Pest Management Grants Final Report

Contract Number 98-0332

Contract Title: Demonstration and Implementation of a Reduced Risk Pest Management Strategy in Fresh Cut Roses

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Acknowledgements

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Abstract

Our goal was to develop and implement a pest management program using reduced risk pesticides and biological control agents to manage the key pests of cut roses. This program represents the largest effort to implement an IPM program on floriculture crops in the United States. Eight growers spanning the major rose production areas of California participated. Data were collected at each location from an IPM and a conventional practice greenhouse. We used a comprehensive sampling plan that provided information on the density of insects, mites, and diseases. Based on thresholds developed for each of the pests, we took no action; applied a reduced risk pesticide; or released biological control agents.

Twospotted spider mite and western flower thrips densities were the same or significantly lower in the IPM compared to the conventional practice greenhouses. Biological control of mites was successful at all locations. Pesticide use was generally lower in the IPM greenhouses. Efforts to reduce prophylactic applications of fungicides using a model to predict powdery mildew incidence need further study.

Future work will concentrate on reducing the time needed to scout the crop, examine more effective ways to release natural enemies, and further refine the predictive model for powdery mildew control.

Executive Summary

The goal of this project was to develop and implement a pest management program emphasizing reduced risk pesticides and biological control agents to manage the major pests of California fresh cut roses. Eight growers spanning the major rose production areas of California (San Diego, Santa Barbara, and Santa Cruz Counties) participated in the program. Data were collected and compared at each grower location from an IPM and a conventional practice greenhouse. Data were collected on a weekly basis by trained scouts using a comprehensive sampling plan that provided information on the density of insects, mites, and diseases. Specifically, fixed precision sampling plans were developed for twospotted spider mites and western flower thrips. This type of sampling plan is developed through intensive surveys of a crop to determine a particular pest's spatial distribution in the crop. The degree of acceptable error (the "precision" of the plan) is determined (or "fixed") in advance and the number of samples needed to obtain that precision is calculated from a knowledge of the pest's distribution in the crop. Although they take effort to develop, these types of sampling plans are often more accurate and efficient than other sampling approaches. This represents the first used of such plans in a floriculture IPM program. Data were collated, summarized and returned to the scouts who would then meet with the growers to discuss control strategies. Based on thresholds developed for each of the pests, no action was taken; an application of a reduced risk pesticide was made; or biological control agents were released.

Twospotted spider mite and western flower thrips densities were the same or significantly lower in the IPM compared to the conventional practice greenhouses. Biological control of twospotted spider mites using the predatory mite, *Phytoseiulus persimilis*, was successful at all locations. Pesticide use was generally lower in the IPM greenhouses. Cost of mite control was initially higher under IPM, but costs became comparable after four to eight weeks as predators became established and release rates were lowered. Cost of thrips control was comparable under each control method. Efforts to reduce prophylactic applications of fungicides using a simulation model to predict incidences of infection by powdery mildew need further study.

All growers in the program recognized the advantages of the IPM approach, but the labor associated with scouting the crop, collating data, and releasing natural enemies reduced the economic value of this program. Future work will concentrate on reducing the time needed to scout the crop, examine more effective ways to release natural enemies, and further refine the predictive model for powdery mildew control.

This program represents the largest effort to demonstrate and implement an IPM strategy on floriculture crops in the United States. Drawing on the partnerships that are central to the Alliance concept, we have shown that high quality roses can be produced with substantially fewer pesticides and with the incorporation of biological control into mainstream floriculture. Effective partnering with the biological control industry has also been a hallmark of this program. This has lead to the widespread use of predatory mites in commercial rose production in California, representing the largest use of biological control by the floriculture industry in the United States.

Body of the Report

Introduction

The rose is the most popular garden plant in the world as well as one of the most important commercial greenhouse cut flowers. Rose production is currently the strongest component of the $ 500 million cut flower industry in California. In 1999, California growers produced 71% of the US crop with a wholesale value of $54 million (USDA 2000). Red roses are the most popular cut rose, but the market for lavenders and bicolors has been expanding rapidly. In the United States roses are grown in soil, rockwool, and hydroponically; most roses in California are grown in a modified hydroponic system using the bent cane production method. Most production is centered in San Diego, Santa Barbara and Santa Cruz Counties.

The International Cut Flowers Association (ICFA) (formerly Roses, Inc.) has estimated that arthropod and disease control through application of spray materials is approximately 7.5% of production costs (Jim Krone, Executive Vice President, ICFA, personal communication). If estimates for training, safety and capitol equipment costs are included, costs rise to 12-15% of production costs. The need for frequent pesticide applications against key pests has resulted in the widespread development of pesticide resistance in western flower thrips (Immararaju et al. 1992), mites (Fergusson-Kolmes et al. 1991), whiteflies (Prabhaker et al. 1985) and aphids (Kerns & Gaylor 1992). This has further increased the frequency of sprays needed to prevent damage thereby increasing control costs and reducing the availability of effective pesticides. Increased regulations promulgated due to concerns over environmental contamination and worker safety have also increased the pressure to reduce reliance on conventional pesticides in greenhouses. For example, re-entry restrictions imposed by the federal Worker Protection Standard prevent workers from entering the greenhouse for pre-determined periods after pesticide use. In crops such as fresh cut roses that must be harvested two or three times a day, this has reduced the number of effective pesticides available to growers. In addition, the Food Quality Protection Act has caused the loss of materials important in the greenhouse rose production system; more will likely be lost in the near future. The frequency of pesticide sprays typical in a rose range has impeded the implementation of IPM procedures, particularly the use of biological controls. Pesticides targeting hard-to-kill floriculture pests frequently kill natural enemies, which favors continued reliance on conventional pesticides while discouraging the adoption of biological control.

Despite the fact that rose production generally occurs along the coast, we still encountered a range of environmental conditions within and between the three regions, meaning that our IPM program needed to be flexible enough to accommodate these differences. We proposed a reduced-risk pest management program for fresh cut roses that is comprised of three integrated components: 1) monitoring procedures for key pests; 2) application of economic and action thresholds to guide pest control decisions; and 3) reduction and substitution of conventional pesticides with reduced risk materials and biological control. An economic analysis comparing the success and cost of our reduced risk strategy to conventional grower programs was made.

Materials and Methods

Eight growers spanning the major rose production areas of California (San Diego, Santa Barbara and Santa Cruz Counties) participated in the program (Figure 1). Each grower contributed an IPM and a conventional practice house. All pest management decisions in the former were based on the IPM program we developed, while the grower did all pest management in the latter. Scouting was done weekly at all locations. The project included growers with several different rose varieties and both bent cane and upright training techniques. We tried to keep these two variables standardized within a location. Fixed precision sampling plans that were previously developed for twospotted spider mites (TSSM) and western flower thrips (WFT) were used in our scouting program. This type of sampling plan is developed through intensive surveys of a crop to determine a particular pest's spatial distribution in the crop. The degree of acceptable error (the "precision" of the plan) is determined (or "fixed") in advance and the number of samples needed to obtain that precision is calculated from a knowledge of the pest's distribution in the crop. Although they take effort to develop, these types of sampling plans are often more accurate and efficient than other sampling approaches. Sampling for all other pests was done as plants were inspected during TSSM sampling.

Twospotted spider mites

We have determined that the first leaf above the bend on 38 randomly selected plants needs to be sampled per 10,000 ft^2 of greenhouse area. Our plan is a binomial (presence/absence) sampling plan with a tally threshold of 5, which means that plants are classified as infested (present) if the scout finds more than 5 mobile mites (eggs are not counted) on the sampled leaf or not infested (absent) if there are 5 or fewer mobile mites. The number of samples taken per greenhouse was adjusted for greenhouse size. For example, a 5000 ft^2 greenhouse would require 19 samples. A truly random sample would have been too time consuming to be practical. Thus we randomized our sampling by using a different, randomly selected starting point each week. Rose greenhouses are typically laid out in rows of eight plants on each side of a center aisle for a total of 16 rows. To take 19 samples we sampled one plant each of 13 rows and two plants in each of the remaining 3 rows. Starting with a different row each week ensured that the pattern of sampling varied from week to week. mite treatments were initiated when 5, 10, or 20 percent of the plants were infested in San Diego, Carpinteria, and Watsonville, respectively.

These samples were also used to determine co-occurrence of TSSM with predator mites, *Phytoseiulus persimilis*, (Persimilis) and they were inspected for secondary pests and for diseases. In addition to the fixed samples described above, as the scouts walked down each row they took directed samples where damage symptoms of insects, mites or pathogens were present. These plants were flagged for spot treatment. In the IPM houses, TSSM were controlled with Avid, Sanmite, Triact, M-Pede, or Floramite until fewer than 25 percent of the sampled plants had more than 5 mobile stages on the sampled leaf. At that point Persimilis releases began. Persimilis releases were based on co-occurrence of TSSM and predator on the sampled leaf. Co-occurrence is calculated as:

$$\text{\% co-occurrence} = \left[\frac{\text{Number of plants with TSSM and Persimilis}}{\text{Number of plants with TSSM}} \right] \times 100$$

If co-occurrence was greater than 80 percent, no release was made. If co-occurrence was between 50 and 80 percent, spot releases were made on the infested plants at the rate of approximately 5 predators per plant. If co-occurrence was less than 50 percent, broadcast releases of predators were made in the entire house at the rate of approximately 1 to 5 predators per plant. All predator releases were made to leaves just below those on which mites were present. Predators were kept refrigerated and released as soon as possible after arrival at the greenhouse, as per the supplier's instructions.

Western flower thrips

The sampling plan for WFT used yellow sticky traps and a general threshold of 25 to 50 thrips/trap/week. Three 4 in by 6 in yellow sticky traps are placed per 10, 000 ft^2. The traps are placed at flower level and are evenly distributed in the house (at the ends and center of the middle row, for example). The lower threshold of 25 thrips/trap/week is used in more susceptible varieties (such as white or yellow flowers) or in areas of heavy thrips pressure. The higher threshold of 50 thrips/trap/week is used in less susceptible varieties (such as red flowers). There is currently no cost effective biological control agent for WFT in cut roses. Our IPM program was based on directed sprays of Conserve or Azatin when the threshold was reached. Pesticides for thrips were directed to the terminal shoots and developing buds.

Powdery mildew

Each demonstration site contained an Adcon (http://www.adcon.com; Klostemeuburg, Austria) weather station that collected data on temperature, leaf wetness, and relative humidity. This device contains a radio transmitter that automatically sends data to a base station as it is collected. A predictive model for powdery mildew based on these environmental conditions was evaluated. Powdery mildew is primarily affected by temperature, with infection occurring between 65 and 81°F. Disease pressure is a function of how long the appropriate conditions occur. Pressure is cumulative, meaning that several days of favorable conditions are needed to create high disease pressure. Conversely, several days of unfavorable conditions will create low disease pressure. As the data is received at the base station, it was processed by a computer according to the parameters of the disease model and a measure of disease pressure was generated. Farm advisors and growers received a weekly fax reporting the current disease pressure (ranked on a scale of 0 to 100) and information gathered by scouting on presence of powdery mildew spores. Evaluated together this information allowed farm advisors and growers to make informed decisions about mildew control. For instance, if disease pressure was moderate but no mildew was seen (and thus no inoculum was present), there was no need for a control spray application. If there was only a small amount of mildew but pressure was high, then control sprays applied on a short interval were appropriate. The model is not fully functional but it already provides a tool to better predict the need for mildew control, enabling growers to move away from calendar sprays or routine sulfur volatilization. The latter is important because it is suspected that sulfur may have chronic sub-lethal effects on the Persimilis mite predator. Our IPM program used Kaligreen, Pipron, Compass, and Triact. The eridicant (Pipron) was used at higher mildew pressure, while the other materials were emphasized under other conditions.

Secondary pests

Plant inspections for whiteflies, aphids, mealybugs, Botrytis, downy mildew, and rust were done as part of the plant inspections for TSSM. Yellow sticky traps were also used to monitor whiteflies and winged aphids. We emphasized the use of materials that were compatible with the Persimilis predator for control of these pests.

Results

Twospotted Spider Mites

A comparison of TSSM levels under IPM and conventional control across all nurseries is shown in Figure 2. There were significantly more plants with no mites and significantly fewer plants with mites at the two levels measured under IPM. Similar results were observed at the individual nurseries (Figures 3, 4, 5, 6, and 7). Despite this success, the cost of IPM was significantly higher than the cost of conventional TSSM control (Figure 8).

Western Flower Thrips

There were significantly fewer WFT caught in the IPM houses than in the conventional houses across all nurseries (Figure 9). The largest differences in thrips levels between the two treatments occurred during the summer months when WFT pressure is generally highest (Figure 10).

Rose Powdery Mildew

An example of the relationship between the mildew index and disease occurrence is shown in Figure 11. This graph relates the mildew index (red line), relative humidity (green line) and disease occurrence (blue squares).

Secondary Pests

There was no significant difference in aphid or whitefly yellow sticky trap catch (Figure 9) and neither of these insects caused problems during our study. The citrus mealybug, *Planococcus citri*, was a problem at two locations.

Discussion

Our goal as we analyzed the data was to determine if there were differences in pest densities and control costs under the two management programs. We looked for significant differences in pest levels and control cost per square foot under the two techniques.

Twospotted spider mites

Predatory mites were successfully used in each of the IPM greenhouses and almost eliminated the need for miticide applications in those houses. Despite this, the control cost per square foot per application was almost 2.5 times higher in our IPM houses than in the conventional houses. There are two reasons for this difference. First, IPM is generally most expensive during the initial four to eight weeks. Since only two of our sites were under IPM for longer than this, our cost comparison is not based on typical conditions. When conventional control costs are compared to those that might be expected under a maintenance IPM program, the costs are comparable (Table 1). A second reason for the difference in control costs is the lower than normal mite levels that were observed in the control houses. At most of our sites IPM was already underway in houses that were not part of our study. As a result, overall mite levels at most nurseries were low, meaning that once mites were controlled in an area re-infestation from other areas was slow to occur.

Western flower thrips

The monitoring program and the use of reduced risk pesticides for control of western flower thrips worked very effectively in the IPM greenhouses. This was a critical component of the entire program, since thrips are considered the key pest of roses (and for that matter, all cut and potted flowering crops). The need to control thrips with pesticides often limits the use of biological control in floricultural crops. Our success in combining the two was due in part to the ability to direct pesticide applications to the flowers in the bent cane system. While thrips levels were low under both management programs, the fact that they were significantly lower in the IPM houses during the peak summer season gives us confidence that our threshold is appropriate.

Powdery mildew

Despite the fact that the index remained near 100 at most sites for the majority of the study period, disease was not always observed. We suspect that other factors such as relative humidity play a role in disease development. Further study is needed to add refinements such as this to the model.

Secondary pests

Effective IPM implementation was hindered at two sites by the citrus mealybug, *Planococcus citri*. This pest is generally not a problem for rose growers until IPM is implemented, when the cessation of broad spectrum pesticide applications can allow this pest to develop. It is generally only a problem at sites where roses are or were grown adjacent to areas to crops such as Stephanotis, on which citrus mealybug is a key pest. Unfortunately natural enemies of the mealybug are not currently available, and the most effective mealybug pesticides are detrimental to spider mite predators. We are working with the natural enemy suppliers to try and change this situation. In the interim, we will continue to evaluate reduced risk pesticides for efficacy against the citrus mealybug.

Summary and Conclusions

The goal of this project was to develop and implement a pest management program based on reduced risk pesticides and biological control agents in the major rose production areas of California. This program represents the largest effort to demonstrate and implement an IPM strategy on floriculture crops in the United States. Data were collected on a weekly basis at each grower location from an IPM and a conventional practice greenhouse. We used a comprehensive sampling plan that provided information on the density of insects, mites, and diseases. The use of fixed precision sampling plans for twospotted spider mites and western flower thrips as part of our sampling program represents the first used of such plans in a floriculture IPM program. Based on thresholds developed through previous research for each of the pests, no action was taken; an application of a reduced risk pesticide was made; or biological control agents were released. Our objective as we analyzed the data was to determine if there were differences in pest densities and control costs under the two management programs.

Twospotted spider mite and western flower thrips densities were the same or significantly lower in the IPM compared to the conventional practice greenhouses. Biological control of mites using the predatory mite, *Phytoseiulus persimilis*, was successful at all locations. Pesticide use was generally lower in the IPM greenhouses. Cost of mite control was initially higher under IPM, but costs became comparable after four to eight weeks as predators became established and release rates were lowered. Cost of thrips control was comparable under the two control methods. Efforts to reduce prophylactic applications of fungicides using a simulation model to predict incidences of infection by powdery mildew needs further study.

Overall, we are satisfied that the rose IPM program was successful. A testament to the effectiveness of the mite biological control is emphasized by the fact that most of the growers wanted to abandon their conventional treatments in favor of using predatory mites. We allowed this to occur after we felt enough data had been collected for a good comparison of the IPM to conventional treatments. Future work needs to concentrate on reducing the sampling effort while still allowing the collection of sufficient information to allow good pest management decisions. The development of effective IPM techniques for secondary pests is also needed.

Key findings are:

- Twospotted spider mite densities were the same or significantly lower in the IPM compared to the conventional practice greenhouses. IPM programs for TSSM were initially more expensive than conventional programs, although this difference tended to equalize after four to eight weeks.
- Western flower thrips densities were the same or significantly lower in the IPM compared to the conventional practice greenhouses. This was especially noticeable during the summer period of peak thrips pressure. Cost of thrips control was comparable under the two control methods.
- Our efforts to reduce prophylactic applications of fungicides for powdery mildew using a simulation model to predict likelihood of disease outbreak needs further refinement.
- Secondary pests for which there are no cost effective natural enemies or reduced risk pesticides (such as citrus mealybug) can be a limiting factor in successful IPM programs.
- Internet: A web site is under development that will contain specific information for growers about how to implement IPM in cut roses. When it is available it will be linked to http://entomology.ucdavis.edu> click on 'Faculty'; click on 'Parrella'.

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Prabhaker, N, DL Coudriet and DE Meyerdirk. 1985. Insecticide resistance in the sweetpotato whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae). J. Econ. Entomol. 78: 748-752.

USDA. 2000. USDA Floriculture Crops 1999 Summary. USDA-NASS Sp Cr 6-1(00).

Publications and Presentations Produced

CA Casey and MP Parrella. Development and implementation of an integrated pest management program for greenhouse cut roses. International Organization for Biological Control Thrips Research Workshop. Niagara-on-the-Lake, Ontario, Canada, June 2000.

MP Parrella, CA Casey, JP Newman, KL Robb and SA Tjosvold. Glasshouses: integrating natural enemy release and biological pesticides for insect pest management in roses. California Conference on Biological Control II. Riverside, CA, July 2000.

CA Casey and MP Parrella. Area-wide implementation of IPM: biological control strategies in glasshouse cut roses. Beyond Pesticides: Advances in Biological Control Research and Implementation in Greenhouses and Conservatories, Section Symposium, Entomological Society of America Annual Meeting, Montreal, Canada December 2000.

Casey, CA and L Bolkan. Integrated pest management works for rose growers. GrowerTalks, July 2001.

Internet: A web site is under development that will contain specific information for growers about how to implement IPM in cut roses. When it is available it will be linked to http://entomology.ucdavis.edu> ; click on 'Faculty'; click on 'Parrella'.

Appendix

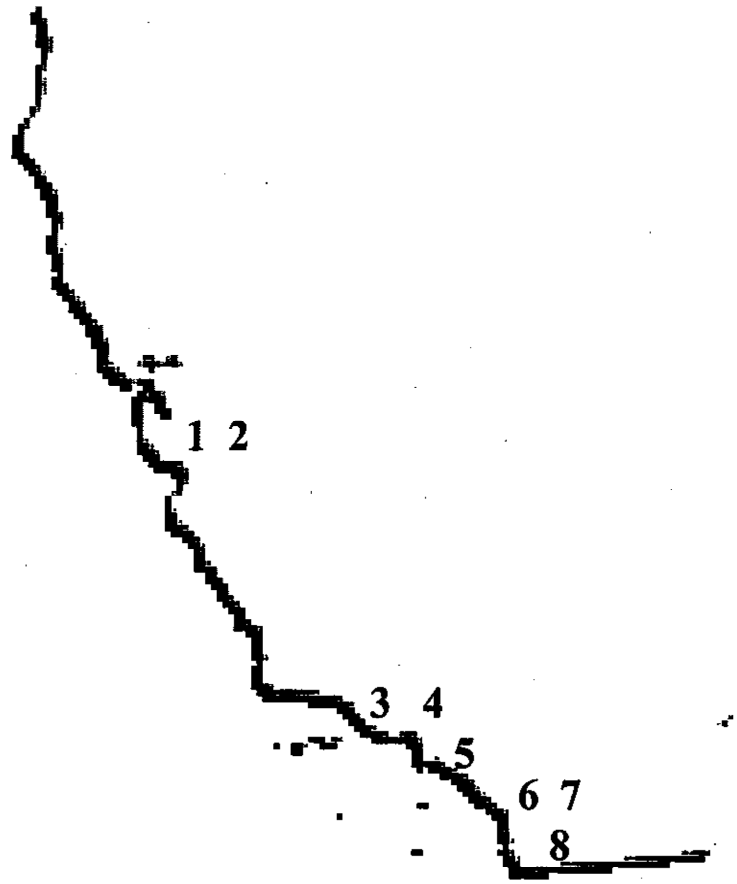

Figure 1. Location of the Rose Pest Management Alliance sites.
1 = Kitayama Brothers, Watsonville
2 = Aspen Nurseries, Watsonville
3 = Westerlay Roses, Carpinteria
4 = Myriad Flowers, Carpinteria
5 = Sunshine Flowers, Oxnard
6 = Dramm and Echter, Encinitas
7 = Roseflor, San Marcos
8 = Kocher Flowers, Encinitas.

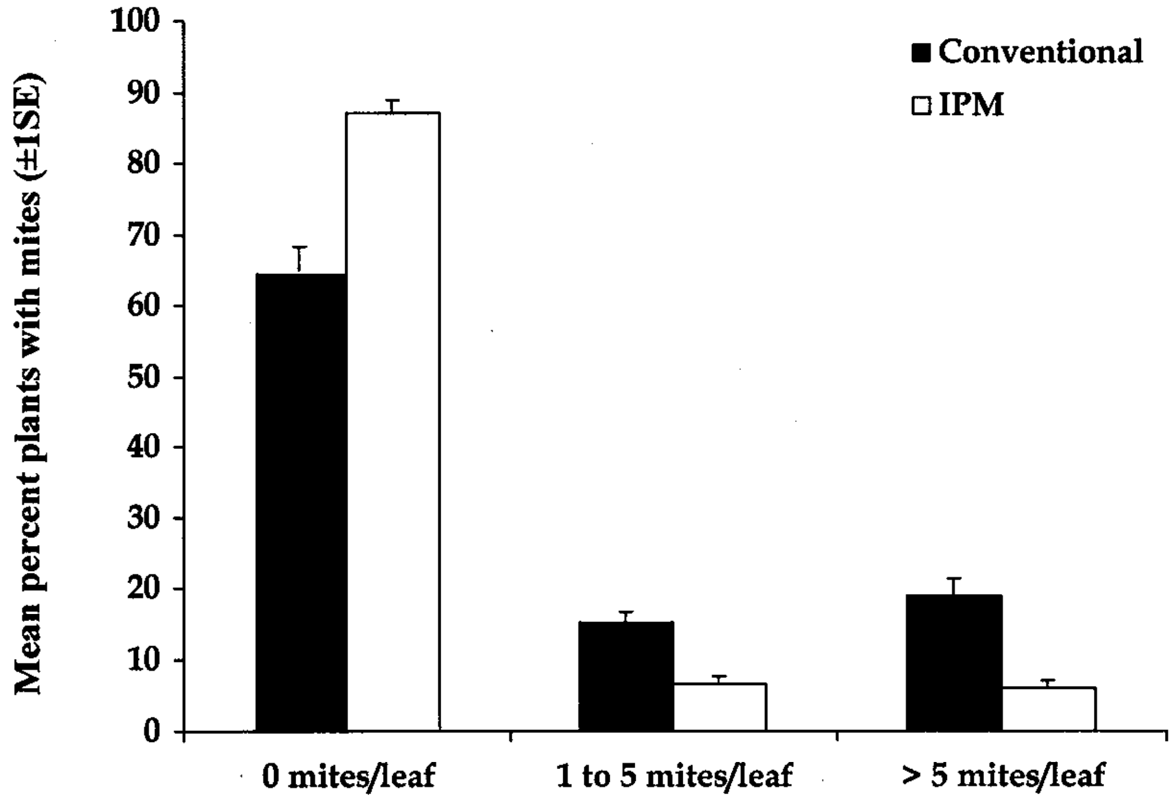

Figure 2. Twospotted spider mite densities under conventional and IPM programs across all nurseries. There were significantly more plants with no mites ($p = 0.0001$) and significantly fewer plants with mites at the other levels measured (1 to 5/leaf; $p = 0.0001$; >5/leaf, $p = 0.0001$).

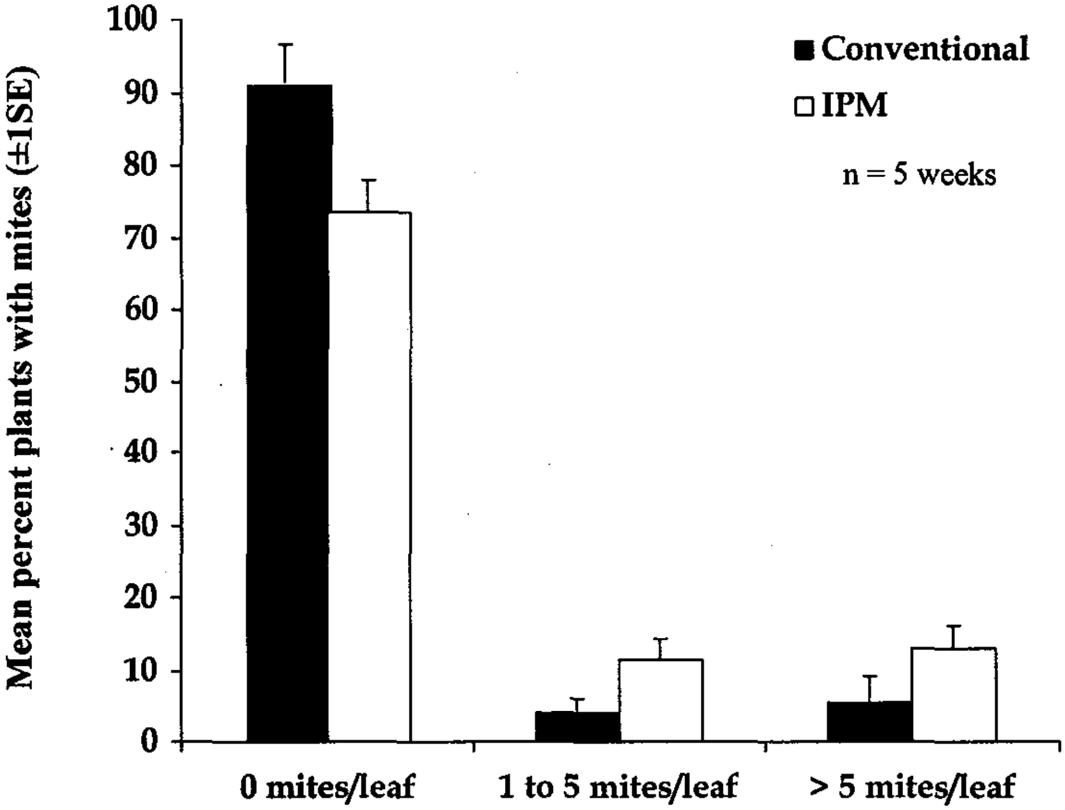

Figure 3. Twospotted spider mite densities under conventional and IPM programs at Aspen Nurseries, Watsonville. There were significantly more plants with no mites ($p = 0.0318$). There was no significant difference in mite density at the 1 to 5/leaf ($p = 0.0733$) or >5/leaf level ($p = 0.1332$).

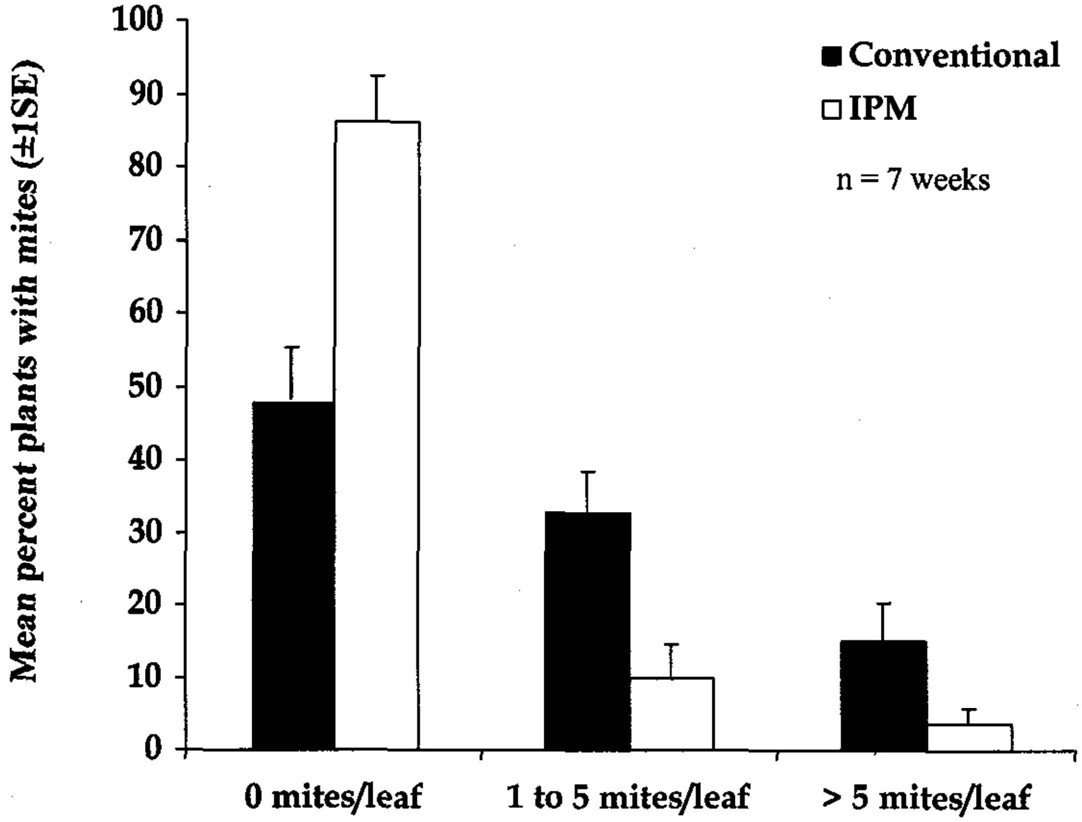

Figure 4. Twospotted spider mite densities under conventional and IPM programs at Myriad Flowers, Carpinteria. There were significantly more plants with no mites ($p = 0.0016$) and significantly fewer plants with mites at the other levels measured (1 to 5/leaf; $p = 0.0097$; >5/leaf, $p = 0.0583$).

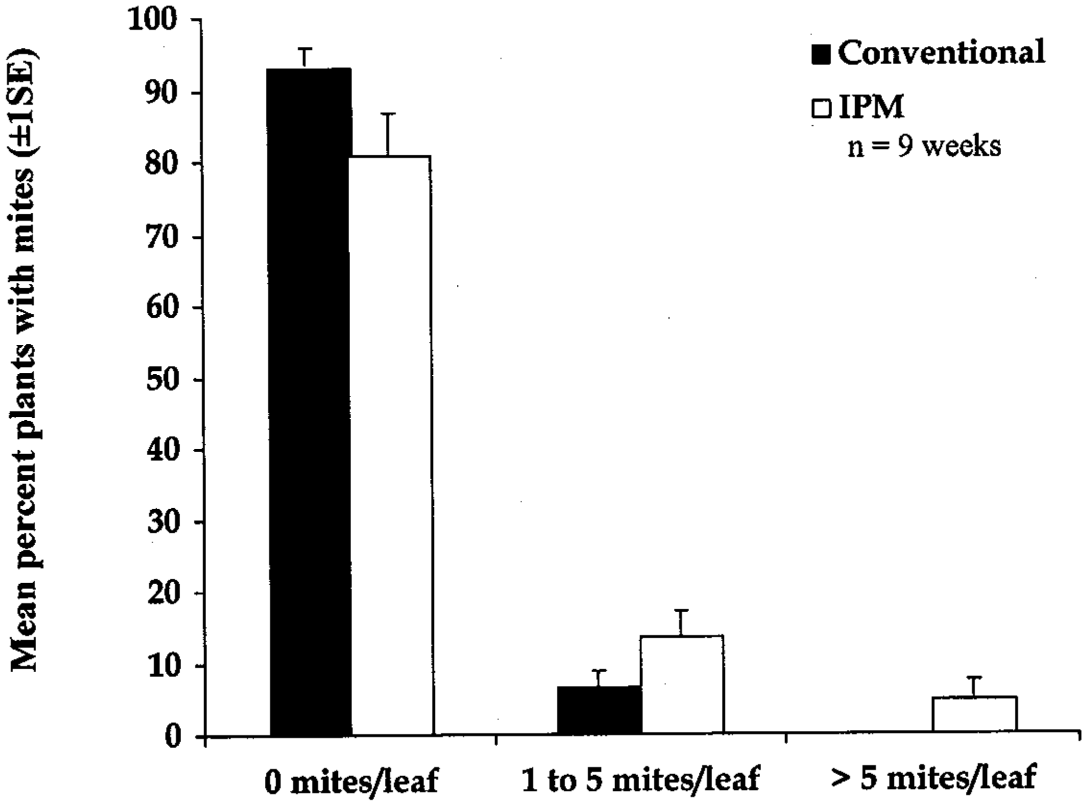

Figure 5. Twospotted spider mite densities under conventional and IPM programs at Sunshine Flowers, Oxnard. There was no significant difference between the two treatments (0/leaf, $p = 0.0666$; 1 to 5/leaf, $p = 0.1248$; >5/leaf, $p = 0.1296$).

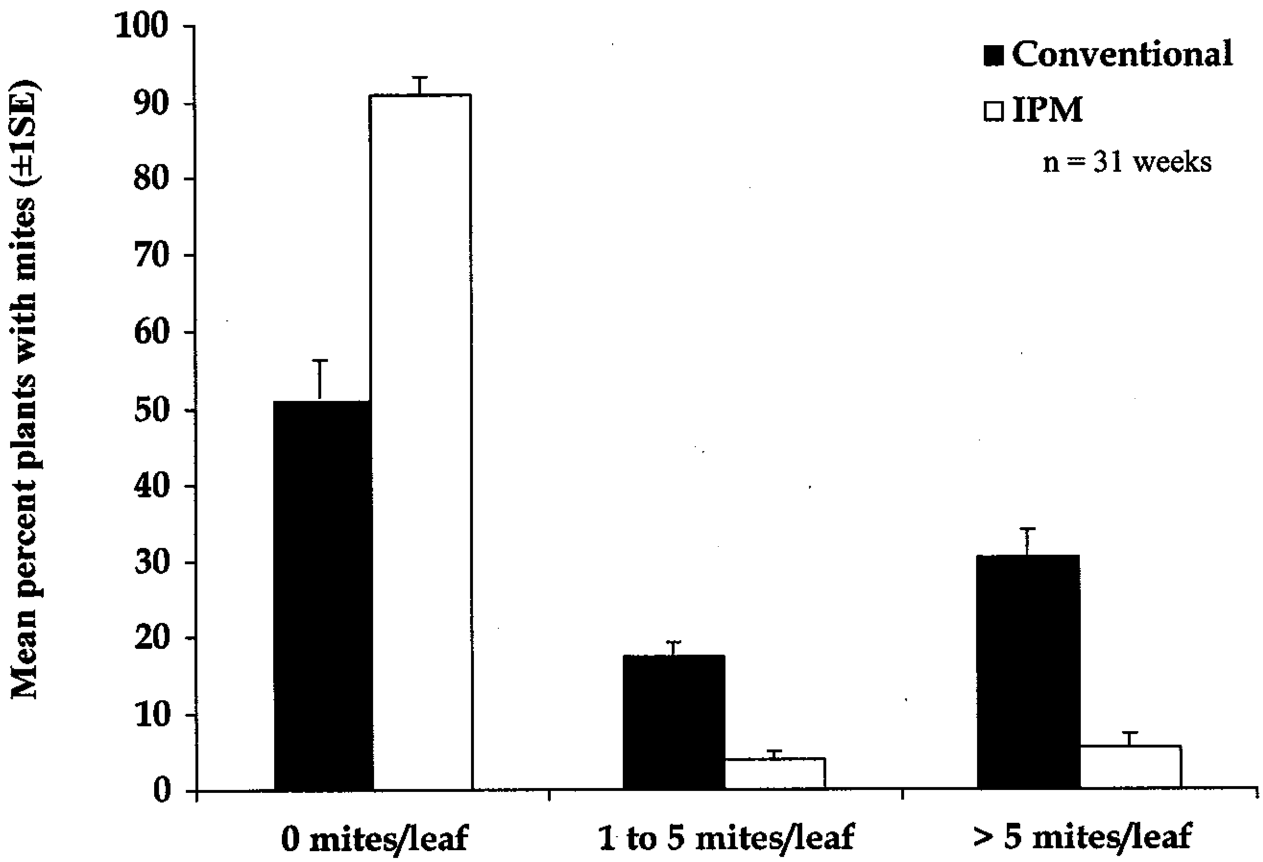

Figure 6. Twospotted spider mite densities under conventional and IPM programs at Kocher Flowers, Encinitas. There were significantly more plants with no mites ($p = 0.0001$) and significantly fewer plants with mites at the other levels measured (1 to 5/leaf; $p = 0.0001$; >5/leaf, $p = 0.0001$).

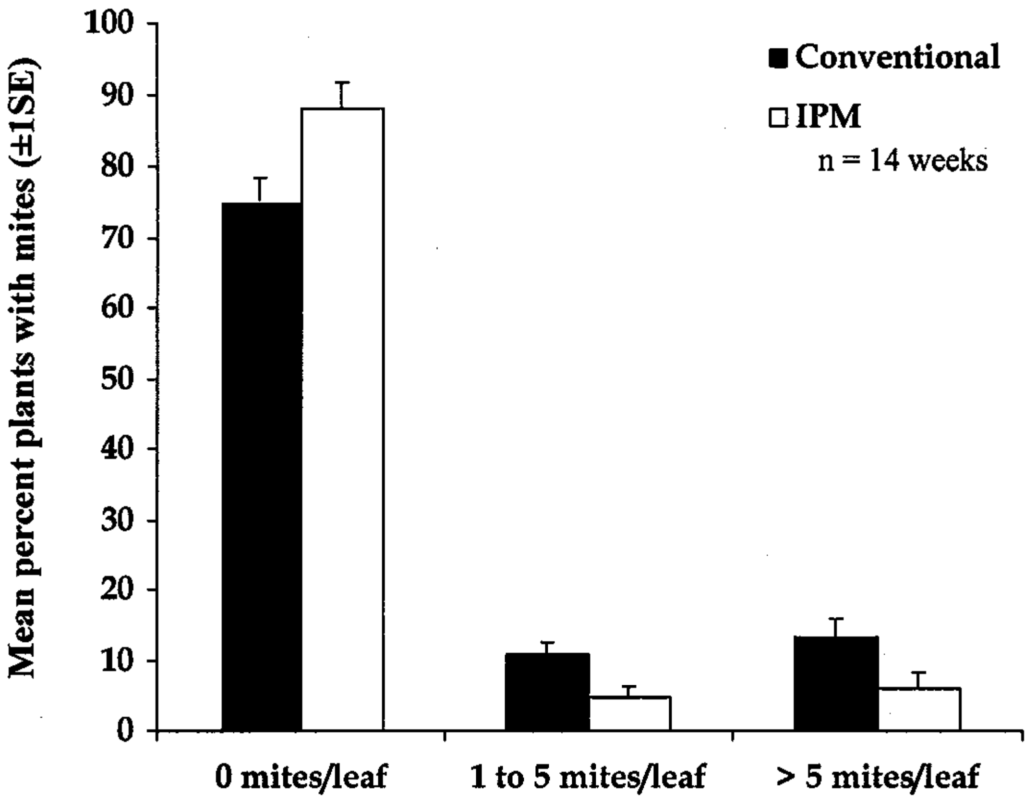

Figure 7. Twospotted spider mite densities under conventional and IPM programs at Roseflor, San Marcos. There were significantly more plants with no mites ($p = 0.0138$) and significantly fewer plants with mites at the other levels measured (1 to 5/leaf; $p = 0.0146$; >5/leaf, $p = 0.0452$).

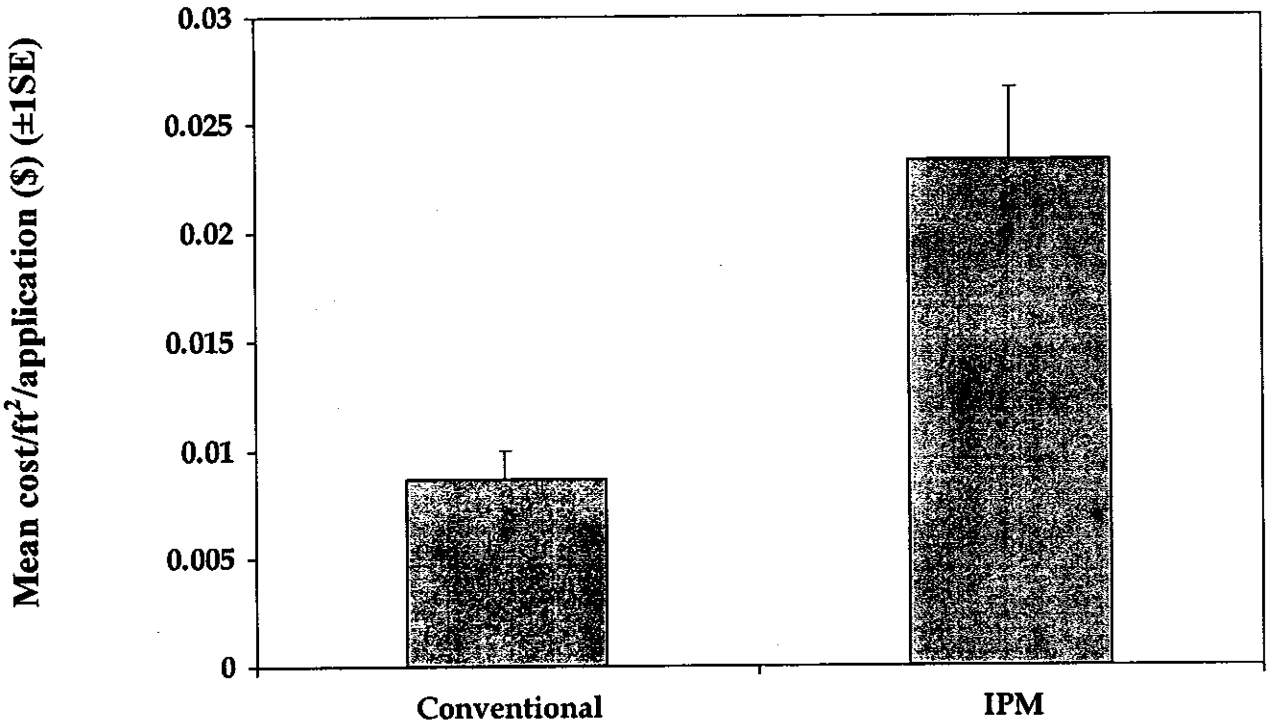

Figure 8. Cost of mite control under conventional and IPM programs. The cost of using IPM for twospotted spider mite control was significantly higher under IPM than conventional methods.($p = 0.0150$).

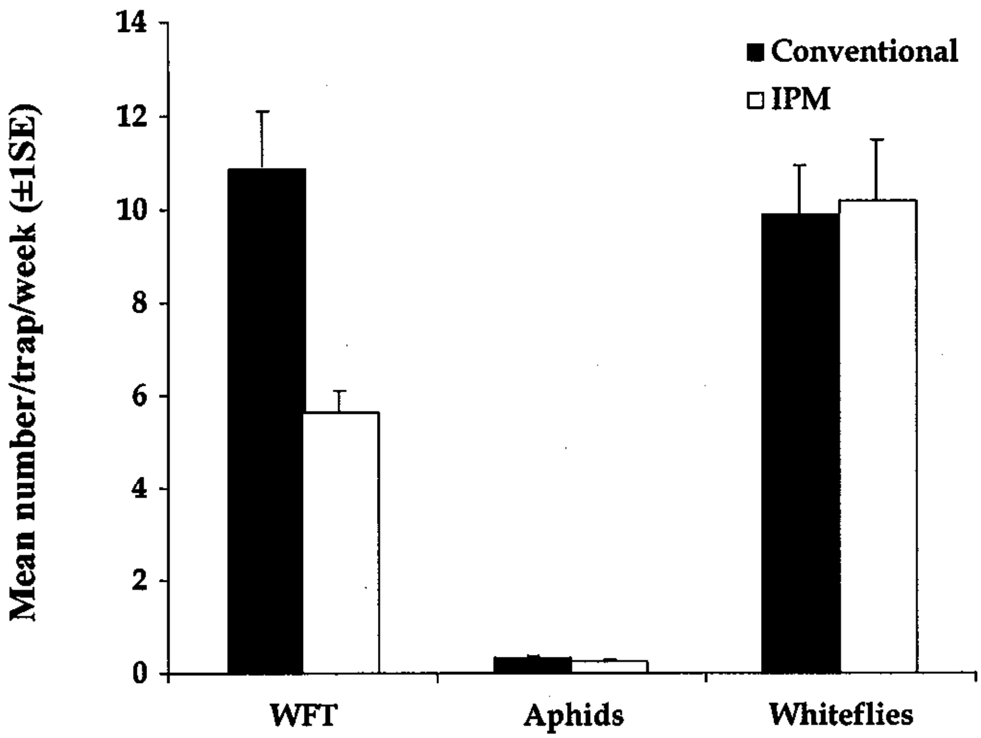

Figure 9. Yellow sticky trap catch in conventional and IPM houses across all nurseries. There were significantly fewer western flower thrips ($p = 0.0001$) trapped in the IPM houses. There was no significant difference in density due to treatment for either aphids ($p = 0.1204$) or whiteflies ($p = 0.8615$).

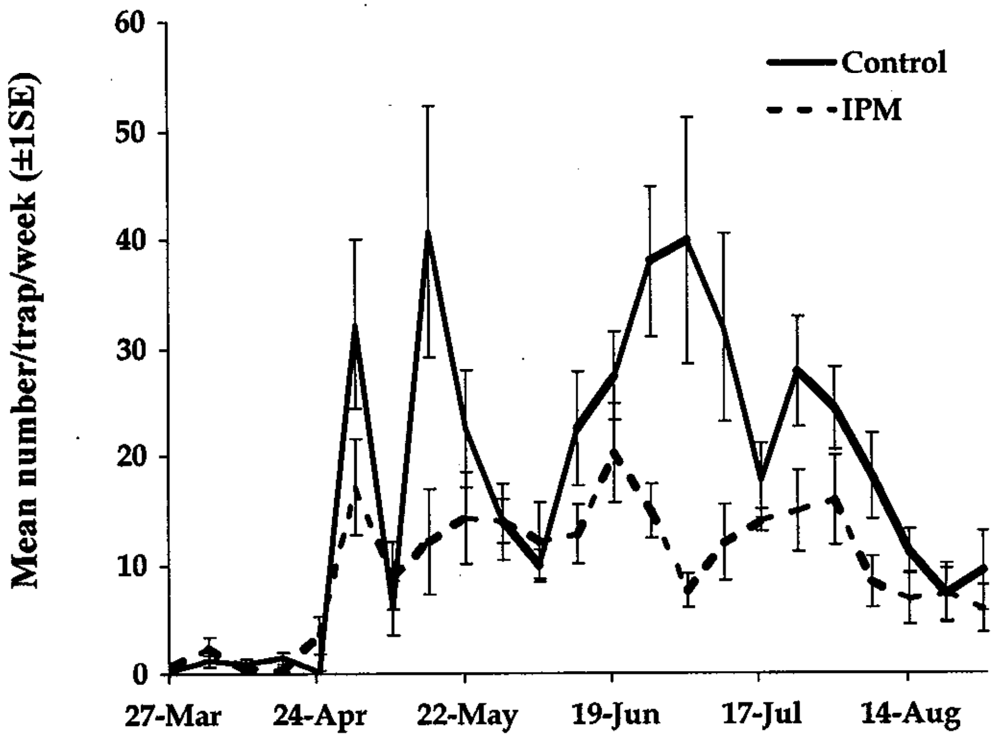

Figure 10. Western flower thrips populations in conventional vs. IPM houses by date. The largest significant differences in thrips levels between the conventional and IPM treatments were observed from mid-June to mid-August, the period of peak thrips pressure.

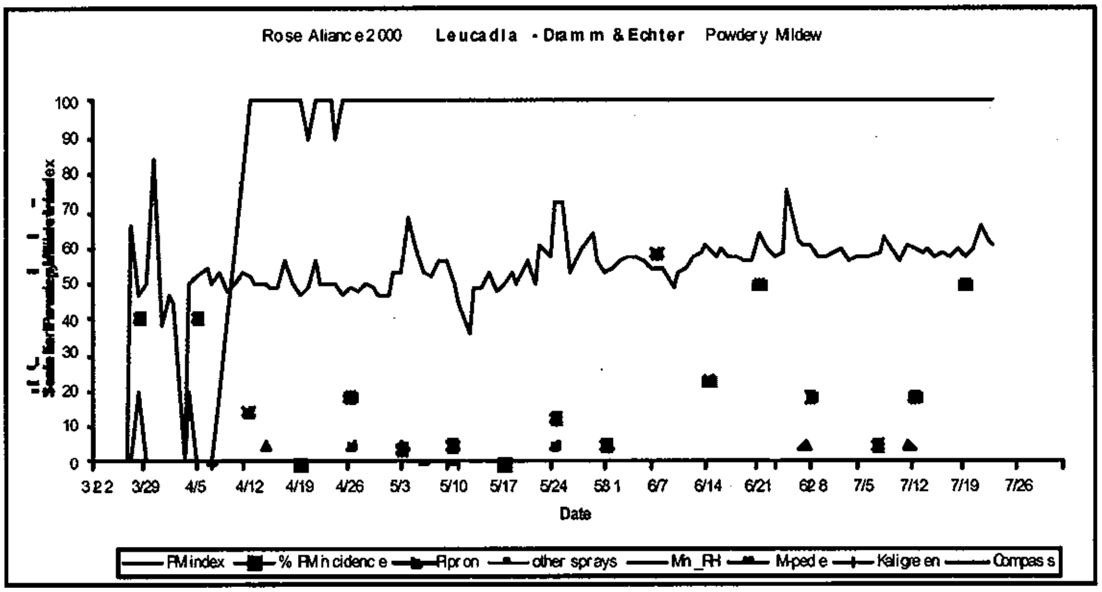

Figure 11. Powdery mildew occurrence in the IPM house at Dramm and Echter, Encinitas. The mildew index is high for the duration of the study, while mildew incidence fluctuates.

Treatment	Cost/ft.^{2}/application	Amount Used per Application
Conventional	\$0.006 to \$0.01	100 to 150 gallons/ 10,000 ft.^{2}
IPM Startup	\$0.02 to \$0.03	1 to 50 vials/10,000 ft.
IPM Maintenance	\$0.005 to \$0.008	2 to 5 vials/ 10,000 ft.^{2}

Table 1. Miticide costs under conventional control, IPM startup (first four to eight weeks) and IPM maintenance. One vial contains 2000 *Phytoseiulus persimilis*.