activity of natural control agents (hymenopterous parasites) has been disrupted through previous pesticide use.

The key to further reductions of pesticide use and the potential associated benefits lies in the establishment of accurate economic injury thresholds. The economic injury thresholds should be based on all costs of pesticide application borne by the grower including the costs of controlling or bearing the loss from outbreaks of the leafminer.

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INTEGRATED PEST MANAGEMENT DEMONSTRATIONS IN COMMERCIAL CHRYSANTHEMUMS[1]

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Abstract. **Four IPM (integrated pest management) demonstrations were conducted on chrysanthemum** (Chrysanthemum morifolium **Ramat.) farms in Manatee and Lee Counties, Florida during 1979 and 1980. Agromyzid leafminers** (Liriomyza **spp.) and the twospotted spider mite** (Tetranychus urticae **Koch) were the arthropod pests for which the greatest amounts of insecticides and miticides were applied. Reductions in use of insecticides and miticides averaged 25.4%, reductions in use of fungicides and bactericides averaged 4.6%, and reductions in use of equipment to apply pesticides averaged 19.4% in the IPM areas as compared to the areas under the growers' pest control practices. The full potential of IPM in chrysanthemums will not be realized until effective means to manage leafminer flies are developed.**

Chrysanthemums (*Chrysanthemum morifolium* Ramat.) for the cut flower market are grown in Florida from August through May. The wholesale value of cut chrysanthemum flowers in Florida during 1979 was $8.2 million (2). The high value of this crop and its requirements for flowers and foliage free of pest damage have been considered justification for frequent use of pesticides. Applications of 75-100 pesticide doses may be made to a single crop during its 14-16 weeks of growth.

Applications of such large quantities of pesticides may have many disadvantages. Cost of chemicals, labor and equipment for application are great. Repeated applications of certain pesticides to a pest population may result in a tolerant pest biotype and outbreaks of secondary pests (5). The *Liriomyza* spp. leafminers are believed to have developed resistance to many of the insecticides that have been used for leafminer control (3, 6, 8). As a result, there is no pesticide available to maintain chrysanthemums free of leafmines. Others disadvantages of frequent pesticidal applications include danger of pesticide exposure to applicators and to personnel performing cultural operations such as pinching, disbudding, and harvesting. The overuse of chemicals also presents a potential ecological hazard.

The University of Florida Institute of Food and Agricultural Sciences (IFAS) Extension and Research units developed and implemented an integrated pest management (IPM) demonstration for chrysanthemum production. Objectives of the program were to produce the highest quality chrysanthemum crop and maintain the above disadvantages at the lowest practical level. The principal means by which the latter objective was pursued included initiating the crop in an environment of low pest level, reducing subsequent invasion of pests, and applying chemical controls only when threshold pest levels had been reached.

Materials and Methods

Design of demonstration test areas. Demonstrations were conducted 4 times during 1979 and 1980 on portions of a farm in Manatee County and in Lee County, Florida. IPM demonstration areas ranged from 1,440 to 3,640 linear feet of pompon chrysanthemum beds 3.5 ft wide (Table 1). In each demonstration, ten 30-foot sections of chrysanthemum bed were designated as sampling stations from which pest populations were monitored twice each week. Five sampling stations were established with the same cultivars adjacent to the IPM study as comparison areas in which the grower performed his normal pest control practices. All plants within each demonstration were planted during the same week.

Cultural methods to reduce pests: Several cultural practices were performed to reduce pest levels prior to

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Table 1. Number of marketable stems and leafmines from samples taken from four IPM demonstrations and number of linear bed feet in each demonstration.

Farm	Season	No. linear bed ft in IPM	Type stem produced	Cultivar	Marketable[z] stems produced: Grower	Marketable[z] stems produced: IPM	No. leafmines/stem[y] at harvest: Grower	No. leafmines/stem[y] at harvest: IPM
Lee County	Fall 1979	1440	Pinched	Manatee Iceberg	20.5	21.6	—	—
				White Marble	23.0	22.6	—	—
	Spring 1980	2880	Pinched	Manatee Iceberg	24.7	24.5	13.0	14.7
				Florida Marble	22.5	24.9	5.6	4.0
Manatee County	Fall 1979	1824	Nonpinched	Manatee Iceberg	15.6	15.6	32.8	34.0
				Firepower	15.4	15.7	4.6	3.1
	Spring 1980	3648	Nonpinched	White Sands	14.8	15.8	14.8	13.1
				Manatee Iceberg	14.1	13.5	37.6	36.1

[z]Average number of marketable chrysanthemum stems in one row across a bed from a sample of 10 randomly selected sites.
[y]Average number of leafmines per stem from 15 randomly selected stems.

planting and to reduce the invasion by pests after planting. Weeds in post rows, on ditch banks, accesses, and other surrounding areas harbored mites, leafminers, lepidopterous larvae, thrips, tarnished plant bugs, and nematodes that could colonize chrysanthemums. These weeds were chemically or mechanically removed. Between cropping seasons, weeds were kept mowed to prevent seed production. During the month before the first planting, the soil was rototilled several times to destroy germinated weed seed and thus starve nematodes that had been sustained in the off season (1, 7). The tilling further reduced numbers of nematodes by exposing them to the drying effects of the sun (4). Plant residues from completed crops were removed or tilled into the soil immediately following harvest. In doing so, the life cycles of leafminers and disease organisms that could attack crops later were interrupted and sources of food for leafminers, lepidopterous larvae and other important pests were eliminated.

Sampling methods. An IPM scout was employed to sample for nematodes, plant pathogens, weeds, insects and mites that could affect the chrysanthemum crops. He inspected the upper 2/3 portion of 10 randomly selected stems at each station to evaluate densities of leafminer larvae, various noctuid larvae (cabbage looper, *Trichoplusia ni* (Hubner); beet armyworm, *Spodoptera exigua* (Hubner); and southern armyworm, *S. eridania* (Cramer)), thrips (*Frankliniella* spp.), and aphids (green peach aphid, *Myzus persicae* (Sulzer); chrysanthemum aphid, *Macrosiphoniella sanborni* (Gillette); and cotton aphid, *Aphis gossypii* Glover). The lower 1/3 of full grown stems was not sampled because leaves on that portion of the stem are not included in the marketed cut-flowers. Thus, arthropod damage to those leaves would have little impact on flower quality. Growing terminals or flowers of those 10 stems were inspected for flower thrips (*Frankliniella* spp.) and twospotted spider mites (*Tetranychus urticae* Koch) and their eggs. The scout randomly selected 10 leaves from the upper 2/3 portion of the stems at each sampling site and using a 14X hand lens, counted twospotted spider mites and eggs present.

Plants from entire 30-foot sections of bed were disturbed by a brush of the scout's hand or by shaking the support wires of larger plants. Plant bugs (*Taylorilygus pallidulus* (Blanchard) and others) taking flight at this disturbance were counted. Terminals of 100 plants at each station were assayed for presence of chrysanthemum aphid, the beet armyworm and southern armyworm. Bacterial and fungal disease symptoms were recorded wherever observed. Nematodes in the soil were monitored from soil samples taken from 10 sites in the IPM area and 5 sites in the grower area periodically throughout the season: preceding the demonstration crop where possible, just prior to planting, and periodically during the crop's development. The decision either to fumigate chemically or to sterilize the soil by steam ideally should be based on information from the soil samples. However, current knowledge of assay methods for all potentially damaging soil-borne pathogens is lacking and decisions must be based on field history, crop value, and sensitivity to disease. Because chrysanthemums are a high value crop sensitive to nematodes and soil fungi and the planting range is intensively cropped, the decision to treat the soil was made. Steam is the most dependable and thorough, as well as least polluting, means of controlling soil-borne pathogens and was the suggested procedure. However, the grower who had steam available chose to treat with a chemical soil fumigant. Fumigation was more compatible with his management schedule in the particular planting selected for IPM. Since any IPM system, to be successful in the agricultural community, must give the grower latitude within his management procedures, the grower's option was honored.

Action thresholds. Thresholds of insect and mite presence (Table 2) were established for this program for each arthropod pest to determine when chemical controls would be applied. Thresholds were developed from the authors' best estimates of densities of arthropods causing economic loss. Remedial control measures were performed over the entire IPM area when the action threshold was reached at any one of the 10 sampling sites. The IPM scout was able to record the presence of very small leafminer larvae soon after their eggs hatched. Thus, a higher threshold was given than would have been established if leaf-

Table 2. Chemical action thresholds for arthropod pests of chrysanthemum used in IPM demonstrations.

Crop stage	No. twospotted spider mites[z]		No. aphids		No. thrips		No. lepidopterous larvae		No. plant bugs on 30 ft. of bed	No. leafminer larvae on upper 2/3 of 10 stems
	On 10 leaves	On 10 buds or flowers	On 100 terminals	On upper 2/3 of 10 stems	On 10 open flowers	On upper 2/3 of 10 stems	On 100 terminals	On upper 2/3 of 10 stems		
Weeks 1-6 (open canopy)	5	3	5 colonies[y]	50	—	3	3	3	1	50
Week 6—Flower color showing (closed canopy)	3	3	5 colonies	50	—	3	3	3	1	10
Flowering	3	10	5 colonies[y]	50	10	—	3	3	—	10

[z]Motile mites and mite eggs combined.
[y]A colony is considered as 5 or more aphids.

miners could not have been detected early in their development.

Thresholds for disease symptoms were not formally established. However, under rainy conditions, especially when these coincided with leafminer outbreaks, or when bacterial leafspot was known to be active in the area, application of bacterial control measures was recommended. Nematodes, weeds, and soil-borne diseases were known to occur in the soil of the demonstration areas. Thus, preventive fumigation was applied as a routine measure in each IPM demonstration.

Results and Discussion

Insects and mites. In each of the 4 demonstrations, the leafminer and the twospotted spider mite were the most damaging arthropod pests. Pesticides applied for control of these (Ambush permethrin, Vydate oxamyl, Temik aldicarb, Vendex hexakis, and Morestan oxythioquinox) usually were adequate to prevent significant development of other pests present on the farms (cabbage looper, southern armyworm, beet armyworm, thrips, and various aphids). Thus, only leafminers and mites were encountered regularly by the scout.

Recorded in Tables 3-5 are the seasonal averages and highest densities of leafminers and mites for each of the 4 demonstrations and the numbers of pesticidal doses applied to control these arthropods. The cultivars 'Manatee Iceberg' and 'Yellow Manatee Iceberg' were usually more heavily infested with the major pests than were other cultivars. Accordingly, data are recorded in 2 categories—one for 'Iceberg' type cultivars and one for all other cultivars. Population densities of the twospotted spider mite did not exceed the established threshold during the fall of 1979 and the spring 1980 demonstrations on the Manatee County farm. No miticides were applied in the IPM nor the comparison areas specifically for their control; however, several applications of oxamyl and aldicarb were used for leafminer control and may have prevented increases in mite densities there.

On the Lee County farm, in the fall of 1979, dense mite populations developed throughout October and did so again in late March and throughout April in the spring 1980 demonstration. Eight miticidal applications were made in the IPM area and 15 in the comparison area during the first demonstration there (Table 5). During the second demonstration at the Lee County farm, 6 miticides were applied to flowers under the IPM program and 10 in the comparison area administered under the grower's regular program (Table 4).

Peak leafminer activity occurred on the Lee County farm, fall 1979 demonstration, during mid-October. Pesticides for leafminer control in the IPM area were applied soon after the first leafminer larval densities exceeded the established threshold. More active mines were permitted from the IPM area than from the comparison area (Table 3), but this did not result in a higher number of mines large enough to be noticed by a consumer in the stems as harvested for the market (Table 1). Fifty-three insecticide/miticide doses were applied to the grower comparison area while only 36 were applied to the IPM area.

Leafminer densities in the IPM and grower areas were consistently about equal throughout both seasons at the

Table 3. Average density during period of occurrence and highest daily average number of active leafminer larvae per 10-stem sample in Chrysanthemum IPM demonstrations.

Farm	Season	Period of occurrence	No. active leafminer larvae[z]							
			IPM area				Grower comparison area			
			Iceberg cvs		Non-Iceberg cvs		Iceberg cvs		Non-Iceberg cvs	
			Mean	High	Mean	High	Mean	High	Mean	High
Lee County	Fall 1979	7 Sept. to 6 Dec.	19.3 ±44.3	209.8	7.5 ±17.9	65.2	9.1 ±19.7	79.0	5.2 ±13.0	50.0
	Spring 1980	7 Feb. to 1 May	67.2 ±64.0	203.8	18.4 ±16.4	65.8	82.2 ±85.7	241.0	22.0 ±21.4	90.7
Manatee County	Fall 1979	26 Oct. to 8 Jan.	99.4 ±85.2	257.3	—	—	85.0 ±76.9	237.8	—	—
	Spring 1980	7 Mar. to 2 May	64.2 ±71.2	204.0	21.9 ±25.0	93.2	56.5 ±61.8	193.0	17.7 ±19.3	65.0

[z]Data were collected twice each week and are averages of 10 sampling sites in the IPM area and 5 sampling sites in the grower area. Means are expressed ± 1 standard deviation.

Table 4. Average density during period of occurrence and highest daily average number of twospotted spider mites and eggs per 10-leaf sample in chrysanthemum IPM demonstrations.

			No. twospotted spider mites and eggs[z]							
			IPM area				Grower comparison area			
		Period of	Iceberg cvs		Non-Iceberg cvs		Iceberg cvs		Non-Iceberg cvs	
Farm	Season	occurrence	Mean	High	Mean	High	Mean	High	Mean	High
Lee County	Fall 1979	1 Oct. to 5 Nov.	6.3 ±10.0	31.6	1.3 ±2.1	7.0	1.2 ±1.8	5.5	0.4 ±0.5	1.3
	Spring 1980	11 Feb. to 1 May	6.9 ±9.3	30.8	0.8 ±1.7	8.3	12.4 ±16.0	52.0	1.6 ±3.5	14.0
Manatee County	Fall 1979	13 Nov. to 27 Nov.	0.8 ±0.8	2.2	—	—	0.4 ±0.7	1.6	—	—
	Spring 1980	—	—	—	—	—	—	—	—	—

[z]Data were collected twice each week and are averages of 10 sampling sites in the IPM area and 5 sampling sites in the grower area. Means are expressed ± 1 standard deviation.

Table 5. Number of insecticide and miticide doses applied to chrysanthemums in 4 IPM demonstrations.

		Insecticides for leafminer		Other insecticides		Miticides		Total		% reduction
Farm	Season	Grower	IPM	Grower	IPM	Grower	IPM	Grower	IPM	in IPM
Lee County	Fall 1979	38	28	0	0	15	8	53	36	32.1
	Spring 1980	27	17	4	4	10	6	41	27	34.1
Manatee County	Fall 1979	37	27	12	8	0	0	49	35	28.6
	Spring 1980	31	28	14	14	0	0	45	42	6.7

Manatee County farm (Table 3). In the fall of 1979 there were 2 periods of peak activity. One occurred during late October and early November, and the other occurred in late November and continued throughout December. In the IPM area, pesticidal treatments directed at the leafminer were not recommended during the mid-November period of low activity.

The materials used for leafminer control during the fall season were not sufficient to reduce leafminer populations effectively once they began to increase. In light of this information, the use of thresholds to determine the timing of leafminer control measures was abandoned and leafminer controls were applied on a regular basis throughout the spring on both demonstration farms.

Pesticidal reduction. Reductions in insecticide and miticide use in the IPM area ranged from 6.7%-34.1% with an average of 25.4% reduction when compared to the area managed under the grower's normal practices (Table 5). There was a 0%-10% reduction in use of fungicides and bactericides in the IPM area (Table 6).

Pesticides are often applied in tank-mix combinations, thus application costs can not be estimated solely from records of doses applied. The number of times that pesticide application equipment was actually used in each of the demonstrations is recorded in Table 6. In each demonstration there was a reduction in equipment use in the IPM area. The reduction ranged from 5.4%-27.8% with an average of 19.4%.

Conclusions

Pesticide use and its associated costs can be reduced in a chrysanthemum crop without loss of flower production and quality. These demonstrations have made clear, however, that improved techniques for management of the leafminer fly must be developed before the full potential of IPM in this crop can be realized.

Introduction of IPM to a farm should be made on an economically sound basis. Scouting services to implement IPM are an added production cost. Sampling techniques used by scouts to estimate the status of pests and beneficial organisms must be simple and reliable. Proper interpretation of collected information must be made in a manner consistent with high quality flower production and reduced pesticide applications and costs.

Table 6. Number of bactericide/fungicide doses applied to chrysanthemums and number of passes through fields by equipment to apply all pesticides in 4 IPM demonstrations.

		Bactericides/fungicides			Number equipment passes to effect applications		
Farm	Season	Grower	IPM	% reduction in IPM	Grower	IPM	% reduction in IPM
Lee County	Fall 1979	49	45	8.2	55	41	25.5
	Spring 1980	20	18	10.0	32	26	18.8
Manatee County	Fall 1979	7	7	0.0	36	26	27.8
	Spring 1980	18	18	0.0	37	35	5.4

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CONTROL OF GLIOCLADIUM IN CHAMAEDOREA PALMS[1,2]

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Abstract. **The fungus,** Gliocladium vermoeseni **(Biourge) Thom. causes leaf and stem necrosis of all commercially produced** Chamaedorea **species. Optimum growth of** G. vermoeseni **on potato dextrose agar (PDA) was at 24-27 C. Growth inhibition at 30 C or greater suggests that high temperatures may account for decline in severity of the disease during summer months in Florida. Fungus growth was completely inhibited by 1.0 ppm or greater of benomyl in PDA. Foliar sprays of benomyl, benomyl + mancozeb, and chlorothalonil were used at 0.6g, 1.35g, and 1.34g a.i./liter, respectively. All stems of** C. cataractarum, C. elegans, **and** C. seifrizii **developed symptoms when needle-punctured prior to inoculation, but in unwounded, inoculated stems of these palm species symptoms developed in 0/4, 0/8, and 2/4 stems, respectively. Disease was more severe in stems having chlorotic to green leaves removed than in stems having senescent, dry leaves removed prior to inoculation.**

Leaf and stem necrosis of Chamaedorea palms is a common disorder in Florida. Following infection of sheaths (petiole bases), leaves of affected plants become chlorotic and eventually die. Lower leaves on a plant are usually affected first. When the dead or yellow leaves are removed, the palm stems appear barren and quality is reduced.

The disease is caused by the fungus, *Gliocladium vermoeseni* (Biourge) Thom., (2, 5). This fungus is a serious problem in California where it is involved in the death of street plantings of Phoenix palms (3). The disease in Chamaedorea palms in Florida was described by J. E. Reynolds (5). Only palms wounded prior to inoculation became infected in his tests, but others (4) found wounds were not necessary for infection. The palms Reynolds found susceptible were *C. elegans, C. erumpens, C. seifrizii, C. tenella* and *Chrysalidocarpus lutescens.* Eleven other palm species of 10 genera were resistant to the fungus.

No experimental data on control of the fungus in nurseries has been reported previously. This study was performed with the objective of developing information for control of *G. vermoeseni* in Florida nurseries.

Methods and Materials

The fungus culture (no. 79-58) used for in vitro and inoculation experiments was isolated from diseased tissue of *C. seifrizii* and then maintained on PDA (potato dextrose agar). For growth studies, 7 mm diameter cores from 72 hr old cultures were transferred to the center of fresh 9 cm diameter PDA plates. Benomyl was incorporated into molten PDA before pouring plates. Final concentrations of benomyl were 0, 0.1, 1, 10, 100, 500, and 1000 ppm. The fungus was incubated on the benomyl-PDA plates at 27 C. Five replications were used for each treatment in all growth studies and radial growth was measured at 96 hr incubation at designated temperatures. Each experiment was performed at least twice.

Inoculum for experiments on *C. seifrizii, C. elegans,* and *C. cataractarum* was prepared from cultures grown on V-8 juice agar by the method used by Reynolds (5). Wounds in palms were made by puncturing the outer 2 petiole bases 5 times using a sterilized needle, and inoculum was applied with a sterile cotton swab. Inoculated sites on plants and appropriate controls were enclosed in plastic for 3-10 days following inoculation. Symptom development was observed for 21 days. The influence of needle-wounding on disease development was evaluated in 4-11 month old palms while removal of senescent vs. green leaves was compared in plants approximately 2.5 years old.

Fungicides were evaluated in a commercial nursery on 6 month old *Chamaedorea seifrizii* growing in 14-inch diameter pots. A benomyl soil drench (0.6g a.i./liter, 0.5 liters/pot) at 30-day intervals; benomyl, mancozeb, benomyl + mancozeb, and chlorothalonil sprayed at 7-day intervals; and benomyl + mancozeb sprayed at 14-day intervals were applied during May 25 to July 13, 1979. Concentrations of benomyl, mancozeb and chlorothalonil sprayed alone or combined were 0.6g, 1.35g, and 1.34g a.i./liter, respectively.

Senescent and diseased leaves were removed from stems in treatments A through G and treatment I (Table 2) be-

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[2]Mention of fungicide names in this study does not imply endorsement or registration for use in Chamaedorea palms. For English conversions of metric units, see the table provided at the beginning of these proceedings.