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Pest Management in Retail Greenhouses

Quick Links:

Choices for greenhouse pest management can vary depending on the size of a greenhouse and how a greenhouse is used. Basic integrated pest management practices such as inspecting incoming plants, weekly monitoring, sound cultural practices, pest identification and problem diagnosis are similar, whether a greenhouse is used for production or for retail sales, or whether the greenhouse is 3,000 sq. ft. or 30,000 sq. ft. in size.

Retail greenhouses have many challenges for managing pests that are different from production greenhouses. Retail greenhouses are open to the public, usually for long hours and often 7 days a week, making the timing of pesticide treatments difficult. These greenhouses contain a variety of mature plants ready for sale, often with delicate blooms. Plants arrive regularly from many different sources increasing the likelihood that pests will be brought into the greenhouse. Some plants are quickly sold while others remain in the greenhouse for long periods of time. The longer that plants stay in the greenhouse, the probability increases that insects will migrate to these plants. Another challenge is that many retailers now showcase gifts and other hard goods like wind chimes, knick-knacks and stuffed toys in their retail greenhouse and must be considered when treating plants for pests.

Many retail greenhouses are seasonal businesses with a high rate of employee turnover. Employees may have little experience in basic plant care or pest management. Providing basic training to employees on insect and disease identification will prevent major outbreaks and save time and money. Training is especially important for employees receiving incoming plants. Also, basic training on the proper care and maintenance of plants will help to prevent cultural problems and conditions favoring disease outbreaks.

Integrated Pest Management

Integrated pest management involves inspecting incoming plants, consistent monitoring, using good cultural practices, accurately diagnosing plant problems and pest management decisions.

Incoming Plants

Inspecting incoming plants is very important to prevent problems in retail greenhouses. Foliage of incoming plants should be carefully inspected for insect pests such as aphids, whiteflies and thrips, diseases such as powdery mildews, downy mildews, *Botrytis* blight and symptoms of virus infection or foliar nematodes. Stems and crowns of plants should be inspected for insects any abnormalities caused by disease and root health should be inspected.

Inspect all incoming shipments of plants and do not accept those with pest problems that cannot be cured such as viruses, bacterial leaf spots or foliar nematodes. For confirmation, send samples of plants showing symptoms to a diagnostic laboratory. Inspect plants upon arrival, taking plants out of the containers when possible and inspecting roots. When opening boxes, be able to recognize flying insects such as adult whiteflies, fungus gnats and shore flies. Adult whiteflies may be a sign that there are additional whiteflies on plants in immature stages. If adult fungus gnats are observed, inspect the plant stems at the soil line and roots for any damage. Observe new growth on plants for signs of thrips or aphids. Signs of thrips activity include distorted new growth or curled leaves. Tapping plants/new growth/flowers over a sheet of white paper will dislodge small insects and mite, making them easy to see. Signs of aphid infestation include empty white skins, curled new growth and shiny honeydew. Caterpillars will chew holes in the leaves, and are found primarily on perennials. If you notice a few caterpillars, they can be quickly handpicked and destroyed.

On shipments of foliage plants, inspect stems, petioles and under leaves for scale and mealybug. Look for stippling on foliage for signs of mites. If only a few incoming plants have mites, you can try washing off the underside of the leaves to wash off the mites. Knock plants out of containers and inspect the root systems for insect activity such as root mealybug or root aphids, or root diseases that cause root rot.

If you find insect activity and decide to keep the shipment, quarantine the plants from others in the greenhouse and treat immediately. Plants with root rot diseases will unlikely recover in a reasonable length of time for retail sale even after treatment. Plants with viral or bacterial diseases or foliar nematodes will not recover and should not be accepted. Plants infected with viral diseases may show symptoms such as a mosaic pattern (a pattern of yellow and green, healthy tissue on the same leaf), leaf distortion, yellow streaking, ring spots, or unusual line patterns. Plants infected with bacterial diseases may show a greasy or water-soaked appearance to the leaves. Plants infected with foliar nematodes can have off color leaves with brown angular spots with a distinct margin. You may see a patch-like symptom that resembles a fungal leaf spot disease.

Monitoring

Retail greenhouses should have a weekly, integrated pest management (IPM) program in place to detect problems early. A regular monitoring program using sticky cards and plant inspection is the basis of all pest management programs. Early detection and treatment will result in better pest control, while pest populations are low and before pests move throughout the greenhouse. Retailers will find through experience that some plants will need to be monitored more carefully than others throughout the course of a year.

Using Sticky Cards

Yellow sticky cards are recommended to detect winged insects including adult stages of fungus gnats, shore flies, thrips and whiteflies. Use small, 3" X 5" cards and change them each week to keep track of hot spots and to prevent them from becoming unsightly. Place some cards just above the plant canopy (to detect thrips and whiteflies) and some cards at pot rim level to detect fungus gnats. An explanation displayed to customers would be helpful and a good marketing too, something as simple as a sign saying, "The yellow sticky cards you see help us to trap pests, use fewer pesticides and keep plants healthy". Some retails prefer not to use sticky cards due their "ickyness" when covered with insects.

Plant Inspection

Plant inspection can be done when hand-watering or cleaning plants in addition to a regular weekly inspection. To conduct a weekly inspection, randomly select plants at ten locations in an area of 1,000 sq. ft., examining plants on each side of the aisle. Start this pattern at a slightly different location each week, walking through the greenhouse in a zigzag pattern down the walkway. Use a 10x handlens to examine the underside of leaves for insect pests and inspect root systems to determine plant health.

Record-keeping

Record information collected from sticky card counts and plant inspection including the pest numbers and their location, root health, overall plant health and the numbers and species of plants inspected. Records of pest numbers and locations will help to identify sources of pests and indicate whether treatment is needed or if control measures were successful or need repeating. Monitoring and record keeping will help to determine if the pest population decreased, increased or stayed the same since treatment has begun, if treatments need to continue and where pests coming from. Are insects established in the greenhouse on weeds, or on a specific plant or group of plants, or did they arrive with a new shipment?

Decision Making

Diagnosis

Accurate diagnosis is key to management whether you choose pesticides or biological control. Many pesticides and most natural enemies are often specific to just one pest or

group of pests. If you are having trouble diagnosing a problem, visit the University of Massachusetts Extension website: www.umass.edu/umext/floriculture [1] and click diagnostics.

Cultural Practices for Management

Cultural mistakes are common problems in greenhouses. For example, most varieties of phlox and bee balm when placed in the shade will develop powdery mildew. Retailers can prevent powdery mildew and other diseases by choosing varieties of plants that are disease resistant whenever possible and by using proper cultural practices. Overwatering is another common cultural mistake. Plants that are overwatered will promote root diseases. Plants that have wet foliage for extended periods of time, will develop foliar diseases.

Space plants so that they are both attractive to the customer and sufficient to promote good air circulation. This will help prevent *Botrytis* and other foliar diseases. Promptly rogue out any plants that show signs of diseases. Train workers to regularly clean and groom plants so they are attractive and free of disease. Aprons with pockets are useful to hold debris from groomed plants until it can be disposed of properly. Train employees to properly water plants to avoid overwatering and be sure plants are watered early in the day so that the leaves dry quickly.

It is difficult to control pests in a year-round greenhouse, once pest populations are established. To prevent establishing populations, it is important to discard unsold plants whenever possible, monitor and treat any plants that are held over each year. Retail greenhouses will sometimes hold over plants that do not sell during a holiday period which will serve as a source for pests.

Pest Management Options

When only a few plants are infested, plants can be moved and treated outdoors (weather permitting) or moved into a production house for treatment. This is also the best option if gifts and other hard goods are displayed in the greenhouse. Small infestations can be spot treated. Heavily infested and/or diseased plants should be promptly removed into a trash bag, tied up and removed from the greenhouse.

Biological Control

Biological control is an option for managing pests on plants in retail greenhouses. Natural enemies are living organisms that need to be released when pest populations are low and are not effective for clean-up, once high populations of pests are established. Natural enemies include predators, parasitoids, beneficial nematodes and beneficial bacteria and fungi. Choosing natural enemies and a release schedule will need to be customized according to the specific pests and populations, size of the greenhouse, size and number of plants in the greenhouse, and how long plants will be in the greenhouse.

As suggested with the use of sticky cards, retail greenhouses using natural enemies may also want to display information to their customers about their use of natural enemies.

Information on using natural enemies can be obtained from the floriculture website, www.umass.edu/umext/floriculture [1] and from the *2011-2012 New England Greenhouse Floriculture Guide*.

Pesticides

There are many pesticides available for greenhouse use. Some pesticides will leave an unsightly residue or burn blooms and some pesticides will specifically be labeled, safe for blooms. See table1 and table 2 for selected pesticides labeled for greenhouse use. Additional pesticides and more detailed information is available in the *2011-2012 New England Floriculture Guide, A Management Guide for Insects, Diseases, Weeds and Growth Regulators.*

Consider the pesticide container size and recommended application rates with regard to storage, shelf life and purchase price. Some pesticides sold as water soluble packets for safe handling, may have recommended application rates of 1 packet per 100 gallon of water. Other pesticides are sold in large quantities relative to small, recommended application rates. This is not a problem for large greenhouses, however, small retailers will not use enough pesticide to justify the expense. Greenhouses open year-round may invest in a wider selection of pesticides because they are used more often than a seasonal business. For best results, it is recommended that pesticides be used within one or two years. When choosing a pesticide, also consider how many different crops are listed on the label, the restricted entry interval (REI), pesticide residue and plant and blossom safety. See the websites at the end of this article to review pesticide labels, before purchasing a product.

The REI is located on the pesticide label and is the length of time between treatment and when the treated area or the greenhouse can be re-entered, depending up the pesticide's label. Most pesticides for greenhouse use will have a re-entry period of 4-24 hours. During busy times of the year, the REI may influence which material to choose.

Worker Protection Standards

In addition to REIs, there will be reference to the Worker Protection Standard (WPS) in the "Agricultural Use Requirement" section on the label. The WPS contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific information about personal protective equipment and REIs. Horticultural employers who use pesticides and who have one or more employees must comply with all of the provisions of the WPS. Owners of agricultural establishments and members of their immediate family are exempt from some WPS requirements. However, they must observe the appropriate REIs and must use the proper personal protective equipment listed on the pesticide label.

Every retail greenhouse manager should have a copy of the following publications to explain responsibilities and comply with WPS, including the training of employees. These publications are available from: US Environmental Protection Agency [2]

- *WPS Reference Guide*
  Includes complete addition of EPA's "How to Comply Manual" plus technical information on pesticide safety.
- *For Workers: "Protect Yourself from Pesticides Guide for Agricultural Workers."*
  Bilingual (English/Spanish). Also available in seven other foreign language translations.
- *For Handlers: "Protect Yourself from Pesticides Guide for Pesticide Handlers."*
  Available in both English and Spanish.

Questions pertaining to Worker Protection Standards can be answered by your state Department of Agriculture or Extension Specialist.

In Massachusetts , questions pertaining to WPS can be answered by contacting one of the following individuals:

- Jill Warren, Dept. of Agricultural Resources (Dept. of Food and Ag.)
  Tel. 617-626-1771 Email: Jill.Warren@state.ma.us [3]
- Natalia Clifton, Pesticide Education Program, UMass Extension
  Tel. 413-545-1044 Email: nclifton@ent.umass.edu [4]

Pesticide application methods for small retail greenhouses

Pesticide application methods will vary according to the size of the greenhouse. Hand-pump sprayers are used in many small greenhouses for pesticide applications. This method is adequate for spot treatments but is not the best choice for treating an entire greenhouse. It is difficult to maintain continuous pressure and the spray coverage is likely to be uneven as the pressure changes when using a hand-pump sprayer. For some greenhouses a better choice would be a small generator sprayer that provides constant pressure for uniform application. This equipment is likely to be more expensive than hand-pump sprayers, but will result in better pest management. Some small retail greenhouses may also choose total release pesticides that are safe for blooms and require no special application equipment. Coverage will be inadequate on large mature plants and has limited effectiveness against many pests, such as immature whiteflies. Total release pesticides should not be used in retail greenhouses that contain hard good gift items.

References:

Websites for Companies, Pesticide Labels and MSDS listed in this article.

- Pesticide Labels & MSDS - C&P Press
  www.greenbook.net [5]
- CDMS Labels & MSDS Info
  www.cdms.net [6]
- Olympic Company Product Labels
  www.olympichort.com [7]

- Biosafe Systems
  http://www.biosafesystems.com/ [8]

2011-2012 New England Greenhouse Floriculture Guide [9]

Distributors for Pesticides and Other Pest Management Products

- Griffin Greenhouse & Nursery Supplies, Tewksbury , MA (978) 851-4346
  www.griffins.com [10]
- W.H. Milikowski, Stafford Springs CT (860) 684-5811
- Helena Chemical Company, Hatfield , MA (413) 247-3126

Distributors for Biological Control Products

- Green Spot, Nottingham , NH www.greenmethods.com [11]
- IPM Laboratories, Locke , NY www.ipmlabs.com [12]
- Koppert, Romulus , Michigan www.koppert.com [13]
- Syngenta, www.syngentabioline.com [14]

For contact information for additional commercial suppliers, see *Suppliers of Beneficial Organisms in North America* by Charles Hunter, available from the California Environmental Protection Agency, available online at http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm [15]

Resources

- New EnglandGreenhouse Update
  www.negreenhouseupdate.info [16]
- Stack, L. Editor. *2011-2020 New England Greenhouse Floriculture Guide; A Management Guide for Insects, Diseases, Weeds and Growth Regulators*. Northeast Greenhouse Conference: http://www.negreenhouse.org/index.html [17]
- UMass Extension Plant Diagnostic Lab (Plant disease diagnosis, weed ID, insect ID)
  Contact: mbdicklo@umext.umass.edu [18] Plant Diagnostic Laboratory
  Phone: (413) 545-3208
  http://www.umass.edu/umext/floriculture/grower_services/index.html [19]
- Worker Protection Standards
  http://www.epa.gov/oecaagct/htc.html [2]
- Pundt L. 2009. Pest Management for Retail Greenhouses and Garden Centers. [20]
  University of Connecticut

TABLE 1. SELECTED INSECTICIDES LABELED FOR GREENHOUSES

Insecticide (common name, trade name, reentry interval, toxicity)	Application/Target Pests	*Available Container Sizes	Crops and Comments

Insecticide (common name, trade name, reentry interval, toxicity)	Application/Target Pests	*Available Container Sizes	Crops and Comments
Abamectin (Avid 0.15 EC) 12 hr. REI, Warning	Foliar application for leafminers, mites, thrips and whiteflies.	Avid 8 oz. and 1 Qt.	Greenhouse ornamentals except ferns and Shasta daisies. Repeat applications to newly developed tissue may be necessary.
Acetamiprid (TriStar 30 SG) 12 hr. REI	Foliar application for aphids, mealybugs, whiteflies, scale insects, caterpillrs and others.	TriStar 8 0z., 2 lb.	Greenhouse ornamentals and some vegetable transplants. Translaminar and systemic.
Azadirachtin (Azatin XL, Molt-X, Ornazin) 4 hr. REI, Caution	Foliar application for aphids, caterpillars, leafminers, thrips, whiteflies. Foliar application for fungus gnat and shorefly adults and soil application for larvae.	Azatin XL, 1 Qt.	Greenhouse ornamentals, herbs and vegetables. Insect growth regulator for immature stages of insects. Repeat applications needed.
Bacillus thuringiensis Subsp. *kurstaki* (Dipel DF) 4 hr. REI, Caution	Foliar application for many caterpillars	Dipel DF 10.3%, 1 lb.	Greenhouse ornamentals, herbs and vegetables.
Beauveria bassiana Strain GHA (Botanigard ES, Botanigard 22 WP, Mycotrol O)) 4 hr. REI, Caution	Foliar application for aphids, mealybugs, thrips and whiteflies.	Botanigard ES 1 Qt. and 1 Gal. Botanigard WP 3 lb. Mycotrol O 1 Qt.	Greenhouse ornamentals, herbs and vegetables. Contains a fungus that must contact the target pest. Do not tank mix with fungicides. Thorough spray coverage needed. Treat when insect populations are low. Do not apply through irrigation system.Note: The ES formulation has been shown to cause edema-like symptoms on tomato plants.
Bifenazate (Floramite SC)	Foliar application for mites	Floramite SC 1 Qt.	Greenhouse ornamentals. For all life stages of two-spotted spider mite.

Insecticide (common name, trade name, reentry interval, toxicity)	Application/Target Pests	*Available Container Sizes	Crops and Comments
4 hr. REI, Caution			
Pymetrozine (Endeavor 50 WDG) 12 hr. REI, Caution	Foliar application for aphids.	Endeavor 6-2.5 oz. Water soluble packets	Greenhouse ornamentals. Feeding inhibitor, aphids stop feeding within hours. Translaminar, systemic. Controls aphids for up to two weeks.
Horticultural Oil (SuffOil-X, Ultra -Pure Oil) 4 hr. REI, Caution	Foliar application for aphids, fungus gnat adults, mealybugs, scale, mites, thrips and whiteflies. Also powdery mildew.	Ultra-Pure Oil, SuffOil-X 2.5 Gal.	Most greenhouse ornamentals, herbs and vegetables. A two-week interval between treatments is recommended. May burn flowers. See label for plant safety.
Imidacloprid (Marathon II) 12 hr. REI, Caution	Foliar application for aphids, leafminers, mealybugs, thrips (suppression) and whiteflies.	Marathon II 250 ml	Greenhouse ornamentals and vegetable bedding plants. Control for up to three weeks. Broad label including vegetable transplants.
Insecticidal Soap (M-Pede) 12 REI	Foliar application for aphids, leafminers, mites, mealybugs, root mealybug, shore flies, scale, thrips, whiteflies	M-Pede 2.5 Gal.	Greenhouse ornamentals, herbs and vegetable bedding plants. Good coverage is needed. Works on contact. Avoid treatment when plants are stressed.
Spinosad (Conserve SC) 4 hr. REI, Caution	Foliar applications for thrips, leafminers and caterpillars	Conserve 1 Qt.	Greenhouse ornamentals. Contact and stomach poison. Thorough coverage important. Thrips resistance reported.
Pyriproxyfen (Distance EC) 12 hr. REI, Caution	Foliar application for whiteflies, scale and mealybug. Soil application for fungus gnats and shore fly larvae.	Distance EC 1 Qt.	Most greenhouse ornamentals. See label for plant safety. For immature stages.
Parasitic nematodes	Soil application for fungus gnat larvae		Greenhouse ornamentals, herbs and vegetable

Insecticide (common name, trade name, reentry interval, toxicity)	Application/Target Pests	*Available Container Sizes	Crops and Comments
(Scanmask, Nemasys, NemaShield) REI Exempt		Scanmask Large, middle, hand application, dispersible sprayable form.	bedding plants. Apply to moist growing media, temperatures between 50-85F.

TABLE 2. SELECTED FUNGICIDES LABELED FOR GREENHOUSES

Fungicide (common name, trade name, reentry interval, toxicity)	Application/Target Diseases	*Available Container Sizes	Crops and Comments
Bacillus subtilis QST713 (Cease) 4 hr. REI	Cease: Suppresses diseases such as *Rhizoctonia, Pythium, Fusarium, Phytopthora, Alternaria, Botrytis,* powdery mildew, downy mildew, leaf spot diseases.	Cease 1 Gal.	Preventative biological fungicide. Also labeled for herbs and leafy vegetables.
Bacillus subtilis GB03 (Companion) 4 hr. REI	Companion: Supresses diseases such as *Rhizoctonia, Pythium Fusarium, Phytophthora*	Companion 1, 2.5, 5 Gal.	Preventative biological fungicide.
Chlorothalonil (Daconil Ultrex) 12 hr. REI,	Foliar application for broad spectrum of foliar diseases including blackspot, *Botrytis*, powdery mildew and rust and others	Daconil Ultrex 5 lb.	Greenhouse ornamentals.
Fenhexamid (Decree WDG) 4 hr. REI,	Foliar application for *Botrytis* only.	Decree 2.5 lb.	Greenhouse ornamentals.
Fludioxonil (Medallion	Foliar application for *Alternaria, Botrytis,*		Greenhouse ornamentals.

Fungicide (common name, trade name, reentry interval, toxicity)	Application/Target Diseases	*Available Container Sizes	Crops and Comments
WP) 12 hr. REI, Caution	*Cercospora* and *Rhizoctonia*. soil application for *Rhizoctonia* and *Thielaviopsis.*	Medallion 8-1 oz. packets	
Hydrogen dioxide (Oxidate, ZeroTol) 0 hr. REI 1 hr. REI (spray)	Foliar application for anthracnose, downy mildew, powdery mildew. Soil drench for *Pythium* root rot.	ZeroTol 27% 2.5, 30 Gal.	ZeroTol: Greenhouse ornamentals. Oxidate: Greenhouse vegetables, herbs. Contact oxidizing sanitizer.
Ipodione (Chipco 26019) 12 hr. REI,	Foliar application for *Alternaria* and *Botrytis*. Soil application for *Rhizoctonia* and others.	Chipco 26019 2 lb.	Greenhouse ornamentals.
Phosphorous acid (Alude) 4 hr. REI	*Pythium, Phytophthora,* Downy mildew and others.	Alude 2.5 Gal.	Systemic fungicide, stimulates plants' natural defenses. Preventative.
Potassium bicarbonate (Milstop SP, Kaligreen) 4 hr. REI, Caution	Foliar application for powdery mildew and others.	Milstop SP 5 lb.	Greenhouse ornamentals, herbs and vegetables. Contact eradicant fungicide. Uniform coverage important. High rates may burn some plants.
Thiophanate methyl (Cleary's 3336 F, FungoFlo F, OHP 6672 F) 12 hr. REI,	Foliar application for broad -spectrum of foliar diseases, anthracnose and soil application for *Rhizoctonia* and *Thielaviopsis*.	Cleary's 3336-F, FungoFlo F 1Qt., 1 Gal. and 2.5 Gal. OHP 6672 F 2.5 Gal.	Greenhouse ornamentals. Systemic fungicide. *Botrytis* has shown widespread resistance.
Thiophanate methyl and chlorothalonil (Spectro 90	Foliar application for *Alternaria*, *bBtrytis*, *Cercospora*, powdery	Spectro 90 WDG 5 lb.	Greenhouse ornamentals. Contains the active ingredients found in Daconil and Cleary's 3336.

Fungicide (common name, trade name, reentry interval, toxicity)	Application/Target Diseases	*Available Container Sizes	Crops and Comments
WDG) 12 hr. REI,	mildew, *Rhizoctonia* and others.		
Triadimefon (Strike WDG) 12 hr. REI,	Foliar application for powdery mildew, rust, black spot of roses.	Strike 8 oz.	Greenhouse ornamentals. Systemic fungicide.
Trichoderma harzianum Rifae strain KRL-AG2 (PlantShield HC)	*Pythium, Rhizoctonia, fusarium, Cylindrocladium* and *Thielaviopsis.* Suppression of botrytis and powdery milcew.	PlantShield 1 lb., 3 lbs.	Preventative biological fungicide. Becomes active when soil temperatures are above 50F.
Triflumizole (Terraguard 50 W) 12 hr. REI,	Foliar application for *Alternaria, Rhizoctonia,* powdery mildews, rust diseases. Soil application for *Rhizoctonia, Thielaviopsis*.	Terraguard 50 W 1 at.	Greenhouse ornamentals. See label precautions for use on impatiens.

*****Consider the recommended application rate and the available container sizes to help choose a pesticide for small greenhouses.

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Links:
[1] http://www.umass.edu/umext/floriculture
[2] http://www.epa.gov/oecaagct/htc.html
[3] mailto:Jill.Warren@state.ma.us
[4] mailto:nclifton@ent.umass.edu
[5] http://www.greenbook.net/
[6] http://www.cdms.net/
[7] http://www.olympichort.com/
[8] http://www.biosafesystems.com/
[9] http://www.umass.edu/umext/floriculture/pest_management/ne_pest_manage_guide.html
[10] http://www.griffins.com/
[11] http://www.greenmethods.com/
[12] http://www.ipmlabs.com/
[13] http://www.koppert.com/

[14] http://www.syngentabioline.com/
[15] http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm
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[20] http://www.hort.uconn.edu/ipm/greenhs/htms/09pest%20management%20for%20retail%20greenhousesjf.pdf