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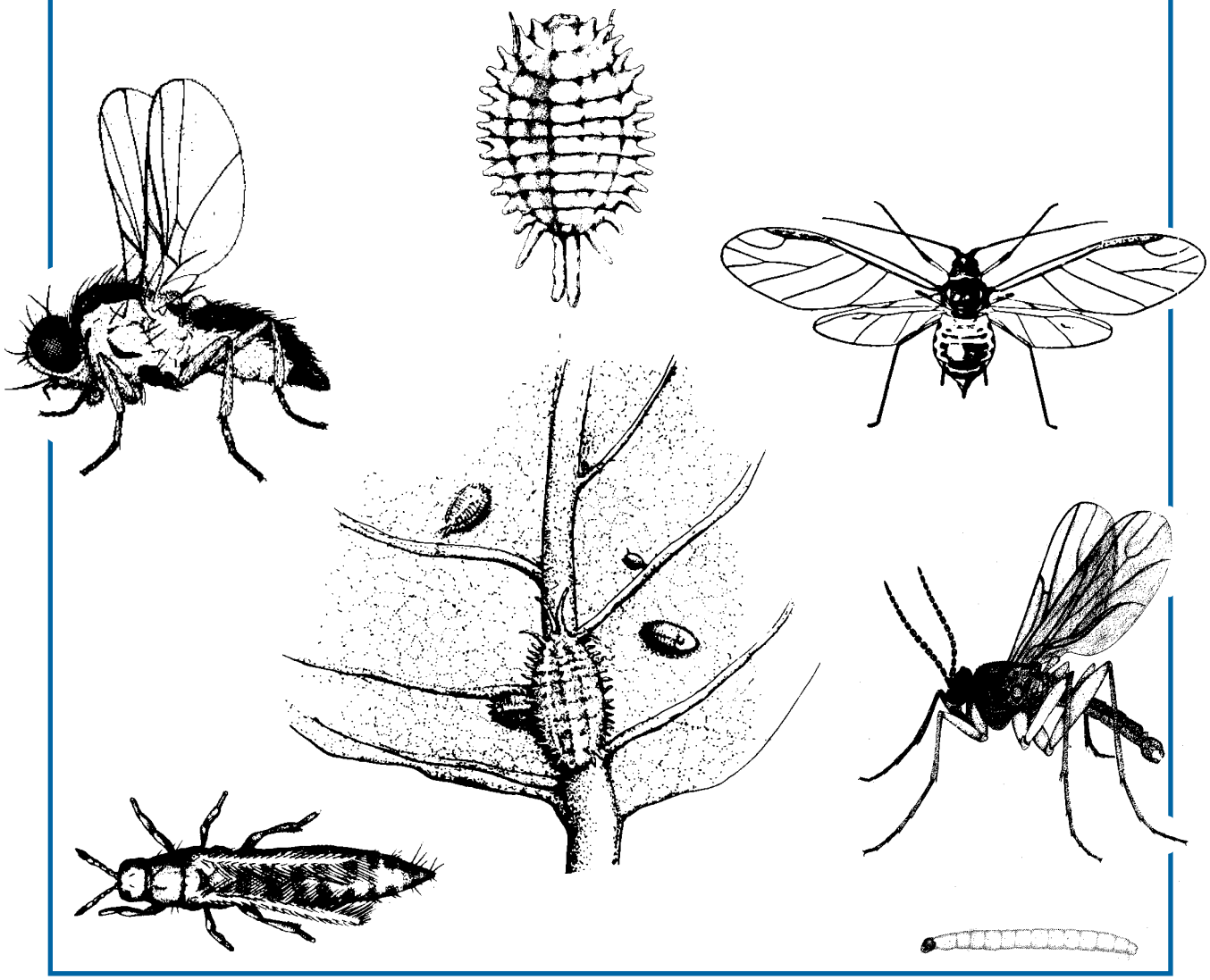
Insect and Mite Management In Greenhouses



The University of Tennessee
Institute of Agriculture

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Insect and Mite Management In Greenhouses

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Integrated Pest Management

Integrated Pest Management (IPM) is a term that refers to the use of various strategies to manage greenhouse insect and mite pests. The focus of IPM 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. IPM involves the use of cultural, physical, biological and/or pesticidal management strategies.

IPM programs typically require producers to be proactive rather than reactive. An effective IPM program begins by regularly scouting the greenhouse crop for insect and mite pests. An IPM 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 IPM programs indicated that they have reduced costs and increased worker safety. As a result, employees often respond to IPM programs with increased enthusiasm. The objective of this publication is to assist greenhouse producers in starting an IPM program.

Pest Management Basics

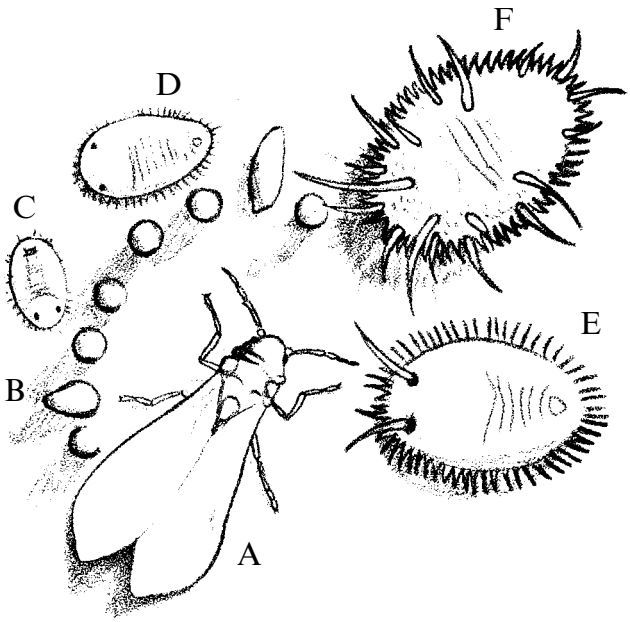
Identification

Identifying insect or mite pests and the number of each species in a greenhouse requires diligence, but this information is critical in order for greenhouse producers to avoid spraying an inappropriate pest control material such as an insecticide or miticide. When greenhouse producers know exactly what pests are present and the plants they are present on, then the appropriate insecticide or miticide can be applied. A 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

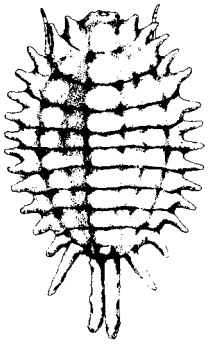
Clean greenhouses provide fewer opportunities for insect and mite pests to establish and thrive. Weeds in pots or underneath benches serve as reservoirs for many greenhouse insect and mite pests. Weeds underneath benches are not typically sprayed with insecticides and miticides. In addition, many weeds serve as a source for viruses transmitted by insects such as the western flower thrips (*Frankliniella occidentalis*). Avoid standing water and allow water to properly drain away from the greenhouse since excess water provides an ideal breeding 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.

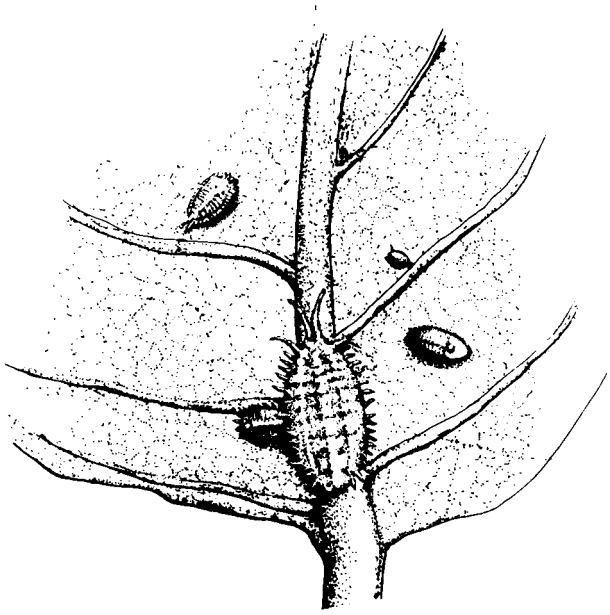
Illustrations of Common Insect and Mite Pests of Greenhouse Crops

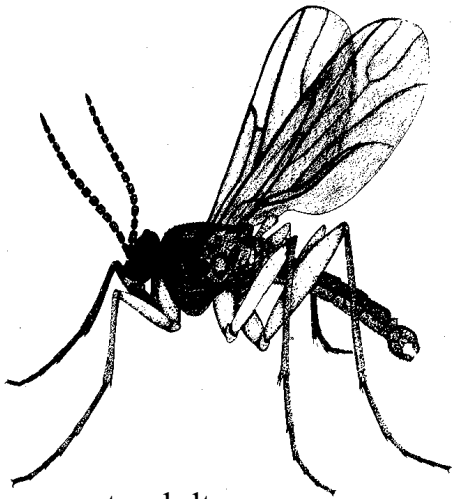


Greenhouse whitefly. A, Adult. B, Eggs. C - E, Nymphs. F, Pupa

Mealybug, adult female



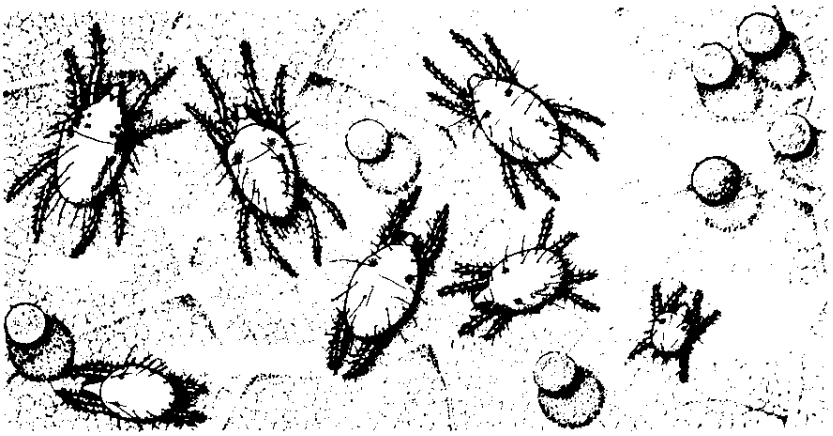




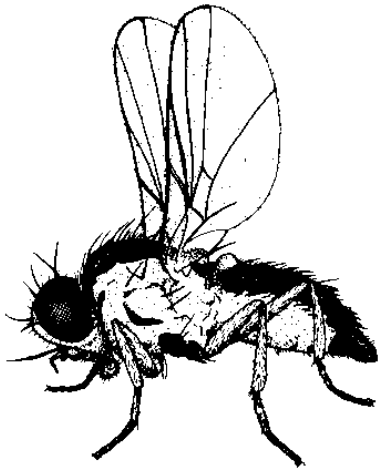
Fungus gnat, adult

Fungus gnat, larva

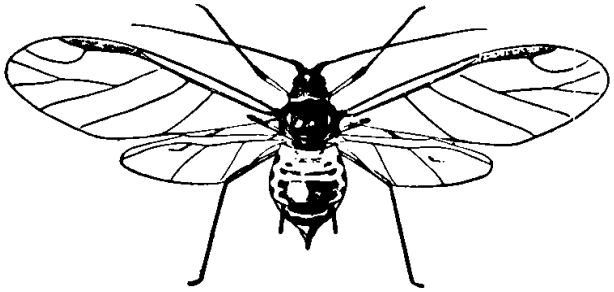
Drawings do not indicate the relative size of the pest; e.g., thrips are much smaller than aphids.



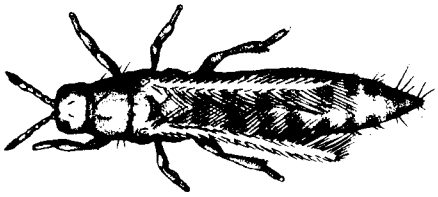
Spider mites



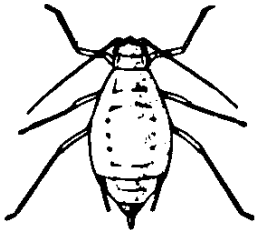
Leafminer, adult



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 titled "Excluding Insect Pests Using Micro-Screening."

Management

Once insect or mite pest populations are at or above an 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). The use of alternative pest control materials has increased. 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 and/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 a chewed hole. Pathogens, including beneficial fungi and entomopathogenic nematodes, work in a similar manner to parasitoids since they also consume the inside of target insect host. Biological control requires considerable management skill and education in order 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 IPM 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 in this publication.

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-by-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 square feet to 1,000 square feet of greenhouse space unless the situation requires the need for more, which will depend 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 monitor changes in populations of individual pest numbers and determine changes in insect and mite 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 are 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 underside 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 — A 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 IPM is that insect and/or mite pest 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, no discreet action thresholds for greenhouse insect and mite pests exist. 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 Microscreening

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-inch mesh screen whereas western flower thrips require a 0.0075-inch 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 No.
- 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, faculty 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 pest. 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 pests are too low to support continued reproduction of the given natural enemy.

A biological control program must be designed for each greenhouse operation based on a 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 insecticide and mitcides 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 in order to prevent insect and mite pest populations from reaching damaging levels. Identification and early detection of insect and/or mite pests is important to determine the type of natural enemy or enemies needed and when releases should be implemented in order to maximize effectiveness. Biological control is not a 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.

Table 1. Biological Control Agents of Insects and Mite Pests of Greenhouses

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.
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 shelf life. 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*	Parasitoid larvae complete development inside leafminer larvae and then adult 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, *Phytoseiulus persimilis*	Requires temperature <80 degrees F and humidity between 60% to 80% to be effective. Only feeds on twospotted spider mite.	Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm , humid conditions.
	Predatory mite, *Mesoseiulus longipes=Phytoseiulus longipes*	Tolerates warmer and drier conditions than *P. persimilis*. Used for control of twospotted spider mite.		

Pests	Predators	Comments	Parasites/Pathogens	Comments
Mites	Predatory mite, *Neoseiulus californicus=Ambylseius californicus*	Survives longer without prey than *P. persimilis*. Used for control of twopsotted spider mite, broad mite and cyclamen mite.		
	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, *Aphytis melinus*	Primarily attacks armored scale.
			Parasitoid, *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 attacks the first instar immature.	Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm, humid condiditons.
	Predatory Mite, *Neoseiulus cucumeris=Amblyseius cucumeris*	Only attacks first instar immature. Can survive on pollen in the absence of prey.		
	Predatory Mite, *Hypoaspis miles*	Feeds on thrips pupae in growing media. Short shelf life. May be incorporated into growing media.		
	Minute pirate bug, *Orius insidiosus*	Both adults and immature are predacious. Survive on pollen in the absence of prey. Also feed on aphids, spider mites and whiteflies.		
Whitefly	Ladybird beetle, *Delphastus catalinae*	Both adult and larva feed on eggs and nymphs. Requires high whitefly population for survival.	Parasitoid, *Encarsia formosa*	Prefers temperatures >72 F. Adults lay eggs in mid-instar whitefly nymphs and feed on early-instar nymphs. Most effective against greenhouse whitefly.
			Parasitoid, *Eretmocerus eremicus*	Primarily used against sweet potato whitefly B-biotype (formerly silverleaf whitefly).
			Entomopathogenic fungus, *Beauvaria bassiana*	Requires warm, humid conditions.

Alternative Pest Control Materials

Alternative pest control materials, in this case insecticides and miticides, are those that, in general have activity on specific target insect or mite pests while being less harmful to natural enemies. Proper timing of applications is important in order 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 thuringiens*is (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 parasitoids, 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 seeds. It acts as an insect growth regulator, insect feeding deterrent, repellent, oviposition inhibitor, sterilant, and/or direct toxin. The other material derived is the clarified hydrophobic extract of neem oil, which suffocates and desiccates insects and mite pests. Neem oil has contact activity only so thorough coverage of all plant parts is important.

Horticultural oils:

These oils 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 soaps 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 reached, then a pest 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).
- Mode of action.
- Application method.
- Human toxicity.
- Potential phytotoxicity.
- Potential impact on nontarget 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. As such 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 mean another application is warranted in order 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, according to label directions. It is important to consider the following prior to making an insecticide or miticide application:

1. Read the pest control material 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 recommended labeled rate.
5. Flowers and bracts are generally more sensitive than leaves; 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 resulting in phytotoxicity.
7. Maintain records of observed phytotoxic symptoms for 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 Pest

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, SP = soluble powder, V = vapor, WDG = water-dispersible granular, WG = wettable granule. WP = wettable powder. WSP = water-soluble packet. 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, SSP = spray surface of potting mix, ULV = ultra-low volume, V = vapor.

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

PESTICIDE	APHIDS	LEAFMINERS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50} (mg/kg)	APPLIC. METHOD	FORM	COMMENTS
Adept (diflubenzuron)		X	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. For lepidopterous leafminers not dipterous leafminers.
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	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	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, DR, LV, ULV	EC	Slow acting. Apply as soil drench for control of fungus gnat larvae. Repeat applications may be needed.
Azatrol (azadirachtin)	X		X	X		X	X	X	X	BO	4	>5,000	HV, LV	EC	Insect growth regulator so is only active on the immature stages of most insect pests. Repeat application after 7 to 10 days. May be tank-mixed with other pest control materials.
BotaniGard (*Beauveria bassiana*)	X			X		X				MI	4	---	HV, LV	L,WP	Need to apply before insect populations build up. Requires relative humidity >65%. Do not use thermal pulse fogger for low-volume applications.
Citation (cyromazine)		X	X							IGR	4	3,300	SSP, DR, LV	WP	Labeled for dipterous leafminer and also shorefly larvae.

PESTICIDE	APHIDS	LEAFMINERS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50} (mg/kg)	APPLIC. METHOD	FORM	COMMENTS
Conserve (spinosad)		X	X			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	Avoid applications to wandering jew, poinsettia, Dutchmans Pipe, and chrysanthemums.
Dipel Pro DF (*Bacillus thuringiensis* subsp. *kurstaki*)								X		MI	4	>15,000	HV	AS	Target insect must eat this material in order 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.
Discus N/G (imidacloprid + cyfluthrin)	X	X	X	X		X	X	X	X	NN+PY	12	>5,000	DR,HV,LV	L	Fungus gnat larvae in the soil will be controlled by drench or incorporation. Thrips suppression on foliage only. Effective on soft scale while suppression only on armored scale. Target scale crawlers if using a foliar application. Caterpillar control on foliage only.
Distance (pyriproxyfen)			X	X			X			IGR	12	>5,000	DR,SSP, LV	L	Has translaminar activity. Do not apply to poinsettia after bract development.
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.

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Enstar II/AQ (kinoprene)	X		X	X		X	X		X	IGR	4	4,900-5,000	HV,LV	EC	Slow acting. Most 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.
Hachi-Hachi (tolfenpyrad)	X			X		X	X			CBOX	12	83 - 120	HV, LV	EC	Contact activity only. Does not have translaminar properties.
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.
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.
Kontos (spirotetramat)	X			X	X				X	TA	24	>2,000	HV, DR	SC	Has systemic activity against mites when used preventatively.
Magus (fenazaquin)				X	X					QUIN	12	434	HV, LV	SC	Contact activity only. Does not have translaminar properties.

PESTICIDE	APHIDS	LEAFMINERS	FUNGUS GNATS	WHITEFLIES	MITES	THRIPS	SCALE	CATERPILLARS	MEALYBUGS	CLASS	REI (hr)	ORAL LD_{50} (mg/kg)	APPLIC. METHOD	FORM	COMMENTS
Marathon (imidacloprid)	X	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 armored 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.
Molt-X (azadirachtin)	X		X	X		X	X	X	X	BO	4	>5,000	HV,LV	EC	Insect growth regulator. Is only active on the immature stages of most insect pests. Repeat applications after 7 to 10 days. May be tank-mixed with other pest control materials.
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.
Nemasys, ScanMask, Entonem, NemaShield (*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.
NoFly WP (Paecilomyces fumosoroseus Strain FE 9901, blastospores)	X			X		X			X	MI	4	>5,000	HV	WP	

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Ornazin (azadirachtin)	X		X	X				X		IGR	12	5,000	HV, LV	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	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	X	X	OP	24	>2,000	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	HV, LV, ULV	SC	Only active on spider mite eggs. Can only use once per crop cycle. Most effective when applied at the first sign of mite activity and egg laying. At that time, the susceptible female mite, egg and first stage mite largely or totally make up the population.
Overture (pyridalyl)						X		X		Unclass-ified	12	>5,000	HV, LV	WP	Takes longer (7 to 10 days) to kill thrips than other pest control materials.
Pedestal (novaluron)		X		X		X		X		IGR	12	>5,000	HV	SC	Only active on nymphal stages. May sterilize adult female whiteflies. Suppression of leafminers only.
Perm-Up (permethrin)	X	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. Primarily for control of leafminer adults.

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Precision (fenoxycarb)	X	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. For lepidopterous leafminers not dipterous leafminers.
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.
Preferal Microbial Insecticide *(Isaria fumosorosea* Apopka Strain 97 [ATCC 20874] [formerly *Paecilonyces fumosoroseus])*	X	X		X	X	X			X	MI	4	No acute toxicity, infectivity or pathogen-icity	HV, LV	WP	
ProMite (fenbutatin-oxide)					X					OT	48	2,510	HV	WSP	Kills spider mites in 7 to 10 days. Provides up to 4 weeks of residual activity. Only effective on larvae, nymphs and adults.
Purespray Green (paraffinic oil)	X		X	X	X	X	X		X	OR	4	>5,000	HV	EC	Contact activity only, so thorough coverage of all plant parts are required. Active on most life stages of insect and mite pests. May cause foliar injury if sprayed under humid conditions (>80%).
Pylon (chlorfenapyr)			X		X	X				PL	12	560	HV, LV	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.

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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		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 provides suppression of thrips.
Sanmite (pyridaben)				X	X					PD	12	3,020-3,350	HV	WP	Provides extended residual activity. Labeled for control of broad mite.
Scimitar (lambda-cyhalothrin)	X	X		X		X		X		PY	24	>5,000	HV	L	Contact activity only. May be harmful to natural enemies. Primarily for control of leafminer adults.
Shuttle O (acequinocyl)					X					ND	12	>5,000	HV	SC	Using Shuttle O in successive miticide applications is not recommended. No translaminar activity.
Sirocco (abamectin and bifenazate)	X			X	X	X				ML and CARB	12	>310	HV	SC	Contains two miticides with different modes of action.
SuffOil-X (petroleum oil)	X		X	X	X	X	X		X	OR	4	>5,000	HV	EC	Contact activity only so thorough coverage of all plant parts is required. Active on most life stages of insect and mite pests. Do not spray when humidity is >80%.
Talstar (bifenthrin)	X	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 mite. Primarily for control of leafminer adults.

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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	66	HV	EC	Contact activity only. Thorough coverage of all plant parts is essential.
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 properties.
Triact 70 (neem oil)	X			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. Do not apply to known sensitive plant species, such as impatiens flowers, fuscia flowers, hibiscus flowers, some rose flowers, ornamental olive trees, or some carnation varieties without prior testing. Not for use on roses. Only labeled for a limited number of plants.
TriStar 30SG (acetamiprid)	X	X		X		X	X		X	NN	12	1,064	HV	WSP	Systemic insecticide with translaminar properties. Extended residual activity. Apply as spray. Not labeled for drench applications.
Ultra-Pure Oil (petroleum oil)	X		X	X	X	X	X		X	OR	4	>5,000	HV	EC	Contact activity only so thorough coverage of all plant parts is required. Active on most life stages of insect and mite pests. Do not spray when humidity is >80%.

Precautionary Statement

In order 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.

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This publication contains pesticide recommendations that are subject to change at any time. The recommendations in this publication are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. The label always takes precedence over the recommendations found in this publication.

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