Greenhouse IPM with an Emphasis on Biocontrols

Produced by the Pennsylvania Integrated Pest Management Program
Greenhouse IPM with an Emphasis on Biocontrols

Produced by the Pennsylvania Integrated Pest Management Program

The PA IPM Program is a collaboration between the Pennsylvania Department of Agriculture and The Pennsylvania State University aimed at promoting Integrated Pest Management in both agricultural and nonagricultural settings.

PennState
College of Agricultural Sciences
Agricultural Research and Cooperative Extension
Department of Entomology
Department of Plant Pathology

Pennsylvania Department of Agriculture
Preface

The Pennsylvania Integrated Pest Management Program (PAIPM) is pleased to provide Greenhouse IPM with an Emphasis on Biocontrols, designed to help greenhouse growers implement biological control (biocontrol) and Integrated Pest Management (IPM). PAIPM is a collaboration of the Pennsylvania Department of Agriculture and The Pennsylvania State University. PAIPM strives to promote IPM in agricultural, urban, and suburban environments. For a full description of PAIPM, visit our Web site: http://paipm.cas.psu.edu/.

This manual was produced in response to the lack of material on greenhouse IPM and biocontrol. It begins with an introduction to IPM and its principles, information on starting an IPM/biocontrol program and using compatible pesticides, and then addresses many of the most common greenhouse pests and their biocontrols. The emphasis throughout is biocontrol. This manual is designed to educate commercial greenhouse operators, crop consultants, and IPM scouts to develop biocontrol systems for greenhouses that will maximize yields while reducing pesticide usage. Not all biocontrols or all pests are included in this manual; it focuses on some of the most common pests and the biocontrols used to manage them. Pesticides mentioned in this manual are current as of January 2005.

Greenhouse production is rapidly growing in Pennsylvania and surrounding states, providing plentiful food and ornamental crops. At the same time, the public is demanding greenhouse-grown food produced with minimal pesticide applications. IPM provides an avenue to meet these demands by heavily relying on alternatives to pesticides such as biocontrol and good horticultural practices, and turning to pesticides only when absolutely necessary.

The institutional collaboration embodied by PAIPM allows us to draw on Department of Agriculture technical experts and Penn State faculty. Moreover, more than 10 years of effort in implementing biocontrol and IPM in working, commercial greenhouses in Pennsylvania means that the information contained in this manual is very practical and designed to instruct greenhouse operators through a stepwise process. For instance, PAIPM has provided one-on-one instruction for greenhouse growers in implementing IPM including pest monitoring, biocontrol, starter plant inspection, and proper pesticide selection. In addition, this program provided a training opportunity for PDA plant inspectors, cooperative extension personnel, and others so that the IPM message could be carried across the state.

We hope that this manual will encourage growers to develop their own IPM programs and train their employees to become familiar with IPM practices.

—Cathy Thomas, PDA PA IPM coordinator;
Ed Rajotte, professor of entomology and Penn State PA IPM coordinator
Acknowledgments

Project Coordinator
J. Kenneth Long Jr., PA IPM program assistant, Penn State

Primary Author
Cathy Thomas, PA IPM coordinator, Pennsylvania Department of Agriculture

Editorial Modifications
James Steinhauer, former PA IPM coordinator, Pennsylvania Department of Agriculture

Contributing Authors
Dr. R.A. Dunn, Institute of Food and Agricultural Sciences, University of Florida
Dr. Gary W. Moorman, professor of plant pathology, Penn State
Dr. Ruth Welliver, virologist, Pennsylvania Department of Agriculture

PA IPM Program Staff
Cathy Thomas, PA IPM coordinator, Pennsylvania Department of Agriculture
Dr. Ed Rajotte, professor of entomology, Penn State, PA IPM Coordinator
Kristie Auman-Bauer, public relations and outreach coordinator, Penn State
Lyn Garling, education specialist, Penn State
Kristine Kuhn, IPM information specialist, Penn State
J. Kenneth Long Jr., PA IPM program assistant, Penn State

Reviewers
David Bingaman, chief of conservation and agricultural technology division, Pennsylvania Department of Agriculture
Carol Glenister, president and entomologist, IPM Laboratories, Inc.
Rayanne Lehman, entomologist, Pennsylvania Department of Agriculture
Dr. Ed Rajotte, professor of entomology, Penn State
Jim Stimmel, entomologist, Pennsylvania Department of Agriculture
Dr. Karl Valley, chief of Plant Protection Division, Pennsylvania Department of Agriculture

Designer
Barbara First, graphic design specialist, Penn State

Editor
Amanda Rudisill, writer/editor, Penn State

Photo Credits
Cathy Thomas, PA IPM coordinator, Pennsylvania Department of Agriculture
Tracey Olson, plant pathologist, Pennsylvania Department of Agriculture
Sandy Gardosik, entomologist, Pennsylvania Department of Agriculture
# Contents

Getting Started with Greenhouse IPM ........................................ 5  
Principles of IPM ..................................................................... 6  
IPM Techniques ................................................................. 7  
Biocontrol ............................................................................ 13  
Pesticide Compatibility ......................................................... 15  

Key Greenhouse Pests ............................................................. 20  
Soil Dwellers ...................................................................... 22  
Sucking Pests ...................................................................... 28  
Leaf-Chewers .................................................................... 59  
Plant Pathogens .................................................................. 63  

Biocontrol Organisms ............................................................. 73  
Predators ............................................................................. 73  
Parasitoids .......................................................................... 76  
Parasites ............................................................................. 79  
Pathogens ........................................................................... 80  

Glossary ................................................................................ 81  

Resources ............................................................................. 85  

Appendixes ........................................................................... 90  
  Appendix A. Monitoring and Scouting Techniques for Greenhouse Plants .......... 91  
  Appendix B. Greenhouse IPM Crop Information Reporting Form ..................... 92  
  Appendix C. Beneficial Organisms .................................................. 95  
  Appendix D. Quick Methods for Evaluating Biocontrol Shipments .................. 97  
  Appendix E. Biocontrol Suppliers ............................................. 99  
  Appendix F. Biorational Pesticides .......................................... 100
Definition of IPM

Integrated Pest Management (IPM) is an approach to managing pests by using appropriate physical, cultural, biological, and chemical tactics that are safe, profitable, and environmentally compatible. One of the tactics included in IPM is using biocontrols—enlisting predators, parasites, or pathogens of pest organisms to help manage the pests. IPM allows growers to use fewer chemical pesticides and still produce a quality product.

Biocontrol

IPM/biocontrol requires a hands-on approach over an extended period to learn and apply successfully. Growers need to learn pest monitoring techniques, pest and parasite life cycles, timely release of parasites, population assessment of both parasitized and nonparasitized pests, how to determine economic pest thresholds, appropriate biocontrols available, and, when necessary, the blending of compatible chemical controls with biocontrols to manage the pest complex.

This manual enables growers to develop a practical management strategy within the production constraints of their own greenhouses. Experience has shown that growers using IPM/biocontrol systems have been able to increase crop quality and yield. The program also reduces pesticide resistance in target pests, creates a safer working environment, and reduces grower dependence on pesticides, thus potentially lowering costs of production and increasing income levels through the marketing of high-quality, higher-yielding crops.

Pennsylvania greenhouse IPM projects with cooperating growers have been funded by grants from the United States Environmental Protection Agency—Region 3, Pesticide Environmental Stewardship Program, the Pennsylvania Department of Agriculture, The Pennsylvania State University, the Pennsylvania Vegetable Growers Association, and Sustainable Agriculture Research and Education (SARE).

HISTORICAL ACCOUNT OF EUROPEAN BIOCONTROL

Most past successes in greenhouse biocontrol have occurred in the Netherlands and the United Kingdom, mainly because at one time these two countries contained more than half of the world’s greenhouse vegetable acreage. In the late 1960s, cucumber grower Jan Koppert cautiously started experimenting with predatory mites to control red spider mites. The success of these experiments laid the foundation for biological crop protection. Koppert is currently the international market leader in biological greenhouse crop protection. Large-scale production of natural enemies such as Encarsia formosa and Aphidius colemani takes place in the main facility located in the Netherlands. In addition to Koppert, several other large producers include Biobest (Belgium), a leader in bumble bee pollination and biocontrol production; Syngenta Bio-line (England and California); and Applied Bio-Nomics Ltd., Canada’s largest producer of biocontrols.
Principles of IPM

Integrated Pest Management: A Combination of Management Tactics

IPM involves the integration of cultural, physical, biological, and chemical pest management techniques such as exclusion, sanitation, scouting, using compatible pesticides, accurate pest identification, threat assessment, and record keeping. The main focus of this manual is biocontrol, but the basic principles of IPM are scouting and thresholds. Scouting is simply inspecting the crop (usually weekly) for the presence of pests. Thresholds are simply deciding whether pests are abundant enough to require a control treatment. If scouting and thresholds were the only IPM methods practiced by a grower, pesticide use could usually be reduced by at least 50 percent compared to spraying on a regular schedule.

Understanding the life cycle and behavior of insect pests is important in developing an effective control strategy. Knowledge about the weak link in a pest’s life cycle can help growers choose the most appropriate control strategy. Knowledge of the biocontrol organism’s life cycle is also essential for a proper biocontrol release strategy.

Scouting

Scouting is accomplished in various ways including using sticky traps, pheromone traps, baits, visually inspecting plants, among others. Specific scouting tactics for pests are listed where appropriate.

Various resources are available to help identify the pests that may occur in greenhouses. A monthly guide from Cornell and Rutgers, Northeast Greenhouse IPM Notes, is available at http://www.rce.rutgers.edu/pubs/greenhouseipmnotes/ (accessed 6/3/2004).

Thresholds

Economic threshold (ET) is the number of pests whose injury to the plants cause a crop loss in dollars greater than the amount of money managing the pest would cost. Basically, the ET is the level that actually produces damage that is more expensive than intervention. The ET is usually expressed in numbers of pest individuals per some unit (e.g., pests per square foot, per plant, per feet of row).

The purpose of the ET is to give growers time to implement a management tactic before economic loss is reached, thereby saving as many dollars as possible while making sure that it is cost-effective to implement the management tactic. The ET is the signal to take action.

In practice, many crops have no established ET. Over time, growers must determine their individual ETs for a given pest. One grower may accept 10 to 15 thrips per sticky card per week, while another grower with a history of Impatiens Necrotic Spot Virus (INSV) will not accept five thrips per sticky card per week. Or the ET may depend on the growth stage of the crop. A generally acceptable threshold for whiteflies might be one-half per card per day when the crop is young, and two per card per day as the crop reaches maturity. In some cases, biocontrol organisms should be released as soon as a pest is detected.

County extension educators can provide current information on pest outbreaks as well as other recommendations on management.

REFERENCES


Exclusion
How can pest problems be prevented before they start?

CLEAN TRANSPLANTS
In many cases, serious pest and disease problems that plague growers throughout the growing season result from purchasing infested transplants, cuttings, or plugs. Inspect what you are buying! Selecting a reputable grower ensures a quality transplant. If you are growing your own transplants, follow strict sanitation procedures and inspect seedlings weekly for pest and disease development. Preventing a problem before it becomes established can save a lot of time, effort, and expense.

- Insect screens can exclude aphids, whiteflies, and thrips from entering through doors and ventilating systems.
- Cover all soil floor surfaces with concrete, black plastic, or weed barrier.
- Inspect incoming plants immediately to prevent unwanted pest entry.
- Keep people and “pet plants” out of crop areas as much as possible.
- Keep doors closed.

Cultural Control
What can be done to develop healthy, resistant plants?
Making the greenhouse less friendly to pests is possible by manipulating the greenhouse environment. Varying the time of planting or harvesting, applying water and fertilizer, and rotating crops in greenhouses may have a significant effect on the survival and growth of pest populations. Other cultural tactics include using a proper growing medium (correct pH, consistency, texture, etc.), controlling the temperature and humidity, maintaining appropriate amounts of nutrients and water, and choosing resistant varieties of plants.

Sanitation
How can weeds and crop residue be managed to prevent a pest recurrence?

SANITATION
Weed management is critical to the success of a biocontrol program both before and during crop production. Weeds serve as reservoirs for pests and diseases and may upset the predator–prey balance you are trying to establish in the crop. Maintaining a weed-free zone around the outside perimeter of the greenhouse is also critical for the same reason. Using an herbicide to quickly knock down a well-developed weed population will have pests scrambling for another food supply, which will probably be your crop. Physically remove weeds and destroy them on a continuing basis (Figure 1).

To prepare for next year’s spring greenhouse crop, the end-of-season cleanup is critical to prevent carryover of pests and diseases into the next crop cycle.

- Remove and destroy all plant debris including weeds both inside and outside the greenhouse, especially those near doors and vents. If plants are infested with pests, place them in a bag and destroy. Do not place infested plant material in dump piles near greenhouses.
- Pressure-wash the interior of the greenhouse with a disinfectant solution.
- Increase greenhouse temperature (after crop removal) to over 80°F for several weeks. This increases the metabolism of pests left in the greenhouse, causing them to starve in the absence of a food source. High sunlight and temperature can pasteurize the greenhouse. Heat treatment is preferred over cold treatment since cold temperatures induce insect hibernation rather than starvation.
• Eliminate areas of standing water—insects will survive with a water source.
• Remove areas of algae since it is a food source and breeding area for fungus gnats and shore flies.
• Consider installing insect screens over vents to prevent whiteflies, thrips, and winged aphids from entering.
• The soil or growth medium should be treated for pests and diseases through crop rotation and/or steaming. This will reduce carryover of pests such as thrips and spider mites, which tend to hide in sheltered areas until favorable environmental conditions return. Steaming is effective in eliminating insects, diseases, weeds, and nematodes.

After crop removal and other greenhouse treatments, place yellow sticky cards in the empty greenhouse to monitor for any lingering winged pests. Check the cards weekly to determine if further action is required. Some growers find it helpful to monitor for pests by placing sticky cards in the greenhouse 1 to 2 weeks before planting the next crop.

Always use the cleanup procedures listed above before using a chemical treatment. This will reduce the need for chemicals at the beginning of the next crop cycle when plants are young and tender. If pesticides are used as a corrective measure to destroy pests from a previous crop and natural enemies or bumble bees for pollination will be used in the next crop cycle, use the following guidelines:
• Use selective pesticides that are nontoxic or only slightly toxic to natural enemies (check biocontrol supplier for current recommendations).
• Use pesticides with short residual activity. Some compounds persist for a few days and others persist for many months. If you plan to use biocontrols for pest control or bumble bees for pollination, do not use long residual pesticides.
• Some of the long residual pesticides to avoid include synthetic pyrethroids, carbamates, chlorinated hydrocarbons, and organophosphates. For example, Endosulfan (Thiodan®) requires a three-month waiting period before using bumble bees.
• Some short residual compounds include pyrethrins (Pyganic®, listed by the Organic Materials Review Institute), insecticidal soap, horticultural oil, and azadirachtin (insect growth regulator).

For specific information on chemicals and their effects on natural enemies, consult a biocontrol supplier. For specific information on many compounds, see http://www.koppert.nl/e0110.html and http://www.biobest.be/ (accessed 9/27/2004).

Scouting

Which pests are present?

Crop scouting is the cornerstone of a successful IPM program. Early detection and treatment of pests is critical in high-value greenhouse vegetable and ornamental crops. With regular (weekly) scouting, insects, diseases, and cultural problems are detected early before they become major problems. Instead of relying on a weekly spray program, use this time to scout the crop to determine if a spray treatment is really necessary. Growers who scout weekly feel they save money by avoiding unnecessary sprays in addition to making the environment more worker friendly.

Designate one employee (two people for larger operations) who will be trained to scout for pests and evaluate the effectiveness of pest control treatments. Many growers find that hiring a crop/IPM consultant is worth the cost since this person is experienced in identifying problems.

SCOUTING TOOLS
• hand lens at least 10x or greater (Figure 2)
• scouting report forms and clipboard
• flagging tape
• sticky cards (traps), both yellow and blue
• clothes pins to attach sticky cards
• insect sample vials
• labels for vials
• marking pen
• forceps
• plastic spoons for collecting soil samples
• plastic bags for plant samples
• pH meter
• soluble salt meter (to determine presence of total dissolved salts in media)
• min/max thermometer

Figure 2: A hand lens is a critical IPM tool for proper pest identification. Choose a hand lens with 10x power or greater.