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INTEGRATED PEST MANAGEMENT DEMONSTRATIONS FOR COMMERCIAL GYPSOPHILA[1]

J. F. PRICE, A. W. ENGLEHARD, A. J. OVERMAN
University of Florida, IFAS,
Agricultural Research & Education Center,
5007 - 60th Street East,
Bradenton, FL 33508

V. W. YINGST
University of Florida, IFAS,
Cooperative Extension Service, Lee County,
3406 Palm Beach Blvd.,
Ft. Myers, FL 33905

M. K. IVERSON
University of Florida, IFAS,
Cooperative Extension Service, Manatee County,
1303 - 17th St., Palmetto, FL 33561

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Abstract. **Two domenstration IPM programs (one each in Manatee and Lee Counties) were performed with field grown gypsophila (*Gypsophila paniculata* L.). Thresholds for pesticidal action were used for leafminer (*Liriomyza* sp.), the twospotted spider mite (*Tetranychus urticae* Koch), flower thrips (*Frankliniella* sp.), beet armyworm (*Spodoptera exigua* (Hubner)), and other lepidopterous larvae. A scout monitored areas of gypsophila fields under IPM management and under the growers' normal pest control practices. Pesticides were recommended when pest densities reached threshold levels. Insecticide usage was reduced 47.6% in the IPM area of the Manatee County demonstration. Insecticides/miticides were reduced 100% and fungicides were reduced 83% in the IPM area as compared to the grower managed area of the Lee County demonstration. In the Lee County demonstration, the use of pesticide application equipment was reduced 86% in the IPM area. Continued reductions in use of pesticides in gypsophila may have important beneficial effects in the management of the leafminer pest of gypsophila.**

Gypsophila (*Gypsophila paniculata* L.), baby's breath, is a high value flower crop grown in open fields in Florida. In 1973, 330 acres valued at $4.5 million were grown in this state (1). Production of gypsophila has expanded considerably since that time.

Gypsophila is usually planted in Florida as rooted cuttings, although the crop is sometimes grown from roots dug and stored from a previous season. During about the first 6 weeks after setting plants, gypsophila produces several branches, but remains low growing and compact. Most of the plant mass during that time is comprised of lanceolate leaves ca. 3 in. x ½ in. After that period, the leafy sideshoots rapidly elongate upward into flower bearing panicles having few leaves. Leaves that do grow on the panicles usually are much smaller than the other leaves produced by the plant. A plant produces flower panicles over a period of 2 months or more; however, individual panicles develop and mature over a much shorter period.

Arthropod pests of gypsophila produced in the field include leafminer (*Liriomyza* sp.), the twospotted spider mite (*Tetranychus urticae* Koch), flower thrips (*Frankliniella* sp.), and several lepidopterous larvae including the cabbage looper (*Trichoplusia ni* (Hubner)), granulate cutworm (*Feltia subterranea* (Fab.)), southern armyworm (*Spodoptera eridania* (Cramer)), and beet armyworm (*S. exigua* (Hubner)). The twospotted spider mite and most lepidopterous larvae rarely attack plant structures other than leaves near the ground. The beet armyworm feeds on new leaves and may damage the developing meristem. Flower thrips colonize the inflorescence and may not economically damage the flower, but sometimes thrips are so numerous that they become a nuisance to persons harvesting the crop.

The principal nematode pest of the crop is the root-knot nematode (*Meloidogyne* spp.) which is endoparasitic to the plant roots and may survive the storage period of roots used as planting stock. Gypsophila is also subject to diseases from *Pythium*, *Phytophthora* and *Rhizoctonia* soon after planting. The plant crown is sometimes infested with crown gall, *Agrobacterium gypsophilae* (Brown) Starr and Weiss. *Botrytis* and *Alternaria* cause deterioration of gypsophila flowers, particularly when flowering occurs during rainy periods.

Numerous pesticides are commonly applied in grower practice to control the various pests of gypsophila. Some insecticides or miticides are applied when the pest status does not warrant chemical intervention. Repeated applications of certain broad spectrum pesticides may lead to excessive increases in the leafminer and twospotted spider mite populations (2, 3, 4). There is at this time no insecticide registered for use on gypsophila that will effectively control leafminers during outbreak conditions.

Research and extension units of the University of Florida's Institute of Food and Agricultural Sciences developed and implemented an integrated pest management (IPM) program for gypsophila on a farm in Lee County and a farm in Manatee County. The farms chosen were noted for producing high quality flowers. The objective of the program was to demonstrate that growers could produce high quality gypsophila crops while maintaining, at the lowest practical level, the disadvantages of pesticide use (costs of application, development of resistant pests, outbreaks of secondary pests, dangers of exposure to personnel and ecological hazards) (3). The means by which this objective was pursued included initiating the crop in an environment of low pest level, reducing subsequent invasions of pests and, where practical, applying chemical controls after minimum pest levels had been attained.

Materials and Methods

Design of demonstration test areas. IPM demonstrations were initiated in October 1979 on the Manatee County farm (cv. 'Bristol Fairy') and in January 1980 on the Lee County farm (cv. 'Perfecta'). The demonstration areas included 3750 and 7860 linear feet of row on the Manatee County and Lee County farms, respectively. In both demonstrations, ten 100-foot sections of row were designated as sampling sites from which pest populations were monitored once each week on the Lee County farm and twice each week on the Manatee County farm. Five sampling sites were established

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adjacent to the IPM study as comparison areas in which the grower performed his normal pest control practices. All plants in the IPM and comparison area within a single demonstration were planted from the same stock during the same week.

Cultural methods to reduce pests. Apparently healthy, rooted gypsophila cuttings purchased (Lee County farm) from a reputable producer or produced (Manatee County farm) by the grower under conditions of strict quality control were used. Chemical and mechanical weed control (including soil fumigation with MC-33), pre-planting tillage operations and destruction of residues from completed crops were practiced as described by Price et al. (5). These operations were performed to reduce pest levels prior to planting and to reduce the invasion by pests after planting.

Sampling methods. An IPM scout was employed to sample for nematodes, plant pathogens, weeds, insects and mites that occurred in the gypsophila plantings. The scout evaluated nematode populations from soil samples taken from 10 sites in the IPM area and 5 sites in the grower area preceding each demonstration crop where possible, just prior to planting, and at least once during the crop's development.

Sizes of samples taken for important arthropods at each sampling site appear in Table 1. Leafminers and twospotted spider mites were observed to infest leaves at the bases of the gypsophila plants more densely than they infested leaves on flower spikes (Price, unpublished data). Thus at each station the scout randomly selected 5 low growing leaves from each of 25 randomly selected plants in the Manatee County demonstration and 5 leaves from each of 10 plants in the Lee County demonstration. The numbers of leafminer larvae and motile twospotted spider mites and their eggs were counted from the selected leaves. A 14X hand lens was used to count mites in the field at low population densities. When as many as 500 mites were expected from one of the samples, leaf samples were transported to the laboratory and counted using a mite brushing machine and stereomicroscope. All leaves from samples were brushed and inhabiting mites and eggs were collected on a rotating 5 inch diameter glass plate coated with a viscous surfactant agent to retain the arthropods. All mites and eggs, uniformly distributed on the plate, were counted on 1/10 of the area of the plate. Data were multiplied by 10 and recorded. Numbers of lepidopterous larvae were recorded by species from 25 plants at each station until the plants reached 6 inches in diameter, after which only 10 plants were selected for observation at each station. Gypsophila foliage is rarely subjected to pathogenic disorders that could be alleviated by pesticidal applications. Therefore, no formal sampling program for disease symptoms was established although presence of crown gall disease or other unusual, microbial infections were noted by the scout.

Action thresholds. Decisions for the timing and type of pesticidal sprays to be applied to IPM areas were based on the status of pests in the fields. The arthropod densities at which insecticides and miticides were applied appear in Table 1. These levels had not been developed through experimentation, but were the authors' best estimates of practical treatment thresholds based on available information. Pesticidal sprays were applied when the action threshold was reached at any one of the 10 sampling sites in the IPM area. Recommendations were relayed, in the manner described by Price et al. (5), to the grower who then applied the pesticides. Pesticidal sprays for leafminer control were recommended when the number of leafminer larvae at any one station exceeded 20% of the number of leaves sampled (i.e. 25 leafminer larvae when 5 leaves from each of 25 plants were sampled and 10 leafminer larvae when 5 leaves from each of 10 plants were sampled). Miticides were applied when 250 mites (including motile and egg forms) were found on 125 leaves (5 leaves from each of 25 plants) or 100 mites were found on 50 leaves (5 leaves from each of 10 plants).

Chemical action to control lepidopterous larvae was indicated according to the attacking species and the developmental status of the crop. Spray applications were indicated if one lepidopterous larva of any species was found at the sampling site before plants produced lateral branches and the plant exceeded 6 inches in diameter. Pesticides were recommended to control lepidopterous larvae when one beet armyworm or an aggregate of 5 southern armyworms, cabbage loopers, corn earworms, or granulate cutworms were observed at a sampling site after plants developed lateral branches and exceeded 6 inches in diameter but before plants were producing mature flowers. Pesticides were not recommended for lepidopterous larval control until an aggregate of 10 lepidopterous larvae of any of the important pest species was observed at any sampling site after the gypsophila plants were producing mature flowers. A subjective threshold level for thrips control was used based on the thrips activity that caused harvesters to be uncomfortable. Fungicide applications were not recommended until flower buds began to develop because pathogens are usually not a problem on the leaves. After flower buds developed on the panicles, weekly sprays were recommended, and more frequently during rainy periods. Additional fungicidal sprays were permitted when the grower wished to apply fungicides on a regular basis.

Table 1. Sample size at each sampling site and arthropod density at which insecticide and miticide sprays were applied in the IPM area.

Pest	Sample size	Action threshold[z]
Leafminer	125 leaves (Manatee County)	25 live larvae
	50 leaves (Lee County)	10 live larvae
Twospotted spider mite	125 leaves (Manatee County)	250 motile and egg forms
	50 leaves (Lee County)	100 motile and egg forms
Beet armyworms		
Plant stage I[y]	25 plants	1
Plant stage II[y]	10 plants	1
Plant stage III[y]	10 plants	5
Lepidopterous larval group		
Plant stage I	25 plants	1
Plant stage II	10 plants	5
Plant stage III	10 plants	10

[z]Chemical sprays were applied to the entire planting when the action threshold was reached at any one of 10 sampling sites.
[y]Plant stages were: less than 6 inches in diameter (I), larger than 6 inches in diameter but before mature flowers developed (II), when mature flowers present (III).

Results and Discussion

Insects and mites. Southern armyworms, beet armyworms, leafminers and twospotted spider mites were the arthropods for which insecticides were applied on the 2 demonstration farms. Usually Lannate® methomyl and/or Thuricide® *Bacillus thuringiensis* Berliner were used for beet armyworms or southern armyworms. Ambush® permethrin and/or Vydate® oxamyl were applied for leafminer and Kelthane® dicofol for mites. Oxamyl is active against mites and may have affected mite populations accordingly.

In the initial stages of the Manatee County crop, leafminer populations were dense in both the IPM area and the grower area in early November and again in late November through mid-December. During the second period of peak leafminer activity, more active mines were permitted in the IPM area than in the grower area. At harvest, more leafmines greater than ¼ inch long were found in unharvested leaves among plants in the IPM area (0.14/leaf) than in the grower area (0.08/leaf).

Leafminers on the Lee County farm were present at low to moderate levels throughout the season and were most dense on the April 17, 1980 evaluation. Numbers of leafminer larvae present in the IPM and grower areas did not appear to vary according to the practices performed in the respective areas (Table 2).

Southern armyworms and beet armyworms occurred several times throughout the season at the Manatee County farm; however, effective insecticides prohibited sustained presence of these pests. No differences in lepidopterous larval presence was evident between the IPM and grower areas. The treatment threshold for lepidopterous larvae was not attained in either the IPM or grower areas on the Lee County farm.

Twospotted spider mite populations became dense on the Lee County farm after mid-April (Table 2). More mites were recorded from the area under the grower's practices than from the area under IPM. The IPM treatment threshold for mites was attained late in the development of the crop; however, the grower expected to terminate harvest at that time and thus controls were not recommended for mites in the IPM area. Mite populations did not develop on the plants in the Manatee County demonstration.

Diseases. No significant disease symptoms were noted on the Manatee County farm. Truban® ethazol was applied as a drench when plants were set and Dithane M-45® or Manzate 200® mancozeb were applied weekly to prevent possible foliar diseases there. Eight percent and 7.8% of the young plants on the Lee County farm in the IPM and grower areas, respectively, died from damping-off organisms within 2 weeks of planting. Plants on this farm had not received a fungicidal drench at the time of setting. All dead plants were replaced with healthy ones.

Pesticidal reductions. Eleven insecticide doses were applied on the Manatee County farm *in the IPM* area and 21 in the grower area. That represented a 47.6% reduction in insecticide usage in the IPM area compared to the grower area. Twenty-four fungicidal doses were applied in the IPM area of that farm and 26 were applied in the grower area.

In the Lee County demonstration no insecticides/miticides and one fungicide were applied to the IPM area and 11 insecticides/miticides and 6 fungicides were applied in the comparison area. This represented a 100% reduction in use of insecticides and miticides and an 83% reduction in use of fungicides.

Pesticides applied in these demonstrations were often tank-mixed. Thus, application costs cannot be estimated solely from records of doses applied. Records of the number of times application equipment was used give additional information for estimating direct pesticide costs. Application equipment was used 13 times in both the IPM and grower areas on the Manatee County farm, while equipment was used one time on the IPM area on the Lee County farm and 7 times on the grower area there, thus reducing equipment use in the IPM area by ca. 86%.

Crop yields. Flowers were harvested by many people twice weekly over a 2 month period on the Manatee County farm. It was impractical to record yields under those conditions. The grower on that farm believed no noticeable difference developed in quality or yield between the 2 areas.

On the Lee County farm, precise yields from each area were recorded by the grower. The IPM area produced 2,080 bunches of flowers per 2,620 linear feet of gypsophila bed and the grower area produced 1,875 bunches in an equal area. Gypsophila flowers are usually harvested in 8 oz to 16 oz bunches according to the preference of the grower.

Conclusions

The biology of gypsophila and the methods under which it is grown in Florida cause this crop to be well suited for the application of IPM tactics. These demonstrations have shown that there are reasonable levels of arthropod pest activity that can be permitted before the often ecologically disruptive and always costly pesticides must be used to prevent a reduction in quality and/or yield. This factor has great potential significance in light of the present leafminer problem. Observations by the senior author and others (2, 4) support the conclusion that the leafminer fly sometimes reaches economic status in a gypsophila crop only after the

Table 2. Average density (per leaf) during period of occurrence and highest daily average number (per leaf) of leafminer larvae and twospotted spider mites in gypsophila under IPM management (10 sampling sites) and under the growers' normal pest control practices (5 sampling sites).

Farm	Leafminer larvae: Period of occurrence	No. in IPM area[z]: Mean	No. in IPM area[z]: High	No. in grower area[y]: Mean	No. in grower area[y]: High	Twospotted spider mites and eggs: Period of occurrence	No. in IPM area[z]: Mean	No. in IPM area[z]: High	No. in grower area[y]: Mean	No. in grower area[y]: High
Lee County[x]	Feb. 6 to May 15	0.37 ±0.34	1.23	0.35 ±0.28	1.08	Mar. 21 to May 15	20.64 ±23.53	54.94	30.42 ±38.45	95.08
Manatee County[w]	Nov. 2 to Mar. 18	0.26 ±0.36	1.69	0.23 ±0.35	1.83	—[v]	—	—	—	—

[z]Data are an average from 10 sampling sites.
[y]Data are an average from 5 sampling sites.
[x]Samples were taken once each week.
[w]Samples were taken twice each week.
[v]An insignificant population of twospotted spider mites developed on the Manatee County farm.

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]

J. F. Price, A. J. Overman, and A. W. Englehard
University of Florida, IFAS,
Agricultural Research & Education Center,
5007 - 60th Street East, Bradenton, FL 33508

M. K. Iverson
University of Florida, IFAS,
Cooperative Extension Service, Manatee County,
1303 - 17th St., Palmetto, FL 33561

V. W. Yingst
University of Florida, IFAS,
Cooperative Extension Service, Lee County,
3406 Palm Beach Blvd., Ft. Myers, FL 33905

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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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