plots—Fall 1979.

TM			IPM		
Insecticide	No. appl.	Cost ($)	Insecticide	No. appl.	Cost ($)
Methomyl	3	39.77	Methomyl	1	7.95
B. thuringiensis	1	9.88	*B. thuringiensis*	1	9.88
Acephate	1	14.70	Acephate	1	14.70
Dimethoate	7	71.43			
Total	12	135.78	Total	3	32.53

There was no consistent relationships between parasitism of VLM larvae or adult VLM emergence and treatment (Table 3). It is possible that there was sufficient adult parasite movement between plots to minimize actual treatment effects.

Table 3. Parasitism of vegetable leafminer larvae in large snap bean plots—Fall 1979.[z]

Date	Treatment	% Parasite emergence	% Fly emergence
10/24	IPM	2	20
	Control	—[y]	—[y]
10/31	IPM	36	9
	Control	13	7
11/07	IPM	35	2
	Control	40	11
11/14	IPM	7	2
	Control	18	4
11/20	IPM	51	13
	Control	58	2

[z]No statistically significant differences were found between treatments on any date.
[y]Samples not collected.

The most common plant-parasitic nematodes recovered from soil samples during the course of 4 experiments were *Quinisulcius acutus* (Allen) Siddiqi, *Helicotylenchus dihystera* (Cobb) Sher, and *Rotylenchulus reniformis* Linford and Oliveira. Very low numbers of *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans Stekhoven and *Heterodera* spp. were found occasionally. Mean numbers of nematodes/100 cm^3 of soil reached maxima of 273 (*Q. acutus*), 45 (*H. dihystera*), and 130 (*R. reniformis*), but no yield reductions were associated with any of these populations (Table 4). No correlations could be established between *Q. acutus* and *H. dihystera* populations and snap bean yield at any time in crop development. Although *R. reniformis* has been shown to be a potential threat to snap bean, and equations have been developed to describe the depressant effects of this nematode on yield (6), the populations encountered in these tests were apparently subthreshold. In several cases the carbofuran treatment did significantly reduce nematode populations (by as much as 86%), but no yield increase was associated with the control (Table 4).

Table 4. Mean yields (g) of snap beans in four nematode tests, 1978-79.[z]

Test no.	Treatment	Total weight	Weight/plant
1	No nematicide	1324	28.8
	Carbofuran	1485	27.3
2	No nematicide	1240	20.7
	Carbofuran	1225	22.6
3	No nematicide	647	35.8
	Carbofuran	687	37.1
4	No nematicide	752	27.6
	Carbofuran	693	30.5

[z]No significant differences were found between treatment means by student's t-test ($P \leq 0.05$).

Discussion

These experiments demonstrate that IPM can make a positive impact on the production of snap beans in south Florida. Even though detailed action thresholds are not presently known, the use of the 20% and 10% defoliation action levels prebloom and postbloom respectively, led to savings of $103.25/ha ($41.80/acre) in cost of spray material alone. In the 1980-81 bean season, private sector agricultural consultants charged $19.76/ha ($8.00/acre). This represents a net return to the cooperating grower of $83.49/ha ($34.30/acre) for the crop harvested from the IPM demonstration area.

The laboratory diagnosis of *Pythium* crown rot in the bean field also resulted in substantial fungicide savings. Unnecessary benomyl applications were omitted, and an estimated $74.10/ha ($30.00/acre) in material was saved. In the grower's opinion, this was the single most important benefit he saw in the demonstration. It appears that extension service diagnostic laboratories close to the areas of operation will certainly increase the usefulness of scouts' constant surveillance of snap beans and other vegetables.

Snap beans are well suited to an IPM approach. The marketable part of the crop needs protection from pests for only 2.5-3 weeks. Repeated experimentation has shown that substantial savings can be made before fruiting. Since more information is needed about action thresholds for pod feeders, such as *Heliothis* spp., it was decided to recommend an insecticide spray at the appearance of pinpods, based on monitoring of crop phenology. Similarly, Musgrave *et al.* (8) recommended that a detection plan be used for caterpillar pests in a high-cash-value vegetable crop, due to the extreme expense for an effective sampling plan for the highly clumped species.

The results reported above further confirm the theory (9, 17) that overuse of broad-spectrum insecticides induces outbreaks of VLM, an increasingly serious pest of many south Florida vegetables in recent years. In the Fall 1979 experiment a significantly higher VLM population was found in the TM area after 7 broad-spectrum insecticide sprays. This compares quite favorably with the observation of significant increase in TM plots in Fall 1978 (17), when VLM populations increased considerably after 6 broad-spectrum sprays.

Maximum initial nematode populations per 100 cm^3 of soil were 15 (*H. dihystera*), 20 (*R. reniformis*), and 72 (*Q. acutus*). Applications of granular nematicide sometimes reduced these nematode numbers, but no significant increases in yield were observed. Regression equations have been developed which clearly show the adverse impact of *R. reniformis* populations at harvest on snap bean yield (6). However, no correlation could be established between initial and final populations of any of these nematode species. Therefore, it appears that growers will have to make decisions about the need for nematode control measures, such as oxamyl sprays (6), based on counts taken at harvest of previous crops.

Literature Cited

1. Boyer, W. P., and W. A. Dumas. 1963. Soybean insect survey as used in Arkansas. Coop. Econ. Insect Rep. 13:91-92.
2. Christie, J. R., and V. G. Perry. 1951. Removing nematodes from soil. Proc. Helminthol. Soc. Wash. 18:132-134.
3. Greene, G. L. 1971. Economic damage levels of bean leaf roller populations on snap beans. J. Econ. Entomol. 64:673-674.
4. ————, and D. R. Minnick. 1967. Snap bean yield following simulated insect defoliation. Proc. Fla. State Hort. Soc. 80:132-134.
5. Horsfall, J. G., and R. W. Barratt. 1945. An improved grading system for measuring plant disease. (Abstr.). Phytopathology 35:655.
6. McSorley, R. 1980. Effect of *Rotylenchulus reniformis* on snap bean and methods for control by oxamyl. Nematropica 10:89-95.
7. Miratick, S. M., and J. M. Kraft. 1973. Efficiency of various selective media and determining *Pythium* populations in soil. Mycopathol. Mycol. Appl 50:151-161.
8. Musgrave, C. A., H. W. Beck, S. L. Poe, W. H. Denton, J. O. Strandberg, J. M. White, W. G. Genung, and V. L. Guzman. 1979. Dispersion analysis and sampling plans for insect pests in Florida celery. Proc. Fla. State Hort. Soc. 92:106-108.
9. Oatman, E. R., and G. G. Kennedy. 1976. Methomyl induced outbreak of *Liriomyza sativae* on tomato. J. Econ. Entomol. 69:667-668.
10. Pohronezny, K., J. Francis, and V. Waddill. 1980. Tomato pest management program-guideline for scouts. Ext. Plant Path Rep. No. 28:10pp.
11. ————, and V. Waddill. 1978. Integrated pest management-development of an alternative approach to control of tomato pests in Florida. Ext. Plant Path Rep. No. 22.7pp.
12. ————, ————, W. M. Stall, and W. Dankers. 1978. Integrated control of the vegetable leafminer (*Liriomyza sativae* Blancard) during the 1977-78 tomato season in Dade County, Florida. Proc. Fla. State Hort. Soc. 91:264-267.
13. Schuster, D. J., R. T. Montgomery, D. L. Gibbs, G. A. Marlowe, J. P. Jones, and A. J. Overman. 1980. The tomato pest management program in Manatee and Hillsborough counties, 1978-80. Proc. Fla. State Hort. Soc. 93:235-239.
14. Stevens, F. L. 1913. The fungi which cause plant disease. MacMillan Co., New York. 754pp.
15. Thorne, G. 1961. Principles of nematology. McGraw-Hill, New York. 533pp.
16. Tsao, P. H. and G. Ocana. 1969. Selective isolation of species of Phytophthora from natural soil on an improved antibiotic medium. Nature 223:636-638.
17. Waddill, V. H., R. McSorley, and K. Pohronezny. 1980. Field monitoring: basis for integrated management of pests on snap beans. Trop. Agric. (Trinidad) 58:157-169.