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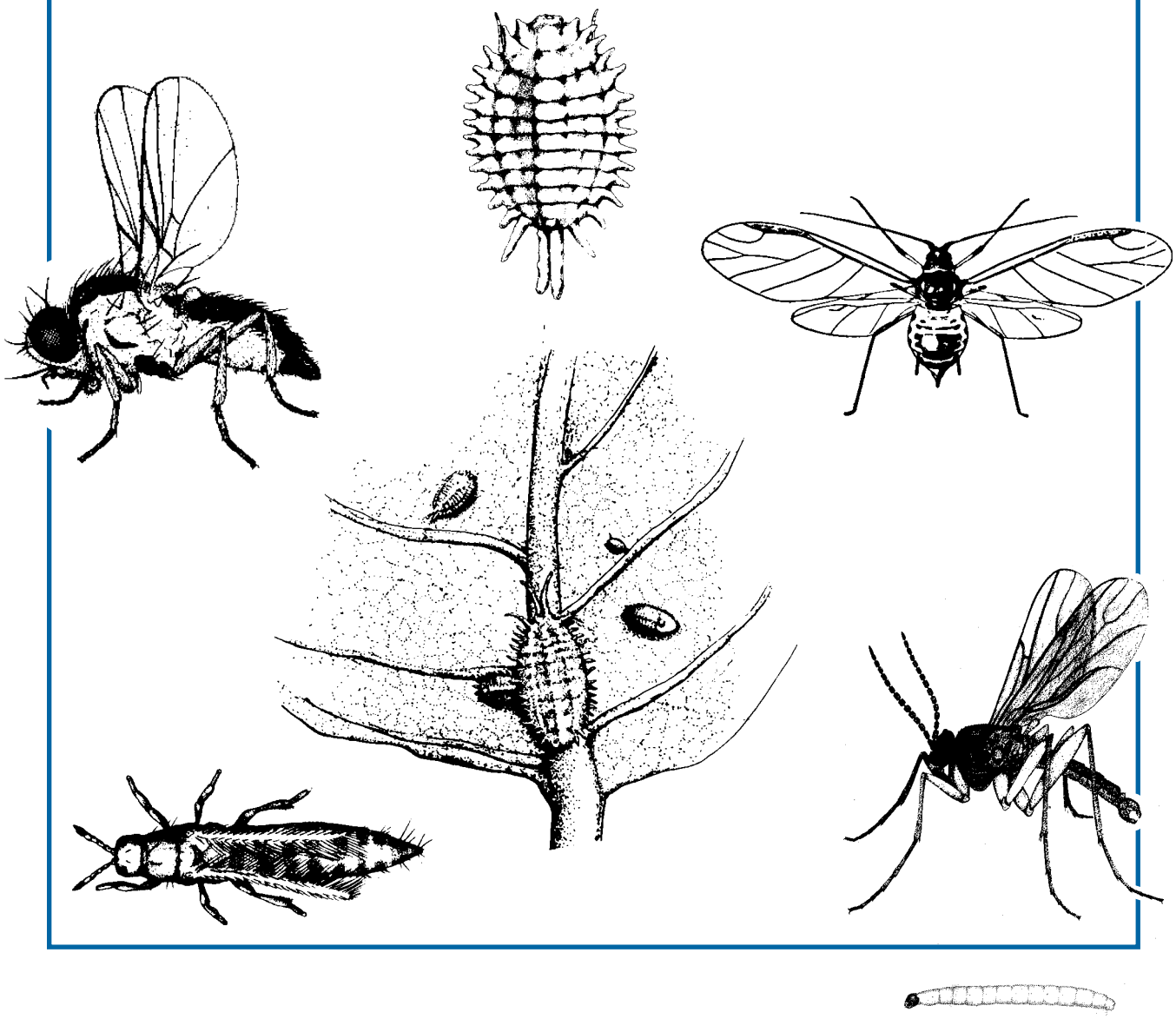
PB1594-Insect and Mite Management in Greenhouses

The University of Tennessee Agricultural Extension Service

UT Extension
PB 1594

Insect and Mite Management In Greenhouses



THE UNIVERSITY of TENNESSEE

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Originally Developed by Elizabeth Will, Graduate Student,
James Faust, Assistant Professor, Ornamental Horticulture and Landscape Design, and
Frank A. Hale, Associate Professor, Entomology and Plant Pathology,
Agricultural Extension Service, University of Tennessee

Insect and Mite Management In Greenhouses

Frank A. Hale, Professor, Entomology and Plant Pathology, University of Tennessee Extension, and
Raymond A. Cloyd, Associate Professor, Extension Specialist in Ornamental Entomology
Integrated Pest Management, Department of Entomology, Kansas State University

Pest Management

Pest Management (PM) is a term that refers to the use of various strategies to manage greenhouse insect and mite pests. The focus of PM is to use a variety of management strategies to deal with existing pest problems, rather than relying solely on pest control materials such as insecticides and/or miticides. PM involves the use of cultural, physical, biological and/or chemical management strategies.

PM programs typically require growers to be proactive rather than reactive. An effective PM program begins by regularly scouting the greenhouse for insect and mite pests. A PM program may include establishing action thresholds for specific insect and/or mite pests and then implementing a pest management strategy once a threshold has been reached. Greenhouse producers who have successfully implemented PM programs indicated that they have reduced costs and increased worker safety. As a result, employees often respond to PM programs with increased enthusiasm. The objective of this publication is to assist greenhouse producers in starting a PM program.

Pest Management Basics

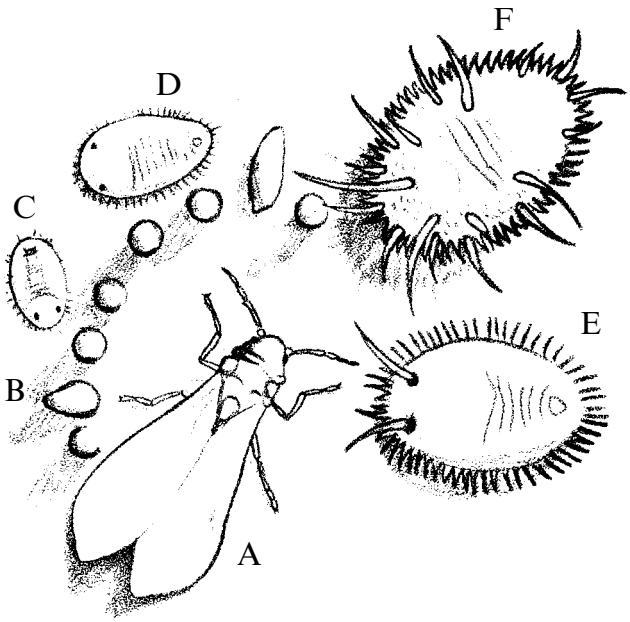
Identification

Identifying the insect or mite pest and the number of each species in a greenhouse requires diligence, but this information is critical for greenhouse producers to avoid spraying an inappropriate pest control material such as an insecticide or miticide. When greenhouse producers know exactly which pests are present and the plants they are present on, then the appropriate insecticide or miticide can be applied. An extremely valuable pictorial guide for pest identification is *"Identification of Insects and Related Pests of Horticultural Plants"* by R.K. Lindquist and R.A. Cloyd, which is published by O.F.A. Services, Inc. The University of Tennessee Soil, Plant and Pest Center in Nashville is another valuable resource.

Sanitation

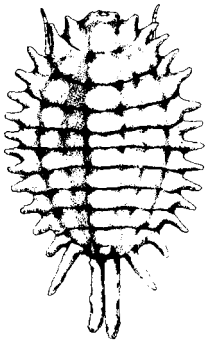
Clean greenhouses provide fewer opportunities for insect and mite pests to establish and thrive. Weeds in pots or underneath benches serve as reservoirs for many greenhouse insect and mite pests. Weeds underneath the benches are typically sprayed with insecticides and miticides. In addition, many weeds serve as a source for viruses transmitted by insects such as western flower thrips (*Frankliniella occidentalis*). Avoid standing water and allow water to properly drain away from the greenhouse, since excess water provides an ideal environment for fungus gnats and shore flies. Remove plant debris and old stock plants from the greenhouse or place into containers with tight-sealing lids, because winged adult insects will abandon desiccating plant material and migrate onto the main crop.

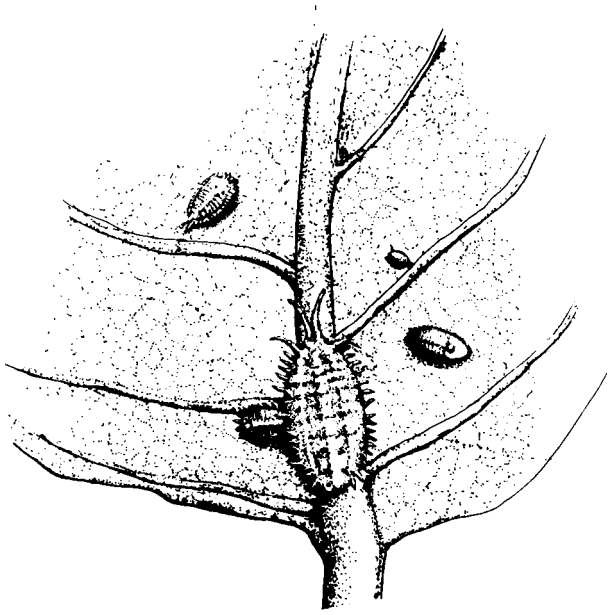
Illustrations of Common Insect and Mite Pests of Greenhouse Crops

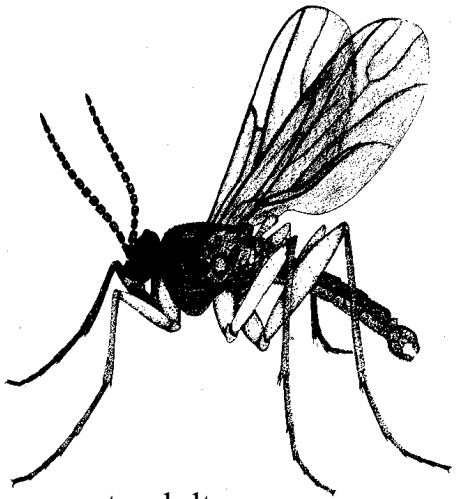


Greenhouse whitefly. A, Adult. B, Eggs. C - E, Nymphs. F, Pupa

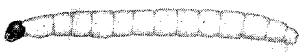
Mealybug, adult female





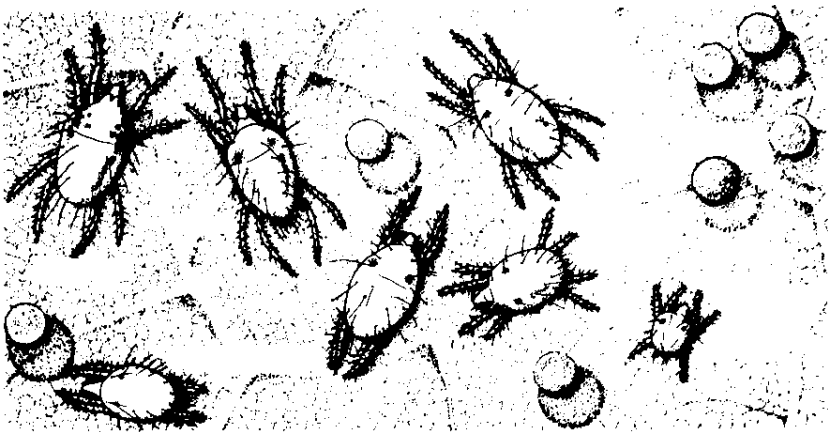


Fungus gnat, adult

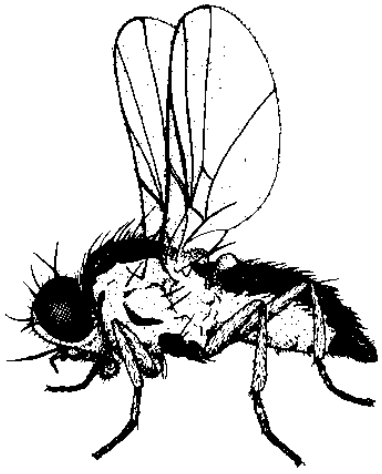


Fungus gnat, larva

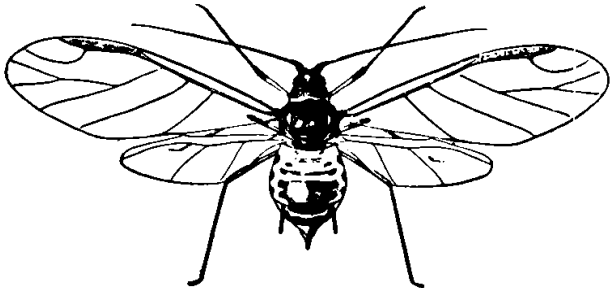
Drawings do not indicate the relative size of the pest; e.g., thrips are much smaller than aphids.



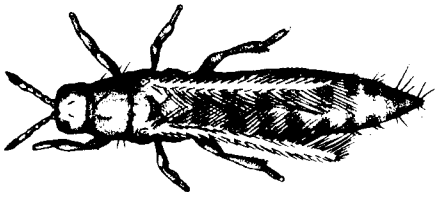
Spider mites



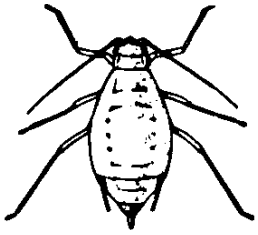
Leafminer, adult



Aphid, winged



Thrips, adult



Aphid

Drawings do not indicate the relative size of the pest; e.g., thrips are much smaller than aphids.

Exclusion

Preventing insect or mite pests from entering the greenhouse is easier than attempting to kill them after they have entered the greenhouse. Many greenhouse producers introduce insect and mite pests into greenhouses when they receive shipments of infested plant material from another source. Carefully inspecting new plants before placing them into a greenhouse can minimize problems with insect and mite pests. Exclusion can also be achieved by screening greenhouse openings, including side and ridge vents with specially designed screening material. Refer to the section entitled "Excluding Insect Pests Using Micro-Screening."

Management

Once insect or mite pest populations are at or above the action threshold, the application of an insecticide or miticide may be warranted. Insecticides and miticides are expensive, so it is important to select the appropriate product and follow proper application procedures (refer to label). There has been an increase in the use of alternative pest control materials. These materials have relatively low mammalian toxicity and are generally less harmful to biological control agents or natural enemies than most conventional pest control materials. Biological control is the use of natural enemies such as predators, parasitoids or pathogens to manage insect or mite pests. Predators consume their prey (host) either partially or entirely, while parasitoids lay their eggs inside or on their prey. The immature parasitoid then feeds on the internal contents of the prey. Eventually, the parasitoid matures and the adult either emerges near the dead host or exits from it through a chewed hole. Pathogens work similar to parasitoids, since they also consume the inside of target insect host. Biological control requires considerable management skill and education to be successful in commercial greenhouse production systems.

Scouting for Insect and Mite Pests in the Greenhouse

Scouting is a key component in developing a successful PM program. It is not possible to make pest management decisions without routinely examining sticky cards or visually inspecting plants for the presence of insect and mite pests and determine their numbers. Detecting insect and mite pests when populations are low allows for flexibility in selecting pest management strategies such as removing infested plants or plant parts, using reduced risk insecticides or miticides, and making spot applications to infested plants containing high numbers of insect and mite pests. The following information provides guidance for developing an insect and mite pest scouting program. Line drawings of the key greenhouse insect and mite pests are presented on the preceding pages.

What should be inspected while scouting for pests:

1) sticky cards
2) aboveground plant parts such as leaves, stems and flowers
3) roots

Sticky Cards

- Place sticky cards just above the plant canopy. Use sticky cards that are 3 x 5 inches.
- Thrips may be more attracted to blue cards; however, yellow sticky cards capture a variety of insect pests including winged aphids, whiteflies, leafminers, fungus gnats and shore flies.
- When scouting for fungus gnat adults, place sticky cards horizontally on pots or on the growing medium surface.
- It is not necessary to count all insects on a sticky card. Select a 1-inch vertical column (not horizontal) and be consistent each time sticky cards are monitored. In addition, one side of a sticky card may be used.
- Place one sticky card per 500 to 1,000 square feet of greenhouse space unless the situation requires more, depending on crops grown and virus susceptibility.
- Scout sticky cards weekly, identifying all the insects on sticky cards with a 10X hand lens. Record insect numbers on a worksheet that allows you to check changes in populations of individual pest numbers to determine changes in pest populations at each location through time.

- Replace sticky cards every week or if they become full of insects, which will make identification difficult.
- Insect pests that may be captured on sticky cards:
  - Whitefly adults
  - Leafminer adults
  - Thrips adults
  - Scale and mealybug adult males
  - Fungus gnat adults
  - Winged adult aphids
  - Shore fly adults
- Insect and mite pests not captured on sticky cards:
  - Non-winged aphids
  - Mites, including twospotted spider mite, broad mite and cyclamen mite
  - Mealybug immatures and adult females
  - Scale immatures and adult females
  - Egg, larva/nymph and pupa stages of many greenhouse insect and mite pests

Aboveground Plant Parts and Roots

- Randomly examine plants over an area represented by a sticky card. Pay particular attention to specific plant varieties that tend to see more susceptible to certain insect and mite pests.
- Examine leaf undersides, especially young leaves, for the life stages of whiteflies, mealybugs, aphids, spider mites and scales.
- Examine the topside of leaves for:
  - Leafminer tunnels
  - Distortion and discoloration resulting from feeding by thrips, aphids, whiteflies, spider mites, scales and mealybugs or egg-laying damage from leafminer females.
  - Honeydew – a sticky, clear substance excreted by aphids, soft scales, whiteflies and mealybugs.
  - Sooty mold – dark fungal growth that uses honeydew as a food source.
- Examine terminal growth for immature thrips and aphids.
- Examine open flowers for thrips larvae and adults.
- Examine the main plant stem for scales and mealybugs.
- Look at the base of stems, leaves and other protected crevices for mealybug life stages and immature thrips.
- Examine plant roots for the presence of fungus gnat larvae and root mealybugs.

Pest Thresholds

One principle of PM is that insect and/or mite pests must be present in numbers that will cause unacceptable crop damage before action should be taken to control the designated insect or mite pest(s). Currently, there are no discreet action thresholds for greenhouse insect and mite pests. However, greenhouse producers usually establish a threshold number based on past experience. Information obtained from scouting records maintained in previous years may help to determine action thresholds for the next season. For example, a greenhouse producer may determine that five adult whiteflies per sticky card per week are acceptable. Therefore, whenever more than five adult whiteflies, on average, are detected on a sticky card for one week, a management strategy should be initiated.

Excluding Insect Pests Using Micro-Screening

Pests can be excluded from greenhouses by placing screens on greenhouse openings, including side and ridge vents. The size of the screen mesh is determined by the pests to be excluded. For example, leafminers can be excluded with 0.025" mesh screen, whereas western flower thrips require a 0.0075" mesh screen.

The two major problems with screening are (1) increased resistance to air flow, which results in reduced cooling capacity in the greenhouse, and (2) protecting the screen from accidental damage by greenhouse equipment or employees.

Placing a screen over greenhouse vents will restrict air movement into the greenhouse, thus reducing the effectiveness of the fans at pulling air through the greenhouse. Properly designed screening is necessary to reduce the effect of the

screen on greenhouse cooling. UT Extension faculty can assist you in designing a proper insect-screening system. To do so, the following information is required:

Exhaust Fan Information
- Manufacturer
- Model #
- Fan Diameter
- Power (horsepower)
- Number of Exhaust Fans
- Greenhouse Floor Area (square feet)
- Area of the Vent Opening (square feet)

Extension faculty may need to visit your facility to measure the pressure drop when the fans are turned on. This procedure takes only 30 minutes. With this information, we can determine the area of screen necessary to avoid severe reduction in the greenhouse cooling capacity, and the possibility of burning out greenhouse fan motors.

Management of Insects and Mite Pests of Greenhouse Crops

Biological Control

Biological control is the use of living organisms to reduce the population levels of insect and mite pests. Biological control agents (natural enemies or beneficials) typically will not entirely eliminate the target insect or mite. Some beneficials are capable of surviving on alternate food sources such as pollen, nectar or other insects and/or mite pests when populations of the target pest are too low to support continued reproduction of the given natural enemy.

Biological control must be designed for each greenhouse operation based on trial-and-error. A major challenge is to integrate natural enemies into a pest management program that includes pest control material treatments, which may be harmful to natural enemies. Alternative insecticides, miticides and application techniques are available that are less likely to have detrimental effects on natural enemies. Biological control is more successful when implemented prior to insect and/or mite pest populations having reached damaging levels. As a result, greenhouse personnel must systematically scout for insect and mite pests on a regular basis to prevent insect and mite pest populations from reaching damaging levels. Identification and early detection of insect and/or mite pests are important to determine the type of natural enemy or enemies needed and when releases should be implemented to maximize effectiveness. Biological control is not a "quick fix" for control of existing insect and mite pest problems, but can be an effective part of a pest management program in which the goal is to reduce reliance on insecticides and miticides.

Types of Commercially Available Biological Control Agents

The larvae and/or adults of predators including the ladybird beetle, green lacewing and minute pirate bug feed on mites, aphids, mealybugs and thrips. Each may have a particular prey preference and require certain environmental conditions such as temperature and relative humidity to be successful (**see Table 1**). Parasitic wasps or parasitoids are host-specific and in general they tend to attack only one type of insect pest or life stage. In addition, they may be stage-specific, meaning that parasitoids will insert their eggs into the eggs or other life stages such as larvae or adults of certain insect pests. Immature parasitoids feed in or on the host, eventually killing it. Entomopathogenic nematodes are soil-dwelling, microscopic roundworms that enter insect hosts and emit a bacterium lethal to insect hosts, killing them within 48 hours.

The entomopathogenic nematodes enter an insect through natural openings such as the mouth, anus or spiracles (breathing pores) and regurgitate bacterium, which paralyzes and kills the insect host. The entomopathogenic nematodes feed on the reproducing bacterium and continue to multiply in the insect carcass, eventually exiting to find a new host after the food source dissipates. For sources of predators, parasitoids and entomopathogenic nematodes, see University of Tennessee Extension Factsheet SP290-Z, "*Commercial Sources of Predators, Parasitoids and Pathogens*."

Table 1. Biological Control of Insects and Related Pests

Pests	Predators	Comments	Parasites/Pathogens	Comments
Aphid	Lacewings, *Chrysoperla* spp. and *Chrysopa* spp.	Introduce as eggs or larvae. Feed on several different insect and mite pest in the absence of aphids.	Parasitoid, *Aphidius colemani*	Effective against green peach and melon aphid.
	Aphid midge, *Aphidoletes aphidimyza*	Inactive during short days unless light provided.	Parasitoid, *Aphelinus abdomalis*	Effective against potato aphid.
	Ladybird beetle, *Hippodamia convergens*	Feed on all aphid life stages. Both adults and larvae are predacious.	Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm, humid conditions. Kills insect hosts similar to parasitoids.
Fungus gnat larvae	Predatory mite, *Hypoaspis miles* Rove beetle, *Atheta coriaria*	Soil predatory mite that persists in growing medium. 7-11 day life cycle. Short shelflife. Can incorporate into growing media before filling pots. May be used with Bacillus *thuringiensis* subsp. *israelensis*, and entomopathogenic nematodes. Both the adult and larva of this rove beetle are predacious and feed on all life stages of fungus gnats. Adults are mobile and can fly. Feed on all mealybug life stages.	Entomopathogenic nematode *Steinernema feltiae* (Scanmask, Entonem, Nemasys and NemaShield)	Attack fungus gnat larvae. Apply directly to growing medium. The growing medium must be moist prior to and after applying the entomopathogenic nematodes.
Leafminer larvae			Parasitoids *Dacnusa sibirica, Diglyphus isaea*	Larvae complete development inside leafminer larvae and then adult parasite emerges. Temperatures may influence effectiveness.
Mealybugs	Lady beetle *Cryptolaemus montrouzieri*	Feed on all mealybug life stages. Primarily effective when mealybug populations are high. Less effective when exposed to low light conditions.	Parasitoid *Leptomastix dactylopii*	Only attacks citrus mealybug. Excellent searching ability and performs well at low mealybug densities.
Mites	Predatory mite, *Neoseiulus barkeri=Amblyseius mckenzei*	Effective against broad mites.	Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm, humid conditions. Kills insect hosts similar to parasitoids.
	Predatory mite, *Phytoseiulus persimilis*	Requires temperature <80 degrees F and humidity between 60 to 80% to be effective. Only feeds on twospotted spider mite.		
	Predatory mite, *Mesoseiulus longipes=Phytoseiulus longipes*	Tolerates warmer and drier conditions than *P. persimilis.* Used for control of twospotted spider mite.		

Table 1. Biological Control of Insects and Related Pests (Cont)

Pests	Predators	Comments	Parasites/Pathogens	Comments
Mites	Predatory mite, *Neoseiulus californicus=Ambylseius californicus*	Survives longer without prey. Used for control of twopsotted spider and cyclamen mites.		
	Predatory midge, *Feltiella acarisuga*	Feeds on twospotted spider mites. Only larvae are predaceous; adults do not feed.		
Scale	Ladybird beetle *Lindorus* or *Rhyzobius lophanthae*	Both the adult and larva attack armored and soft scales.	Parasitoid wasp, *Aphytis melinus*	Primarily attacks armored scale.
			Parasitoid wasp, Metaphycus *helvolus*	Primarily attacks soft scale. Brown soft scale can encapsulate eggs.
Thrips	Predatory mite, *Amblyseius degenerans*	Survives on pollen in absence of prey. Only attacts the 1st instar immature.	Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm, humid condiditons. Kills host similar to action of parasitoids.
	Predatory Mite, *Neoseiulus cucumeris=Amblyseius cucumeris*	Only attacks 1st instar immature. Can survive on pollen in the absence of prey.		
	Predatory Mite *Hypoaspis miles*	Feeds on thrips pupate in growing media. Short shelf life. May be incorporated into growing media.		
	Minute pirate bug, *Orius insidiosus*	Both adults and immature are predacious. Survives on pollen in the absence of prey. Also feed on aphids, spider mites, and whiteflies.		
Whitefly	Ladybird beetle, *Delphastus cetalinae*	Both adult and larva feed on eggs and nymphs. Requires high whitefly population for survival.	Parasitoid wasp, *Encarsia formosa*	Prefers temperatures >72 degrees F. Adults lay eggs in mid-instar whitefly nymphs and feed on early-instar nymphs. Most effective against greenhouse whitefly.
			Parasitoid wasp, *Eretmocerous eremicus*	Primarily used against sweet potato whitefly B-biotype (formerly silverleaf whitefly).
			Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm, humid conditions. Kills host similar to action of parasitoids.

Alternative Pest Control Materials

Alternative pest control materials, in this case insecticides and miticides, are those that have activity on specific target insect or mite pests while being less harmful to natural enemies. Proper timing of applications is important to control specific insect or mite pests.

Insect growth regulators

Insect growth regulators or IGRs are used to kill the young (= immature) stages of plant-feeding insects including mealybugs, scales and whiteflies. Insect growth regulators regulate insect development and are typically placed into three general categories: juvenile hormone mimics or analogs, ecdysone antagonists and chitin-synthesis inhibitors. Juvenile hormone mimics or analogs inhibit development and cause insects to remain in an immature stage, thus preventing insects from completing their life cycle. Ecdysone antagonists disrupt the molting process of insects by inhibiting metabolism of the molting hormone ecdysone. Chitin-synthesis inhibitors interfere with enzymes during the molting process that stimulate the synthesis and formation of chitin, an essential component of an insect's exoskeleton. As a result, insects fail to reach adulthood because they die in an immature stage, or they mature into sterile adult females.

Microbials

These are insecticides containing microorganisms such as bacteria or fungi that cause diseases of insects. They are usually very specific for the targeted insect pest and are slow-acting, typically requiring repeat applications. *Bacillus thuringiensis* (Bt) is an example of a toxin-producing bacteria used against the larval stage of moths (caterpillars) and fungus gnats. *Beauvaria bassiana* is a fungal pathogen or entomopathogenic fungus used against aphids, mites, thrips and whiteflies. Spores (conidia) of the fungus germinate on the surface of the insect and hyphae penetrate the cuticle. Similar to paroistoids, the fungus consumes the internal contents of the host. In addition, the insect dies from a toxin produced by the fungus.

Neem products

These insecticides are based on extracts from the tropical and subtropical neem tree, *Azadirachta indica*. Azadirachtin, the most commonly used material, is derived from the oil of neem tree leaves or seeds. It acts as an insect-growth regulator, insect-feeding deterrent, repellent, oviposition inhibitor, sterilant and/or direct toxin.

Horticultural oils

These are petroleum or plant-based materials that suffocate insect and mite pests by blocking the breathing pores (spiracles) and disrupting cell membranes. Horticultural oils have short residual activity.

Insecticidal soaps

These are derivative of potassium salts of fatty acid chains that act by disrupting insect cell membranes. Insecticidal soaps have short residual activity.

Selective feeding blockers

These materials inhibit the feeding behavior of insects by interfering with neural regulation of fluid intake through the mouthparts. Insects starve to death within 48 hours.

Conventional Pest Control Materials

Selecting a Pest Control Material

Once a perceived pest threshold has been reached, then pesticide control material (insecticide or miticide) applications may be initiated. A pest control material choice is dictated by:

- Effectiveness on the existing insect or mite pest(s)
- Pest control mode of action
- Application method
- Human toxicity
- Potential phytotoxicity
- Potential impact on non-target organisms, including natural enemies
- Cost
- Restricted entry interval (REI)

Table 2 lists insecticides and miticides labeled for control of insect and mite pests in greenhouses.

Rate or dosage

Most insecticide or miticide labels contain a range of rates that may be used. The low rate is often considered the *preventative rate*, while the high rate is considered the curative rate. If the insect or mite pest population is excessive, then the *curative rate* should be used: however, if the insect or mite population is relatively low, the preventative rate may be used.

Application frequency

Application frequency is a very important and often-overlooked factor in determining the effectiveness of an insecticide or miticide. Many insecticides and miticides have short residual activity. These materials, in general, need to come into direct contact with insect or mite pests to be effective. Most insecticides and miticides are effective on certain life stages (e.g., larva, nymph and adult). For example, *Bacillus thuringiensis* subsp. *israelensis* (sold as Gnatrol™) only kills the larval stage of fungus gnats; whereas the eggs, pupae and adults are not affected. A second application needs to be applied later as the eggs hatch into larvae. Meanwhile, unaffected adults lay additional eggs, which means another application is necessary to control the next generation of larvae. An application of an adulticide will kill fungus gnat adults, thus preventing egg-laying.

Phytotoxicity

Insecticides and miticides can cause plant injury if not used properly and according to label directions. It is important to consider the following prior to making an insecticide or miticide application:

1. Read the pesticide label to determine if there are precautionary statements indicating plant species that should not be treated.
2. Always test-spray a small sample of the crop when applying an insecticide or miticide for the first time. Most symptoms will appear within 10 days following application.
3. Not all plant varieties respond the same. There are often specific varieties of a particular species that are more susceptible than others.
4. The higher the insecticide or miticide concentration used, the more potential for problems associated with phytotoxicity. Therefore, do not apply insecticides or miticides at concentrations higher than the labeled rate.
5. Flowers and bracts are generally more sensitive than foliage; therefore, control insect and mite pests prior to plants' flowering.
6. The spray solution should be agitated frequently; otherwise, the solution at the bottom of the tank may be at a higher concentration and will result in phytotoxicity.
7. Maintain records of observed phytotoxic symptoms of all plants.
8. Tank-mixing two pest control materials may increase the possibility of phytotoxicity.
9. Do not use the same sprayer for herbicides and insecticides or miticides. Always have a separate sprayer for each general type of pest control material.
10. Avoid making frequent applications of insecticidal soaps and horticultural oils, as this may increase the risk of phytotoxicity.

Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests

Abbreviations used in Table 2:

CLASS: BO = botanical; **CA** = carbamate; **CARB** = carbazate; **CBOX** = carboxamide; **CH** = chlorinated hydrocarbon; **IGR** = insect growth regulator; **ND** = Napthoquinone derivative; **MI** = microbial; **ML** = macrocyclic lactone; **OP** = organophosphate; **OR** = other; **OT** = organic tin compound; **NN** = neonicotinoid; **PD** = pyridazinone; **PL** = pyrrole; **PP** = phenyl pyrazole; **PDZ** = pyridine azomethine; **PY** = pyrethroid; **SO** = soap; SP = spinosyn; **TA** = tetronic acid; **TET** = tetrazine.

FORMULATION:

A = aerosol (includes total release and directed); AS = aqueous suspension; D = dust; DF = dry flowable; EC = emulsifiable concentrate; FL = flowable; G = granular; L = water soluble liquid; ME = microencapsulated; P = pelleted; SC = suspension concentrate; SM = smoke; SP = soluble powder; V = vapor; WDG = water-dispersible granular; WG = wettable granules; P = wettable powder; WSP = water soluble packets; WSG = water soluble granular

APPLICATION METHOD:

A = aerosol (includes total release and directed); **DR** = drench; **F** = fumigant; **G** = granular; **HV** = high-volume spray; **LV** = low-volume spray; **SM** = smoke; **SSP** = spray surface of potting mix; **V** = vapor.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Adept (diflubenzuron)		X	X				X		IGR	12	>40,000	HV,DR	WP	Active primarily on immature stages. Long residual activity. Can be applied as a spray or drench.
Akari (fenpyroximate)				X					PP	12	7,193 and 6,789	HV	SC	Primarily active on the larval stage. Provides up to 21 days of residual activity. Does not have translaminar properties.
Aria (flonicamid)	X		X					X	OR	12	>2,000	HV,LV	WDG	Selective feeding blocker. Prevents insects from feeding. Systemic insecticide with translaminar activity.
Attain (bifenthrin)	X	X	X	X		X	X		PY	12	>1,300	A	A	Thorough coverage is necessary to contact insect and mite pests. Treat late in day. Vent before entry. Also labeled for broad mites.
Avid (abamectin)	X		X	X	X				ML	12	4,200	HV	EC	Do not apply to ferns or Shasta daisy. Insecticide/miticide derived from soil microorganisms. Has translaminar activity.
Azatin (azadirachtin)	X	X	X				X		BO	4	5,000	HV	EC	Slow-acting. Apply as soil drench for control of fungus gnat larvae. Repeat applications may be needed.
BotaniGard *(Beauveria bassiana)*	X		X		X				MI	4	---	HV	L,WP	Need to apply before insect populations build up. Requires relative humidity >65%.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests (Cont)

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Celero (clothianidin)	X		X					X	NN	12	3,900 male rat 4,700 female rat	HV	WSG	Systemic insecticide with translaminar properties. Extended residual activity. Apply as spray or drench.
Citation (cyromazine)		X							IGR	4	3,300	SSP,DR	WP	Also labeled for dipterous leafminer and shorefly larvae.
Conserve (spinosad)					X		X		MI + SP	4	>5000	HV	SC	Provides rapid knockdown of high thrips populations. Rotate with other insecticides with different modes of action to avoid resistance. Also labeled for control of leafminers.
Decathlon (cyfluthrin)	X	X	X		X	X	X	X	PY	12	1,793 and 3,084	HV,LV	WSP	Works by contact activity only. May be harmful to natural enemies.
Dibrom 8 (naled)	X		X	X		X	X		OP	24	235	HV	EC	Apply to steam pipes; however, may corrode pipes after continued use. Avoid applications to wandering jew, poinsetta, Dutchman's pipe and chrysanthemums.
Dipel Pro DF (*Bacillus thuringiensis subsp. kurstaki)*							X		MI	4	>15,000	HV	AS	Target insect must eat this material to be killed. Feeding stops immediately, with death in 2 to 3 days. Thorough coverage of all plant parts is essential. Compatible with most natural enemies.
Distance (pyriproxyfen)		X	X			X			IGR	12	>5,000	DR,SSP	L	Has translaminar activity. Do not apply to poinsettia after bract development.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests (Cont)

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Duraguard (chlorpyrifos)	X	X			X	X	X		OP	24	135	HV	ME	Micro-encapsulated formulation. May be applied as a spray or drench.
Duraplex (chlorpyrifos + cyfluthrin)	X	X	X		X		X		OP+PY	24	630	A	A	Controls fungus gnat adults. Is most effective when plants are small.
Endeavor (pymetrozine)	X		X						PDZ	12	>5,000	HV	WG	Selective-feeding blocker. Prevents insects from feeding. Systemic insecticide with translaminar activity.
Enstar II (kinoprene)	X	X	X		X	X		X	IGR	4	4,900-5,000	HV	EC	Slow-acting. Minimally active on immature stages of certain insects.
Flagship (thiamethoxam)	X		X			X		X	NN	12	>5,000	HV,LV	WG	Systemic insecticide with translaminar properties. Extended residual activity. Only effective on soft scales, not armored scale.
Floramite (bifenazate)				X					CARB	4	>5,000	HV	WSP	Only active on spider mites. Provides up to 4 weeks of residual activity. Minimal impact on most predatory mites.
Gnatrol *(B. thuringiensis subsp. israelensis)*		X							MI	4	>15,000	DR	AS	Larvae must ingest material to be killed. Feeding stops immediately, with death occurring in 3 to 5 days. Works best on the early larval instars. Compatible with most natural enemies.
Hexygon (hexythiazox)				X					CBOX	12	>5,000	HV	WP	Provides up to 30 days of residual activity. Only kills the egg and larval stages with no activity on adult spider mites. Use only once per crop cycle.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests (Cont)

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Insecticidal Soap (potassium salts of fatty acids)	X		X	X		X		X	SO	4	10,000	HV	L	Avoid applying more than three times in succession or phytotoxicity may result. Short residual activity.
Judo (spiromesifen)			X	X					TA	12	>2,000	HV	SC	Has translaminar properties. Provides up to 28 days or residual activity. Minimally effective against adults. Compatible with most predatory mites.
Kelthane (dicofol)				X					CH	12	3,060	HV,LV	WP	In addition to twospotted spider mite, provides control of cyclamen mite.
Marathon (imidacloprid)	X		X		X	X		X	NN	12	4,143 and >4,870	G LV,DR	G WP, L	Systemic insecticide with translaminar properties. Extended residual activity. Effective on soft scale, not hard scale.
Mavrik Aquaflow (fluvalinate)	X		X	X	X	X	X		PY	12	2,020	HV	FL	Contact activity only. May cause respiratory allergic response.
Mesurol (methiocarb)	X				X				CA	24	20	HV	WP	Spray plants thoroughly to obtain adequate coverage. Also may be used for snail control. May leave residues on plants.
M-Pede (potassium salts of fatty acids)	X		X	X		X		X	SO	12	>10,000	HV	L	Avoid applying more than twice in succession or foliar discoloration may result. Short residual activity.
Naturalis *(B. bassiana)*	X		X		X				MI	4	---	HV	L	Need to apply before insect populations build up. Requires relative humidity >65%.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests (Cont)

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Nemasys, ScanMask, Entonem *(Steinernema feltiae)*		X							B	0	---	DR	WSP	Only active on fungus gnat larvae. Apply before fungus gnat populations build up. Two to three applications may be needed.
Ornazin (azadirachtin)	X	X	X				X		IGR	12	5,000	HVLV	L	Slow-acting. Has insect growth regulator, anti-feedant and repellent activity. Requires a spray solution pH between 4 and 8.
Orthene (acephate)	X		X		X	X	X	X	OP	12	688 and 1,127	HV	SP	Has systemic and translaminar activity. Phytotoxic to certain plants, including several chrysanthemum cultivars. Wait 2 weeks for symptoms to appear. Tank mix with Tame for control of thrips.
Orthene 1300 (acephate)	X	X	X		X	X	X		OP	24	>2,000 and <5,000	A	A	Has translaminar activity. Phytotoxic to certain plants, including several chrysanthemum cultivars. Wait 2 weeks for symptoms to appear. Treat as late in day as possible and vent before reentry.
Ovation (clofentezine)				X					TET	12	>5,200	HVLV	SC	Only active on spider mite eggs. Can only use once per crop cycle.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests (Cont)

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Pedestal (novaluron)			X		X		X		IGR	12	>5,000	HV	SC	Only active on nymphal stages. May sterilize adult female whiteflies.
Perm-Up (permethrin)	X	X	X			X	X		PY	24	2,000	HV,LV	EC	Contact activity only. Marginal leaf burn of salvia possible. May cause necrosis on open petals.
Precision (fenoxycarb)	X	X				X			IGR+ CA	12	10,000	WP	SSP, D,HV, LV	Only active on larvae or nymphs. Must be applied before insect pest populations build up.
Preclude (fenoxycarb)	X		X		X	X			IGR+ CA	12	10,000	A	A	Only active on larvae or nymphs. Treat as late in day as possible. Vent before reentry.
Pylon (chlorfenapyr)		X		X	X				PL	12	560	HVLV	L	Has translaminar activity. Provides extended residual activity. Avoid spraying plants in bloom. Also labeled for control of broad and cyclamen mite.
Pyreth-it (pyrethrin plus PBO)	X	X	X			X	X		BO	12	1,500	HV	EC	Works as a contact only. Short residual activity.
Pyrethrum TR (pyrethrin plus PBO)	X	X	X	X		X			BO	12	1,500	A	A	Short residual activity. Not recommended for use on open blooms or on bracts displaying color. Treat as late in day as possible. Vent before reentry.
Safari (dinotefuran)	X	X	X		X	X		X	NN	12	2,450	HV, LV, DR	SG	Systemic insecticide with translaminar properties. Extended residual activity. Very water-soluble. Applied as spray or drench. Labeled for leafminers and thrips, but only provide suppression of thrips.

Table 2. Pest Control Materials Labeled for Use in Greenhouses for Control of Insect and Mite Pests (Cont)

Pesticide	APHIDS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50}	APPLIC. METHOD	FORM	COMMENTS
Sanmite (pyridaben)			X	X					PD	12	3,020-3,350	HV	WP	Provides extended residual activity. Labeled for control of broad mites.
Scimitar (lambda-cyhalothrin)	X		X		X		X		PY	24	>5,000	HV	L	Contact activity only. May be harmful to natural enemies.
Shuttle (acequinocyl)				X					ND	12	>5,000	HV	SC	Only labeled for control of twospotted spider mite. No translaminar activity.
Talstar (bifenthrin)	X	X	X	X	X	X	X	X	PY	12	632	HV	WP,FL	Contact activity only, so thorough coverage of all plant parts is critical. Also labeled for control of broad mites.
Talus (buprofezin)			X			X		X	IGR	12	>5,000	HV,LV	WSP	Only active on immature stages (larvae or nymph). May sterilize adult female whiteflies.
Tame (fenpropathrin)	X		X	X		X	X	X	PY	24	1,089 for mallard duck	HV	EC	Contact activity only. Can be tank-mixed with Orthene for effective control of thrips
TetraSan (etoxazole)				X					IGR	12	2,600 and 4,500	HV,LV	WDG	Mite growth regulator. Active on eggs, larvae and nymphs. No activity on adults. Has translaminar propeties.
Triact (neem oil)	X		X	X					BO	4	>5,000	HV	EC	Active on eggs, larvae (nymphs) and adults. Apply early morning or late evening. Short residual activity.
TriCon (sodium tetraborohydrate decahydrate)	X		X	X				X	OR	12	>5,000	HV	L	Contact activity only. Repeat applications may be needed every 7 to 10 days. Not for use on roses. Only labeled for a limited number of plants.

Precautionary Statement

To protect people and the environment, pesticides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store or dispose of a pesticide. According to laws regulating pesticides, they must be used only as directed by the label. Persons who do not obey the law will be subject to penalties.

Disclaimer Statement

Pesticides recommended in this publication were registered for the prescribed uses when printed. Pesticides registrations are continuously reviewed. Should registration of a recommended pesticide be canceled, it would no longer be recommended by The University of Tennessee.

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