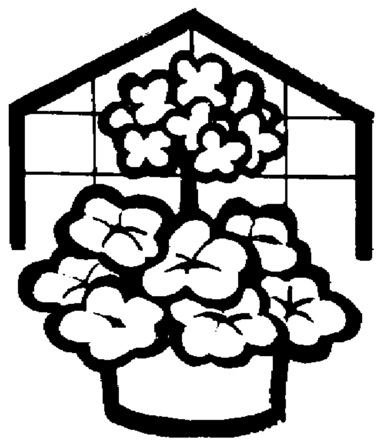
Pest Management Strategic Plan
for
Commercial Greenhouses in the Northeastern United States



Summary of a Workshop held
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The green industries, including greenhouse production, rank in the top four for market value of agricultural products in all 12 states in the Northeast region. They have a wholesale value of over $700 million in the six states for which statistics are reported. The variation in size and organization of Northeastern greenhouses is vast, including type of production (wholesale/retail), technology used, marketing options, and production season.

Because greenhouses create an ideal habitat for a variety of diseases, insects, and weeds, pest management activities are a primary factor in the cost of production and affect both yield and quality of the product. The variety of crops grown in a typical greenhouse operation makes pesticide selection complex, especially if there are food and ornamental crops in the same greenhouse, as is frequently true in bedding plant production. Limited pesticide options for some pest/crop combinations make pesticide rotation difficult, and insecticide resistance has developed in some insect populations. The appearance of new pests, and increasing importance of some old pests, leads to a continued need for education in pest identification. Integrated pest management (IPM) has been widely adopted, although the level of adoption, and sometimes the understanding of IPM, varies. Cultural methods of pest management are common but there is a desire for greater information on environmental methods of control and sanitation options. Biological control is becoming more common as a method of pest management, and there is a great need for both research and training in current and new biological control options.

PRIORITY ISSUES FOR COMMERCIAL GREENHOUSE PRODUCTION IN THE NORTHEASTERN UNITED STATES

The following list of priority issues for research, education, and regulation is based on the ranking of the list of 166 needs generated at the workshop. This list is arranged by priority within the areas of research, education, and regulatory needs. For the complete list of needs and their rankings, see Appendix 1. Information from other stakeholder surveys from Northeastern states is summarized in Appendix 2.

Research

- Development of banker plant biological control systems for a broader range of insect pests
- Development of new and more effective biological control organisms for root rot diseases
- Comparative economics of various biological control systems vs. pesticides
- Protocol for frequent use of disinfecting agents (for example, ZeroTol, XeroTon, KleenGrow) for management of *Xanthomonas*. Issues of importance are phytotoxicity to species and cultivars, efficacy, options for use as a preventative, use in overhead watering systems, and use in propagation systems.
- Development of a quick test for *Phytopthora* identification for use by growers and diagnostic labs
- Development of methodologies for maintaining viability of biological control agents during packaging and shipping (quality control)

- Development of easy-to-use, accurate and affordable disease test kits (like the virus test kits currently available) for more diseases
- Organic or products with low “days to harvest” intervals for management of powdery mildew in rosemary
- INSV-resistant varieties of ornamental host plants

Education

- Training on use of disinfection materials for disease management of *Botrytis*, *Pythium*, and *Thielaviopsis*
- Training on using environmental controls to manage *Botrytis* with current changes in heating and ventilation for cost savings, include concept of dewpoints, stress of rapid changes, etc.
- Comparison of efficacy and costs of different application techniques for biological control organisms
- Guidelines on what, when, how many, and how to apply biological control organisms taking into consideration the variations in greenhouse operations: size, environmental conditions, crops, etc.
- Training on using sanitation for insect management, including information on overwintering or survival in greenhouses without plant material
- Training of IPM scouts with an emphasis on hands-on training and creation of materials that owners can use to train new workers
- Creation of a communication/resource hub, creating an information path from industry to extension and research and back
- Creation and dissemination of educational materials on new/upcoming/potential pests: identification, biology, damage caused, hosts, etc., color photos, other species they can be confused with
- Training on cultural methods for fungus gnat and shore fly management, algae management for shore fly management, including droplet size for overhead irrigation, effect of nutrients and water management for shore fly management, management of standing water when using plastic trays
- Training on use of disease test kits as a part of scouting for disease management: for INSV and other diseases where kits are available
- Training on importance of weed management for disease and insect management: inside and outside greenhouse, especially with lower pesticide use and increasing use of biological control organisms, including nook and cranny weed management

Regulatory

- Development of additional effective pesticides for thrips
- Sale of disease test kits in smaller units to encourage use by growers
- Clear labeling of materials for management of pests in the greenhouse including standardization of label language pertaining to site/pests/plants.
- Clarification on use of low volume sprayers for pesticides, particularly appropriate rates and directions on pesticide labels

PEST MANAGEMENT STRATEGIC PLAN PROCESS

This Pest Management Strategic Plan (PMSP) covers commercial greenhouse production for the 12 states in the NE-IPM region: Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. Commercial greenhouse production includes both floricultural crops and vegetable crops, although in this region there is a much greater production of ornamentals than vegetables in greenhouses. Floricultural crops, as defined by the USDA, include bedding plants in flats, pots or hanging baskets, potted crops usually used inside (such as chrysanthemums and poinsettias, herbaceous perennials, foliage crops, and cut flowers) and propagative materials—such as cuttings and liners.

The development of a PMSP is a method of setting pest management priorities for a commodity and demonstrating stakeholder involvement in the process. A PMSP is developed by growers, commodity associations, university research and extension specialists, Cooperative Extension educators, crop consultants, and relevant agency representatives to address pest management needs and priorities for specific commodities in a particular state or region. The plans take a pest-by-pest approach to identifying the current management practices (chemical and non-chemical) and those under development. Ideally, a PMSP outlines the current state of pest management for a commodity at the state, regional, or national level and presents a prioritized list of needs for research, regulatory activity, and extension education (National Information System for the Regional IPM Centers http://www.ipmcenters.org/pmsp/index.cfm. Benefits of Crop Profiles and Pest Management Strategic Plans, O. Norman Nesheim & Russell F. Mizell, III, University of Florida).

Pest Management Strategic Plans (PMSPs) were developed to make realistic and current information on pest management practices and needs readily available to the Environmental Protection Agency (EPA) for use in regulatory decisions and risk/benefit assessments. The role of PMSPs has expanded into guidance for pest management research, education, and implementation based on stakeholder priorities. Funding agencies recognize PMSPs as credible documentation of stakeholder interest. Feedback from target audiences is valuable for initiating and guiding projects. Being able to cite stakeholder interest has become an important component for successful funding applications. This is particularly important for specialty crops that do not traditionally receive the same degree of private sector investment in crop protection materials. (Glen W. Koehler, 2005, New England Pest Management Network)

Advisory Group

The initial step in creating the PMSP was to identify an advisory group representing as much of the region as possible. We contacted 34 individuals from state universities working in research and extension, state departments of agriculture, industry, and IPM programs. We received 27 responses, which covered 11 states. The advisory group assisted with identifying the pests of interest and growers or other stakeholders to participate, prioritizing needs, and reviewing the final document.

The advisory group helped to identify a "Top 10" list of pests (from the large number of insects, diseases, weeds, and vertebrates that affect greenhouse crops) to consider for the PMSP. They first sent us lists of disease, insect weed and vertebrate pests important in their areas and then voted on the combined list to identify the "Top 10" list of pests (Table 1) from a total list of 26. While all pest issues are important, with a broad geographical region and a diverse production system like commercial greenhouses, it seemed essential to focus on those pests with the greatest effect on production. "Importance" in this case is a combination of frequency of occurrence, potential for damage, and difficulty of control.

Table 1: Top 10 greenhouse pests for the Northeast
(arranged alphabetically)

Insects	**Diseases**
Aphids	Botrytis
Fungus gnats	Powdery mildew
Mites	Pythium
Shore fly	Rhizoctonia
Thrips	
Whitefly	

Because the value of a PMSP is based in large part on the input from growers and other stakeholders, the advisory group also helped to identify potential participants from the entire region. In some cases, stakeholders were asked to help identify the most important pest issues. Others were suggested as participants for a two-day workshop to discuss the specifics of the PMSP.

A draft PMSP was created, primarily covering existing pest management tools for the top 10 pests, plus some additional background information. It was based on available information from the region, including the Cornell Guide for the Integrated Management of Greenhouse Floral Crops. This draft was used as the basis for the discussion at the two-day workshop.

Workshop
A face-to-face workshop was held October 22-23, 2008 to discuss the draft document. The participants were fairly diverse—nine states were represented at the meeting, with 3 growers, 4 industry representatives, 9 Extension personnel, 1 research scientist, 1 Department of Agriculture representative, 1 IR4 representative, and 1 NE-IPM representative. While the discussion centered on the Top 10 pests, other pests that were of importance to the industry were also covered and added to the final document. The 20 pages of comments and suggestions from the discussion were included as edits in the completed PMSP. The most important task for the group was to create a list of needs for research, education, and regulation in pest management in commercial greenhouses. One hundred and sixty four needs were listed, covering a broad range of pest management methods and issues (Appendix 1).

Ranking the list of needs
After the meeting, the complete list of needs was organized by type (research, education, regulatory) and sent to the workshop participants, the advisory group, grower and industry organizations in the region, and Cooperative Extension educators working with the greenhouse

industry to be ranked. Each need could be ranked as high, medium, or low importance. Sixteen people/groups ranked the needs, including 2 growers, 12 extension personnel, 1 industry rep, and 1 Department of Agriculture representative. Nine of those ranking the list were not at the workshop. Needs most frequently ranked of high importance (56% of respondents or higher) are included in the section on priorities.

Review process

The review process was extensive and took approximately two months. First, the final documents were placed on the NYS IPM website. We then emailed 44 people asking them to review the documents, focusing on the parts that were in their areas of expertise. This list of contacts included IPM specialists, researchers, consultants, educators, and growers from 9 of the states in the Northeastern region. Those contacted had attended the two-day meeting in Ithaca, Fall 2008, or assisted with the development of the PMSP. One email reminder was sent to the group after the original request. We received 12 reviews of the documents covering a range of expertise. Reviewers' comments were incorporated into the final document.

COMMERCIAL GREENHOUSE PRODUCTION IN THE NORTHEASTERN UNITED STATES

The commercial greenhouse industry was defined for this project as any production of plants for sale that were grown under cover. This includes both floricultural and vegetable/edible crops, wholesale and retail production, and a wide variety of sizes of operations and types of greenhouse structures. Some characteristics of commercial greenhouse production in the northeast are the diversity of crops produced, a predominance of family-owned and operated businesses, and the high intensity of production, especially in the use of labor. While there is little organic greenhouse production of ornamental crops in the region, there is some organic vegetable production in greenhouses or high tunnels.

Greenhouses are also used to house plant collections at arboretums and botanical gardens. While these "collection greenhouses" are not included in this plan, the pests that they deal with are similar to those found in commercial greenhouses and the management methods may be similar.

Production regions

The Northeastern U.S. is a corridor of high green-industry production, in terms of percent of total value of agricultural products. This area extends along the East Coast from Maryland to Maine. Commercial greenhouses can be found in most counties in this 12-state region. Within the Northeastern Region, most states have grower organizations for greenhouse producers, which may advocate for the industry with government, serve as a clearinghouse for information and education, and help market greenhouse products.

Production statistics

Commercial greenhouse production is important to the economy of the northeastern US. The green industries, including floriculture greenhouses, rank in the top 4 for market value of agricultural products in each of the 12 states in the region, and for 5 states, they rank number 1. This does not include those operations growing solely edible crops, although vegetable transplants and herbs would be included in the bedding plant category.

According to the 2002 Census of Agriculture, the Northeast Region had 22% of the operations growing floriculture crops in the U.S. In 2007, there were 1,878 floriculture operations included in the northeastern states included in the USDA Floriculture Survey (MD, NJ, NY, PA) (Table 2). On average, 37% of the operations have gross sales of over $100,000, although the percentage is higher in MD and NJ. There was an average decrease of 9% in floriculture operations with gross sales of $100,000+ from 2005 to 2007. These numbers are generally considered to be low estimates of number of operations.

Table 2: Number of operations by gross value of sales in states covered in the USDA Floriculture Crops 2007 Summary

State	Total # floriculture operations	% of operations with $100,000+ in gross sales	% loss in # operations from 2005
CT	288	35	Not available
MA	431	32	Not available
MD	140	44	3
NJ	337	47	12
NY	698	33	9
PA	703	29	10

CT and MA had 101 and 138 operations with gross sales of $100,000+, respectively, in 2005

For those states covered by the Floriculture Crops Summary for 2005 and 2007, the expanded wholesale value of floriculture crops ranged from $75 to $200 million (Table 3). While there are variations by state and by individual operation, the 2007 production, in value of sales, was approximately 51% annual bedding plants, 21% each potted crops, and herbaceous perennials, 2% foliage crops, and 3% cut flowers (for MD, NJ, NY, and PA). Between 2006 and 2007, there was an approximate overall loss in wholesale value of 4%, primarily in foliage plants and flowering potted plants. There was an increase in wholesale value of cut flowers and herbaceous perennials in NY and an increase in wholesale value of foliage plants in PA and MD.

Table 3: Production statistics for those NE states covered in the USDA Floriculture Crops Summary

State[x]	Wholesale value ($ x 1000)	Covered area[y] (sq ft x 1000)
CT	85,649	9,300
MA	75,318	9,301
MD	88,127	5,880
NJ	162,218	19,809
NY	199,028	24,848
PA	161,378	18,907

[x]Statistics for MD, NJ, NY, and PA are from the USDA 2007 Floriculture Crops Summary, for CT and MA from the 2005 Summary.

Even with the high value of floriculture production there have been significant reductions in support and funding for research and extension related to floriculture crops. This creates a challenge as growers look for research-based answers to their technology and pest management questions.

General production practices and worker activities

An average ornamental greenhouse business will produce or sell over 200 different species/cultivars each year. Crop production can vary for each grower from as little as 4 weeks (for plugs) to up to 5-6 months (for poinsettias). Some growers operate only in the spring and early summer while others are in production year-round. While greenhouse environments may be similar, the importance of bedding plants and spring sales affects production start dates across the region. All of these variables make it difficult to create a timeline of worker activities that relate to pest management. However, based on several production surveys from the region, there are also similarities in production practices

Size of operation

While there are some large, primarily wholesale, operations, the “typical” greenhouse operation in the Northeast is small. In New York it ranges from 1,000-200,000 sq ft with an average of 23,000 sq ft; in New Jersey almost half are under 10,000 sq ft. The type of greenhouse, the type of glazing material, and the degree of automation usually are related to the size of operation; smaller operations are likely to have single-bay, poly covered greenhouses with little automation. Greenhouses vary from single unit plastic-covered Quonset-style or even high tunnels to gutter-connected multi-bay houses with polycarbonate walls. The larger the operation, the more likely they are to have automated watering, environmental control, seeding and potting machines, product transport, etc.

Labor

Many greenhouses are family owned and operated and rely heavily on family for the production and business management tasks. They will often bring in people during peak sales times. Keeping experienced help is difficult due to the seasonal nature of the operations. Employee turnover is high. Larger operations hire more workers and more full-time, year-round workers.

Crops

As new crops come into the market, the diversity of plant materials produced continues to increase. The majority of growers produce bedding plants (>80%), hanging baskets (>80%), and potted flowering plants (70%). In a comparison of greenhouse growers in New York State between 2000 and 2006, fewer growers were producing poinsettias in 2006, but production of other flowering potted plants, herbs, and greenhouse vegetables had increased.

Propagation

Most growers (60-80% in New York and New Jersey) buy plugs. Forty to 60% grow their own plugs and 30-50% buy prefinished plants. The choice of whether to grow or buy, and at what stage to buy (plug or prefinished), is based on where growers can find cost savings. For niche products or markets, they are likely to grow their own plugs. Vegetable transplants may be direct seeded or purchased.

Production chain and marketing

Ornamental greenhouses frequently combine retail and wholesale sales. In New Jersey, 33% of operations produced entirely for the wholesale market, 17% entirely retail. In New York, 75% of the income from greenhouse ornamental sales came from retail. Specialization and niche markets are important and found to increase sales for both wholesale and retail operations.

Wholesale growers sell primarily to garden centers, mass marketers, and other growers. Their competition is primarily other wholesale operations. Smaller growers may be combined with other agricultural production such as fruit or vegetable production. They consider large retail chains as their primary competition.

There is some import and export of ornamentals. Larger wholesale operations are most likely to export plant materials. Retail operations, even medium sized ones, may import plant materials if they have identified cost savings compared to producing their own. In New Jersey, 44% of operations sold all of their product in state, 23% sold only on site, and less than 10% sold more than half their production out of state.

Factors that affect production

New York growers identified energy costs, weather, labor costs, and hard good costs as primary limitations to a successful business. Limiting factors for plant quality were insect control, weather, disease control, and environmental control (cost for manipulating). Availability of extension programs and agricultural consultants, and existence of growers' organizations have also been noted as affecting success of production.

Worker activities

Potting and transplanting

Crops are typically grown in soil-less media in pot sizes varying from ½" diameter plugs to 14" hanging baskets. Depending on whether growers are producing their own plugs or the size of the purchased plug, plants may be transplanted 1 or more times before they reach saleable size. Plants may also need to be spaced on the greenhouse benches as they grow. Larger and wholesale operations are most likely to have automatic seeders, potting machines, product, and transport systems.

Watering

Watering methods may include hand watering, drip irrigation, overhead watering booms, overhead misting systems, and ebb and flood and hydroponic systems. Hand watering and drip irrigation are the most common. Watering techniques must be tailored to each crop and pot size so the wide diversity of crops in the same greenhouse restricts the use of automatic watering for the smaller and/or retail grower.

Fertilization

The most commonly used method is soluble fertilizer applied through the irrigation system. The amounts and types of fertilizer depend on the crop and the stage of growth. Slow release fertilizer is also used in larger pots. Workers may test the soil media to determine pH and electrical conductivity of the medium throughout the crop production period.

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Pinching and cutting back

Plants may be pinched to encourage branching or cut back to meet a particular market window. Many specialty crops are pinched or cut back.

Harvest, marketing and sales

Wholesale growers pull product onto rolling carts to match orders and then ship to markets that range from big box stores to small garden centers. Many small and medium growers produce and sell from the same location. They may move product from a production area to a retail area or sell directly from the production benches.

Vegetable production in greenhouses

Most of the information in this PMSP is oriented toward commercial ornamental production in greenhouses. Statistics on commercial greenhouse vegetable production in the United States are difficult to find. In 2003, there were approximately 800 acres of tomato greenhouse operations in the whole U.S. Five hundred acres were in large farms (>80 acres), approximately 100 acres in medium farms (10-18 acres), and 200 acres in small farms (<10 acres) (Cook and Calvin, 2005).

There are no large vegetable greenhouses in the Northeast but Village Farms, one of the largest greenhouse tomato firms in the U.S., had a farm in Pennsylvania in 2003. Only two of the medium sized operations counted in 2003 were in the Northeast (NY). There is currently a 24-acre tomato production greenhouse in Maine, which was not included in the 2003 report.

The U.S. acreage of greenhouse vegetable production increased 40% from 1996 to 2003. Anecdotal evidence indicates that the greenhouse vegetable industry continues to increase in the Northeast, primarily the number of small vegetable greenhouses. Small operations vary considerably. Greenhouse production may provide season extension, adding spring and fall production to the main field crop in summer. A variety of crops may be grown in the same greenhouse over time, including tomatoes, peppers and cucumbers in the summer and greens in the winter. Vegetable crops may be combined with cut flowers. The type of greenhouse used varies from high tunnels to gutter connected greenhouses with temperature control.

Some production issues and activities are the same as in greenhouses used for floriculture crops. Labor and energy costs are important. Marketing ranges from local retail sales to nationwide distribution by wholesalers. Vegetable producers are more likely to grow in soil beds or use hydroponics than the soil-less mixes of floriculture. Crops are more likely to be direct seeded. While there are many different varieties available, the number of crops grown at the same time is usually much less in a vegetable greenhouse. Drip irrigation is common. Harvest practices are crop specific and may involve a greater degree of handling and packaging than for floriculture crops.

While many of the insect and disease pests are the same in vegetable and floriculture greenhouses, some are specific to the crop grown. High tunnels are more open so Lepidopterous pests may be more common on vegetable crops. Bacterial canker and leaf mold are greenhouse tomato diseases not commonly found in floricultural crops. Pesticides with the same active ingredient usually have different trade names for vegetable and ornamental crops and for certain pests there are fewer labeled pesticides for food crops. Few plant growth regulators are used in vegetable production. Integrated pest management practices for vegetable production are fundamentally the same as for ornamentals. Biological control is common in large vegetable greenhouses and becoming more common in smaller operations, particularly with the increase in organic production.

Pest management

Greenhouse pests are usually managed through a combination of cultural and chemical methods. Physical control through screening is occasionally done, but usually on larger greenhouses. Commonly used cultural practices include removing organic debris from floors and benches, removing weeds from inside and outside the greenhouse, allowing a crops-free period of at least a month between crops, disinfecting floors, walls, and benches, and disinfecting used pots and flats before reusing. Pesticides may be applied to the foliage through a variety of types of sprayers or applied to pots individually, either incorporated into the medium, applied as a drench or applied in granular form.

Issues in pest management

Some of the issues that arise with the use of pesticides in greenhouse production, as with other types of production, include pesticide resistance, label clarity, and licensing requirements. The potential for development of pesticide resistance may be one of the most important issues. It has already been reported for several insects and insecticides. Not all growers understand how resistance develops and how pesticide classes should be rotated, or the interaction of mixtures of chemicals on rotation requirements. Additional education needs to be provided on these topics.

Use of plant growth regulators (PGRs):

Ornamental crop producers use several synthetic growth regulators which are applied either as a spray on the foliage, as a drench on the growing mix, or as a dip for bulbs. They are used to control vegetative growth, rooting, and flowering. Because of the potential for negative effects of PGRs on the crop, the environment, and the grower, they are labeled as pesticides and applicators must be licensed. Most are active at low concentrations so they must be handled carefully and with skill to achieve the desired results. PGR use varies with crop species and environmental conditions.

Adoption of integrated pest management (IPM)

IPM has been promoted for at least 20 years and most growers include some aspects of it in their production. The following statements are based on IPM adoption surveys conducted in New York, Vermont, and New Jersey. The majority of producers integrate some aspect of cultural management with chemical management of pests. Least-risk pesticides are used by over half of the growers. Nearly all growers scout for pests, either whenever they are in the greenhouse or on a set schedule. Few hire an outside consultant to scout or identify a specific employee to do the scouting, but those that have additional employees often train them to identify pests and assist with scouting. Keeping scouting records is not yet a common practice. However, basing pest management tactics, including chemical applications, on scouting results is becoming the norm. Almost all growers identify the disease or insect pest before deciding what type of control to use. Use of sticky cards and other methods for insect monitoring, and using environmental conditions that encourage disease to determine when to apply fungicides are fairly common practices. Most growers inspect plants for pest problems on arrival although not all ‘quarantine’ them before treating the problem. There is still an identified need for additional training in IPM practices, especially in disease and insect identification.

Use of biological control

The use of microbial, soil applied products for disease and insect management is more widely accepted than the use of predators or parasites for insect management. The assumption that biological control of insects cannot be integrated with chemical control and the potential complexity of integrating a biological control program into a crop production scheme has limited its adoption. However, the reduction in efficacy of some widely used pesticides and the increasing availability of information on the use of natural enemies for insect control is encouraging the use of biological control in greenhouse crops in the northeast. Nearly 30% of those surveyed in New York in 2008 said they have used biological control of some sort. There is still a great need for educational materials on the use of biological control organisms, and experienced users to assist growers, to increase the adoption rate in commercial greenhouse production. General information on toxicity of insecticides to beneficial insects is in Table 4.

Organic and sustainable production

There is an increasing interest in organic and sustainable production of ornamentals. Organically produced greenhouse vegetables and vegetable transplants are currently available, although not widely. In New York in 2008, 15% of growers currently market some products as organic or sustainable and 39% think they will in the future. In a 2003 New Jersey survey, 12% of growers were considering organic production. They identified pest issues and product quality as the limitations to acceptance of organic production. A variety of organizations are discussing the creation of standards for organic and sustainable production of ornamental plants. Veriflora provides certification of sustainable production for plants and cut flowers. Scientific Certification Systems has a current project to create sustainability standards for all agricultural products in the US. At this time, certification for sustainability is primarily sought by large companies where the market demands it. Most greenhouse growers in the Northeast Region have not yet been certified. However, sustainability as a marketing tool is being promoted by the industry and can take a variety of forms, including eliminating pesticides and offering pot recycling to customers.

KEY PESTS

The pest portion of this PMSP is divided into disease, insect/mite, weed (including algae), and vertebrate sections. There is additional information on plant growth regulators. The disease and insect/mite sections are the most comprehensive. Each includes identification and management information for the "Top 10 Pests", and a table of labeled pesticides. It should be noted that not all the pesticides listed are labeled in all the states of the northeast region. These tables are not intended for use by growers but are to give an indication of the available pesticides, and their respective pesticide class or group, that are available for management of a particular pest.

Less detailed information on species that are considered important but not key is also included. Each section is followed by a list of new pests and those that are increasing in importance, and pesticides currently being registered. The insect section includes a table on toxicity of labeled insecticides to the major beneficial insects.

	Top 10	**Other**
Diseases	Grey mold, Botrytis blight	Alternaria leaf spot
	Powdery mildew	Bacterial blight of geranium
	Pythium root rot and damping off	Bacterial leaf spots
	Rhizoctonia root/stem/crown rot and damping off	Black root rot
		Chrysanthemum white rust
		Cladosporium leaf mold
		Downy mildew
		Impatiens necrotic spot virus
		Phytophthora damping off, root and crown rot
		Sclerotinia stem rot
		Southern wilt of geranium
Insects and mites	Aphids	Leafminers
	Fungus gnats	Cyclamen mites
	Two-spotted spider mites	Mealybugs and scale insects
	Shore fly	
	Western flower thrips	
	Whiteflies	

DISEASES

Primary Source: 2009 Cornell Guide for the Integrated Management of Greenhouse Floral Crops

Gray Mold, Botrytis Blight

(*Botrytis cinerea*)

Damage and Importance

The common gray mold fungus, *Botrytis cinerea*, attacks a wide variety of ornamental plants, probably causing more greenhouse losses than any other single pathogen.

Identification

The fungus is usually identified by the development of fuzzy grayish spore masses over the surface of the rotted tissues, although such sporulation will not develop under dry conditions.

The fungus causes a brown rotting and blighting of affected tissues. It commonly attacks the stems of geranium stock plants and wounds on cuttings. As a result of Botrytis infection, very small seedlings can be rotted; stems of poinsettia, snapdragon, zinnia, exacum, or lisianthus can be girdled; and petal tissues of many plants, including carnations, chrysanthemums, roses, azaleas, and geraniums, can be spotted and ruined. The foliage or stems of many other plants can be infected including: cyclamen, bacopa, osteospermum, vinca (*Catharathus roseus)*, and tomato (full size plants and transplants).

Disease Spread

Spores of botrytis are produced on distinctive dark-colored, hair-like sporophores and are readily dislodged and carried by air currents to new plant surfaces. The spores will not germinate and produce new infections except when in contact with water, whether from splashing, condensation, or exudation. Only tender tissues (seedlings, petals), weakened tissues (stubs left in taking cuttings, tissues infected by powdery mildew), injured tissues (bases of cuttings), or old and dead tissues are attacked on most crops. Active, healthy tissues, other than petals, are seldom invaded. Petals shed from crops in hanging baskets may encourage Botrytis leaf infections on the crops grown below.

Management

IPM

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Visual recognition (signs) -- Magnification	Easy -- Increased accuracy	 -- More time consuming	A trained eye can easily recognize this disease when it is sporulating -- Often not necessary
Detection & Monitoring	Plant Inspection--especially lower in the plant canopies	Catch other pests	Too late once you can visually identify	
Action Triggers (Thresholds)	Thresholds vary by crop, growth stage and setting			Botrytis presence often an indicator to adjust environmental conditions

Environmental

Because high humidity is required for spore production and free water is necessary for spore germination and infection, Botrytis blight can usually be controlled by watering early in the day and by heating and ventilating to prevent any condensation on the plant surface at sunset. Use fans and grow on open benches rather than solid surfaces to assist in good ventilation.

Because the fungus readily attacks old or dead tissues and produces tremendous quantities of airborne spores, the importance of strict sanitation cannot be overemphasized. All old blossoms and dead leaves should be removed, and all fallen leaves and plant debris under the benches or on benches from hanging baskets should be gathered and carefully disposed in a sealed container.

Fungicides

Fungicides may be required under some greenhouse conditions, especially with highly susceptible crops such as exacum, geranium, poinsettia, lisianthus, bacopa, osteospermum and fuchsia. Fungicide resistance occurs for *Botrytis cinerea* (benzimidazole and dicarboximide materials). Materials containing solely Group 1 active ingredients are unlikely to control greenhouse populations of Botrytis. Because there is only partial resistance to Group 2 (dicarboximide) fungicides, these materials are still effective.

<u>Some Currently Registered Pesticides for Botrytis</u>

(see Table 4 for information on fungicides)

Common name (class/group)

Group 1

Chlorothalonil + thiophanate-methyl (M5 + 1)

Thiophanate-methyl + mancozeb (1 + M3)

Group 2

Iprodione (2)

Vinclozolin (2)

Group 11

Azoxystrobin (11)

Pyraclostrobin (11)

Trifloxystrobin (11)

Group 12

Fludioxonil (12)

Group 17

Fenhexamid (17)

Group M1

Copper hydroxide(M1)

Copper hydroxide + mancozeb (M1 + M3)

Copper salts of fatty and rosin acids (M1)

Copper sulfate pentahydrate (M1)

Group M3

Copper hydroxide + mancozeb (M1 + M3)

Mancozeb (M3)

Thiophanate-methyl + mancozeb (1 + M3)

Group M5

Chlorothalonil (M5)

Chlorothalonil + thiophanate-methyl (M5 + 1)

Miscellaneous

Bacillus subtilis

<u>Critical issues and needs</u>

Resistance management requires rotational application of fungicides.

Powdery Mildew
(various fungal species)

Damage and Importance

One of the most easily recognized of all plant diseases, powdery mildew affects a wide range of greenhouse crops. Seriously affected plants are unsaleable. Poinsettia crops are vulnerable to a powdery mildew disease that affects during finishing. Other plants affected by powdery mildew in the greenhouse include: African violet, dahlia, gerbera, hydrangea, rosemary, rose, verbena, cucumber, and tomato.

Identification

Powdery mildew is characterized by the presence of a whitish, powdery mildew growth on the surfaces of leaves, stems, pedicels, sepals, bracts or petals. The fungal threads and the spores (which develop on short, erect branches) are visible with a strong hand lens. Under some conditions, however, the threads are so sparse that the mildew can be detected only by examination under strong light with a good lens or dissecting microscope. In some cases, the mildew develops only in small areas in which the leaf cells are killed and turn black. On some plants, such as grape ivy, rose, and delphinium, the young foliage and stems often become severely distorted in addition to being covered by the whitish mildew growth.

Powdery mildew can often be distinguished from downy mildew by the leaf surface on which the mildew is found. In most cases downy mildew will sporulate on the lower leaf surface in limited areas whereas powdery mildew is mostly a problem on the upper leaf surface and is often spread out rather than in discrete spots. Under low humidity conditions, powdery mildew may be found primarily on the lower surfaces of lower leaves on the plant, while under high humidity, downy mildew sometimes sporulates on the upper leaf surfaces.

Poinsettia powdery mildew disease develops rapidly during the fall. While scouting for whiteflies on poinsettias, also watch for powdery mildew colonies on the upper or lower surface of older leaves. At times a yellow spot on the upper leaf surface may indicate a mildew colony growing on the undersurface.

Disease Spread

Powdery mildew spores are easily detached and carried by air currents to surrounding plants where they initiate new infections. Unlike the spores of nearly all other fungi, the powdery mildew spores can germinate and initiate infections at humidity levels far below those commonly encountered in the greenhouse. So this disease may continue to worsen on potted plants when moved to retail locations, homes, or public interiorscapes.

Management

IPM

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Visual recognition (signs) -- Magnification	Easy -- Increased accuracy	 -- More time consuming	A trained eye can easily recognize this disease -- Magnification often not necessary
Detection & Monitoring	Plant inspection	Catch other pests	On some hosts it may be difficult to see signs, may have to look for distortion or spotting	Important to scout often and control before the disease is out of hand
Action Triggers (Thresholds)	Thresholds vary by crop, growth stage and setting			Powdery mildew is often an indicator of need to increase air movement

Environmental

As a deterrent to mildew in greenhouses, ventilation and heating should be adjusted to avoid poor air circulation and high-humidity conditions. Irrigate plants early in the day. Heat at least one hour before sunset, and provide adequate ventilation. Horizontal airflow systems assist in management of powdery mildew.

Fungicides

Under some conditions, fungicides are essential for mildew control. Systemic and non-systemic protectant materials are available for spray application. Some greenhouse crops and varieties are resistant to powdery mildew. To prevent crop damage from poinsettia powdery mildew, once detected, pick off affected leaves and initiate fungicide treatment immediately.

<u>Some Currently Registered Pesticides for Powdery Mildew</u>

(see Table 4 for information on fungicides)

Common name (class/group)
Group 1
Chlorothalonil + thiophanate-methyl (5 + 1)
Thiophanate-methyl (1)
Thiophanate-methyl + mancozeb (1 + M3)
Group 3
Myclobutanil (3)
Triadimefon (3)
Triflumizole (3)
Group 5
Chlorothalonil + thiophanate-methyl (5 + 1)
Piperalin (5)
Group 11
Azoxystrobin (11)
Kresoxim methyl (11)
Pyraclostrobin (11)
Pyraclostrobin + boscalid (11 + ?)
Trifloxystrobin (11)
Group M1
Copper hydroxide (M1)
Copper salts of fatty and rosin acids (M1)
Copper sulfate pentahydrate (M1)
Group M2
Sulfur (M2)
Group M3 (not the active ingredient providing control for above disease)
Thiophanate-methyl + mancozeb (1 + M3)
Group M5
Chlorothalonil (M5)
Miscellaneous
Bacillus subtilis
Hydrogen dioxide
Neem oil
Potassium bicarbonate
Trichoderma harzianum

State/local pesticide restrictions or limitations, export issues, etc.

Kresoxim-methyl and myclobutanil not labeled for use on LI.

Pythium Root Rot and Damping Off
(*Pythium spp***.)**

Damage and Importance

Pythium is one of the most common fungi found in the roots of greenhouse crops. It is most often invasive on roots weakened from excessive moisture or nutrient levels. The genus *Pythium* includes many species that vary in their ability to cause disease and their sensitivity to fungicides.

Pythium can be introduced into a greenhouse in plants, soil, water, and growing media, and may be maintained in crop residue from previous seasons. Greenhouse insects such as shore flies can also carry *Pythium*. Most *Pythium* species spread in water through swimming zoospores. Zoospores that reach the plant root surface can infect, eventually destroying the root tissue and absorbing nutrients as a food source. *Pythium* forms resting spores on decaying plant roots, which can survive, prolonged adverse conditions on containers, in greenhouse growing media and water, providing a reservoir of inoculum.

Identification

*Root Rot***:** Pythium causes a brown wet rot that makes roots soften and disintegrate. It typically attacks below the soil surface and may extend up into the base of the stem, blackening it.

*Damping off***:** Seedlings fail to emerge because seeds are attacked after imbibition. May also occur post-emergence as Pythium invades roots tips and progresses up the stem killing the seedling or cutting.

Management

IPM

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Visual recognition (symptoms) --- Microscopic examination --- ELISA --- Culturing	Easy --- Confirm pathogen presence --- Genus specific results possible --- Obtain isolates to I.D. species and test pathogenicity	Could confuse with certain other causes of root decline --- Requires microscope More time consuming --- Expensive --- Time consuming requires specialized media and training for species identification	 --- Experience needed with fungal morphology --- --- Not used for routine GH diagnosis
Detection & Monitoring	Plant inspection	Catch other pests	Other causes of root decline may be hard to distinguish	Look for patterns, especially those that have to do with wet areas of bench, etc.
Action Triggers (Thresholds)	Thresholds vary by crop, growth stage and setting			

Environmental

Avoid using a mix with poor drainage (and consequent low air pore space). Avoid excessively high levels of soluble salts in the growing mix. Use evenly-applied watering techniques and a bench surface that does not allow puddling at the base of the pots. Handle and store mix carefully to avoid contamination with unpasteurized soil. Pythium can also be spread in systems that use re-circulating water.

Fungicides

For most effective management, because fungicide resistance has been observed, alternate two fungicides during production of highly susceptible crops such as poinsettia, geranium, and lily.

Some Currently Registered Pesticides for Pythium

(see Table 4 for information on fungicides)

Common name (class/group)
Group 1(not the active ingredient providing control for above disease)
Etridiazole + thiophanate-methyl (14 + 1)
Group 4
Fludioxonil + mefenoxam (12 + 4)
Mefenoxam (4)
Group 11
Pyraclostrobin (11)
Group 12(not the active ingredient providing control for above disease)
Fludioxonil + mefenoxam (12 + 4)
Group 14
Etridiazole (14)
Etridiazole + thiophanate-methyl (14 + 1)
Group 28
Propamocarb (28)
Group 33
Fosetyl – A1 (33)
Phosphorus acid (33)
Miscellaneous
Trichoderma harzianum

Rhizoctonia Root/Stem/Crown Rot and Damping Off
(*Rhizoctonia solani)*

Damage and Importance

The fungus Rhizoctonia is often found associated with soil or media and most often attacks at the stem base. It has a wide host range.

Identification

Rhizoctonia causes a drier root or stem rot that Pythium. Affected tissues are brown or tan. It is favored by an intermediate range of moisture; neither too wet nor too dry. Cankers formed by Rhizoctonia usually appear at the soil line and can lead to a sudden wilting and death. Occasionally Rhizoctonia will cause foliar blight on certain greenhouse crops with dense, humidity-holding canopies.

Disease Spread

Warm temperatures often favor Rhizoctonia, so losses will typically occur during spring bedding plant production and summer pot plant propagation. *Rhizoctonia* can be introduced into a greenhouse through soil, contaminated growing media, containers and plant residue from previous seasons.

Management

IPM

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Visual recognition (symptoms) --- Incubation and microscopic examination --- Culturing	No specialized equipment needed --- Confirm pathogen presence --- Can get Isolates to I.D. species and test pathogenicity	Could confuse with certain other causes of damping off or crown and root rot --- Requires time and microscope --- Time consuming requires specialized media (lab use only)	--- Experience needed with fungal morphology --- Not used for routine GH diagnosis
Detection & Monitoring	Plant inspection	Catch other pests	Other causes of root decline and damping off may be hard to distinguish	Occasionally may be able to see fine "threads" (mycelium) of the fungus. Soil and media particles may cling to stem or leaves
Action Triggers (Thresholds)	Thresholds vary by crop, growth stage and setting			

Environmental

Good sanitation practices are the primary defense against Rhizoctonia.

Biological

Good control has been shown with soil applied microbial biocontrol agents.

Fungicides

Fungicides may be necessary especially to control outbreaks in susceptible crops or young plants.

<u>Some Currently Registered Pesticides for Rhizoctonia Root/Stem/Crown Rots and Damping Off</u>

(see Table 4 for information on fungicides)

Common name (class/group)
Group 1
Etridiazole + thiophanate-methyl (14 + 1)
Thiophanate-methyl (1)
Group 2
Iprodione (2)
Group 3
Triflumizole (3)
Group 4 (not the active ingredient providing control for above disease)
Fludioxonil + mefenoxam (12 + 4)
Group 7
Flutolanil (7)
Group 11
Azoxystrobin (11)
Pyraclostrobin (11)
Trifoxystrobin (11)
Group 12
Fludioxonil (12)
Fludioxonil + mefenoxam (12 + 4)
Group 14 (not the active ingredient providing control for above disease)
Etridiazole + thiophanate-methyl (14 + 1)
PCNB (14)
Miscellaneous
Trichoderma harzianum

Table 4. Fungicides* **Active Ingredient** Brand name	**Class / Group #**	**Efficacy**	**Comments (Pros & Cons)**
Azoxystrobin Heritage	11	Powdery Mildew Rhizoctonia	Conduct small-scale tests to ensure safety when applying to plants not listed on the label and before using in a tank mix with any material. Do not use a silicone-based surfactant. For resistance management do not make more than three sequential applications of Heritage—alternate with two applications of a non-strobilurin fungicide. Con – potential for fungicide resistance to develop.
Bacillus subtilis **(QST 713 strain)** Cease	44 and/ or NC ? ?	Powdery Mildew	This is a biological fungicide/bactericide used as a foliar spray at 2-8 qts/100 gal per acre. The label suggests small-scale tests on plants not specifically listed.
Chlorothalonil Concorde DF Concorde Daconil Ultrex 82.5% Daconil Weather-Stik 54F Echo Ultimate T&O Echo 90DF Echo Zn T&O Echo 720 T&O Manicure 6 Flowable Pegasus L Countdown L&G Quali-Pro Chlorothalonil 720 SFT Quali-Pro Chlorothalonil DF Quali-Pro Chlorothalonil 500 ZN	M5	Botrytis	Bloom discoloration noted on petunia and hydrangea flowers. Do not apply to *Pittosporum* or *Schefflera*. Do not use in mist blowers or other high-pressure spray equipment. See labels for additional plants. Pro – low likelihood of resistance to this fungicide

Chlorothalonil plus thiophanate-methyl Spectro 90WDG	M5, 1	Thiophanate-methyl is largely ineffective on Botrytis due to fungicide resistance. Chlorothalonil component is effective against Botrytis>	Label cautions that the user should conduct tests for safety to plants not mentioned on the label before widespread use. Spectro is not recommended for use on Swedish ivy, Boston fern, or Easter cactus (*Hatiora gaertneri*). Do not apply Spectro to *Pittosporum* or *Schefflera* more than once to avoid phytotoxicity.
Copper hydroxide Champ Dry Prill 57.6% Champion 77WP Nu-Cop 50WP Nu-Cop 3L Nu-Cop HB	M1	Botrytis Powdery mildew	Note label precautions for treating some crops. Apply to a small number of plants and observe for 7–10 days for symptoms of phytotoxicity before commercial use. Do not tank mix with Aliette without buffering the spray solution. Pro – low likelihood of resistance developing to this fungicide.
Copper hydroxide + mancozeb Junction 15DF	M1, M3	Botrytis – both components. Powdery mildew copper hydroxide component.	The pH of the spray solution should be less than 6.5 to avoid phytotoxicity. Label cautions grower to conduct small-scale tests on other ornamentals not listed on the label for signs of phytotoxicity before commercial use. Pro – low likelihood of resistance developing to this fungicide.
Copper salts of fatty and rosin acids Camelot 58EL	M1	Botrytis Powdery mildew	Pro – low likelihood of resistance developing to this fungicide. Con – only for use on azalea.
Copper sulfate pentahydrate Phyton 27 21 .36%	M1	Powdery Mildew	Pro – low likelihood of resistance developing to this fungicide.
Dicloran Botran	14	Botrytis	Chrysanthemum, geranium

Dimethomorph Stature DM	40	Foliar Phytophthora, not effective against Pythium.	
Etridiazole Terrazole 35 WP Truban 30W Truban 25 EC	14	Pythium	Note that rates vary with the soil volume. Foliage must be rinsed off with water immediately after application to avoid phytotoxicity. Drench application is preferable to soil mix incorporation.
Etridiazole + thiophanate-methyl Banrot 8G Banrot 40W	14, 1	Pythium (from etridiazole component)	Mix with soil, broadcast, or sidedress.
Fenhexamid Decree 50 WDG	17	Botrytis	For resistance management, avoid making more than two consecutive applications of this product. Do not apply more than 6 lb. of product per crop per season. Con – potential for fungicide resistance to develop.
Fludioxonil Medallion 50% WP	12	Botrytis Rhizoctonia	Use up to 30 oz. Medallion per 1,000 sq. ft. (80 lb. product/acre) per year or crop cycle. Do not apply to leatherleaf fern. Drench applications to impatiens or New Guinea impatiens or geraniums may cause stunting or chlorosis. Use with extreme caution as a foliar spray on geraniums, especially at high growing temperatures. Test the recommended rates on a small number of plants for phytotoxicity before widespread use. On Long Island, for use in enclosed structures only.
Fludioxonil plus mefenoxam Hurricane	12, 4	Pythium (from mefenoxam component)	Stunting and/or chlorosis have been noted with application to impatiens, New Guinea impatiens, pothos, geranium, and Easter lily. Drench treatments qualify for an exception to the 48-hour REI: see label for details.
Flutolanil Contrast	7	Rhizoctonia	Use as a drench at 3-6 oz/100 gal, using 1-2 pints/sq ft. Sprays are made at 3-12 oz/100 gal on a 14-21 day interval. Also labeled for cutting and bulb dips.

Fosetyl – Al Aliette 80WDG	33	Pythium	Systemic protection. Allow foliage to dry before overhead irrigation. May not be compatible with foliar fertilizers or with compounds containing metal ions. Do not apply within seven days of any copper application.
Hydrogen dioxide ZeroTol 27%	NC N/A ?	Disinfectant, general	No residual. Contact action against exposed microbes (e.g. fungal spores).
Iprodione 26GT (Bayer) Chipco 26019 Flo (Bayer) Sextant 23.3% EC Chipco 26019 Brand (Bayer) Chipco 26019 N/G Iprodione Pro 2SE Lesco 18-Plus Sextant	2	Often only partially effective against Botrytis due to fungicide resistance, still valuable. Rhizoctonia	Make no more than four foliar applications per year, totaling no more than 10 qt. product/acre/year, with no more than 2.5 qt. or 2.5 lb. product/acre in any application. Users should apply a label rate on a small number of plants to test for plant safety. Do not use on spathiphyllum, and do not use as a soil drench on impatiens or pothos.
Iprodione + thiophanate methyl 26/36	2, 1	Botrytis control (from iprodione primarily) Rhizoctonia (from both components)	
Kresoxim methyl Cygnus	11	Powdery Mildew	For use on bedding plants, cut flowers, roses, poinsettias, and trees; in greenhouses, make no more than eight applications per year. For resistance management, alternate each application of Cygnus with two sequential applications of a non-strobilurin fungicide. Con – potential for fungicide resistance to develop in this fungicide class.

Mancozeb Dithane T/O Rainshield 75% Lesco Mancozeb DG Dithane F-45 Rainshield T&O Fore WSP Rainshield T&O Fore Rainshield T&O Pentathlon DF 75% Pentathlon LF 37% Protect DF	M3	Botrytis	Test a small section of the plant to be treated if the plant is not listed on the label: user assumes all risk in treating unlabeled plants. Adding a spreader-sticker may improve performance. For Dithane F-45, must use product with label listing ornamentals.
Mefenoxam Mefenoxam 2 Quali-Pro mefenoxam 2 AQ Subdue MAXX 21.3% MEC	4	Pythium (some Pythium isolates are insensitive to mefenoxam); Rotate with another Pythium material.	For use on container-, bed-, and bench-grown ornamental plants as a soil drench or incorporated in soil media. Use is not limited to plants mentioned on the label. Pothos and English ivy are extremely sensitive to mefenoxam: see label for precautions.
Myclobutanil Eagle 20 EW (see note) Eagle 40 WP (see note) Hoist (see note)	3	Powdery mildew	User should test for possible phytotoxicity to plants not listed on the label.
Neem oil extract, clarified Triact 70	NC?	Powdery Mildew	Conduct trials to be sure of safety to your crop. Do not spray without testing first. Con – Phytotoxicity from oil at high humidities. Risk of defoliation on poinsettias.
Oxycarboxin Plantvax	7		
PCNB Glacier 10G Hi-Yield T & O Terraclor 75% WP Terraclor 400F	14	Rhizoctonia	Drench and dip applications. Apply only once to bedding plants to avoid phytotoxicity.

Phosphorus acid Alude Vital	33	Phytophthora Pythium	Mixtures with some foliar fertilizers and copper materials may cause phytotoxicity to some plants: test for crop safety before use
Piperalin Pipron 84.4%L	5	Powdery Mildew	
Polyoxin D zinc salt Endorse	19, ?	Powdery mildew Botrytis	New active ingredient.
Potassium bicarbonate Armicarb Kaligreen Milstop	NC	Powdery Mildew	Con – repeated sprays add salt to plants – get leaf scorch or stunting (salts in soil) if applied too often.
Propamocarb Banol TOF 66.5% EC	28	Pythium	Application at seeding or transplanting, or bare root dip at potting, as well as drenches to established plants.
Pyraclostrobin Insignia	11	Botrytis Powdery mildew	Plants: See label for extensive list of tolerant species; test for phytotoxicity on a small sample of plants before widespread use. Do not use on impatiens or petunias when in flower. Do not use with organosilicone-based adjuvants. For resistance management, make no more than two sequential applications of Insignia before alternating with a material with a different mode of action (i.e. do not rotate with Compass O, Cygnus, or Heritage).
Pyraclostrobin + boscalid Pageant	11, 7	Botrytis Powdery mildew	To avoid phytotoxicity, do not use with organosilicone-based adjuvants. Discoloration may occur on impatiens or petunia flowers. For resistance management, do not make more than 2 consecutive treatments with Pageant before rotating to a fungicide with a different mode of action. Do not alternate with another Group 11 (strobilurin or QoI) fungicide.

Streptomyces grisioviridis Mycostop	Streptomycin 25	Botrytis	
Sulfur Microthiol Disperss	M2	Powdery Mildew	Added benefit of mite control. Do not use when greenhouse temperature will exceed 90° F in the next three days. Do not use within two weeks of an oil spray. Protectant.
Thiophanate-methyl 3336-F 42.5% 3336-WP 50% Allban 50WSB Allban Flo 46.2% F OHP 6672 50% W T-Bird 85 WDG Quali-Pro TM 4.5 F Quali-Pro TM 85 WDG	1	Rhizoctonia Powdery mildew Botrytis populations in greenhouse are likely to be resistant.	Plants: bedding plants, herbaceous annuals, perennials Same spectrum of activity as benomyl. Surfactants may improve performance of foliar sprays. Limited systemic action.
Thiophanate-methyl + mancozeb Zyban WSB 79.6%	1, M3	Botrytis Powdery mildew	Not for use on French marigold or gloxinia. Foliar only.
Triadimefon Strike 50 WDG	3	Powdery Mildew	Systemic fungicide Ineffective against rose powdery mildew in some trials. Effective against powdery mildew on poinsettias.
Trichoderma harzianum (KRL – AG2) Plant Shield HC 1.15%	NC	Rhizoctonia Some suppression of Botrytis and powdery mildew.	This is a biological fungicide. It may be applied as a spray at 0.25-0.5 oz/gal for suppression of foliar pathogens, or drenched at 3-5 oz/100 gal for suppression of soil pathogens. Follow all label precautions.
Trifloxystrobin Compass Fungicide 50 WDG Compass O 50 WDG	11	Botrytis Powdery Mildew Rhizoctonia	For resistance management, limit the number of sequential applications of Compass; use no more than 2 or 3 applications before rotating to a non-strobilurin. Petunia, African violet and New Guinea impatiens may show phytotoxicity. Con – potential for fungicide resistance to develop.

Triflumizole Terraguard 50W Terraguard SC	3	Powdery Mildew	Do not use on impatiens plugs; for impatiens transplants do not exceed 2 oz/100 gal rate. For all bedding plant plugs, do not exceed 2 oz/100 gal. For use on ornamentals grown in greenhouses.
Vinclozolin Touché EG	2	Botrytis Rhizoctonia	Label recommends that the grower conduct small-scale tests before broad use of any non-labeled ornamental species. Do not spray poinsettias in color, and do not spray after November 1. Do not use on V-14 Glory. Some poinsettia cultivars may show leaf spotting.

*It should be noted that not all the pesticides listed are labeled in all the states of the northeast region. These tables are not intended for use by growers but are to give an indication of the available pesticides, and their respective pesticide class or group, that are available for management of a particular pest.

OTHER DISEASES

Alternaria leaf spot

Alternaria spp.

Symptoms

This disease is common on dusty miller, marigold, impatiens, zinnia, and geranium. Small purple to brown leaf lesions develop under conditions of warmth and high moisture. On impatiens, spots have a purple to black rim and a light center and are only a few millimeters in diameter. They are easily confused with bacterial leaf spot, or impatiens necrotic spot virus (INSV), but their uniformly small size and the tendency of the leaf to turn yellow help distinguish them.

Management

Reduce the periods of leaf wetness to facilitate disease management. Overhead irrigation favors this disease. Plugs may arrive already infected. Examine plants closely. Fungicides are available to help control this disease.

Some Currently Registered Pesticides for Alternaria

(see Table 4 for information on fungicides)

Azoxystrobin
Bacillus subtilis
Captan
Chlorothalonil
Chlorothalonil in smoke formulation
Chlorothalonil plus thiophanate-methyl
Clarified extract of neem oil
Copper hydroxide
Copper hydroxide plus mancozeb
Copper salts of fatty and rosin acids
Fixed copper tannate
Flutolanil
Fludioxonil
Iprodione
Ipridione plus thiophanate-methyl
Kresoxim methyl
Mancozeb
Mancozeb plus thiophanate-methyl
Myclobutanil
Paraffinic oil
PCNB
Polyoxin D zinc salt
Potassium bicarbonate
Pyraclostrobin
Thiophanate-methyl

Triadimefon
Trifloxystrobin
Triflumizole
Vinclozolin

Bacterial Blight of Geranium
Xanthomonas hortorum pv. *pelargonii*

Symptoms

Bacterial blight can cause leaf spots as well as systemic infections in geraniums. Leaf symptoms are either an overall tiny spotting (1/16 –1/8 in. diameter) or a wedge-shaped yellow to brown area often followed by leaf wilting. The disease can cause black dieback of growing points and stem cankers at the base of the petioles. In hot, humid weather, the bacteria may spread from infected leaves into the stem, causing the plant to wilt and die.

Zonal and ivy geraniums (*Pelargonium x hortorum* and *P. peltatum*) are most likely to develop symptoms of this disease; a few cases of leaf spots on Regal geraniums have been observed. Hardy *Geranium* species may be a source of bacteria that can cause disease on greenhouse crops of *Pelargonium* species. Geraniums grown from seed can become badly diseased if they are grown with an infested cutting crop. Plants in families other than the Geraniaceae are not susceptible.

Management

Grow culture-indexed cuttings only. *Xanthomonas*-free material for cuttings is assured through careful culture indexing. Grow stock plants using individual tube watering systems. Splashing water easily spreads the organism. Subirrigation may spread the disease from root system to root system. Keep stock from different suppliers separate, and grow seedling geraniums separate from cutting crops. Do not hang ivy geraniums over a bench or floor crop of geraniums. Do not grow hardy (perennial) *Geranium* species near greenhouse crops of *Pelargonium* spp. Rogue out symptomatic plants immediately. Thoroughly sanitize areas where infected plants were grown.

Bactericides are available for the prevention of spread of bacterial blight. Avoid spraying other materials that might serve to spread the bacteria.

Some Currently Registered Pesticides for Bacterial Blight of Geranium
(see Table 4 for information on fungicides)

Bacillus subtilis
Copper hydroxide
Copper hydroxide plus mancozeb
Copper salts of fatty and rosin acids
Copper sulfate pentahydrate
Fixed copper tannate

Bacterial Leaf Spots
Pseudomonas and *Xanthomonas* spp.

Symptoms and Disease Development

Bacterial pathogens *Pseudomonas* and *Xanthomonas* can both cause foliar spotting on various crops. *Pseudomonas* spp. can produce irregular water-soaked areas on leaves of plants including impatiens and New Guinea impatiens under wet conditions. Pseudomonas leaf spots on impatiens are variable in size and may blight the entire leaf; spots often start at the leaf edge. Zinnia and English ivy are susceptible to different bacteria (*Xanthomonas* spp.) causing angular tan spots with yellow haloes.

Management

Inspect incoming material and use disease-free cuttings and seeds (zinnia leafspot caused by *Xanthomonas* is known to be seed-borne). Splashing water can move bacteria and spread disease. Eliminate overhead irrigation where possible. Avoid watering late in the day, rather irrigate when the leaves will dry quickly.

Some Currently Registered Pesticides for Bacterial Leaf Spots

(see Table 4 for information on fungicides)

Bacillus subtilis
Copper hydroxide
Copper hydroxide plus mancozeb
Copper salts of fatty and rosin acids
Copper sulfate pentahydrate
Fixed copper tannate

Black root rot
Thielaviopsis basicola

Symptoms and Disease Development

Pansies, violas, calibrachoas, petunias, and vinca (*Catharanthus roseus* and *Vinca* minor) are among the most commonly susceptible greenhouse plants. The disease may be first noticed due to stunting or pale colored, seemingly nutrient-deficient foliage. Thielaviopsis causes a black root rot and sometimes a dark dry stem base lesion, High pH and poor drainage encourage Thielaviopsis root rot. Losses have also occurred in hanging baskets of fuchsia grown at high pH (6.5–7.0) and in poinsettia crops.

Management

The disease is rarely a problem in growing media adjusted to pH 4.5 to 5.0. Cleaning pots well is a very important control measure as it common for this fungus to survive on pots and trays. Prevention of contamination of media with outside soil can also help control this disease. Good water management is also important as this disease is more likely to be a problem on over-watered plants.

Fungicide drenches can be effective especially when used preventively if this disease has been a problem in the past, because the fungus survives in greenhouses from year to year and may be moved about by people, fungus gnats, etc..

Some Currently Registered Pesticides for Thielaviopsis
(see Table 4 for information on fungicides)

Etridiazole plus thiophanate-methyl
Fludioxonil
Fludioxonil plus mefenoxam
Thiophanate-methyl
Triflumizole

Chrysanthemum white rust
Puccinia horiana

Chrysanthemum white rust (CWR) is caused by the fungus *Puccinia horiana*. This disease does not occur naturally in the US, however it has appeared here occasionally over the past few years, apparently as the result of importation.

Symptoms and Disease Development
This disease first appears as small yellow foliage spots that begin less than ¼" in diameter. A characteristic feature that helps separate these spots from other spots is the tiny brown speck in the center of the lesion. Below these spots a raised tan to pink colored pustule develops which fades to white with age. These pustules are where spores are released. The best place to look for the spots is on the young leaves and flower bracts. Also check mums growing outside near the greenhouse, as well as including Montauk daisy (*Leucanthemum X superbum)*.

Management
To help prevent this disease from occurring at your operation, carefully inspect incoming mums especially from other growers. Imported cut chrysanthemums should never be handled in or near a mum growing facility—a particular challenge for greenhouse/florist operations. Cool humid conditions favor this disease (temperature range from 63 – 75 F).

Chrysanthemum white rust is a federal quarantine pest; growers are obligated to report it. If you are not sure if you have white rust, contact your extension office or NY Ag and Markets to get a confirmation.

Some Currently Registered Pesticides for Chrysanthemum White Rust
(CWR treatment post detection is determined by the USDA)
(see Table 4 for information on fungicides)

Azoxystrobin
Chlorothalonil
Kresoxim methyl
Mancozeb
Myclobutanil
Triadimefon

Cladosporium Leaf Mold
Fulvia fulva (syn. *Cladosporium fulvum*).

Cladosporium leaf mold is primarily a problem on greenhouse-grown tomatoes, but can occur in the field when humidity is high.

Disease Development

Fungal spores germinate under high humidity (85% or greater) and cool to warm temperatures (40 to 90ºF), but disease rarely occurs below 50ºF. Wind, splashing irrigation water and rain, workers, tools, and insects readily disseminate spores. Contaminated seed can also initiate epidemics. The pathogen survives between tomato crops in and on crop residues, and in the soil as spores (conidia) or dormant resting structures (sclerotia).

Symptoms

Disease symptoms are usually limited to foliage, and first appear on the upper sides of older leaves as pale green or yellow spots. Leaf spots have irregular borders, but when infection is severe these spot coalesce and kill large areas of the foliage. The upper surface of affected leaves turns an olive green with more intense color near the center of lesions. Leaves eventually curl, wither, and may drop from the plant. Blossoms, stems, and fruit can be attacked by *F. fulva*. Affected fruit has a black, leathery rot on the stem end with an irregular margin.

Management

Plant only high quality seed free from the leaf mold pathogen. Hot water treatment can reduce seed contamination, but can reduce germination.. In greenhouse production, thoroughly sterilize production areas by steam to eliminate *F. fulva*. Minimize wetting the foliage when irrigating tomatoes. Maintain night temperatures higher than outside temperatures. Resistant varieties are available, but many races of the pathogen exist, and resistance can be overcome quickly by the appearance of new races.

Fungicides control leaf mold, but should be used in combination with as many cultural control strategies as possible to be most effective. Read label carefully for specifications regarding use on tomatoes as a food crop.

Some Currently Registered Pesticides for Cladosporium

Pyraclostrobin

Reference: High Plains IPM Guide, a cooperative effort of the University of Wyoming, University of Nebraska, Colorado State University and Montana State University.

Downy mildew
Peronospora and Plasmopara spp, primarily.

Downy mildew is a newly important disease of bedding plant crops and is not as common as foliar blights caused by Botrytis. Downy mildew, caused by fungus-like organisms in the Oomycetes, can occur very rapidly and can be difficult to control. Some of the greenhouse crops prone to infection by one of the downy mildews include: coleus, bacopa, basil, snapdragon, salvia, alyssum, impatiens, jamesbrittenia, pansy, rose, rosemary, and ornamental cabbage. Perennials susceptible to downy mildew include aster, coreopsis, geranium, geum, lamium, potentilla, veronica and viola.

Symptoms

Symptoms can be confused with other plant problems. Leaves may become mottled and yellowed, appearing to have nutritional deficiencies. On some plants, downy mildew infection may look similar to injury from foliar nematodes. In both cases, angular lesions are bounded by leaf veins. However, downy mildew infection eventually results in a soft, fluffy gray, brown or purple fungal sporulation developing on the underside of leaves. On some plants including coreopsis, the fungal sporulation is white. Systemically-infected plants may be stunted and off-color.

Symptoms can vary depending upon the host plant. On coleus leaves are spotted, twisted, or drop from the plant. On snapdragons, infected plants are yellow and stunted. You may see downward leaf curling on the young seedlings. On salvia, angular yellow blotches can be seen between the leaf veins. On pansy, leaves turn mottled and off-color with purple blotches. Pale green or yellow patches develop on geum. Purplish patches occur on lamium and veronica. On roses, leaves develop angular dark purple to black areas that resemble phytotoxicity from a spray application.

Life Cycle

Downy mildews usually develop during cool (50 - 75 F), wet conditions with high relative humidity. A film of water is needed for spore germination and infection. Prolonged periods of leaf wetness promote this disease. Fungal spores are easily spread by splashing water and wind, sometimes over very long distances. Infection is sometimes carried in the seed.

In most cases there is no good mechanism for downy mildew to survive off host plants. It may be introduced through seed or plugs into the greenhouse. Look at incoming plants closely. This disease may travel via wind currents and consequently be worse in certain years when the weather pattern favors spore movement from the south.

Management

Become familiar with the symptoms on susceptible crops and regularly scout to detect downy mildew early when fungicides are more effective. With a 10 to 20x handlens, look on the underside of leaves for the gray, purple, brown or white blooms of sporangia (microscopic stalks bearing spores). The fungal stalks may branch in a pattern that looks like "deer antlers". Remove all infected plants. Spores can be easily moved from plant to plant. Downy mildew may sometimes be carried over in infected plant debris in the soil or in weed hosts. In the greenhouse, keep relative humidity below 85 percent to decrease fungal sporulation and disease development.

Protect susceptible crops with preventative fungicide applications during cool, wet weather. Repeated applications may be needed. Rotate among fungicide classes to delay the development of resistance. Use of systemic (e.g. Dimethomorph) and contact (e.g. mancozeb) fungicides in rotation is a good strategy.

Some Currently Registered Pesticides for Downy Mildew
(see Table 4 for information on fungicides)

Aluminum tris o-ethyl phosphonate
Azoxystrobin
Captan
Chlorothalonil
Chlorothalonil plus thiophanate-methyl
Clarified extract of neem oil
Copper hydroxide
Copper hydroxide plus mancozeb
Copper salts of fatty and rosin acids
Copper sulfate pentahydrate
Dimethomorph
Etridiazole
Etridiazole plus thiophanate-methyl
Fixed copper tannate
Fludioxonil plus mefenoxam
Fosetyl-A1
Kresoxim methyl
Mancozeb
Mancozeb plus thiophanate-methyl
Phosphorus acid
Polyoxin D zinc salt
Potassium phosphate
Trifloxystrobin

Reference: University of Connecticut Integrated Pest Management Greenhouse Downy Mildew Factsheet.

Impatiens Necrotic Spot Virus

Spread by the western flower thrips, INSV has caused devastating losses to some bedding plant crops in cases where the grower was unaware that the thrips population had skyrocketed. Young seedlings are more susceptible than older plants. Almost all crops are susceptible, but losses have been most dramatic in impatiens, particularly double-flowered varieties. New Guinea impatiens, begonia, coleus, browallia, nemesia and many other bedding plants are susceptible.

Symptoms
INSV causes a wide variety of symptoms, which vary by the host plant. Many species are stunted and distorted by INSV infection. INSV-infected plants may also show ringspots, mottling, or browning along the veins. Impatiens show black leaf spots as well as blackening of sections of the stem. Not all infected plants show symptoms; symptomless plants (including weeds) may be the source of virus for crops that are highly susceptible. Tomato spotted wilt virus (TSWV) is a closely related virus. Symptoms are very similar to those of INSV but TSWV is far less common in bedding plants. Tomato and pepper transplants are especially vulnerable to TSWV.

Disease Development

Vegetatively propagated flower crops in hanging baskets have often provided inoculum (and thrips vectors) for a seed crop grown below them. Flowering pot plant crops or weeds in the same greenhouse may also provide inoculum of INSV that may injure bedding plants. Begonias are often a source of the virus.

Control

Discard symptomatic plants immediately and guard constantly against thrips population buildup to avoid losses. Monitor the thrips population with yellow sticky cards, and initiate treatment if more than 10 thrips are caught per card per week, assuming three cards per 1,000 sq. ft. greenhouse. Keep vegetable transplants separate from flower crops, and grow plants from cuttings well separated from plants from seed. Maintain a strict weed control program. Beware of growing or carrying over virus-infected plants that may appear healthy. (no chemical treatments available)

Phytophthora Damping off, Root and Crown Rot

Phytophthora spp

Symptoms and Disease Development

Sudden wilting of an individual shoot or an entire plant is an indication of Phytophthora infection. Deteriorated or water-soaked roots or stem/foliar lesions may also be noticed. Phytophthora is favored by deep planting and by wet, poorly drained growing mixes. Avoid growing Phytophthora-sensitive plants in ebb-and-flood benches because the zoospores can easily spread the disease from pot to pot. Remove symptomatic plants promptly. Petunias, gerberas, vincas (*Catharanthus),* and pansies seem to be particularly susceptible.

Chemical Control

The same fungicides that work against Pythium will work against Phytophthora because both are oomycetes (commonly called “water molds”). Resistance has occurred in greenhouse Phytophthora populations, so always be careful to rotate among materials for the control of the disease.

Some Currently Registered Pesticides for Phytophthora Damping off, Root and Crown Rot

(see Table 4 for information on fungicides)

Aluminum tris o-ethyl phosphonate
Azoxystrobin
Captan
Chlorothalonil
Chlorothalonil plus thiophanate-methyl
Clarified extract of neem oil
Copper hydroxide
Copper hydroxide plus mancozeb
Copper salts of fatty and rosin acids
Dimethomorph
Etridiazole

Etridiazole plus thiophanate-methyl
Fixed copper tannate
Fludioxonil plus mefenoxam
Fosetyl-A1
Mancozeb
Mancozeb plus thiophanate-methyl
Mefenoxam
Phosphorus acid
Potassium phosphate
Propamocarb
Pyraclostrobin
Trifloxystrobin

Sclerotinia Stem Rot
Sclerotinia sclerotiorum

Host list

This disease can be found in the greenhouse or landscape. Many fleshy-stemmed greenhouse plants can be infected with Sclerotinia Stem Rot including: tomato, petunia, snapdragon, sunflower, lobelia, marigold, and zinnia, to name a few. A total of over 170 species could be affected, including many vegetables.

Symptoms

Symptoms begin as a watery stem rot with white, moldy growth on stems, petioles, and lower leaves. If conditions remain moist, a large amount of cottony, moldy growth can be seen on the dead tissue. As this growth progresses, hard, black, irregularly-shaped bodies called sclerotia form on the surface or often inside affected stems.

Life Cycle

The hard, black sclerotia can survive without a host plant for up to seven years in dry soil. Disease is dependent on high humidity and cool temperatures (60-70 degrees F is ideal). In addition to the sclerotia causing direct infection, small, cup-like fruiting structures, called apothecia, can be formed.. The apothecia produce enormous numbers of spores that spread by air movement and can also cause infections.

Management

During the growing season, the greenhouse soil surface and atmosphere should be kept as dry as possible by continuous air circulation. All infected plant parts should be removed from the greenhouse as they appear on plants. Look at incoming plants closely, as this disease can be shipped in on plants.

Fungicides are available for control. Good spray coverage of stems and the bases of plants is essential when controlling this disease.

Some Currently Registered Pesticides for Sclerotinia Stem Rot

(see Table 4 for information on fungicides)

Azoxystrobin
Chlorothalonil
Chlorothalonil plus thiophanate-methyl
Etridiazole plus thiophanate-methyl
Fenhexamid
Fludioxonil
Iprodione
Mancozeb
PCNB
Pyraclostrobin
Thiophanate-methyl
Trifloxystrobin
Triflumizole
Vinclozolin

Reference: Sclerotinia Stem Rot of Tomatoes in Greenhouses Vegetable Disease Information Note 4 (VDIN-004) Charles W Averre, Extension Plant Pathologist, North Carolina State University.

Southern Wilt of Geranium
Ralstonia solanacearum

Ralstonia solanacearum is a bacterium that has various races that vary in their host and climate adaptation. Race 1 has been reported to cause disease on many flowering plants, including geranium (*Pelargonium x hortorum*), as well as field crops. It is seen occasionally in US greenhouse production, particularly in the South. Race 3 is found throughout the world except in the U.S. and Canada. The race/biovar of most concern to the U.S. is Race 3 biovar 2, because of its potential ability to cause damage to potato, tomato, eggplant and geraniums in cooler climates than Race 1. In recent years, geranium cuttings produced in Kenya, Costa Rica and Guatemala were found to carry this race of *R. solanacearum*, resulting in a massive eradication effort in U.S. greenhouses under a federal quarantine in 2003. To keep this pathogen out of the United States, a joint effort has been made by USDA, the geranium propagators, and the greenhouse industry. Clean stock production procedures have been carefully refined in offshore propagation facilities.

Symptoms and Identification

Yellowing and wilting of leaves is the only aboveground symptom caused by *Ralstonia* in geraniums, whereas *Xanthomonas hortorum* pv. *pelargonii* will cause tiny, round, brown leaf spots (if the bacteria have been splashed onto the leaves), as well as wilting. Remember that wilting in geraniums is most often caused by *Pythium* attack on the root systems. Seek help with diagnosis from a qualified laboratory rather than assuming that your crop is infected with *Ralstonia*. Test kits are available to check on-site for the presence of *Xanthomonas* or *Ralstonia* bacteria in geraniums that have suspicious wilting symptoms. Identification of the particular race of *Ralstonia* may only be done at a USDA-approved testing lab; the grower-friendly test kits will only identify the organism as *Ralstonia solanacearum*, and can't distinguish between Race 1 and the very serious Race 3.

Management

Careful sanitation practices are important for each individual grower. To minimize risk, separate geraniums from different suppliers and from different ship dates. Avoid hanging geraniums over other crops. Do not grow geraniums in the same greenhouse with tomato transplants. Do not subirrigate geraniums. Chemical controls are not as important as rouging out infected plants. Some phosphorus acid materials have shown real promise for protecting plants against *Ralstonia solanacearum*; copper treatments would help with sanitation but are not beneficial for reducing root uptake of inoculum.

Some Currently Registered Pesticides for Southern Wilt of Geranium

(see Table 4 for information on fungicides)

Aluminum tris O-ethyl phosphonate
Copper hydroxide
Copper hydroxide plus mancozeb
Copper salts of fatty and rosin acids
Fixed copper tannate

NEW DISEASES AND THOSE OF INCREASING IMPORTANCE

*Puccinia horiana**
Chrysanthemum white rust
    Quarantine significant pest – control by eradication

*Ralstonia solanacearum**
Southern wilt in geranium
    Race 3, biovar 2 is on the Select Agent list - control is by eradication only

Peronospora sp.*
Basil downy mildew
    In the US since 2007, in the NE since 2008; seedborne

Coleus downy mildew
    Widespread but awareness still is lagging a bit; possibly
    Seedborne. Different from the basil downy mildew even though coleus downy mildew can be inoculated on to basil experimentally.

Plasmopara obducens
Impatiens downy mildew
    Damaging effects in landscape plantings, possibly seedborne.

Fusarium oxysporum f. sp. *chrysanthemi*
Fusarium wilt of chrysanthemum
    Becoming more prevalent with warming climates?

*Thielaviopsis basicola**
Black root rot

Increasing as more growers are recycling plug trays, pots and flats

Xanthomonas axonopodis pv. *begoniae*
Attacking some of the new forms of begonia in the trade

*See the "Other diseases" section for additional information on these diseases

PESTICIDES IN THE PROCESS OF REGISTRATION

Active ingredient	**Trade name**	**Active against**	**Comments**
Mandipropamid		Downy mildew and *Phytophthora*	Not yet registered
Fluopicolide	Adorn (V-10161)	*Pythium* and *Phytophthora*	Newly registered with EPA
Fluoxastrobin	DisArm	*Pythium* and *Phytophthora*	Newly registered with EPA
Kasumin		Bacteria	Not yet registered
Bacillus subtilis var *amyloliquefaciens*	Taegro		

INSECTS AND MITES

Primary Source: 2008 Cornell Guide for the Integrated Management of Greenhouse Floral Crops

Aphids

(*Myzus persicae, Aphis gossypii, Aulacorthum solani*)

Damage and Importance

Aphids can infest most greenhouse crops. Their mere presence can ruin the beauty of a plant. Feeding can cause stunting and plant/leaf deformities. Large infestations can reduce plant vigor. They produce a sweet, sticky secretion called "honeydew," which leads to unsightly grey sooty mold. White cast skins that they leave behind as they molt from one stage to another are unsightly. Aphids are responsible for the transmission of about 60% of all plant viruses on agricultural crops world-wide.

Identification

Aphids are all generally small (1-3mm) and soft bodied, and have a pair of unique structures that resemble "tailpipes" near the end of their abdomen, called cornicles. Adults may or may not have wings. More than 20 aphid species can infest various greenhouse crops. Three of the most common are:

Green peach aphid (*Myzus persicae*): Very common aphid. Color varies from light green to rose. Have a pronounced indentation between the bases of their antennae on the front of their head. Color of the cornicles is the same as the body except the extreme tips, which are dark.

Melon aphid (*Aphis gossypii*): Small, very common aphid. Color varies from light yellow to very dark green, almost black. Have no pronounced indentation between the bases of their antennae. The entire length of their cornicles is always black, regardless of their body color.

Foxglove aphid (*Aulacorthum solani*): Also called glasshouse potato aphid. Broad host range, and has often been found on ivy and zonal geraniums, salvia, and cineraria, among many other crops, in the northeastern U.S. Looks very much like green peach aphid in size, shape, and color, except they are shiny, and the area of the abdomen around the bases of the cornicles is darker green than the rest of the body.

Biology

Aphids reproduce parthenogenetically, i.e., all the insects present are females, and each female gives birth to more females without the need to mate. These females give birth to living nymphs rather than lay eggs. An unborn aphid already contains a complement of developing nymphs. Aphid nymphs are genetic clones of their mothers. Populations can increase explosively – newborns can reach adulthood and begin to reproduce in as little as 7 days. As a colony increases in age and size on individual plants, the proportion of winged forms increases.

They feed by inserting their stylet-like mouthparts through plant tissue directly into the phloem and removing plant sap. Aphids may be found feeding on buds, stems, and the lower surfaces of leaves. Some will migrate to new host plants or young plant tissue and will actively search for soft, fresh plant tissue. As plants begin to form flower buds, a previously undetected aphid infestation can become terribly apparent as they move up the plant onto the recently developed stems, buds, and flowers. Aphids on the upper canopy will be easier to contact with sprays. Systemic insecticides will be most effective against those feeding on new growth. Aphids on older growth lower in the canopy are often most difficult to kill chemically, and may be responsible for producing new aphids that will reinfest the upper canopy. Green peach aphids are prone to develop winged forms on mums, and may be more likely to spread quickly throughout a mum crop. Melon aphids do not develop winged forms as readily and are not as likely to be detected on yellow sticky cards.

Management

IPM

White cast skins on leaves of a plant may indicate an aphid colony on the leaves or stems above. Ants are often attracted to the honeydew, so if you see ants on your plants, inspect them carefully for aphids. Group aphid-susceptible plants together for easier monitoring. Inspect plant material brought into your growing areas; do not purchase infested plants or cuttings. Inspect the greenhouse thoroughly for all sources of all pests, including aphids, before a new crop arrives. If possible, quarantine newly-arrived plants, and inspect thoroughly before moving them into production areas.

The scouting procedure is made up of three components: plant inspection, sentinel plants, and yellow sticky cards. Yellow sticky cards for winged adults, coupled with plant inspections for non-winged aphids, can give a good overall picture of the presence, size, and location of an infestation, and reveal if control strategies are working. Sentinel plants can indicate whether an insecticide or a natural enemy was effective. It is important to know what living, dead, and parasitized aphids look like. Parasitized aphids should not be crushed or removed from plants. Parasitoid wasps will emerge from these cases to continue parasitizing aphids.

A. Plant Inspection. Some form of foliar scouting must be used to monitor aphids, because yellow sticky cards used alone will only reveal the activity of winged aphids, which are much less common than the wingless forms. A map of infested locations may help to target areas to be sprayed and monitored.

B. Sentinel plants. When infested plants are found during plant inspection, some of these plants are marked with flagging tape or survey flags, and are used as “sentinel plants”. The insects on these sentinel plants are then monitored weekly to note whether control measures are having an effect. Examine plants carefully and frequently to determine if repeat applications will be required. For example, if aphids on the sentinel plants are increasing even though insecticides are being applied, then you have an early indication that something is wrong before a large infestation can develop.

C. Yellow sticky cards. Yellow sticky cards can monitor when winged aphids are active and may detect a migration of aphids into the greenhouse, particularly in the spring and summer. In New York we suggest using one 3-by-5 inch card per 1,000 sq. ft. Cards should be positioned vertically just above the crop canopy. Additional cards placed near doors or vents can detect whether insects are moving into the greenhouse from outside. Cards should be counted at least weekly, and changed weekly or when they are full.

	Methods	Pros	Cons	Comments
Diagnosis/ID	Images Magnification			ID required for effective biological control
Detection	Plant inspection Sentinel plants Tap test Cast skins Predator insects Yellow sticky cards	See other insects	Few winged adults	
Monitoring	Plant inspection Sentinel plants Yellow sticky cards		Few winged adults	
Action Thresholds*				

*There are very few action thresholds identified for pest crop interactions in greenhouse settings. For insects that vector diseases, such as thrips and impatiens necrotic spot virus, the threshold may be 1 insect. The threshold may also depend on the stage of the production cycle and whether the plant is produced for wholesale or retail sale.

Cultural/Mechanical

Sanitation is vital. Eliminate all weeds within or near your greenhouses. Discard old stock plants, hanging baskets that have not sold, and don't keep "pet" plants. Screen doors and vents to prevent migration into the greenhouse, especially during the fall and spring. Avoid planting aphid-susceptible cultivars near doorways or vents where they could be infested from an outside source.

Aphid control is much more successful when an infestation is detected and controlled early in a crop. There are fewer aphids, spray coverage is better while the crop canopy is sparse, and the risk of phytotoxicity is reduced. Among the worst times to first notice an aphid infestation is when they are crawling all over the flowers. Therefore, a regular scouting program should be implemented to detect aphids throughout the crop.

Biological Control

Commercially available natural enemies for aphids include ladybird beetles, lacewings, parasitic wasps (e.g. *Aphidius colemani*), predaceous midges (*Aphidoletes aphidomyza*), and insect-pathogenic fungi (*Beauveria bassiana*). It is usually best to use fungal pathogens while the infestation is small, not against a major infestation. Repeated applications at 3-5 day intervals may be necessary for a rapidly growing infestation. Researchers and growers are investigating the use of various natural enemies for aphid control on greenhouse crops, including the use of banker plants, impact of hyperparasitism and the possible negative impact on retail sales when the natural enemies or evidence of their presence, such as aphid "mummies" are visible.

Chemical

Systemic or translaminar insecticides tend to be more effective than contact insecticides, provided that a sufficient amount of insecticide reaches the aphid feeding sites. Contact insecticides can be very effective with thorough spray coverage and good canopy penetration. Two applications of foliar sprays, a week apart, are often needed, but follow label directions. Keep careful scouting records to evaluate the effectiveness of various chemicals under your own conditions. Some strains of aphids have developed resistance to some pesticides.

<u>Some Currently Registered Pesticides for Aphids</u>

(see Table 5 for information on insecticides and miticides)

Common Name (class)
Group 1A & 1B
Acephate (1B)
Chlorpyrifos (1B)
Chlorpyrifos + cyfluthrin (1B + 3)
Dichlorvos (1B)
Fenpropathrin + acephate (3 + 1B)
Methiocarb (1A)
Naled (1B)
Group 3
Bifenthrin (3)
Chlorpyrifos + cyfluthrin (1B + 3)
Cyfluthrin (3)
Cyfluthrin + imidacloprid (3 + 4A)
Fenpropathrin (3)
Fenpropathrin + acephate (3 + 1B)
Fluvalinate (3)
Permethrin (3)
Pyrethrins + piperonyl butoxide (3 + 27A)
Pyrethrins + rotenone (3 + 21)
Pyrethroid (3)
Group 4
Acetamiprid (4B)
Clothianidin (4A)
Cyfluthrin + imidacloprid (3 + 4A)

Dinotefuran (4A)
Imidacloprid (4A)
Nicotine (4B)
Thiamethoxam (4A)
Group 6
Abamectin (6)
Group 7
Fenoxycarb (7B)
Kinoprene (7)
Pyriproxyfen (7C)
Group 9
Flonicamid (9C)
Pymetrozine (9B)
Group 18
Azadirachtin (18B)
Group 21
Pyrethrins + rotenone (3 + 21)
Group 27
Pyrethrins + piperonyl butoxide (3 + 27A)
Miscellaneous
Beauveria bassiana NC
Horticultural oils
Insecticidal soap
Neem oil
Soybean oil

State/local pesticide restrictions or limitations, export issues, etc.

- Resistance to certain organophosphate, carbamate, and synthetic pyrethroid insecticides is common in aphids.
- Some efficacious materials are not registered in all states in the Northeast.

Critical issues and needs

- Efficacy/resistance information lacking for most pesticides
- Lack of effective biocontrols for all species
- Early detection time consuming/unreliable
- Species/strain identification by experts is slow compared to aphid reproduction rate

Fungus Gnats
(*Bradysia* spp.)

Damage and Importance

The first few weeks of a crop are most critical for fungus gnat control. Chewing by larvae can cause direct root damage, and provide an entry into the roots for fungal pathogens. Seedlings and young plants without fully developed root systems are particularly susceptible to their damage. Unrooted cuttings are also particularly vulnerable, with larval feeding interfering with callus formation and thus root initiation. Adult fungus gnats do not cause direct damage to plants, but are considered a nuisance pest to consumers. In addition, adults and larvae have been implicated in the transmission of plant fungal diseases, including *Thielaviopsis, Pythium, Verticillium, Myrothecium*, and *Fusarium* . Larvae may transmit fungal plant diseases via their excretion. Adults may transmit these diseases via excretion or by carrying spores of disease organisms on their bodies. Disease transmission by fungus gnats has been documented in lab studies, but it is not yet clear whether fungus gnats play an important role in disease transmission under commercial conditions.

Identification

Adult fungus gnats are small (approx. 1/8 inch long), blackish grey, gnat-like flies with long gangly legs, many-segmented antennae that are longer than their heads, and have a single pair of grayish transparent wings with a Y-shaped vein near each wing tip. They are weak flyers and may be found running/flying near soil level. Fungus gnat larvae are the damaging stage of this insect. They are usually concentrated in the top 1-2 inches of the growing media, but can be found throughout the pot. The larvae are translucent, worm-like, with a distinctive black head capsule, and are about ¼ inch long just prior to pupation. Larvae might be seen crawling near the surface of the growing medium if the population is very high.

Biology

Mated adult females deposit up to 200 eggs singly or in clusters in crevices or cracks on the surface of the growing media. Adult females prefer to lay eggs where fungus is growing. Larvae prefer to feed on fungi rather than healthy plant tissue. Although fungus gnat larvae can eat plant material, they need fungi in their diet for optimal survival, development, and reproduction. The offspring of a given female will either be all males or all females. At 70° -75° F, these whitish-yellow eggs hatch in 3-6 days. The four larval instars then feed for about 2 weeks and usually pupate near the soil surface within a thread chamber. After 3-7 days in the pupal stage, adults emerge and live for up to 8 days. They can develop from egg to adult in 3-4 weeks. This life cycle is dependent on temperature and as temperatures decrease, the length of their developmental time increases. Optimal temperature for development seems to be 70-75° F. They do not appear to thrive at high temperatures. Overlapping life stages are often present at the same time, though the bulk of the population may exist in only a few life stages.

Management

IPM

For monitoring adults, yellow sticky cards placed horizontally at soil level are most effective. However, fungus gnats can be monitored along with most other flying greenhouse pests by positioning yellow sticky cards vertically just above the crop canopy. Count them weekly and record the numbers to see if the infestation is increasing or decreasing. Because fungus gnats are often particularly damaging to young plants, monitor for adults several weeks before a crop is started, and continue to monitor as the infestation is cleaned up before the new crop is started. To monitor whether larval control is being achieved, use raw potato slices (at least 1 inch thick) or wedges, placed cut-side down on the surface of the growing medium. Check the slices weekly, replace them weekly, and record numbers of larvae found on the potato slices and on the soil surface beneath the slices.

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Images Magnification			Accurate ID of either adults or larvae is fairly easy – note difference between drain fly, shore fly, and fungus gnats
Detection	Yellow sticky cards Potato Observation	Inexpensive, readily available, very useful for direct stick plus misting especially	Adults only, Can catch beneficials May rot or sprout if left too long	Reliability variable
Monitoring	Yellow sticky cards Potato			

Cultural/Mechanical

No growing mixes are immune to fungus gnat infestation, but fungus gnat numbers can vary among growing mixes. Adults are strongly attracted to microbial activity in soil/media. For fungus gnat management, avoid immature composts (<1yr old), including composted pine bark mix. Mixes with any compost are usually more attractive to fungus gnats than pure sphagnum peat. Good sanitation is vital. Clean up spilled growing media, clean up algae, and fix plumbing leaks. Weed control inside and outside the greenhouse is important. Avoid over-watering and sloppy irrigation. Keep compost piles well away from production areas. Cycle plants through the greenhouse as quickly as possible. Some growers have greatly reduced fungus gnat and shore fly adult levels by stretching strips of sticky yellow plastic 6” wide ribbon throughout the greenhouse near the soil level along the sides of benches or beneath benches, in areas of adult activity.

Biological

Releases of natural enemies should be done when populations are low, at start of crop.

1. Nematodes: *Steinernema feltiae* is the most effective nematode species for fungus gnat larvae. Make first application at planting, or soon after, then 2-3 weekly applications. Irrigate the day before application. Apply as a drench. Nematodes are not usually good at reducing a serious infestation, one reason why they should be applied near the start of the crop.

2. Bacteria: Gnatrol is applied as soil drench. The active ingredient is a bacterium that must be ingested by fungus gnat larvae. The bacterial toxin that kills the fungus gnat larva is only effective for 48 hours after application; so repeat treatments with higher label rates at 3 to 5 day intervals for heavy infestations.

3. Predators: Releases of the predaceous mite, *Hypoaspis miles*, may give excellent control. Release soon after planting. A single release has provided 6-8 weeks of control in some cases. The predators are capable of establishing and spreading throughout a greenhouse if the environment is favorable. They live in the top layer of soil and feed on any small arthropods they encounter (including thrips). Check each shipment for viability: shake up the bottle, then shake a small amount of sawdust carrier onto a sheet of paper. Using a handlens, look for rapidly-moving light-brown mites. Potato slices used for fungus gnat larval monitoring may also be useful for *Hypoaspis* monitoring

4. *Others*: A predaceous rove beetle, *Atheta*, is also commercially available. A parasitoid, *Synacra*, and a predaceous fly, *Coenosia attenuate*, occur naturally in many greenhouses.

Chemical

Many insecticides used for fungus gnat control are insect growth regulators and only affect larval stages, not adults. Both an adulticide and a larvicide may be needed against well-established populations.

<u>Some Currently Registered Pesticides for Fungus Gnats</u>

(see Table 5 for information on insecticides and miticides)

Common Name (class)
Group 1
Acephate (1B)
Chlorpyrifos (1B)
Chlorpyrifos + cyfluthrin (1B + 3)
Fenpropathrin + acephate (3 +1B)
Group 3
Bifenthrin (3)
Chlorpyrifos + cyfluthrin (1B + 3)
Cyfluthrin + imidacloprid (3 + 4A)
Fenpropathrin + acephate (3 +1B)
Permethrin (3)
Pyrethrins + piperonyl butoxide (3 + 27A)
Group 4
Acetamiprid (4A)
Cyfluthrin + imidacloprid (3 + 4A)
Dinotefuran (4A)
Imidacloprid (4A)
Group 7
Kinoprene (7)
Pyriproxyfen (7C)
Group 13
Chlorfenapyr (13)

Group 15
Diflubenzuron (15)
Group 17
Cyromazine (17)
Group 18
Azadirachtin (18B)
Group 27
Pyrethrins + piperonyl butoxide (3 + 27A)
Miscellaneous
Bacillus thuringiensis israelensis
Horticultural oil
Insecticidal soap
Nematodes

State/local pesticide restrictions or limitations, export issues, etc.

- Some efficacious materials are not registered in all states in the NE.
- Europe may restrict/ban use of imidacloprid

Critical issues and needs

- Linkage to disease transmission uncertain in some cases

Twospotted Spider Mite
(*Tetranychus urticae*)

Damage and Importance

Spider mites attack virtually every florist crop, including most species of foliage plants. These mites cause severe chlorosis in attacked plants because the mites feed by “stabbing” cells with their piercing mouthparts and sucking up the juices that exude. Spider mites remove chlorophyll from plant cells and reduce photosynthesis. Removal of chlorophyll produces the characteristic stippling or mottling of foliage and sometimes causes leaf drop. In severe infestations, the plants may be covered with the mites’ characteristic webbing, which is why they are referred to as spider mites.

Identification

This pest is the most common species of the spider mite family Tetranychidae to infest greenhouse plants. These close relatives of insects are sometimes referred to as red spiders, although they are not spiders at all. They are minute arthropods, with the largest life stage (adult female) less than a millimeter in size. The body of the adult female and most immature stages is oval-shaped and usually appears light yellow to green with two large dark green spots on either side. All life stages have eight legs except for the larval stage, which has six.

Biology

Survival and developmental time and reproduction are greatly influenced by environmental factors such as temperature, humidity, and host plant, with temperature being most important. Females lay eggs (up to 12 per day) on the undersides of leaves, usually in the fine webbing that the mites constantly produce. One female is capable of laying over 100 eggs during her lifetime.

The eggs hatch in as few as 3 days, depending on temperature, and the newly hatched mites (called larvae) immediately begin to feed. After as few as 5 days, the mites pass through two nymphal stages and become adults. Females will begin laying eggs from 1 to 3 days after emerging as adults, and mating is not required. Egg to adult development may take as few as 7 days at 81° F, and about 20 days at 64° F. At warm temperatures, the mites' ability for rapid population increase becomes apparent. When populations of this pest are low, the mites prefer to attack the lower surface of leaves, but may move upward as populations increase. Spider mites do best under hot, dry conditions, and develop faster on water-stressed plants.

Management

IPM

A weekly routine plant inspection program is the best first step for spider mite management. The scout should inspect plants carefully for the first signs of leaf stippling caused by spider mites. Plants can be randomly chosen from each bench for inspection, with lower leaf surfaces being examined for the presence of mites. Particular attention should be given to areas of the greenhouse where mites are most likely to be spread on workers' clothing, such as along walkways or near entrances. Attention should also be focused on plant species or varieties that are particularly susceptible to mite infestations, or in areas of a greenhouse that have a history of mite problems. Efficient and regular scouting can lead to early detection of an infestation, and an assessment of the location and number of infested plants.

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Images Magnification			Fairly easy to identify
Detection	Tap test weekly Observation of foliage			Use of webbing for detection too late for adequate control

Cultural/Mechanical

Weeds serve as alternate food for spider mites and should be eliminated. Clean greenhouses between crops. Discard unsaleable plants with media as soon as possible.

Biological

Other mite species are known to feed voraciously on spider mites and their eggs, and these beneficial species are commercially available

Chemical

Pesticide resistance can be a common problem in spider mite control. Unfortunately, many strains of mites exist, and many of these strains are resistant to certain acaricides (miticides). Some miticides are not effective against mite eggs, thus a repeat application may be needed after 5-7 days. Thorough coverage of upper and lower surfaces of all leaves is critical for effective mite control. Plants on which an infestation is detected should be marked and re-inspected with a handlens several days after a spray to evaluate the degree of control achieved.

Some Currently Registered Pesticides for Spider Mites

(see Table 5 for information on insecticides and miticides)

Common Name (class)
Group 1
Acephate (1B)
Chlorpyrifos (1B)
Chlorpyrifos + cyfluthrin (1B + 3)
Dichlorvos (1B)
Fenpropathrin + acephate (3 + 1B)
Methiocarb (1A)
Naled (1B)
Group 3
Bifenthrin (3)
Chlorpyrifos + cyfluthrin (1B + 3)
Fenpropathrin (3)
Fenpropathrin + acephate (3 + 1B)
Fluvalinate (3)
Pyrethrins + piperonyl butoxide (3 + 27A)
Pyrethrins + rotenone (3 + 21)
Pyrethroid (3)
Group 5
Spinosad (5)
Group 6
Abamectin (6)
Group 7
Fenoxycarb (7B)
Group 10
Clofentezine (10A)
Etoxazole (10B)
Hexythiazox (10A)
Group 12
Fenbutatin (12B)
Group 13
Chlorfenapyr (13)
Group 18
Azadirachtin (18B)
Group 20
Acequinocyl (20B)
Group 21
Fenpyroximate (21)
Pyrethrins + rotenone (3 + 21)
Pyridaben (21)

Group 23
Spiromesifen (23)
Group 25
Bifenazate (25)
Group 27
Pyrethrins + piperonyl butoxide (3 + 27A)
Miscellaneous
Beauveria bassiana
Horticultural oil
Insecticidal soap
Neem oil
Soybean oil
Propargite

State/local pesticide restrictions or limitations, export issues, etc.

- Resistance.
- Some efficacious materials are not registered in all states in the NE.

Critical issues and needs

- Detection (random plant inspections) prior to symptoms appearing is economically unviable due to cost of labor time
- Limited options for herbs and greenhouse vegetables

Shore Fly
(*Scatella tenuicosta*)

Damage and Importance

Greenhouse workers and consumers consider adult shore flies a nuisance pest. In heavy infestations they also deposit characteristic black "fly specks” on foliage that are unsightly. Larvae are considered algae feeders, and do not feed on crop plant tissue. Adult shore flies are capable of transmitting *Pythium* and other root disease organisms, but whether such transmission commonly occurs in commercial greenhouses has not been evaluated. However, because algal growth and shore flies are common in misted propagation areas, and diseases are particularly severe to young plants during propagation, some growers aggressively manage shore flies in their propagation facilities.

Identification

Shore flies and fungus gnats are often considered together as greenhouse pests, but they belong to two distinct groups of insects. Adult shore flies are small, dark-grey flies (approx. 1/8 inch long), which slightly resemble a *Drosophila* fruit fly, with a robust body and short legs and antennae. They have five distinctive whitish spots on their grey wings. Their single pair of wings lacks the characteristic Y-shaped vein at the tip seen in fungus gnats, and the shore fly adult has short antennae. Larvae of the shore fly are small translucent-white maggots without a distinct head capsule. Pupae are dark brown, spindle-shaped, with a distinctive forked structure at one end of the puparium. They attach themselves, often in groups, to the sides of objects or pots just above the water level.

Biology

Shore flies are adapted to living in a semi-aquatic environment. Larvae and adults are found in close association with algae. Female shore flies lay on average about 300 tiny white eggs singly on moist soil. They develop from egg to adult in 9-11 days. Eggs hatch in about a day and larvae feed for 4 to 6 days on algae, after which they pupate. Adult flies emerge from the pupae in 3 to 5 days and generally live 2 to 3 weeks.

Management

IPM

Yellow sticky cards are useful in monitoring adults. They should be used positioned either horizontally at the soil surface for the greatest trap catch, or vertically just above the plant canopy for general monitoring. Larvae can sometimes be seen by examining algae-covered areas with a handlens. Potato disks do not work for monitoring shore fly larvae.

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Images Magnification			
Detection	Observation Yellow or blue sticky cards	Low cost	Population high when detected	 Blue more attractive
Monitoring	Yellow or blue sticky cards			

Cultural/Mechanical

Shore fly infestations can be reduced by managing algae growth. This includes minimizing fertilizer and irrigation runoff and fixing leaky hoses and irrigation systems. Avoid over-watering and over-fertilizing, and eliminate areas of standing water. In addition, greenhouse walls, benches, gutters, and floors should be cleaned of algal growth as often as possible. A steam cleaner may be effective. There are some chemical products that may aid in algae management. Use according to label directions. One study has noted that Zero-Tol applications reduced algae and shore flies, but also reduced plant growth. Use carefully.

Biological

Nematodes and predaceous mites used for fungus gnat control do not appear to work as well against shore flies because of the semi-aquatic environment in which they live. A predaceous rove beetle, *Atheta*, is also commercially available. In unsprayed greenhouses, a tiny parasitoid of shore flies, *Hexacola neoscatella*e, is common. A predaceous fly, *Coenosia attenuate*, also occurs naturally in many greenhouses. The impact of these on shore flies in commercial greenhouses is unknown.

Chemical

Many insecticides are insect growth regulators and only affect larval stages, not adults. Growers may need both an adulticide and a larvicide for well-established populations.

<u>Some Currently Registered Pesticides for Shore Flies</u>

(see Table 5 for information on insecticides and miticides)

Common Name (class)
Group 1
Chlorpyrifos (1B)
Chlorpyrifos + cyfluthrin (1B + 3)
Group 3
Chlorpyrifos + cyfluthrin (1B + 3)
Group 5
Spinosad (5)
Group 7
Pyriproxyfen (7C)
Group 15
Diflubenzuron (15)
Group 17
Cyromazine (17)
Group 18
Azadirachtin (18B)
Miscellaneous
Steinernema carpocapsae

<u>State/local pesticide restrictions or limitations, export issues, etc.</u>

- Resistance suspected
- Some efficacious materials are not registered in all states in the NE.

<u>Critical issues and needs</u>

- Lack of details on effective use of beneficials

Western Flower Thrips
(*Frankliniella occidentalis)*

Introduction

Several species of thrips can infest greenhouse floral crops, but the most severe and common pest in recent years has been the western flower thrips (WFT).

Damage and Importance

Feeding by these tiny insects causes plant cells to collapse, which may eventually result in distorted leaves or flowers if the damage was done while the thrips were feeding within buds and terminals, or scarred, silvery patches and flecking if the damage is to open foliage or petals. The damaged patches on expanded leaves and petals will also have tiny greenish-black fecal specks that are left by the thrips. They also damage the appearance of African violets by spreading pollen over the flowers as they feed on and break open the pollen sac. The most important and serious damage comes as thrips' feeding can also transmit one of the two incurable tospoviruses that cause severe damage to greenhouse plants, if the thrips are carrying the virus. Both the thrips and the viruses have a very wide host range including flowers, vegetables, and many weeds. One viruliferous western flower thrips adult can infect a plant after feeding on it for only 30 minutes. Western flower thrips acquire the virus as first instar larvae, and retain it for the remainder of their lives. Because the immature stages usually remain on one plant and do not move to other plants, most of the spread of the virus is by the adult stage as they fly or are carried by wind currents. (See INSV in Disease Section)

Identification

Thrips are tiny insects; adults are 1-2 mm in length, with narrow bodies and fringed wings. Colors of western flower thrips can vary from straw-yellow to brown. Some fairly uncommon thrips species can be identified by using a handlens and noting differences in color, shape, size, and other characters, but is not possible to accurately identify which flower thrips (i.e., Frankliniella sp.) species is infesting a crop while in the greenhouse, even with a handlens. Differences in tiny morphological structures in the adult female flower thrips are used to tell one species from another. Therefore, adult flower thrips must be inspected under a compound microscope to accurately determine the species.

Biology

Control of western flower thrips is extremely difficult due to several biological characteristics of this species. Eggs of this species are inserted into leaf, stem, or petal tissue, and are thus protected from insecticides. The egg stage lasts from 2-1/2 to 4 days. The eggs hatch into larvae, which usually remain protected in flower buds or terminal foliage. This is the stage that can acquire INSV. The insect passes through two larval stages, both of which feed in these protected areas. The first larval stage lasts 1 to 2 days, the second larval stage lasts 2 to 4 days. Toward the end of the second larval stage, the insect stops feeding and usually drops into the soil or leaf litter to pupate. The insect passes through two "pupal" stages (prepupal and pupal), during which no feeding and little movement occurs. The prepupal stage lasts 1 to 2 days, and the pupal stage lasts 1 to 3 days. While in the pupal stage in the soil, the insect escapes exposure to insecticides directed at the foliage. The adults, which can survive from 13 to 75 days and lay 40 to 250 eggs (depending on temperature, host plant), are also primarily found feeding in protected areas of the plant such as flowers and terminal buds. The pest's rapid developmental time (egg to adult in 10 to 15 days at fluctuating temperatures between 76 and 86°F) and reproductive rate, in these protected areas, can allow an undetected infestation to quickly become a major problem. At cool temperatures, immature development takes much longer (at 54°F, egg to adult development takes 57 days) and an infestation may escape detection because most of the population may be in immature stages with very few adults. They fly readily (although they are not strong fliers) and can be carried on wind currents, or on clothing, to greenhouses near an infestation. They can fly from a sprayed to an unsprayed area, or can move into or out of a greenhouse through doors or vents. Flight activity may be greatly reduced at cool temperatures (ca. 55°F or lower).

Management

IPM

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Images Magnification	Easy to use	Accuracy to species uncertain. ID certain only under high magnification (high cost)	Accurate thrips identification often dependent on professionals
Detection	Plant inspection Tapping Yellow or blue Sticky cards Sentinel plant	Catch other pests Catch other insects/mites Catch other pests 7D/24hr coverage	Hiding, labor time Time Tapping may underestimate number for threshold – depending on plant type Adults only	Tomato
Monitoring	Card counts Trap plant of tomato or eggplant	Catch increases	Cost and labor time, numbers may be subjective	Is sex/sex ratio important? Is pheromone useful Blue vs. yellow?
Action Thresholds		Adjust to crop/grower tolerance/ INSV history	Subjective, wholesale may exceed retail	

Cultural/Mechanical

Thrips control should start at the end of the previous crop or season, to avoid harboring a sizeable population between crops. In extreme cases, it may be justified to keep some or all greenhouse ranges empty for a time, to greatly reduce or thoroughly eliminate a thrips infestation before the next crop cycle begins. This is best done in the winter, when thrips movement from outdoors is not a problem. All plant material, including all weeds, must be eliminated from the greenhouse, so there is absolutely no food for the thrips. Then, the greenhouse should be kept warm so that the soil temperature is about 60F for about two weeks, to cause any thrips pupae in the soil to finish their development and emerge as adults into a greenhouse without food. This fallow period procedure is undoubtedly very expensive, but may be justified in extreme cases. Inspect incoming plant material for tell-tale signs of thrips feeding injury. If the thrips may be entering from outside sources, consider screening the vents. Use yellow (or blue) sticky cards to monitor for Western flower thrips in the greenhouse. Count and change cards weekly, noting upward population trends that signal the need for treatment. More than 10 thrips per trap per week is a threshold value some growers have found useful, but growers should evaluate this threshold under their own conditions, because the threshold will be affected by many factors including the trap color, size, location, number of cards per sq. ft., crop, stage in crop cycle (early is worse) and presence of INSV or TSWV, to name a few. Greenhouse workers should avoid wearing yellow or blue so that thrips are less likely to be spread on workers' clothing. Avoid spreading the pest by moving from a greenhouse with a noticeable thrips infestation into one that is not yet infested. This may require a change in the usual movement patterns of greenhouse workers. Likewise, avoid moving plants that are infested into an uninfested greenhouse, or vice versa. Eliminate weeds, which may harbor thrips and/or the virus (they don't always show virus symptoms). Because thrips prefer flowers and their populations tend to "explode" with the onset of flowers, flower removal, whenever feasible, can remove a substantial portion of a thrips infestation.

Biological

Research on biological control of western flower thrips is being conducted in many laboratories world-wide. An insect-killing fungal pathogen, *Beauveria bassiana*, is available in the U.S. as BotaniGard or Naturalis-L. Three commercially available species of tiny predaceous mites, *Neoseiulus cucumeris*, *Amblyseius swirskii* and *Iphiseius degenerans*, are available for thrips control. Because these mites can only kill first instar thrips, there must be many more mites than thrips for control to be successful. Such high populations of these predaceous mites may be achieved by weekly releases, or by the use of "slow-release" bags or sachets, or possibly by providing a source of pollen as food for the mites. Another predaceous mite, *Hypoaspis miles*, can be released and established in the soil/growing medium. *Hypoaspis* is a general predator of arthropods in the soil, including thrips pupae. *Hypoaspis* does not usually travel to the foliage. Some growers have reported success with the combination of *Hypoaspis* and *Neoseiulus cucumeris*. Research with the predaceous minute pirate bug (*Orius spp*.) is also being done, but success with *Orius* is crop specific and more often reported from certain greenhouse vegetables than ornamentals. A pheromone is commercially available but little research has been done on how it may best be employed. Recommendations for biological control of thrips on commercial flower crops have yet to be fully developed.

Chemical

Schedule insecticide treatments to best target the susceptible stages of the thrips' life cycle. For many, though not all insecticides, it is effective to use a 5-day treatment interval for 2-3 treatments, in order to have an effect on thrips that will hatch from eggs or emerge from pupae soon after the initial insecticide application. Read and follow all label directions. Ideally, insecticides should be applied with equipment that produces very small spray particles (<100 microns). Spray particles of this size are best because they will penetrate deep into the protected areas of the plant where the thrips are found, and can provide the most efficient use of insecticide if coverage is thorough. Rotating the use of insecticides from different chemical classes may be an effective way to delay the problem of insecticide resistance. However, it is best to maintain the use of an effective insecticide for more than one generation of a pest before rotating to another insecticide. Given the duration of the lifecycle of western flower thrips, an effective insecticide should be used, as needed, for 3 to 4 weeks before switching to an insecticide from another class of chemicals.

<u>Some Currently Registered Pesticides for Western Flower Thrips</u>
(see Table 5 for information on insecticides and miticides)

Common name (class)
Group 1
Acephate (1B)
Chlorpyrifos (1B)
Chlorpyrifos + cycfluthrin (1B + 3)
Fenoxycarb + acephate (7B + 1B)
Methiocarb (1A)
Group 3
Bifenthrin (3)
Chlorpyrifos + cycfluthrin (1B + 3)
Cyfluthrin (3)
Cyfluthrin + imidacloprid (3 + 4A)
Fluvalinate (3)
Permethrin (3)
Pyrethrin + piperonyl butoxide (3 + 27A)
Pyrethrins + rotenone (3 + 21)
Group 4
Acetamiprid (4A)
Cyfluthrin + imidacloprid (3 + 4A)
Dinotefuran (4A)
Imidacloprid (4A)
Nicotine (4B)
Group 5
Spinosad (5)
Group 6
Abamectin (6)
Group 7
Fenoxycarb (7B)
Fenoxycarb + acephate (7B + 1B)
Kinoprene (7)
Group 9
Flonicamid (9C)
Group 15
Novaluron (15)
Group 18

Azadirachtin (18B)
Group 21
Pyrethrins + rotenone (3 + 21)
Pyridalyl (21)
Group 27
Pyrethrin + piperonyl butoxide (3 + 27A)
Miscellaneous
Beauveria bassiana
Horticultural oil
Insecticidal soap

State/local pesticide restrictions or limitations, export issues, etc.

- Resistance to certain organophosphate, carbamate, and synthetic pyrethroid insecticides has been documented in certain western flower thrips populations.
- Some efficacious materials are not registered in all states in the NE.

Critical issues and needs

- Few efficacious materials for resistance management
- Limit options for herbs and greenhouse vegetables
- Usage protocols and quality assurance for biologicals needed

Whiteflies
(*Bemisia argentifolii = Bemisia tabaci* strain B, *Trialeurodes vaporariorum, Trialeurodes abutilonea*)

Damage and Importance

Whiteflies are pests mainly because consumers don't want plants on which whiteflies are noticeable. They infest numerous greenhouse crops, including poinsettia, fuchsia, mums, gerbera, geranium, hibiscus, rose, tomato, many herbs, and many foliage crops. They feed by inserting stylet-like mouthparts through plant tissue into the phloem and removing plant sap. In high populations, their "honeydew" secretion can make leaves sticky and shiny, and lead to the growth of ugly grey sooty mold. Silverleaf whitefly can transmit geminiviruses on outdoor vegetables, and can transmit tomato yellow leaf curl virus in greenhouse tomato transplants.

Identification

Whiteflies are small, white, fly-like insects in their adult stage. The nymphal stages are tiny, flattened, oval scales that have no obvious legs, do not crawl (except immediately after egg hatch for a day or so), and with no obvious heads, thoraxes, or abdomens, do not look like a "typical" insect. Because of their appearance and their location on the undersurfaces of leaves, the nymphal stages may go unnoticed. Distinguishing the species of a whitefly can be difficult. The best stage to use for identification is the pupal stage, which is found on the underside of leaves. The pupal case, which is left behind after an adult emerges, can also be used to identify the species of whitefly. Toward the end of the pupal stage, the red eyespots of the developing adult can be seen through the pupal case. These red eyespots help distinguish the pupal stage from the other nymphal stages. SLWF and GHWF often infest the same crop.

Silverleaf whitefly (SLWF), *Bemisia argentifolii* (=strain B of the sweetpotato whitefly, *Bemisia tabaci*).
The pupa of the SLWF appears from the side to be more rounded, dome-shaped, or even pointed. The SLWF pupa has no such filament fringe.

Greenhouse whitefly (GHWF), *Trialeurodes vaporariorum*.
The pupa of the GHWF is oval, and it has elevated sides that are very straight and perpendicular to the leaf surface. This gives it a disk-like, or "cake-shaped" appearance. Seen from above, the GHWF has a tiny "fringe" of wax filaments around the top "rim" of the pupa.

Bandedwinged whitefly (BWWF), *Trialeurodes abutilonea*.
The BWWF is not uncommon; it is sometimes found on yellow sticky cards, though rarely on the crop. The BWWF is named for the 2 irregular smoky grey lines that zigzag across its front wings. An obvious dark grey band that is fairly wide runs down the length of the pupa.

A 10x hand lens will be needed to examine pupae closely enough to see these characters and differentiate accurately between the species. The adult GHWF is somewhat larger than the SLWF. Both adults are white, as their name suggests, although the body of SLWF is slightly more yellow in color. However, color alone is not a reliable basis for identification. The most noticeable difference is the angle of their wings to their body. The wings of the GHWF adult lie fairly flat over its abdomen, almost parallel with the leaf surface. The wings of the adult SLWF, on the other hand, are held tent-like against its abdomen at approximately a 45-degree angle to the leaf surface. Unfortunately, the primary means of examining adults — insects stuck to a yellow sticky trap — almost inevitably obscures such fine distinctions of appearance.

Biology

Females can lay 200+ eggs and live up to 1-1/2 mos. All life stages are found on lower surfaces of leaves. Tiny spindle-shaped eggs are often laid in semi-circles. Eggs hatch in about 10-12 days at 65°-75°F. Tiny crawlers walk a few millimeters from egg, insert mouthparts into leaf to feed and do not move again until they have completed the remaining three nymphal life stages and emerge as an adult. On poinsettia at 65°-75°F, total egg-to adult development takes 32-39 days on average. Development time is considerably faster at warmer temperatures, perhaps 2-1/2 to 3 weeks. A female can begin to lay eggs from one to four days after emerging from the pupal stage. Mating is not necessary for egg production.

Management

IPM

	Method(s)	Pros	Cons	Comments
Diagnosis/ID	Images Magnification			Q-type requires lab technique
Monitoring	Yellow sticky cards Sentinel/trap crops			No good Sentinel plant for silverleaf

Cultural/Mechanical

Removal of weeds is believed to be helpful as is prompt removal of infested plants and/or leaves but the impact on WF populations is uncertain

Biological

Whitefly biological control could include the release of parasitoids and/or predators, and/or fungal pathogens. For biological controls to be successful, rely on releases of the natural enemies, and use selected insecticides as a back-up. Growers interested in biological control must learn about the natural enemies as well as the whiteflies, and have established a successful whitefly monitoring plan. *Encarsia formosa* is the most commonly used natural enemy for GHWF on greenhouse tomatoes. But this parasitoid species is not as effective against SLWF on ornamentals. When compared with the commercial strain of *E. formosa*, another parasitoid, called *Eretmocerus eremicus*, provides better SLWF control on poinsettia. *E. eremicus* will also control GHWF on poinsettia. For successful SLWF management with parasitoids alone, *E. eremicus* should be released weekly at 3 female wasps/pot/week. But such a release regime is expensive. Our recent research has indicated that a less expensive approach may be to release *E. eremicus* at 1 female wasp/pot/week, coupled with an IGR (Distance, or soon-to-be-registered Applaud) applied once, just before bract coloration. Some growers have reported successful use of parasitoids on the Christmas crop until late October, when smokes and aerosols were used for final clean up. Quality control issues continue to plague the reliability of these parasitoids.

BotaniGard and Naturalis-L contain the insect fungal pathogen *Beauveria bassiana*. This pathogen should be used while whitefly levels are still low. Three to 5 weekly sprays should be applied, then carefully evaluate the degree of control to determine the need for additional sprays. Tank mixes with most conventional insecticides can be used to reduce pest levels, but do not mix with any fungicides, and be sure that the spray tank is clean of all fungicide residues. Do not use 48 hours before or after a fungicide application on the crop. Another fungal pathogen, PFR-97 (*Paecilomyces fumosoroseus*), is registered by Olympic and is expected to be available soon. A predacious mite, *Amblyseius swirskii* is commercially available.

Combinations of natural enemies, such as *Beauveria bassiana* plus *E. eremicus*, or *E. eremicus* plus the tiny predatory beetle *Delphastus pusillus*, or other combinations, may also provide good whitefly biological control.

Eggplants have been employed as greenhouse whitefly attractant/trap and as a banker plant for rearing natural enemies of greenhouse whitefly. No plant has been identified for corresponding uses foe silverleaf whitefly.

Chemical

Many insecticides can provide good whitefly control. Marathon (granular or drench) continues to give excellent long-term control when used properly. Several new IGR insecticides also show excellent activity against nymphs. These IGR’s provide important new insecticide options for pesticide rotation schemes. They are also very compatible with parasitic wasps for whitefly biological control, as discussed later. All whitefly insecticides must be used carefully, according to label directions, or resistance problems are likely to occur. Eggs and the older nymphal stages are the most immune to many insecticides. When using foliar sprays, remember that thorough coverage is easier to achieve early in the crop before the canopy becomes dense. Plants should be spaced so as to maximize spray coverage. A spray wand or spray technique that directs the spray to the undersides of leaves will kill many more whiteflies per application. Nymphs occur on the undersides of leaves, and are generally covered more thoroughly with well-aimed hydraulic or electrostatic sprayers. Adults can be controlled with aerosols, smokes, various types of low or ultra low volume sprayers, or hydraulic sprayers. But adults should be killed before they are able to lay eggs —about 3 to 4 days under northeastern U.S. poinsettia production temperatures. So aerosol or ULV applications should be applied every 3 to 4 days as long as new adults are emerging.

Some Currently Registered Pesticides for Whiteflies

(see Table 5 for information on insecticides and miticides)

Common name (class)
Group 1
Acephate (1B)
Chlorpyrifos (1B)
Chlorpyrifos + cyfluthrin (1B + 3)
Dichlorvos (1B)
Fenpropathrin + acephate (3 + 1B)
Naled (1B)
Group 3
Bifenthrin (3)
Chlorpyrifos + cyfluthrin (1B + 3)
Cyfluthrin (3)
Cyfluthrin + imidacloprid (3 + 4A)
Fenpropathrin (3)
Fenpropathrin + acephate (3 + 1B)
Fluvalinate (3)
Permethrin (3)
Pyrethrins + piperonyl butoxide (3 +27A)
Pyrethrins + rotenone (3 + 21)
Group 4
Acetamiprid (4A)
Clothianidin (4A)
Cyfluthrin + imidacloprid (3 + 4A)
Dinotefuran (4A)
Imidacloprid (4A)
Thiamethoxam (4A)
Group 6
Abamectin (6)
Group 7
Fenoxycarb (7B)
Kinoprene (7)
Pyriproxyfen (7C)
Group 9
Flonicamid (9C)
Pymetrozine (9B)

Group 15
Diflubenzuron (15)
Novaluron (15)
Group 16
Buprofezin (16)
Group 18
Azadirachtin (18B)
Group 21
Pyrethrins + rotenone (3 + 21)
Pyridaben (21)
Group 23
Spiromesifen (23)
Group 27
Pyrethrins + piperonyl butoxide (3 +27A)
Miscellaneous
Beauveria bassiana
Horticultural oil
Insecticidal soap
Neem oil
Soybean oil

State/local pesticide restrictions or limitations, export issues, etc.

- Resistance of some Bio-types
- Some efficacious materials are not registered in all states in the NE.
- Europe ban on whiteflies and whitefly transmitted viruses on any live plant

Critical issues and needs

- Few materials for resistant bio-types
- Better quality control of biologicals

Table 5: Insecticides and Miticides* **Active Ingredient**: Brand name	**Class / Group #**	**Comments (Pros & Cons)**
Abamectin: Ardent 0.15EC (supp), Avid 0.15EC (supp), Flora-Mek 0.15EC (supp), Lucid (supp), Quali-Pro Abamectin 0.15EC (supp)	6	
Acephate: Acephate Pro 75, Avatar, 1300 Orthene TR, Orthene TT & O	1B	Phytotoxicity may be an issue.
Acequinocyl Shuttle 15 SC	20B	
Acetamiprid: TriStar 30SG, TriStar 70WSP	4A	

Azadirachtin: Aza-Direct, Azatin XL, Ornazin 3% EC	18B	
Bacillus thuringiensis* subsp. *kurstaki Biobit, Deliver, Dipel Pro DF, Javelin WG	11 B2	
Bacillus thuringiensis* subsp. *israelensis Gnatrol, Gnatrol WDG	11 A1	
***Beauveria bassiana*:** BotaniGard 22WP, BotaniGard ES, Naturalis-L		Slow acting
Bifenazate Floramite, Floramite SC	25	
Bifenthrin: Attain TR, *Attain Greenhouse, *Menace GC 7.9% Flowable, *OnyxPro, Talstar, *Talstar Nursery, *Up-Star SC, *Wisdom Flowable	3	
Buprofezin Talus 40SC, Talus (water soluble bags)	16	
Chlorpyrifos: *Chlorpyrifos Pro 4, *Duraguard ME	1B	Phytotoxic to some plants.
Chlorpyrifos + cyfluthrin: *Duraplex TR	1B and 3	
Clofentezine Ovation SC	10A	
Clothianidin Celero 16WSG	4A	
Chlorfenapyr Pylon	13	
Cyfluthrin: Decathlon 20WP	3	
Cyfluthrin + imidacloprid: *Discus	3 and 4A	Nursery ornamentals only.
Cyromazine Citation	17	
Dichlorvos: *DDVP	1B	
Dicofol Kelthane	Unknown	
Diflubenzuron Adept, Dimilin	15	Not labeled on some plants.
Dinotefuran: Safari 20 SG	4A	

Etoxazole Tetrasan 5 WDG	10B	
Fenbutatin-oxide (hexakis) ProMITE 50WP	12B	
Fenoxycarb: Preclude TR	7B	
Fenpropathrin: *Tame 2.4EC	3	
Fenpropathrin + acephate: Tame/Orthene TR	3 and 1B	
Fenpyroximate Akari 5SC	21	
Flonicamid: Aria	9C	
Fluvalinate: *Mavrik Aquaflow	3	Respiratory issues
Hexythiazox Hexygon DF	10A	
Horticultural oil: Ultrafine Oil		Phytotoxicity under certain conditions.
Imidacloprid: *Areca, *Benefit 60WP, *Imida E-Pro 1%, *Imida E-Pro 2F, *Imida E-Pro 60WSP, *Majesty, *Mallet, *Marathon 1G, *Marathon 60WP, *Marathon II	4A	
Insecticidal soap: M-Pede, Pro-mate Revoke		Phytotoxicity under certain conditions.
Iron phosphate Sluggo snail and slug bait	Organic	
Kinoprene: Enstar II	7A?	
Metaldehyde Deadline bullets, Deadline M-P's		
Methiocarb: *Mesurol	1A	
Naled: *Dibrom 8E	1B	
Neem oil: Triact 70		
Nicotine: *Fulex Nicotine Fumigator	4B	
Nematodes (entomopathogenic) *Steinernema* Nemasys, NemaShield, Scanmask		

Novaluron Pedestal	15	Western flower thrips – immatures only.
Permethrin: *Astro, *Perm-Up 3.2EC, *Waylay 3.2 AG	3	Phytotoxicity on some plants.
Propargite		
Pymetrozine: *Endeavor	9B	
Pyrethrins + piperonyl butoxide: *Prentox Pyronyl Crop Spray, Pyrenone Crop Spray	3 and 27A	Labeled for herbs.
Pyrethrins + rotenone Pyrellin EC	3 and 21	
Pyrethroid Scimitar	3	
Pyridaben Sanmite	21	
Pyridalyl Overture 35WP		
Pyriproxyfen: Distance	7C	No definitive control on shore flies.
Soybean Oil Golden Pest Spray Oil		
Spinosad Conserve SC, Entrust	5	
Spiromesifen Judo	23	
Thiamethoxam Flagship	4A	

* It should be noted that not all the pesticides listed are labeled in all the states of the northeast region. These tables are not intended for use by growers but are to give an indication of the available pesticides, and their respective pesticide class or group, that are available for management of a particular pest.

OTHER INSECTS AND MITES

Leafminers

(*Liriomyza trifolii* and other species)

Identification/Damage/Biology

Although several species of leafminers can attack floral crops, the most serious and most common are flies of the family *Agromyzidae*, and the most common and severe pest species is *Liriomyza trifolii*. These tiny (2 mm) flies are yellow and black, resemble small fruit flies, and are rather strong fliers. Females make small punctures on upper leaf surfaces with their ovipositors. Females and males feed on exuding plant juices from most of these punctures, but females lay eggs singly beneath the epidermis in some of them. The punctures turn white with time and give leaves a speckled appearance. On hatching, the larvae begin to slash open surrounding cells, using their sickle-like mouth hooks. As the cells are ruptured, the larvae move forward to destroy more cells, continuing in this fashion and leaving behind winding trails ("mines") within a leaf. The mines increase in length and width as the insects grow. The appearance of the larval mines reduces the aesthetic value of a plant. The duration of the life cycle depends on temperature and host plant but may be generalized as follows. Eggs hatch in as few as four or five days. The larvae feed within the leaf for four to six days, molting twice. Third instar larvae usually chew a small slit in the lower leaf surface and drop to the soil or onto lower leaves to pupate. The pupal stage can last from 35 days at 58° F to 9 days at 80° F. Egg to adult development can require 64 days at 59° F and only 14 days at 95° F.

Management

The best initial defense against these pests is to refuse to accept infested cuttings. Incoming plant material should be inspected for leaf stipples and active mines and held for several days to see if mines develop from leaf stipples. Yellow sticky cards can be used to detect adult activity and to monitor population levels. Contact sprays to control adults should be repeated at three- to four-day intervals to kill adults that will continue to emerge from puparia during the 10 to 14 days following initial treatment. Insecticides that have translaminar properties, such as abamectin (Avid), can be very effective against the larvae. Much recent work on biological control of leafminers has been successful on certain flower crops. Releases of parasitic wasps as well as nematodes that attack only insects have been used successfully under certain conditions.

Some Currently Registered Pesticides for Leafminer

(see Table 5 for information on insecticides and miticides)

Abamectin
Acetamiprid
Acephate
Azadirachtin
Bifenthrin
Carbaryl (azalea LM)
Chlorpyrifos
Cyromazine
Dinotefuran
Fenpropathrin
Fenpropathrin + acephate
Horticultural oil
Imidacloprid
Novaluron
Permethrin
Pyrethrins+ piperonyl butoxide
Pyrethrins and rotenone

Tarsonemid Mites

Cyclamen mite: *Phytonemus pallidus*
Broad mite: *Polyphagotarsonemus latus*

Damage

These tiny, insidious mite pests cannot be readily seen without magnification (20X to 40X) and are rarely seen by growers. Their extremely small size makes it difficult to detect the mites before severe feeding damage is evident. The damage they cause can be extensive. The tiny mites hide in protected locations on the plant host and are most commonly found in buds, flowers, young leaves, or in similar locations. The mites feed on plant cells, and foliage or flowers expanding from infested buds is curled, distorted, and/or thickened. Broad mite damage can be caused by a toxin injected as they feed. Cyclamen mites tend to occur in buds and very young leaves. Broad mites can also attack buds and young leaves, but may also be found on more mature leaves, where their feeding damage may cause leaf edges to curl under. On some plants such as cyclamen, gerbera, and tuberous begonia, their feeding may cause the lower surfaces of leaves to become bronzed.

Unfortunately, their extremely small size makes it difficult to detect an infestation before the onset of damage. The injury they cause can resemble thrips damage, chemical phytotoxicity, or physiological disorders. Thus plants that display curled, distorted leaves should be carefully examined for the presence of these tiny mites using a hand lens, or preferably a dissecting microscope, so as to avoid inappropriate control actions. Cyclamen mites are serious pests of many flowering and foliage plants, including cyclamen, African violet, begonia, dahlia, exacum, fuchsia, gerbera, kalanchoe, petunia, impatiens, English ivy, geranium, ivy, snapdragon, chrysanthemum, verbena, viola, fittonia, and many others.

Broad mites also attack a wide variety of plants, including African violet, ageratum, azalea, begonia, dahlia, gerbera, gloxinia, hibiscus , ivy, jasmine, New Guinea impatiens, impatiens, lantana, marigold, peperomia, petunia, salvia, snapdragon, verbena, and zinnia, among other plants. Vegetable bedding plants and herbs, such as tomatoes, peppers, beans, basil, and rosemary, can also be attacked.

Biology

Female cyclamen mites lay one to three eggs each day and a total of up to 20 during their lifetimes. Mating is not required for egg production; unfertilized eggs develop into males; fertilized eggs develop into females. The eggs require four days to hatch at 70° F. The life cycle depends on temperature and may be completed in one to three weeks. Cyclamen mites do best at cooler temperatures (60-70F).

Female broad mites lay up to 75 eggs on the leaf surface over 8 to 13 days. Unfertilized eggs develop into males; fertilized eggs develop into females. The larvae hatch in 2 or 3 days. Larvae are slow moving and do not disperse far. In 2 or 3 more days, the larvae develop into a quiescent larval stage. Quiescent female larvae become attractive to the males, which pick them up and carry them to new foliage. Males mate with the females as soon as the adult females emerge from the quiescent stage. Much of the dispersal of a broad mite infestation may be caused by the males that carry the quiescent females to new leaves. Broad mites do best at moderate temperatures (70-80F) and can develop from egg to adult in 1 week. Both cyclamen and broad mites need a microclimate with high humidity.

Identification

Cyclamen mite eggs are oval shaped and are about half the length of the adult. Broad mite eggs can be distinguished from cyclamen mite eggs by rows of white pegs (tubercles) on the egg's upper surface. Immature stages are whitish. Adult cyclamen and broad mites are shiny and elliptical in shape with four pairs of legs. The hind pair of legs of a female is threadlike while that of a male is stout and clawed and used to carry quiescent females. Adults are colorless to translucent yellow-to-orange or pale brown. Broad mites may have a whitish stripe down the center of their backs. It may be necessary to peel apart curled or distorted plant tissue to find these tiny mites.

Monitoring

The mites are too tiny to be easily observed, so susceptible plants should be checked weekly for signs of leaf distortion or other damage symptoms. If symptoms are observed, check damaged plant parts for the presence of mites with at least 20X magnification (a dissecting microscope is best) or send a sample to a diagnostic lab. It is easy to confuse tarsonemid mite damage with thrips damage, chemical phytotoxicity, or physiological disorders. There is no easy way to determine if a mite infestation has been controlled other than observing no further plant distortion after control measures were applied.

Management

These mites may be spread by air currents, direct contact between plants, or workers who handle infested plants. They can also be transported on the legs of adult whiteflies. Chemical control can be difficult because the mites' reclusive habits make it difficult to reach them with acaricides; therefore, it is usually necessary to make two or perhaps three spray applications to achieve control of this pest. When feasible, the mites can be satisfactorily controlled by immersion of the infested plants in 43 to 49°C water (109.4-120.2°F) for 15 minutes. This is obviously not a practical means of control when large numbers of plants are involved, but it can be very useful to eliminate these tiny pests from isolated infestations. If hotspots are detected, infested plants may be rogued out and surrounding plants treated. Species of predaceous mites such as *Amblyseius barkeri* or *Neoseiulus californicus* may also be useful for biological control although further research is needed.

Some Currently Registered Pesticides for Tarsonemid Mite

(see Table 5 for information on insecticides and miticides)

Abamectin
Chlorfenapyr
Fenpyroximate
Pyridaben (broad mite only)
Spiromesifen

Mealybugs and Scale Insects

Mealybugs and scale insects are often difficult to control for several reasons. First, they easily go undetected. In most cases they don't resemble what we normally consider an insect. Because they are often mistakenly overlooked as plant parts it is easy for them to go unnoticed, particularly at the onset of an infestation when their numbers are low. Second, their bodies are covered with waxy secretions that protect them. This makes it difficult for insecticides to penetrate the wax and cause death. Third, they often occur in cryptic places on plants such as the undersides of leaves, in leaf axils, or on roots in some cases. These cryptic habitats make them difficult to detect and to provide protection from sprays. Fourth, they can very rapidly develop overlapping generations with all life stages present at any time and, as will be discussed later, certain stages are not susceptible to insecticides. Repeated sprays are usually required at regular intervals to contact the insecticide-susceptible stages in the population.

Mealybugs and scales are related to aphids and whiteflies and are in the order Homoptera. These soft-bodied insects feed with stylet-like mouthparts by inserting them into the plant tissue and sucking plant juices. Entomologists classify them into three groups: armored scales, soft scales, and mealybugs.

Armored Scales

Armored scales are usually smaller than soft scales, and their shapes vary between species, from circular to an irregular shape resembling an oyster shell. Color may vary with life stage, sex, and/or species, and may be shades of white, gray, red, brown, or green. These insects secrete a hard, waxy shield over their bodies. This shield may be separated from the body of armored scales, whereas it is inseparable from the body of soft scales.

Identification

Some common armored scale pests of greenhouses and interior plantscapes include oleander scale, Boisduval's scale, San Jose scale, Florida red scale, fern scale, greedy scale, purple scale, and cactus scale.

Damage

It is very important to detect the early stages of an infestation to maximize control efforts. Besides detecting the actual insects on the plants, knowing the symptoms of an infestation on the plant is very important. Armored scales can produce either yellow or brown spots or streaks on the leaves. They can cause general yellowing of the foliage, poor growth, and incrustations of both stems and leaves. In very high populations they can cause twig dieback or even kill the plant. Unlike mealybugs and soft scales, armored scales do not produce honeydew.

Biology

Aspects of the biology and life cycle can vary significantly between species, but the following may be considered a generalized biology: The eggs are produced next to the female underneath her scale cover or shield. Some species give birth to living young. Females can produce anywhere from 20 to 400 eggs. These eggs hatch into crawlers, the stage that is susceptible to insecticides. Natural mortality of crawlers without an insecticide is rather high. Crawlers move a short distance from where they were hatched and find a suitable place to settle down and feed. They do not move again for the remainder of their lives. Females pass through two nymphal stages before adulthood. Males pass through two additional short pupal or resting stages. The tiny winged males do not live long. Females begin to produce eggs after mating. The entire life cycle can take anywhere from 60 to 120 days to complete, depending on temperature and the species. Several generations may occur during the year, with all life stages present at any one time.

Some Currently Registered Pesticides for Armored Scale

(see Table 5 for information on insecticides and miticides)

Acephate
Bendiocarb
Bifenthrin
Buprofezin
Cyfluthrin
Dinotefuran
Fenoxycarb
Horticultural oil
Insecticidal soap
S-kinoprene
Pyriproxyfen

Soft Scales

Identification

Soft scales can be fairly large (2–5 mm) and usually have a circular or oval shape. Colors are usually shades of gray or brown, and some species appear black. The shield cannot be detached from soft scales. Common species include black scale, soft brown scale, hemispherical scale, and Niger scale.

Damage

Soft scales can produce distorted foliage from their feeding on young tissue, cause the leaves to turn yellow, and in high populations can cause twigs and branches to die back. Soft scales (and mealybugs) produce a sugary excretory product called honeydew, which can fall onto leaves and cause them to become shiny and sticky. Honeydew can support the growth of unsightly sooty mold. The presence of honeydew and sooty mold is a good indication of an infestation. Because ants are attracted to honeydew, their presence on the plants may also signal an infestation.

Biology

A generalized life cycle for soft scales is fairly similar to that of armored scales. Eggs, or living young, are produced beneath the female’s body, and females can produce more than 1,000 eggs. Crawlers hatch after one to three weeks, crawl over the leaf and stem for several days, and find a suitable feeding site at which they remain through adulthood. As with armored scales, the crawler stage is the most sensitive to mortality factors such as insecticides. Females progress through a total of three to four immature stages before adulthood; males pass through four immature stages. Adult males emerge as tiny, delicate, winged insects that live only a few days. There is roughly a 40- to 80-day life cycle depending on factors such as host plant, temperature, and species. All life stages may be present at any one time.

Some Currently Registered Pesticides for Soft Scale

(see Table 5 for information on insecticides and miticides)

Acephate
Bendiocarb
Bifenthrin
Buprofezin
Cyfluthrin
Dinotefuran
Fenoxycarb
Fluvalinate
Horticultural oil
Imidicloprid
Insecticidal soap
S-kinoprene
Pyriproxyfen
Thiamethoxam

Mealybugs

Identification

Mealybugs are small (1–8 mm long), elongate-oval, soft-bodied insects that are not covered by a hardened cover or shield but with a layer of white, cottony wax. They can be found infesting all parts of a plant, including roots. Some produce short, spinelike filaments along the margins of their bodies, and on some species the posterior filaments can be quite long. Some mealybug pests of greenhouse crops include the citrus mealybug, obscure mealybug, and long-tailed mealybug.

Damage

Mealybug infestations can cause leaf distortion, particularly on new growth. Some species inject a toxin as they feed that can produce necrotic areas, general yellowing, or leaf drop. They produce honeydew that can support the growth of sooty mold. Their production of white cottony wax and their very presence on leaf axils or undersides of leaves detract from the appearance of the plant. Again, because ants can be attracted to honeydew as with soft scales, their presence may signal a mealybug infestation.

Biology

Life cycles vary tremendously between different species but may be generalized as follows: Females produce from 300 to 600 eggs, usually in a white, cottony ovisac. Some species give birth to live young. The eggs mature in the ovisac for approximately two weeks, then hatch into crawlers. Once more, the crawlers are the most susceptible life stage to insecticides. All subsequent life stages of mealybugs are mobile, although they are slow-moving. They are not sessile as are whiteflies and scale insects. It is therefore easy for this pest to move from leaf to leaf or plant to plant and spread an infestation over many plants. Males are tiny, winged insects. Mealybugs have a 30- to 70-day life cycle.

Management

Early detection is very important for effective control. Greenhouse workers should be educated to recognize the pests and their damage symptoms while an infestation is at an early stage. As soon as you detect an infestation, it may be best to isolate the plant(s) if possible to prevent the problem from spreading to uninfested plants. In the long run, it may even be wise to discard a badly infested plant(s) rather than spend time and money at control attempts while risking spreading the infestation.

If contact sprays of synthetic organic insecticides are used, they should be applied against the crawler stage of scales and mealybugs. Repeated applications are therefore necessary to contact the susceptible stages as they are produced. Spray intervals will depend on the residual effectiveness of the insecticide used, which may vary from one to three weeks. The inclusion of a spreader-sticker can aid in coverage, penetration, and residual activity, although the risk of phytotoxicity may be increased. Good coverage is important for contact insecticides. Insecticidal oils and soaps can be very effective, killing more life stages of these pests than many contact insecticides, but there is no residual control, and thorough coverage is critical.

Systemic insecticides may kill actively feeding stages of scales and mealybugs, assuming adequate amounts of insecticide are translocated to the feeding site. Systemics will not kill the egg stage, however. An additional application may be necessary after three to four weeks if the residual activity of the systemic is inadequate after this time period. Fumigant insecticide formulations can be effective against mealybugs and should be applied at 10- to 14-day intervals. Good potential exists for biological control of certain mealybug and scale pests, particularly in interior plantscape settings. Parasitoids and predators of these pests are commercially available, although the supply can be inconsistent at times. Information regarding the use of these natural enemies and integrated control of these pests can be obtained from the commercial insectaries.

Some Currently Registered Pesticides for Mealybugs

(see Table 5 for information on insecticides and miticides)

Acephate
Acetamiprid
Beauveria bassiana (GHA and JW-1 strain)
Bendiocarb
Bifenthrin
Buprofezin
Carbaryl
Chlorpyrifos
Chlorpyrifos + cyfluthrin
Cyfluthrin
Diazinon
Dichlorvos
Dinotefuran

Fenpropathrin
Fenpropathrin + acephate
Flonicamid
Fluvalinate
Horticultural oil
Imidacloprid
Insecticidal soap
S-kinoprene
Malathion
Naled
Neem oil
Permethrin
Pyrethrins + piperonyl butoxide
Thiamethoxam

NEW PESTS AND THOSE OF INCREASING IMPORTANCE

Scirtothrips dorsalis
Chilli thrips

- First detected in the US in 2005, present in Florida and Texas
- Wide host range, including ornamental plants, and causes leaf and bud distortion
- Potential for movement on plant materials to Northeast

Bemisia tabaci, biotype Q
Q-biotype whitefly

- Already found throughout the Northeast
- Resistant or less susceptible to a variety of insecticides that control other biotypes

Maconellicoccus hirsutus
Pink hibiscus mealybug

- Many tropical plants are hosts
- Potential for movement on plant materials to Northeast

PESTICIDES IN THE PROCESS OF REGISTRATION

Active ingredient	Trade name	Active against	Comments
Spirotetramat	Kontos (BYI-8330)	Thrips, coleopterans	Newly registered with EPA
Tolfenpyrad		Thrips, coleopterans	Just submitted to EPA
Beauveria strain		Fungus gnat larvae	
Spinetoram		Thrips	

TOXICITY TO BENEFICIAL INSECTS (Biological Control Organisms)

Pesticides vary in their potential negative effects on those beneficial insects commonly used for biological control. Table 6 ‘Toxicity to biological control organisms’ provides a general overview of the side effects of those pesticides labeled for greenhouse use in the northeast. The beneficials included are predatory mites, wasps, midges, coleopterans, *Orius* and nematodes. For the most up to date information, and an indication of the persistence of the pesticide, check the Koppert and Biobest side effects information on their websites.

Table 6: Toxicity to beneficial insects (biological control organisms)

Information on all species, life stages and pesticide combinations is not available. Non-inclusion in this table does not indicate lack of toxicity. This information is taken from the Koppert and Biobest side effects databases and is current as of this writing. However, some generalizations have been made, and method of application has not been included.

Brand name:	**Predatory mites (Phytoseiulus, Amblyseius, Hypoaspis)**	**Wasps (Aphidius, Encarsia, Eretmocerus,)**	**Midges (Aphidoletes,**	**Coleoptera (Atheta, Lady beetles)**	**Orius**	**Nematodes (Steinernema, Heterorhabditis)**
Abamectin	Toxic to nymph and adult of Phytoseiulus and Amblyseius, Not toxic to Hypoaspis egg, moderately toxic to nymph and adult	Toxic to adults	Toxic to adults	Not toxic to Cryptolaemus adults	Toxic to nymph and adult	Not toxic to larvae
Acephate	Toxic to egg, nymph and adult of Phytoseiulus and Amblyseius, Not toxic to Hypoaspis egg, moderately toxic to nymph and adult	Toxic to adults, some pupae	Toxic to adults Moderately toxic to larvae	Toxic	Toxic to nymph and adult	Moderately toxic to larvae
Acequinocyl	Not toxic to Amblyseius adult Toxic to Phytoseiulus adult					

Acetamiprid	Toxic to adult	Toxic to adults of Encarsia and Aphidius	Toxic to adults	Toxic to adults	Toxic to adult	
Azadirachtin	Not toxic to Phytoseiulus and Amblyseius	Not toxic to Aphidius adults Toxic to Encarsia adults	Not toxic to adults or larvae	Not toxic to adults Moderately toxic to larvae	Not toxic to nymph and adult	Not toxic to larvae
Bacillus thuringiensis* subsp. *kurstaki	Not toxic to Amblyseius and Phytoseiulus	Not toxic	Not toxic		Not toxic to nymph and adult	Not toxic to larvae
Bacillus thuringiensis* subsp. *israelensis	Not toxic to all stages	Not toxic	Not toxic	Not toxic	Not toxic	
Bifenazate	Not toxic to Amblyseius Moderately toxic to Phytoseiulus adult	Not toxic to adults of Encarsia and Eretmocerus	Not toxic to larvae	Not toxic to larvae	Not toxic to adult or nymph	Not toxic to Steinernema larvae
Bifenthrin	Toxic to egg, nymph and adult of Phytoseiulus and Amblyseius, Not toxic to Hypoaspis egg, moderately toxic to nymph and adult	Toxic to pupa and adult	Toxic to larvae and adults	Toxic to adult and larvae	Toxic to nymph and adult	Not toxic to larvae
Buprofezin	Not toxic	Not toxic to pupa and adult	Toxic to larvae Moderately toxic to adults	Moderately toxic to adult Toxic to larvae	Not toxic to nymph and adult	Not toxic to larvae

Chlorfenapyr	Toxic to Phytoseiulus adult	Toxic to adults of Aphidius and Encarsia	Toxic to larvae	Toxic to adults and larvae	Moderately toxic to nymph and adult	
Chlorpyrifos	Toxic to egg, nymph and adult of Amblyseius, Toxic to nymph and adult of Phytoseiulus, not toxic to egg Not toxic to Hypoaspis egg, moderately toxic to nymph and adult	Toxic to pupae and adults of Aphidius and Encarsia	Toxic to adults	Toxic to adult and larvae	Toxic to adult Moderately toxic to nymph	Toxic to larvae
Clofentezine	Not toxic to all stages	Not toxic	Not toxic to adults	Not toxic to adults or larvae	Not toxic to adult	
Clothianidin				Very toxic to adults (*Cryptolaemus)*		
Cyfluthrin	Toxic to egg, nymph and adult of Phytoseiulus and Amblyseius, Not toxic to Hypoaspis egg, moderately toxic to nymph and adult	Toxic to pupa and adult	Toxic to adults and larvae	Toxic to adults and larvae	Toxic to nymph and adult	Moderately toxic to larvae
Cyromazine	Not toxic to all stages	Not toxic to all stages	Not toxic to adults	Moderately toxic to adults Toxic to larvae	Not toxic to adult	Not toxic to larvae

Dichlorvos	Toxic to nymph and adult of Phytoseiulus and Amblyseius, Not toxic to egg Not toxic to Hypoaspis eggs, moderately toxic to nymph and adult	Toxic to adults	Toxic to adults	Toxic to adults and larvae	Toxic to nymph and adult	Moderately to larvae
Dicofol	Toxic to nymph and adult of Phytoseiulus and Amblyseius, Not toxic to Hypoaspis egg, Moderately toxic to nymph and adult	Toxic to adults of Aphidius and Encarsia Moderately toxic to adults of Eretmocerus	Toxic to adults Not toxic to larvae	Not toxic to adults and larvae		Not toxic to larvae
Diflubenzuron	Not toxic to all stages	Not toxic	Not toxic to adults and larvae	Not toxic to adults Toxic to larvae	Toxic to nymph Not toxic to adult	Not toxic to larvae
Dinotefuran				Very toxic to adults (*Cryptolaemus)*		
Etoxazole	Toxic to Phytoseiulus egg					
Fenbutatin-oxide (hexakis)	Not toxic to all stages	Not toxic	Not toxic to adults and larvae	Not toxic to adults Moderately toxic to larvae	Not toxic to adults Toxic to nymph	

Fenoxycarb	Not toxic to all stages	Not toxic to adults	Not toxic to adults and larvae	Not toxic to adults Moderately toxic to larvae	Toxic to adult	Not toxic to larvae
Fenpropathrin	Toxic to egg, nymph and adult of Phytoseiulus and Amblyseius, Not toxic to Hypoaspis egg, Moderately toxic to nymph and adult	Toxic to mummy/pupa and adults	Toxic to adults and larvae	Toxic to adults and larvae	Toxic to nymph and adult	Toxic to larvae
Fenpyroximate	Toxic to egg, nymph and adult of Phytoseiulus an Varies in toxicity to Amblyseius,	Toxic to adults of Aphidius and Encarsia		Not toxic to adults Moderately toxic to larvae	Not toxic to adult	
Flonicamid	Not toxic to adult Phytoseiulus and Amblyseius,	Toxic to adults and larvae of Eretmocerus Moderately toxic to larvae of Aphidius and Encarsia	Not toxic to adults or larvae	Not toxic to adults or larvae		

Fluvalinate	Toxic to nymph	Toxic to adults and larvae of Eretmocerus Moderately toxic to larvae of Aphidius and Encarsia	Toxic to adults and larvae	Toxic to adults or larvae	Toxic to nymph and adult	
Hexythiazox	Not toxic to all stages Phytoseiulus and Amblyseius,	Not toxic to adults and pupae	Not toxic to adults and larvae	Not toxic to adults or larvae	Not toxic to nymph and adult	Not toxic to larvae
Horticultural oil	Toxic to nymph and adult of Amblyseius and Phytoseiulus	Not toxic to adults and pupae/mummies of Aphidius and Encarsia	Not toxic to adults		Not toxic to adult	Not toxic to larvae
Imidacloprid	Toxic to nymph and adult not egg – depends on application method	Toxic to adults and pupae/mummy of Aphidius and Encarsia	Toxic to adults and larvae Not toxic as drench	Toxic to adults and larvae as a spray	Toxic to nymph and adult	
Kinoprene	Not toxic to all stages of Phytoseiulus and Hypoaspis	Toxic to Eretmocerus adults Not toxic to Encarsia adults Moderately toxic to Encarsia pupae		Not toxic to adults or larvae	Toxic to nymphs	

Methiocarb	Toxic to all stages of Amblyseius and Phytoseiulus Moderately toxic to Hypoaspis nymph and adult	Toxic to adults of all species Toxic to pupae of Encarsia and Eretmocerus	Toxic to adults and larvae	Toxic to adults and larvae	Toxic to nymph and adult	
Naled	Toxic to nymph and adult of Amblyseius and Phytoseiulus	Toxic to Encarsia	Toxic to adults	Toxic to adults		
Neem oil	Toxic to nymph	Not toxic to Aphidius adults or larvae			Toxic to adults and nymphs	
Nicotine	Toxic to nymph and adult of Amblyseius and Phytoseiulus	Toxic to Encarsia adult but not pupa	Toxic to adults and larvae		Toxic to nymph and adult	
Novaluron	Not toxic to nymph of Amblyseius and Phytoseiulus			Toxic to larvae	Not toxic to adults Toxic to nymphs	
Permethrin	Toxic to nymph and adult of Phytoseiulus and Amblyseius Not toxic to Hypoaspis egg, Moderately toxic to nymph and adult	Toxic to adults and mummies/pupae	Toxic to adults and larvae	Toxic to adults and larvae	Toxic to nymph and adult	Moderately toxic to larvae

Propargite	Some variation in results but generally toxic to nymph and adult of Amblyseius and Phytoseiulus	Not toxic to Aphidius Toxic to Encarsia	Not toxic to adults Moderately toxic to larvae	Toxic to adults	Toxic to adult	Toxic to larvae
Pymetrozine	Not toxic to all stages of Phytoseiulus and Amblyseius	Toxic to Aphidius adults Moderately toxic to Encarsia and Eretmocerus adults Not toxic to pupae/Mummies	Moderately toxic to adults Toxic to larvae		Not toxic to nymph and adult	
Pyrethrins + piperonyl butoxide	Toxic to nymph and adult of Phytoseiulus and Amblyseius, Not toxic to all stages Hypoaspis	Toxic to adults Not toxic to Aphidius mummies Moderately toxic to Encarsia pupae	Toxic to adults	Toxic to adults and larvae	Toxic to adult	Not toxic to larvae
Pyridaben	Toxic to nymphs and adults of Amblyseius and Phytoseiulus Not toxic to Hypoaspis egg, Moderately toxic to nymph and adult	Toxic to Encarsia and Eretmocerus adults and pupae				

Pyriproxyfen	Not toxic to all stages	Not toxic to adults of Aphidius and Encarsia Moderately toxic to Eretmocerus adults Toxic to pupae of Encarsia and Eretmocerus	Not toxic to adults	Not toxic to adults Toxic to larvae	Not toxic to adult or nymph	
Soybean Oil	Toxic to nymph and adult of Amblyseius and Phytoseiulus	Not toxic to adults and pupae/mummies of Aphidius and Encarsia	Not toxic to adults	Not toxic to adults or larvae	Not toxic to adult	Not toxic to larvae
Spinosad	Some indication of toxicity to adult of Amblyseius and Phytoseiulus	Toxic to adults of Aphidius and Encarsia	Not toxic to adult or larvae	Not toxic to adults or larvae	Moderately toxic to adult Toxic to larvae	
Spiromesifen	Not toxic to egg and adult of Amblyseius Toxic to adult of Phytoseiulus	Not toxic to adults	Toxic to larvae	Not toxic to larvae	Not toxic to nymphs	

Thiamethoxam	Results vary Toxic to Phytoseiulus nymph	Toxic to adult Encarsia Toxic to Aphidius adults and larvae		Toxic to adults and larvae	Toxic to adults and nymphs	

WEEDS AND ALGAE

Primary sources: 2008 Cornell Guide for the Integrated Management of Greenhouse Floral Crops and 2009-2010 New England Greenhouse Floriculture Guide

Weeds

Maintaining weed-free growing conditions is necessary to produce high quality greenhouse crops. Insects and diseases can be kept to a minimum only if proper weed control practices are carried out regularly, along with appropriate control measures.

Weeds may compete with desirable crop plants for light, water and nutrients. The presence of weeds also reduces the aesthetic value of the crops grown and creates a poor impression to customers. Weeds are also a primary source of insects such as aphids, whiteflies, thrips, and other pests such as mites, slugs, and diseases. Many common greenhouse weeds such as chickweed, oxalis, bittercress, jewelweed, dandelion, and ground ivy can become infected with tospoviruses, including impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV), while showing few, if any visible symptoms. Thrips can then vector the virus to susceptible greenhouse crops. Weeds can also carry other plant damaging viruses that are vectored by aphids. Wood sorrel, in particular, can rapidly spread throughout a greenhouse crop as the pods disperse seeds by propulsion.

Management

The first and most important control measure is sanitation. Keep weeds out of the greenhouse by using sterile media, introducing only "clean" plant materials, using physical barriers such as weed block fabric, and controlling weeds outside of the greenhouse (mowing, vegetation-free strips around perimeter, non-auxin-type pre- or post-emergence herbicides with caution). Where possible, screening vents and windows will limit the introduction of wind-blown seed as well as insect movement.

If the weeds are already established in the greenhouse they can be killed by (1) manual removal, (2) emptying the range and allowing the weeds to desiccate, (3) using a postemergence herbicide (see Table 9.2.1), or (4) emptying the range and fumigating. Each method (except fumigation) will remove only the vegetation that is present but does nothing to prevent reestablishment from seed that will be present. Continuous removal can be expensive and time consuming. Currently no residual herbicides are labeled for greenhouse use. Where weeds are a continual problem, clean up the area, remove residual soil, or cover soil with gravel or mulch. Only under extremely rare circumstances would fumigation be recommended for weed control.

Chemical Control of Greenhouse Weeds

There are very specific restrictions on the use of herbicides in greenhouses. Although organic-type products, such as acetic acid herbicides, are now available for use outside the greenhouse, they are not labeled for use in the house. These products should be applied with the same precautions, so that greenhouse windows and vents remain closed during external application to minimize drift and volatility issues. Herbicides labeled for use in greenhouses are listed in Table 7.

Table 7: Herbicides **Active Ingredient:** Brand name	**Group #**	**Comments (Pros & Cons)**
Clethodim: Envoy Envoy Plus	1	Selective, postemergence herbicide. Works by contact. Inhibits lipid synthesis. No residual activity.
Diquat dibromide Reward	22	Non-selective. Works by contact. Cell membrane disruptor. Pro: rapid kill, application when a crop is in the house, low cost, limited injury by spray drift
Fluazifop-P-butyl Fusilade II	1	Selective, post emergence herbicide. Systemic. Inhibits cell division by blocking an enzyme involved in lipid biosynthesis.
Glufosinate-ammonium Finale	10	Nonselective, postemergence herbicide. Systemic. Works by disrupting cell membranes.
Glyphosate Glyphosate Pro II Roundup Pro Roundup Pro Concentrate Roundup Pro Dry Touchdown Pro	9	Non-selective, postemergence herbicide. Systemic. Inhibits enzyme found in plants essential to form specific amino acids. No residual soil activity.
Pelargonic acid and related fatty acids Scythe	27	Non-selective, postemergence herbicide. Works by contact. Pro: lower toxicity than Reward, can use while crops remain in the house. Con: higher cost, slower acting with reduced efficacy in comparison to Reward, odor can be persistent

Algae

Algae are a diverse grouping of plants that occur in a wide range of environments. Algae growth on walks, water pipes, equipment, and greenhouse coverings, on or under benches and in pots is an ongoing problem for growers. Algae form an impermeable layer on the media surface that prevents wetting of the media and can clog irrigation and misting lines, and emitters. It is a food source for insect pests like shore flies, and causes slippery walkways that can be a liability risk for workers and customers. Recent studies have shown that algae are brought into the greenhouse through water supplies and from peat in the growing media. Once in a warm, moist environment with fertilizer, the algae flourish.

Management

Proper water management and fertilizing can help to slow algae growth. Avoid over-watering slow-growing plants and especially crops early in the production cycle. Allow the surface of the media to dry out between watering. Select a growing media with the proper drainage for your crops. Water the growing containers only as needed to prevent excess puddling on the floor. The greenhouse floor should be level and drain properly to prevent the pooling of water.

Proper ventilation reduces the amount of moisture in the greenhouse. Horizontal airflow fans help to regulate greenhouse temperatures and reduce excess condensation. Retractable roof or open roof greenhouses provide superior ventilation benefits.

Avoid excessive fertilizer runoff and puddling water on floors, benches, and greenhouse surfaces. The greenhouse floor should be level and drain properly to prevent the pooling of water prior to installing a physical weed mat barrier.

Algaecides are listed in Table 8.

Table 8: Algaecides **Active Ingredient:** Brand name	**Comments (Pros & Cons)**
Ammonium chloride **(Quaternary ammonium chloride salts, Q salts)** Physan 20/20% Green-Shield 20% Triathalon	Stable. Little residual activity. Inactivated by organic matter so preclean before using. Follow label as recommendations for use vary.
Hydrogen dioxide ZeroTol/27% hydrogen dioxide Oxidate	Wet surfaces before treatment. Do not mix with other pesticides or fertilizers. Check for phytotoxicity. Eye ad skin damage possible from concentrate. Oxidate may be allowable for organic producers
Sodium carbonate peroxhydrate Terracyte G/34% GreenClean Granular Algaecide	Granular and activated by water. Breaks down into sodium carbonate and hydrogen peroxide
Chlorine dioxide Selectrocide T	Use on surfaces or for disinfecting irrigation lines.
Hydrogen Peroxide and Peroxyacetic Acid SaniDate 12.0	Strong oxidizing agent. Clean surfaces before treatment. Thoroughly wet all surfaces.
Sodium hypochlorite Clorox/6.15% sodium hypochlorite	Clorox will bleach clothing and can irritate eyes and unprotected skin. Use with care. Injury has occurred to mums set upon capillary mats treated with sodium hypochlorite. To ensure the effectiveness of chlorine solutions, it should be prepared fresh just before each use. Chlorine is corrosive. Repeated use of chlorine solutions may be harmful to plastics or metals.

Liverworts

Liverworts (*Marchantia polymorpha*) are branching, ribbon-like plants lacking distinct roots, stems, and leaves. They reproduce by spores and vegetatively. Stalked, umbrella-like structures release spores. Small, bud-like branches produced in cup-like structures on the surface of the plant also help spread liverworts from pot to pot by water droplets during irrigation. Liverworts thrive in conditions of high fertility, moisture, and humidity.

Management

Inspect incoming plants for signs of liverworts and isolate infected plants. If the growing media stays moist, small infestations of liverwort can quickly spread through an entire greenhouse. Clean and disinfect empty greenhouses to remove spores. Store growing media properly to prevent contamination by spores. surface moisture levels. Topdressing slow release fertilizers contribute to increased fertility levels on the media surface and to the growth of liverworts. Proper plant spacing helps to reduce humidity levels. Liverworts lack true roots, so allowing the media to dry between watering, helps reduce their vigor.

PLANT GROWTH REGULATORS

Plant growth regulators (PGRs) are compounds used in commercial floriculture, to modify plant growth and development in order to control plant shape and quality. They may be applied as drenches, dips, or foliar sprays. PGRs are regulated in the same way as pesticides because of their potential environmental effects. PGRs are listed in Table 9.

Table 9: Plant Growth Regulators **Active Ingredient:** Brand name	**Class / Group #**	**Mode of Action / Efficacy**
Ancymidol A-Rest	1	Retardants of stem elongation
Chlormequat Chlormequat E-Pro Cycocel	1	Promoter of flowering and/or breaking of dormancy, retardant of stem elongation
Ethephon Pistill	5	Defoliation, promoter of branching and/or pinching, promoter of flowering and/or breaking dormancy, suppressant of flower initiation and development, retardant of stem elongation, suppressants of stem topple
Daminozide B-Nine WSG Dazide 85 WSG	1	Promoter of flowering and/or breaking of dormancy, retardant of stem elongation
Dikegulac-sodium Atrimmec	2	Promoter of branching and/or pinching
Flurprimidol Topflor	1	Retardant of stem elongation
Gibberellic acid GibGro 4LS ProGibb T & O	4	Promoter of stem elongation, promoter of flowering and/or breaking of dormancy, promoter of flower size, suppressant of flower initiation and development

Indole-3-butyric acid Hormodin 1 Hormodin 2 Hormodin 3	6	Promoter of rooting
Indole-3-butyricacid + **1 – naphthaleneacetic acid** Dip 'N Grow	6	Promoter of rooting
1-Methylcyclopropene EthylBloc		Suppressant of senescence
Methyl ester of fatty acids Off-Shoot-O	3	Promoter of branching and/or pinching
N-(phenylmethyl) - H-purine 6-amine + gibberellins A4A7 Fascination	4	Promoter of stem elongation, suppressant of senescence,
Paclobutrazol Bonzi Downsize Paczol Piccolo	1	Promoter of flowering and/or breaking dormancy, retardant of stem elongation
Uniconazole-P Concise Sumagic	1	Retardant of stem elongation

RODENTS

Primary sources: 2008 Pest Management Guide for Commercial Production and Maintenance of Trees and Shrubs and Integrated Pest Management for Multifamily Housing Training – Rodents http://www.stoppests.org/handbook/publichousinghandbook.htm.
The information presented is not strictly for greenhouses.

Determining the Presence of Rodents

The habits of rodents provide numerous signs of their presence, including species, relative numbers and areas of activity. Species can best be identified after rats and mice have been trapped and closely examined.

- Sounds: Gnawing on solid objects; clawing and climbing in walls, above dropped ceilings, and under cabinets; various squeaks; fighting noises.
- Droppings: May be found along runways, near shelters, or other places rodents frequent.
- Urine: Wet and dry rodent urine stains will fluoresce under ultraviolet light.
- Smudge marks: May be found on pipes, beams against walls and outside edges of holes where dirt and oil from their fur is deposited where rodents frequently travel.
- Runs: Smooth or worn areas may be found next to walls, along fences, under bushes and buildings.

- Tracks: Footprints or tail marks may be found in dusty surfaces, sand, soft soil, and snow. The use of nontoxic tracking dust such as chalk powder or unscented talc will help determine the presence of rodents inside buildings.
- Gnawing: May be indicated by wood chips around baseboards, doors, basement windows and frames, stored materials, around pipes in floors and walls, and wherever rats might try to enlarge a crack or enter a structure.
- Burrows: Most commonly made by Norway rats in soft ground, particularly where burrow entrances can be concealed in low, dense vegetation or under concrete slabs, foundation walls, lumber, and piles of rubbish. Norway rats also burrow into soil floors in basements, warehouses, and animal quarters.
- Visual sighting: Frequent observation of rats in daylight generally indicates a high population in the area. Mice may be active during the day or night.
- Nests and food caches: Can sometimes be found when cleaning garages, attics, basements, and other storage places. Rodent species (i.e., squirrels and rats) often store food in attics of buildings.
- Odors: Odors (resulting from deposits of fermenting rodent urine and feces and body oils) in a room may provide a clue to their presence.

Identification

For an effective control program, you must know what species of mammals are involved. Correct identification is essential for selecting the proper damage management measures. Identification can be by activities, feeding behavior, or droppings.

Mice do not travel far from their nests; usually not more than 10 feet. Rats are more likely to live outside in burrows and come inside to feed.

Most rats and some mice are omnivorous, eating nearly any food, although each kind and population has its own preferences. Rats usually begin searching for food shortly after sunset. When hungry, or under crowded conditions, they may also be seen in daylight. Rats and mice may cache considerable amounts of solid food, which they may or may not eat later.

Prebaiting before a control program with a nontoxic bait or unset traps can enhance later acceptance of traps or rodenticides by rats. The most acceptable bait is frequently a local food the rats and mice have already become accustomed to eating.

Long-Term Population Suppression

Rodent populations have a remarkable capacity for growth and survival, but it is often people who provide the conditions under which that potential can be realized. One must base control measures on those circumstances that resulted in food, water, and shelter for the pests.

Sanitation

Remove excess unused materials from the greenhouse, especially if they can be used as a food source or nesting material or nesting sites. Store equipment and materials off the floor and away from walls if possible. Keep area around greenhouse clean of weeds and debris that can camouflage rat burrows.

Exclusion

Rodents can enter the greenhouse through very small holes; ¼ in for mice and ½ inch for rats, for example. Block entry holes with copper mesh and caulk or spackle. Check doors for spaces between door and floor.

Traps

Trapping can be an effective method of controlling rodents especially in conjunction with sanitation and exclusion. Trapping is recommended where use of poisons seems inadvisable and is the preferred method in homes, garages, and other structures where there are few rodents, and nontarget species risks may be great. Trapping has several advantages: (1) It does not rely on inherently hazardous rodenticides, (2) it permits the user to view his or her success, and (3) it eliminates rodent deaths in inaccessible locations, which frequently creates odor problems when poisoning is done within structures.

Mice are curious and can be caught with baited traps. They can become trap shy so trap locations need to be changed over time. Rats must become accustomed to the traps before they will get on them so prebaiting unset traps for a few days is necessary.

Snap traps are cheap and easy to use. Rodents do not die quickly with glue traps. Electronic traps are relatively expensive. Curiosity traps can be effective but may not always kill the rodent. Traps should be placed against walls in corners or along known runways.

Rodenticides for Structural Use

The use of toxicants has often been the primary treatment or intervention in many rodent control programs. Rodenticide applications have not proven ideal in all circumstances. They are contradicted in some situations. It is best to place the bait where it will be in the rodents' normal line of travel. Baits should be placed under cover so the animals will feel secure when they feed. Put out more bait than you think necessary, unless prebaiting for three to five days has already indicated how much is needed. It is generally much safer and more effective to use chronic (multiple-dose) toxicants than acute (single-dose) poisons for rodents. There are times, however, when the quick-acting acute poisons are required, such as when the disease hazard is high or when a very large population must be reduced in a short period of time. Rodenticides are listed in Table 10.

Table 10: Rodenticides (for structural rodent control) Active Ingredient:	Efficacy	Comments (Pros & Cons)
Chlorophacinone	Chronic	
Diphacinone	Chronic	All concentrations >3% are restricted-use
Bromadiolone	Chronic	Good control in Warfarin-resistant rats, toxic to poultry
Warfarin	Chronic	All concentrations >3% are restricted-use
Cholecalciferol (Vitamin D3)	Chronic	
Zinc phosphide	Acute	Effective against Norway and roof rats, house mice
Bromethalin	Acute	Effective against Norway and roof rats, house mice

Voles

It may be more common to find voles in greenhouses than rats or mice. The first step to management is to limit the voles' access to the greenhouse. Voles are easily caught in mouse traps baited with apple pieces. Overhead cover above the trap increases effectiveness (e.g. a box or cubby of some type). Most vole control products include zinc phosphide. A PVC bait station (a T of PVC with a cover over the open upright) will help limit non-target consumption of the bait and can be attached near where voles are entering the greenhouse. Some commercial mouse bait stations would also work for voles.

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APPENDICES

Appendix 1: Raw ranking of research, education and regulatory needs

The complete list of needs identified at the workshop, organized by type (research, education, regulatory), was sent to the workshop participants, the advisory group, grower and industry organizations in the region, and Cooperative Extension educators working with the greenhouse industry for ranking. Each need could be ranked as being of high, medium, or low importance. Seventeen people/groups ranked the needs, including 2 growers, 13 extension personnel, 1 industry rep and 1 Department of Agriculture representative. (Number in blank is number of votes "of high importance" of 17 total votes).

Research

5______1. Thresholds for pest management decisions based on environment (temperature, relative humidity, daylength, light levels, leaf wetness etc.) and stage in production.

6______2. Effect of lower growing temperatures on chemical and biological insect and disease management,

6______3. Interaction of media (organic matter content, texture, water holding capacity) and soil applied pesticides: include compost based media, peat based media, oasis cubes, etc.

5______4. Breeding for resistance/tolerance to pests

1______5. Explanation and basis for reduced pest management needs when plants are moved outside – environment, presence of predator/parasitoid species/?

0______6. Climate change and effect on pest ranges, potential for new greenhouse pests

2______7. Effect of wetting agents on soil-borne pathogens and insect larvae

10_____8. Comparative economics of various biocontrols vs. pesticides

9______9. Development of methodologies for maintaining viability of biocontrol agents during packaging and shipping (quality control)

4______10. Marketing the use of biocontrol to customers

4______11. Interaction of insect-pathogenic fungi, like *Beauveria bassiana*, and insect growth regulators for insect management

4______12. Interaction of insect-pathogenic fungi, like *Beauveria bassiana*, and greenhouse environment for insect management

6______13. Research on Hunter fly for control of flying insects in the greenhouse, including effects of pesticides on hunter fly, rearing methodology, etc.

11_____14. Development of banker plant systems for biological control for a broader range of insect pests

5______15. Development of additional, more effective strains of *Beauveria bassiana* for insect management

6______16. Research on natural enemies for complete range of aphid species including new species (oleander aphid, etc.)

7______17. Management of new or newly predominant aphid species (such as foxglove aphid), including efficacy of chemicals labeled for aphids, development of resistance to pesticides, population development rates, etc.

7______18. Use of Hypoaspis for fungus gnat management: efficacy, conditions under which it works (including the difference in using it in pots and on floors), interaction with cultural methods of fungus gnat management

3______19. Use of *Beauveria bassiana* for fungus gnat and shore fly management

4______20. Nematode management of fungus gnats and shore fly larvae: specifically of nematode species not currently widely available for fungus gnat management, shelf life and efficacy, stage of fungus gnat larvae attacked, interaction with *Beauveria bassiana*,

2______21. Fungus gnats as vectors of root diseases

6_____22. Additional biocontrol agents for spider mite management that are less sensitive to humidity, and their use

4______23. Methodology for mite detection prior to damage symptoms/signs,

3______24. Overwintering biology of mite species

5______25. Biological control of tarsonemid mites on ornamentals and tomato/cucumber in greenhouse production

1______26. Effect of flower removal in conjunction with spraying for management of high thrips populations

6______27. *Orius* banker plant system for thrips management

8______28. Interaction of *Orius* for thrips management with light level, including using *Amblyseius cucumeris* then *Orius* when light levels are high enough for biocontrol

8______29. Encouraging movement of thrips biocontrol organisms throughout infested plants and plant to plant, including application methods and comparative costs/efficacy

6______30. Compatibility of Safari and parasitoids commonly used for whitefly management

4______31. Resistance of Safari to Q biotype of whitefly

7______32. Sentinel/trap plants for silverleaf whitefly and Q biotype whitefly: are there differences in attraction between biotypes?

1______33. Research on Bandedleaf whitefly: is there an economic impact, reproduction in greenhouse, effect of environment and crops as hosts, chemical and biological control in comparison to other whiteflies

4______34. Data on impact of removing infested plants/leaves/weeds from greenhouse on whitefly management.

2______35. Development of new biological control methods for specific scale species, rather than generalist predators

5______36. Interaction of spreader stickers with fungicides, pathogens and biological control organisms for disease management. Include evaluation of new/reformulated adjuvants

8______37. Interaction of soil pH, fertility and disease incidence: to develop cultural management options

6______38. Shelf life of biological control organisms: in media, change with time and/or temperature etc, of storage?

3______39. Correlation of root system differences by variety with susceptibility to root diseases

11_____40. Development of new and more effective biological control organisms for root rot diseases

9______41. Development of easy to use, accurate and affordable disease test kits (like the virus test kits currently available) for more diseases

4______42. Timing of cleaning of plants (leaf removal, etc.) and incidence of botrytis

3______43. Use of plant growth regulators and identification or development of botrytis symptoms – increased incidence in more compact plants?

3______44. Botrytis management in high tunnel/passively heated greenhouses for greenhouse tomato

5______45. Development/use of botrytis alert sensors or models based on temperature and humidity levels

8______46. Biological fungicides for foliar application: comparison of efficacy for botrytis management

5______47. Use of compost in media for botrytis management: include effect of uniformity of available composts

8______48. Varietal resistance in phlox, rosemary, dahlia, dahlietta, bidens, gerbera etc. to powdery mildew

9______49. Organic or products with low “days to harvest” intervals for management of powdery mildew in rosemary

4______50. Use of sulfur canisters at night: micro-thio sulfur for powdery mildew management.

6______51. Use of composts in media for *Pythium* management, for ex. Aged pine bark compost

4______52. Genetic test to identify resistance to Subdue Maxx in *Pythium*

6______53. Interaction of heat, water, nutritional stress, EC level, N level and *Pythium* spp. on disease incidence

5______54. Correlations between soluble salts levels and *Pythium* management

1______55. Description and control of *Rhizoctonia* aerial blight on mums

4______56. Source of INSV coming into greenhouse: plugs, thrips, etc.

7______57. Interaction of biological control of thrips and INSV incidence

9______58. INSV resistant varieties of ornamental host plants

10_____59. Protocol for frequent use of disinfecting agents (for example, ZeroTol, XeroTon, KleenGrow) for management of *Xanthomonas*. Issues of importance are phytotoxicity to species and cultivars, efficacy, option for use as a preventative, use in overhead watering systems, and use in propagation systems.

2______60. Biological control of *Sclerotinia* with soil applied biocontrol organisms

3______61. Iron nutrition interaction with the incidence of *Thielaviopsis*

1______62. Resistance to mefenoxam in *Phytophthora* infecting ornamentals

10_____63. Development of a quick test for *Phytophthora* identification for use by growers and diagnostic labs

2______64. *Alternaria* species important in greenhouse crops, source in greenhouse plants, host range

3______65. Varietal differences in susceptibility of tomato to *Cladosporium*

5______66. ZeroTol efficacy and phytotoxicity data needed (for algae management)

1______67. Data on persistence for KleenGrow (Pace 49, Inc.)

8______68. Comparison of oxidizing agents (including XeroTon) and older quaternary ammonium salts (Greenshield, etc.) and new products like KleenGrow (5^{th} generation Q salt) for algae management

6______69. Evaluate StripIt cleaning agent for weed management

2______70. Resistance to Roundup in greenhouse weeds

7______71. Data on steam/hot water methods of weed management for greenhouse use

8______72. Effect of exterior weeds (or other plants) on populations of beneficial insects inside greenhouse

5______73. Buckwheat hulls (and other mulch materials) for weed management in pots, including evidence of pre-emergence effect

8______74. Naturally weed suppressive compounds as pot mulches and/or floor treatments for weed management: coco mulch, corn gluten

7______75. Oxidizing agents and other disinfection compounds for liverwort management

Education

9______76. Training of IPM scouts with an emphasis on hands-on training and materials that owners can use to train new workers

9______77. Creation of a communication/resource hub: creating an information path from industry to extension and research and back

8______78. Educational materials on interaction of biological control organisms and environment (temperature, relative humidity, daylength, light levels, etc.)

7______79. Training on mode of action (class) of pesticides for resistance management

5______80. Information on varietal differences in tolerance/resistance/high susceptibility to pests

9______81. Creation, and dissemination, of educational materials on new/upcoming/potential pests: identification, biology, damage caused, hosts, etc., color photos, other species they can be confused with

7______82. Training on record keeping, including pesticide use on in-coming propagation materials

5______83. Training on interaction of pH and pesticide efficacy

10_____84. Comparison of efficacy and costs of different application techniques for biological control organisms

8______85. Information on quarantine pests: identification, reporting requirements, allowable management options

6______86. Need for a "prescription" type approach for growers to use biocontrols

9______87. Guidelines on what, when, how many, and how to apply biocontrol organisms taking into consideration the variations in operations: environmental conditions, crops, etc.

5______88. Education on identification and use of hunter fly as a biocontrol, including effect of environment, interaction with pesticides

10_____89. Training on using sanitation for insect management, including information on overwintering or survival in greenhouses without plant material

7______90. Easy to understand aphid identification materials in color, including or especially for new or newly predominant aphid species (oleander aphid, etc),

2______91. Explanation and identification of aphid mummies as a result of aphid biocontrol

5______92. Application methodology for use of nematodes for fungus gnat and shore fly management

9______93. Training on cultural methods for fungus gnat and shore fly management: algae management for shore fly management, including droplet size for overhead irrigation, effect of nutrients and water management for shore fly management, management of standing water when using plastic trays

2______94. Source of fungus gnats coming into the greenhouse: media, time of year media is packaged, etc.

3______95. Use of *Atheta* for fungus gnat and shore fly management, including establishment as population in greenhouse

4______96. Spider mite overwintering in greenhouses and how it relates to management

5______97. Identification and scouting for cyclamen and broad mite, including which plants to check, id including egg and hatched egg, effect of population level and environment, corkiness on foliage of some plants (ivy geranium).

8______98. Application techniques for thrips biocontrol, including which beneficials target which life stages

3______99. Identification of Q biotype of whitefly

3______100. Banded wing whitefly: identification and presence, host range, presence vs. relevance

3______101. Biocontrol using *Amblyseius swirskii* compared to that using other predatory mites for whitefly management

3______102. Identification and general management information on Lepidoptera that infest greenhouse crops

2______103. Possible greenhouse leafminer pests and their host ranges, identification and early damage for scouting, possible look-alikes, and methods of mechanical management

3______104. Identification of mealybug species and hosts, information for scouting including winged males on yellow sticky cards, size comparison of species, etc.

3______105. Sanitation for management of mealybug, including management of resistant stage that survives without plant material

3______106. Biocontrol of mealybug with *Cryptolaemus*, identification to distinguish the beneficial from the mealybug

2______107. Sanitation for management of scale

2______108. Identification of scale insects: species and stages for scouting, effect of environment

4______109. Biocontrol methods for scale management

8______110. Treatment of irrigation water and disease management

9______111. Training on use of disease test kits as a part of scouting for disease management – for INSV and other diseases where kits are available

12______112. Training on use of disinfection materials for disease management of *Botrytis, Pythium,* and *Thielaviopsis*

8______113. Sanitation for management of root diseases as affected by irrigation system and growing system

6______114. Training on the concept of early disposal of infected plants for disease management

4______115. Pros and cons of using adjuvants with fungicides for disease management

11_____116. Training on using environmental controls to manage *Botrytis* with current changes in heating and ventilation for cost savings, include concept of dewpoints, stress of rapid changes, etc.

4______117. Effects of plant nutrition on incidence of *Botrytis*

2______118. Identification and comparison of symptoms: powdery and downy mildew on Rudbeckia and rose

6______119. Management of *Pythium* by limiting water, heat and nutritional stress, including high EC levels

5______120. The benefits of bottom heat as a useful management method for *Pythium*

1______121. Identification of pythium species

2______122. Identification and management of *Rhizoctonia* aerial blight on ornamentals

2______123. Varietal differences in susceptibility of ornamentals to INSV

6______124. Identification of INSV, with color pictures: confusion between disease symptoms, variation in symptoms on different crops, especially early stages (plug trays) and in crops/weeds to prevent the development of INSV harbors

7______125. Management of INSV as thrips management and weed management

6______126. Identification of symptoms of downy mildew at early stages of plant growth

4______127. Information on species and hosts of *Xanthomonas*, including differences in management

4______128. Identification and basic information for *Sclerotinia* management: hosts, effect of environment

5______129. Sanitation for management of *Thielaviopsis*, especially in reuse of pots and trays

6______130. Identification of *Thielaviopsis* including examination of roots to distinguish it from nutritional issues, identification at plug stage for prevention of spread, variation in symptoms with crop species

3______131. Soil pH for management of *Thielaviopsis*

2______132. Identification of species and hosts of *Phytophthora*, types of damage on specific hosts, comparison of disease symptoms, for example, on pansy

0______133. Varietal differences in susceptibility of ornamentals to *Phytophthora*

4______134. Sanitation of irrigation systems for *Phytophthora* control

3______135. Fungicide rotations for management of *Phytophthora*

2______136. Conditions under which *Pseudomonas* is likely to occur

2______137. Seed preparation for management of *Pseudomonas*

0______138. Identification of *Pseudomonas* vs. *Alternaria*

2______139. Cultural management for *Cladosporium* in greenhouse tomatoes

6______140. Broad based IPM strategies for weed management: exclusion and treatment

9______141. Training on importance of weed management for disease and insect management: inside and outside greenhouse, especially with lower pesticide use and increasing use of biological control organisms, including nook and cranny weed management

5______142. Use of weed suppressive ground covers around greenhouses for management of exterior weeds – fine fescues, hard fescues, groundcovers

1______143. Basic information on rodent management and exclusion, tamper proof containers for rodenticides inside structures

Regulatory

7______144. Requiring information on what pesticides have been used on plant materials, including plant growth regulators, from companies shipping them: in writing with shipment, what has been applied and when and including pests they had been inspected for prior to shipping where appropriate

7______145. Labeling of pesticides for use on tomato and pepper transplants and herbs

9______146. Clear labeling of materials for management of pests in the greenhouse including standardization of label language pertaining to site/pests/plants.

2______147. Additional systemic management options for aphid management

5______148. Efficacy trials of pesticides for new (or newly predominant) aphid species

1______149. Additional pesticides for management of larval fungus gnats

3______150. Good translaminar miticide

4______151. Labeling of pesticide materials for spider mite management in greenhouse vegetables and herbs, because of long crop production period for vegetables

3______152. Efficacious pesticides for management of tarsonemid mites

3______153. Need efficacy data for pesticides for shore fly management

13_____154. Development of additional effective pesticides for thrips
.
6______155. Need for an additional systemic pesticide for whitefly management

11_____156. Sale of disease test kits in smaller units to encourage use by growers

4______157. Efficacious fungicides for management of *Sclerotinia* in ornamentals and greenhouse vegetables

2______158. Efficacy of difenthate methyl and rotational products for management of *Thielaviopsis*

3______159. Fungicides for *Cladosporium* management in greenhouse tomato

6______160. Need pre-emergent herbicide labeled for use in greenhouse

9_____161. Clarification of use of low volume sprayers for pesticides, particularly appropriate rates and directions on pesticide labels

Infrastructure building

2______162. Additional/regional site for identification for Q biotype of whitefly

6______163. Need for additional biological control production in the US

2______164. Additional/regional site for identification of *Pythium* strains

Appendix 2: Stakeholder input collected in several states on needs for research, extension and regulatory support for IPM in commercial greenhouses

Connecticut

- Need an IPM certified program from the Department of Ag & UConn. Need two components, UConn and regulatory authority.
- Push IPM, need dollars for bodies to work out in the field to help farmers to put together IPM programs.
- We need more people to do work with growers, like helping to scout and do IPM. We need threshold information, what to look for next week, information on what's expected next.
- Need more funding for staff.

Maine (Mid-Maine Greenhouse Growers)

- Need someone from university or state to give state of the art recommendations on greenhouse control options, what actually works.
- Need more IPM program funding support from federal, state, and region. Can't build programs on competitive funds.
- Never ending need to expand horizons for greenhouse biocontrol, need practical methods for year round greenhouses.

New Hampshire

- Need appropriate pesticide package sizes for small/part time growers.

New York

NY Farm Viability Institute Green Industry Barriers to Success, April 2005

- Potential production system changes that could make a difference
  - #5 - Reduction of chemical use through predators, IPM, new spraying techniques, etc.
- Five year threats to the success of the NY industry
  - #6 - Difficulty in getting pesticides approved

Vermont

- More base funding is needed to support IPM programs (i.e., more funds for personnel and operating expenses).

New England Regional Organizations

- New England Greenhouse Conference
  - For greenhouse operators, finding effective registered pesticides is a priority, registrations change quickly, restricted entry intervals are hard on operations, and pesticide costs are high. It is difficult to find a product that will work on diverse crops in a small space.

  - Greenhouse employee pesticide safety training is an important issue. Greenhouse industry is seasonal, and has to annually deal with applicator trainer education. Regulations require training workers before they work.
- New England Pest Management Network, 2006 Stakeholder Priorities and Feedback

Census - Items relating to greenhouse production

Primary pests for greenhouses
- CT – thrips
- ME – fungus gnats, pythium
- PRO New England mini-survey – thrips, whitefly

Appendix 3: Contact information for state reviewers

State	Name	Address	Phone	e-mail
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