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IPM and Biocontrol in GH/nursery

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Switching to BC and biorational insecticides in Canada and Michigan

Canada

In 2016, 69% of greenhouses use biocontrol for insects and 45% use biocontrol for pathogens.

In 2001, 26% of growers used biocontrol for pest management (Buitenhuis 2017).

Michigan 50% switch to BC. Minnesota, How many growers use biocontrol??

What is IPM?

What is greenhouse IPM?

* A system utilizing multiple methods
* A decision making process
* A risk reduction system
* Information intensive
* Biologically based
* Cost effective
* Site specific
* Multiple tactics:
    legal, cultural, physical,
    genetic, biological, chemical

Olympic Horticultural Products Literature

http://www.ohp.com/Literature/

- **Chemical Class Chart**
- **OHP Product Guide**
- **OHP Vegetable & Herbs Solutions Guide**
- **OHP Disease Solutions Guide**
- **Downy Mildew Solution**
- **OHP PGR Solutions Guide**
- **Best Rate Recommendations for Impatiens**
- **OHP Insect Solutions Guide**
- **Thrips Cocktail**
- **Spider Mite control**
- **OHP Landscape Solutions Guide**

What is greenhouse IPM?

- **When developing an IPM program, it is important to know what pests you have Learn the major characteristics for pest and damage identification and how to monitor for the pests.**

- **Determine threshold levels for each pest. At low densities, biological control and biorational pesticides may be used. High pest densities may call for conventional pesticides, but these should be avoided whenever possible to conserve beneficials.**

What is greenhouse IPM?

Preventative thinking

Assume cuttings will arrive with thrips

- **Misting weekly botanigard sprays (3x)**
- **Nematodes weekly**
- **Mites weekly, bridges help mites move around**
- **Banker plants, for thrips use ornamental peppers for pollen feeding, for *Orius* use *Gerbera***

Insecticides

Chemical class/mode of activity

The mode of action is the mechanism that kills the insects.

1. Organophosphates and Carbamates

Inhibit the enzyme cholinesterase. This prevents the termination of nerve impulse transmission.

2. Pyrethroids and Chlorinated Hydrocarbons

Destabilize nerve cell membranes.

3. Neonicotinyls

Work on central nervous system, cause over-stimulation and blockage of the postsynaptic nicotine acetylcholine receptors.

4. Novel insecticides

Mode of action specific.

IRAC numbers

- The Insecticide Resistance Action Committee (www.irac-online.org) has assigned IRAC numbers for each chemical class, and these numbers are on labels to make it easier to rotate classes of insecticides and prevent resistance
- Neonicotinoid class, 4A

Carbamates, class 1A

Organophosphates, class 1B are in the same group as the mode of action (cholinesterase inhibition) is the same.

Systemic insecticides

Organophosphates

dimethoate (Cygon)

Neonicotinoids

imidacloprid (Marathon, Merit), clothianidin, thiamethoxam, Dinotefuran, acetamiprid

Novel mode of action

pymetrozine (Endeavor)

Translaminar, or local, systemic activity

Microbial- abamectin (Avid)
IGR- pyriproxyfen (Distance)
PR- chlorfenapyr (Pylon)
SP- spinosad (Conserve)
OP- acephate (Orthene)

Recognizing using insecticides that conserve beneficial insects/biocontrol agents

Toxicity to Pollinators of Insecticides Bulletin, Vera Krischik Dept Entomology, UMinnesota
Systemic neonicotinoid insecticides (imidacloprid, clothianidin, dinotefuran, and thiamethoxam)+ others in pink, not allowed on bee friendly labels.

Contact insecticides should not be translocated to pollen and nectar and should not be present in new flowers. Contact insecticides are toxic to bees and do not spray directly on foraging bees or flowers. In greenhouse contact insecticides residue should be minimal after 5 weeks.

Chemical class	Examples of common names	Bee Toxicity			
		No	Low	Mod	High
Carbamates	carbaryl, methomyl				All x
Neonicotinoid	imidacloprid thiamethoxam clothianidin dinotefuran imid+bifenthrin				All x
	Less toxic: acetamiprid (A) thiacloprid (T)		All x		

Chemical class	Examples of common names	Bee Toxicity			
		Non	Low	Mod	High
Organophosphates	acephate, chlorpyrifos, dimethoate, malathion, phosmet				All x
Pyrethroids	bifenthrin, cyfluthrin, fenpropathrin, lambda-cyhalothrin, permethrin				All x
Botanical	pyrethrins azadirachtin			x	x

Chemical class	Examples of common names	Bee Toxicity			
		Non	Low	Mod	High
Insect growth regulators	diflubenzuron tebufenozide	All x			
	azadirachtin buprofezin pyriproxyfen	 x x		x	
	novaluron			x	
	cyromazine			x	
Juvenile hormone	s-kinoprene		x		
Diamides	chlorantraniliprole cyantraniliprole	x			 x
Macrocyclic lactones	abamectin/ avermectin				x

Chemical class	Examples of common names	Bee Toxicity			
		Non	Low	Mod	High
Miticides	acequinocyl, extoxazole, fenpyroximate, fenbutatin-oxide	All x			
	clofentezine, hexythiazox	x,x			
	bifenazate		x		
	pyridaben				x
	chlorfenapyr			x	
	spiromesiifen	x			
Spinosyns	spinosad, less toxic when dry		x		
Tetronic acids	spirotetramat			x	
GABA-channel	fipronil				x

Chemical class	Examples of common names	Bee Toxicity			
		Non	Low	Mod	High
Pyridine carboxamide	flonicamid	x			
Pyridine azomethines	pymetrozine		x		
Avermectin	emamectin benzoate				x
Other insecticides	*Bacillus thuringiensis,*	x			
	potassium salts fatty acids soaps	x			
	horticultural mineral oils, neem oil	x			

What is biocontrol?

Recognizing beneficial insects/biocontrol agents

When should biological control be used?

Biological control is most effective when agents are release during low pest densities.

When using biological control agents in the greenhouse, it is important to avoid broad-spectrum pesticides; these may be detrimental to biological control agents. Carefully choose biorational insecticides to conserve biologyical control agents in the greenhouse.

What is greenhouse biological control?

- **Classic biological control**
- **Conservation biocontrol**
- **Augmentative biological control involves periodic releases of biological control agents. Used in greenhouses.**

Biological Control Agents by Pest

Aphids	***Aphidius matricariae*** **parasitoid**	***Aphidoletes aphidomyza*** **midge larva**	***Hippodamia convergens*** **lady beetle**	***Orius* sp. minute pirate bug**	***Chrysoperla* sp. lacewing larva**	**Predatory thrips**
Mealybugs	***Anagyrus pseudococci*** **parasitoid**	***Leptomastix dactylopii*** **parasitoid**	***Cryptolaemus montrouzieri*** **lady beetle**	***Chrysoperla* sp. lacewing larva**		
Soft Scales	***Metaphycus helvolus*** **parasitoid**	***Metaphycus alberti*** **parasitoid**	***Rhyzobius lophanthae*** **lady beetle**	***Chilocorus orbus*** **lady beetle**	***Chilocorus cacti*** **lady beetle**	**Predatory thrips**
Armored Scales	***Aphytis melinus*** **parasitoid**	***Chilocorus kuwanae*** **lady beetle**	***Chilocorus stigma*** **lady beetle**			
Whiteflies	***Encarsia formosa*** **parasitoid**	***Eretmocerus californicus*** **parasitoid**	***Delphastus pusilus*** **lady beetle**	***Chrysoperla* sp. lacewing larva**	**Predatory thrips**	

Biological Control Agents by Pest

Thrips	*Thripobius semiluteus* parasitoid	*Amblyseius cucumeris* predatory mite	*Hypoaspis miles* predatory mite	*Orius* sp. minute pirate bug	*Chrysoperla* sp. lacewing larva	Predatory thrips
Fungus gnats	parasitic nematodes	*Hypoaspis miles* predatory mite				
Spider mites	*Phytoseiulus persimilis* predatory mite	*Neoseiulus californicus* predatory mite	*Stethorus punctum* lady beetle	*Orius* sp. minute pirate bug	*Chrysoperla* sp. lacewing larva	Predatory thrips

Managing aphids in greenhouse, nursery, garden centers, landscapes

Aphid Parasitoid (*Aphidius matricariae*)

Order Hymenoptera
Family Braconidae
This wasp preys primarily upon green peach aphid. It is not a good parasite of cotton aphid or potato aphid.

***Aphidius* sp.**

Aphid Parasitoid (*Aphidius matricariae*)

Aphidius **is shipped as parasitized aphid mummies (see left).**

Up to 300 aphids are attacked by each female. ***Aphidius*** **takes 10 to 14 days to develop from egg to adult.**

There are usually twice as many females as males.

Aphid Predator (*Aphidoletes aphidomyza*)

Order Diptera
Family Cecidomyiidae
The larval stage of this midge preys on aphids.

***Aphidoletes* are shipped as pupae.**
Release in moist shaded areas.
Adults hatch in 1 to 12 days.
Females lay up to 250 eggs in 10 days.

Larva attacking aphid

Convergent Lady Beetle (*Hippodamia convergens*)

Order Coleoptera
Family Coccinellidae

This is a generalist predator that feeds on soft-bodied insects.

Lady beetles are shipped as adults. Each adult consumes about 5,000 aphids. Within 8 to 10 days of release each female lays 10 to 50 eggs daily on the underside of leaves. Eggs are usually deposited near prey such as aphids.

Convergent Lady Beetle Release Guidelines

- When beetles arrive put the sack in a cool place until late evening or early morning.
- Do not release the beetles during the heat of the day or while the sun is shining.
- Lady beetles should be released when the plants are partially covered with aphids.
- Sprinkle or irrigate the area before releasing beetles.
- Release a few at a time; twice a week.
- For heavy infestation, release all of the beetles at once.
- Retie the bag and place in the refrigerator until all lady beetles are used.

Minute Pirate Bug (*Orius* spp.)

Order Hemiptera
Family Anthocoridae

These predators are effective against mites, thrips, aphids, and small caterpillars.

***Orius insidiosus* adult**

They are shipped as adults. Release by opening the container or placing them on individual plants with a small paintbrush. Only release if there is a food source (pests or pollen).

Green Lacewing (*Chrysoperla* spp.)

Clockwise from top left: eggs, larva, cocoons, adult

Green Lacewing (*Chrysoperla* spp.)

Order Neuroptera
Family Chrysopidae

Larvae are generalists that consume soft-bodied insects and mites. Green lacewing are shipped as eggs, larvae or adults.

Managing mealybugs in greenhouse, nursery, garden centers, landscapes

Mealybug Parasitoid (*Anagyrus pseudococci*)

Adult female

Mealybug Parasitoid (*Leptomastix dactylopii*)

Order Hymenoptera
Family Encyrtidae

This wasp attacks third instar citrus mealybug.

Female on host

Mealybug Destroyer (*Cryptolaemus montrouzieri*)

Cryptolaemus **are shipped as adults and are most effective in high infestations. Optimal conditions are 61 to 91 degrees F, relative humidity between 70 to 80%.**

Adults feeding on mealybug egg mass

Managing soft scales in greenhouse, nursery, garden centers, landscapes

Soft Scales

Order Hemiptera
Family Coccidae

Soft scales can be found on many plants. Waxy covers make plants unsightly. Feeding causes wilting and honeydew, on which sooty mold grows.

Brown soft scale (top) and hemispherical scale

Scale Parasitoid (*Metaphycus* spp.)

***M. alberti* attacks brown soft scale and a related species, *M. helvolus*, also attacks soft scales. Indoors, in locations where it has become established, it may be found in the vicinity of plants attacked by its host.**

***M. alberti* stinging brown soft scale (*Coccus hesperidium*)**

Purple Scale Predator (*Rhyzobius lophanthae*)

Order Coleoptera
Family Coccinellidae

Purple Scale Predator (*Rhyzobius lophanthae*)

Also known as *Rhyzobius lophanthae*, this predator thrives in temperatures of 59 to 77 degrees F and a relative humidity of 20 to 90%.

The primary prey of both the larvae and adults are soft scales, including black, brown, and red, although they may eat mealybugs and smaller insects.

Release rates: 3 to 5 beetles/sq. yd. for light infestations or 4 to 6/sq. yd for heavy infestations.

Twice-Stabbed Lady Beetle (*Chilocorus* spp.)

Order Coleoptera
Family Coccinellidae

Adults and larvae feed on scales. *Chilocorus* species are known for armored scale control, but a few species, such as *C. orbus* and *C. cacti*, feed on soft scales.

***Chilocorus orbus* adult**

Managing armored scales in greenhouse, nursery, garden centers, landscapes

Armored Scales

Order Hemiptera
Family Diaspididae

Armored scales attack a variety of plants. Waxy covers make plants unsightly. Feeding causes discoloration and leaf death.

California red scale (*Aonidiella aurantii*)

Red Scale Parasitoid (*Aphytis melinus*)

Order Hymenoptera
Family Aphelinidae

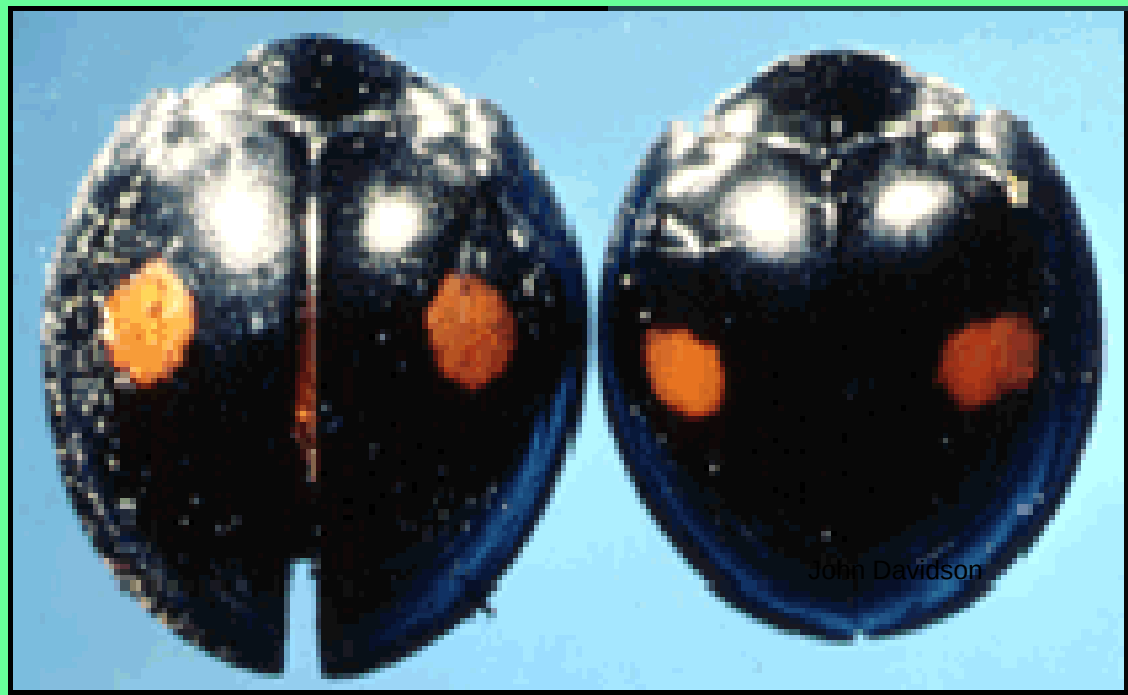
This wasp attacks California red scale, citrus red scale, oleander scale, San Jose scale, ivy scale, and citrus yellow scale.

Female ovipositing into *Aonidiella aurantii*

Twice-Stabbed Lady Beetle (*Chilocorus* spp.)

Order Coleoptera
Family Coccinellidae

Adults and larvae of *Chilocorus stigma* and *C. kuwanae* feed on armored scales.



C. stigma* (left) and *C. kuwanae

Managing whiteflies in greenhouse, nursery, garden centers, landscapes

Whiteflies

Order Hemiptera
Family Aleyrodidae

Whiteflies feed on many plants. Feeding causes discoloration and honeydew, on which sooty mold grows. They may also transmit viruses.

Silverleaf whitefly
(*Bemisia argentifolii*)

Whitefly Parasitoid (*Encarsia formosa*)

Order Hymenoptera
Family Aphelinidae

***Encarsia formosa* is used worldwide for control of whiteflies in the greenhouse. Hosts include greenhouse, sweet potato, and silverleaf whiteflies. Commercial use began in Europe in the 1920's, but by 1945 interest waned due to development of pesticides. After 1970, use was reinitiated and has expanded from 100 to 4,800 hectares of greenhouse crops in 1993 (van Lenteren and Woets, 1988; Hoddle et al., 1998). Most usage occurs in Europe and Russia.**

Whitefly Parasitoid (*Encarsia formosa*)

***Encarsia formosa* was originally described from specimens reared from an unidentified aleyrodid on geranium (*Pelargonium* sp.) in 1924 in a greenhouse in Idaho (USA) (Gahan 1924). *E. formosa* has a cosmopolitan distribution and its native range is uncertain.**

Adults lay 100 to 200 eggs. Wasps develop inside the whitefly nymphs and emerge after 20 days.

Whitefly Parasitoid (*Encarsia formosa*)

***Encarsia formosa* are shipped on strips (below right) that contain parasitized whitefly pupae and more than 1,000 *Encarsia*. Release at the first signs of whiteflies.**

Whitefly Parasitoid (*Encarsia formosa*)

Release rates: for greenhouse tomatoes and peppers, 1 *Encarsia*l4 plants weekly for 8 to 10 weeks; cucumbers, 1 *Encarsia*l2 plants weekly for 8 to 10 weeks; poinsettias, 2 *Encarsia*lplant weekly for 8 to 12 weeks.
For others crops, 10,000 *Encarsia*lacre

Release upon receipt.

Empty pupal cases and black parasitized pupae containing *Encarsia formosa*

Whitefly Parasitoid (*Eretmocerus californicus*)

Order Hymenoptera
Family Aphelinidae

These wasps control sweet potato, silverleaf, and greenhouse whiteflies.

Male

Female

Whitefly Predator (*Delphastus pusillus*)

Order Coleoptera
Family Coccinellidae

Whitefly Predator (*Delphastus pusillus*)

This beetle is effective against greenhouse, sweet potato, and tobacco whiteflies. Larvae and adults feed on all stages of whiteflies and eat spider mites when whiteflies are scarce.

***Delphastus* are shipped as adults and can eat hundreds of whitefly eggs and nymphs daily. Adult females live for 1 month and lay 3 to 4 eggs/day. Use with *Encarsia* and green lacewing.**

Managing fungus gnats in greenhouse, nursery, garden centers, landscapes

Darkwinged Fungus Gnats (*Lycoriella* spp. and *Bradysia* spp.)

Order Diptera
Family Sciaridae

Larvae of these small flies feed on roots and organic matter. They cause wilting and may transmit pathogens.

Larvae (top) and adult darkwinged fungus gnats

Parasitic Nematodes (*Steinernema feltiae*)

Phylum Nematoda
Family Steinernematidae

Nematodes prey on many kinds of insects. They enter their prey through body openings. Nematodes inject hosts with lethal bacteria and feed on the resultant "goo." The hosts die in 48 hours.

Nematodes reproduce and offspring feed on cadavers before emerging to find new hosts.

Managing mites in greenhouse, nursery, garden centers, landscapes

Spider Mites

Class Arachnida
Order Acari
Family Tetranychidae

These common pests attack many different plant species. Feeding causes stippling, yellowing, and leaf drop. In addition, spider mites web profusely on plants.

Two-spotted spider mite (*Tetranychus urticae*)

Spider Mite Predator (*Phytoseiulus persimilis*)

Class Arachnida
Order Acari
Family Phytoseiidae

This mite was accidentally introduced into Germany from Chili in 1958 and then shipped to other parts of the world. Individuals consume 5 to 10 adult spider mites or up to 20 eggs per day. It

Phytoseiulus persimilis **eating a two-spotted spider mite egg.**

Spider Mite Predator (*Neoseiulus californicus*)

Class Arachnida
Order Acari
Family Phytoseiidae

This mite attacks spider mites and tarsonemid mites. Individuals consume one adult or a few eggs per day and can survive longer under starvation conditions.

***N. californicus* prefer a minimum of 60% humidity and temperatures 60 to 85 degrees F.**

Spider Mite Predator
(*Amblyseius swirskii “mite”*)

Class Arachnida
Order Acari
Family Phytoseiidae

Thrips, whiteflies

Prefer a minimum of 60% humidity and temperatures 60 to 85 degrees F.

Spider Mite Destroyer (*Stethorus* spp.)

Order Coleoptera
Family Coccinellidae

Aduts and larvae of this lady beetle feed on spider mites. Adults are shipped. Works best in low pest densities.

Release rate: 200 to 500/acre

***Stethorus punctum* adult (top) and larva**

Spider Mite Destroyer (*Stethorus* spp.)

Above: left to right: spider mite and three life stages of *Stethorus*: larva, pupa, adult

Right: *Stethorus* eggs in mite colony

Managing thrips in greenhouse, nursery, garden centers, landscapes

Greenhouse thrips

Western flower thrips

IRAC numbers

- **The Insecticide Resistance Action Committee (www.irac-online.org) has assigned IRAC numbers for each chemical class, and these numbers are on labels to make it easier to rotate classes of insecticides and prevent resistance**
- **Neonicotinoid class, 4A**

Carbamates, class 1A

Organophosphates, class 1B are in the same group as the mode of action (cholinesterase inhibition) is the same.

IPM: Species of thrips

Thrips

Order Thysanoptera
Family Thripidae

These small insects feed on hundreds of hosts. They cause leaf drop, yellowing, stippling, streaking, and distortion of leaves. Some species transmit viruses.

Greenhouse thrips (above) and western flower thrips

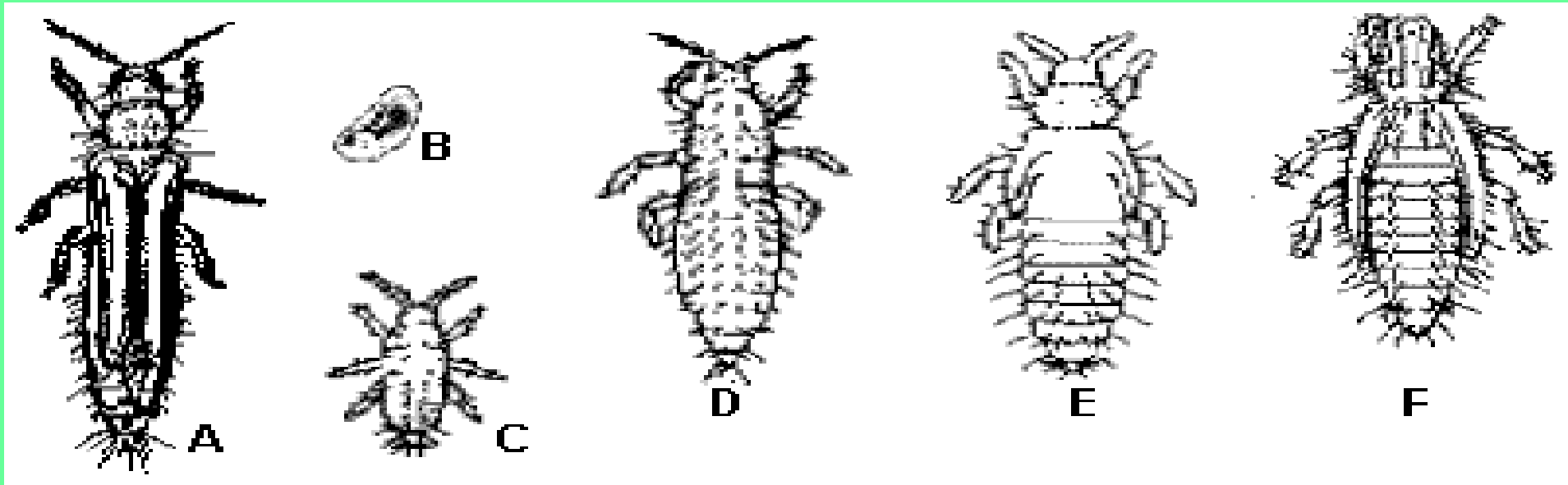
Types of thrips damage

IPM Program For Thrips

Order Thysanoptera, Family Thripidae

GENERAL DESCRIPTION OF THRIPS

- **Four featherlike wings, with fine hairs on the edges.**
- **Six life stages: egg, first instar, second instar, prepupa, pupa, and adult.**
- **Thrips insert eggs into plant tissue or in soil.**
- **The first two instars and adults feed by piercing +sucking**
- **Adult feeding is rasping damaging creating long lesions.**
- **Look for black fecal spots.**



IPM Program For Thrips

DESCRIPTION OF THE PESTS

Western flower thrips (WFT) (*Frankliniella occidentalis*)

- **WFT has three color forms: pale form, is white and yellow, intermediate form with a dark orange thorax and brown abdomen; and a dark form.**

- **WFT usually feed in enclosed tissues such as flowers, buds, or growing tips. Adults also feed on pollen and on spider mites. Eggs laid in plant leaves. Females will lay male eggs if unmated and female eggs are produced once mating has occurred. Development times to complete one generation of western flower thrips varies from 11 days (77° to 87°F) to 44 days (50° to 60°F).**

IPM Program For Thrips

DAMAGE

- **Western flower thrips primarily feeds on flowers but also sometimes on new vegetative growth, whereas greenhouse thrips feeds primarily on foliage. Direct feeding damage includes streaking, spotting, and tissue distortion.**

- **On orchids, western flower thrips feeding and egg laying will leave translucent ‘pimpling’ spots on petals and leaves.**

- **The stippling damage caused by thrips feeding on individual cells is often confused with mite stippling.**

- **Western flower thrips can vector tomato spotted wilt virus as well as many other viruses.**

IPM Program For Thrips

DESCRIPTION OF THE PESTS

- **Greenhouse thrips, *Heliothrips haemorrhoidalis,***

are tiny, black, insects with whitish to translucent wings folded back over their thorax and abdomen. Legs are also a whitish color. Nymphs are whitish to slightly yellowish in color and produce a globule of fecal fluid at the tip of their abdomen. These globules of fluid increase result in black specks on foliage.

Jack Kelly Clark
University of California

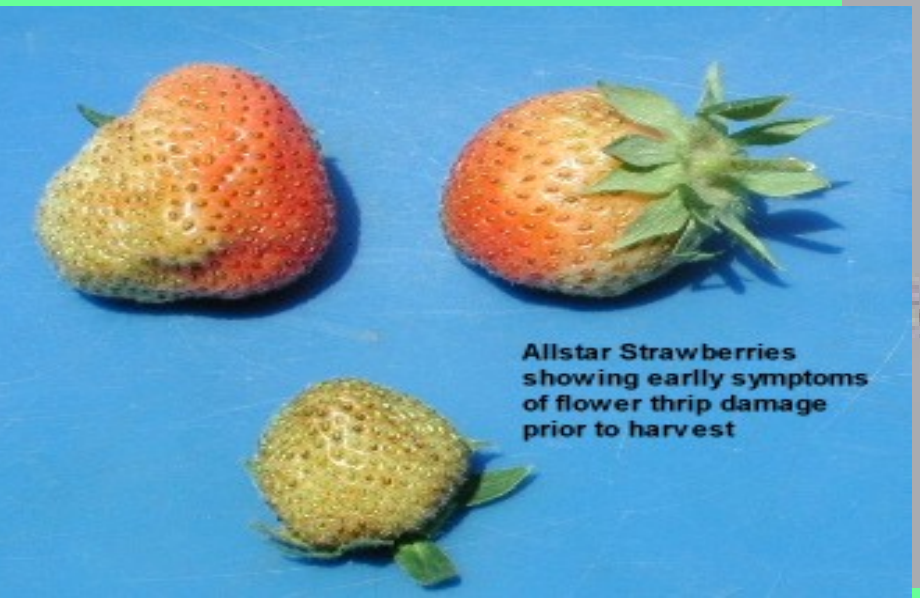
IPM Program For Thrips

Jack Kelly Clark
University of California

DESCRIPTION OF THE PESTS

The Eastern flower thrips (*Frankliniella tritici*),

- **Very common before western flower thrips**
- **Thrips feed on over many plant species.**
- **Feed on all plant parts.**



IPM Program For Thrips

Jack Kelly Clark
University of California

DESCRIPTION OF THE PESTS

- **The chilli thrips or yellow tea thrips, *Scirtothrips dorsalis*, is an extremely successful invasive species from Asia over the last twenty years.**

- **Chilli thrips feed on over 100 plant species.**

- **Feed on all plant parts.**

IPM: Insecticides

IPM Program For Thrips

MONITORING and WHEN TO TREAT

- **It is important to note that correct identification of pest thrips is essential in a monitoring program.**

- **Most insecticides must be applied at least two times, 5 to 7 days apart, for efficacy against western flower thrips.**

White feeding scars and black excrement from greenhouse thrips

Insecticides for thrips GH, nursery

Thrips control for adults+immatures

- **Neonicotinoid insecticides, such as Flagship, Safari and Tristar, have shown effectiveness against thrips.**

- **Mesurol was one of the more effective products for thrips control, but results have been more inconsistent in recent years. Mesurol is a restricted-use pesticide in all states.**

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Insecticides for thrips GH, nursery

Thrips control for immatures use with BC

IGRs, insect growth regulators for immatures

- IGRs **are generally used in combination with adulticides and after a good knockdown has been achieved with other products.**
- Pedestal (novaluron), IGR, **has long been a part of thrips-control programs, causing death at the point of molting.**
- Enstar, IGR, **is labeled for thrips.**
- Fulcrom, Distance (pyriproxifen), IGR, **is labeled for thrips.**

Insecticides for thrips GH, nursery

Thrips control in soil

- **Nematodes, *Steinernema feltiae* have been assisting growers to control the pupal stages of WFT. Applications to the media every two to three weeks. Provides fungus gnat control at the same time.**
- **Distance (pyriproxyfen) +Talsatr (bifenthrin) soil drenches. Microbial insecticides**
- **BotaniGard (*Beauveria bassiana*), Preferal (*Isaria*), Met52 (*Metarhyzium*), Grandevo (*Chromobacterium*)**

Insecticides for thrips GH, nursery

Thrips control for adults+immatures

- **Avid (abamectin)Tank mixed with a neem-azadirachtin-based insect growth regulator (IGR), such as Azatin O, AzaGuard or Molt-X and applied as a foliar application is effective when applied two times, seven days apart.**

Insecticides for thrips GH, nursery

Thrips control for adults+immatures

- Pylon (chlorfenapyr) **Foliar applications are typically made twice, seven days.**
- Conserve (spinosad)
- Aria **is a feeding blocker labeled for thrips suppression, not an knock-down**
- Scirocco (Floramaite, bifenazate + abamectin)

- Mainspring (cyantraniliprole)

- XXpire (sulfloxaflor + spinetoram)

Insecticides for thrips GH, nursery

Thrips control with slower activity

- **Overture (pyridaly) A slower-acting insecticide, taking up to 7 days to see significant reductions in adult thrips populations from a foliar application.**
- **Kontos (spirotetramat) Drench applications show very good results, though they're slow to take full effect (up to three weeks). Foliar spray shown variable results. Geraniums + *Dracaena* are damaged by Kontos.**
- **Aria is a feeding blocker labeled for thrips suppression, not an knock-down**

IPM: Biocontrol

IPM Program For Thrips

BIOLOGICAL CONTROL

Commercially available predators to help control western flower thrips are:

- **Minute pirate bug, *Orius* spp.**
- **Predatory mites, *Amblyseius swirskii* “*Swirskii mite*”, *Neoseilus cucumeris* and *Hypoaspis miles*. *Hypoaspis miles* are soil-inhabiting and feed on thrips pupae.**
- **Parasite of greenhouse thrips is *Thripobius semileteus* (right).**
- **In soil or foliage use fungus or nematodes**

Jack Kelly Clark
University of California

Thrips Parasitoid (*Thripobius semiluteus*)

Order Hymenoptera
Family Eulophidae

This parasitic wasps attacks greenhouse thrips.

Thripobius semiluteus **stalking immature thrips prey**

Thrips Predatory Mite (*Amblyseius cucumeris*)

Class Arachnida
Order Acari
Family Phytoseiidae

This mite feeds primarily on immature thrips, as the adults are too large for them to kill. Release when thrips populations are low.

Ideal conditions are 66 to 80 degrees F and a relative humidity of 65 to 72 percent.

***A. cucumeris* are shipped as adults in bran.**

Thrips Predatory Mite (*Amblyseius swirskii*)
"Swirskii mite"

Class Arachnida
Order Acari
Family Phytoseiidae

This mite feeds primarily on immature thrips and whiteflies. Release when thrips populations are low.

Ideal conditions are 72 to 80 degrees F and a relative humidity of 72 percent.

Predatory Mite (*Hypoaspis miles*)

Class Arachnida
Order Acari
Family Phytoseiidae

This mite attacks fungus gnats and thrips pupae. Females lay eggs in soil. Eggs hatch in 1 to 2 days. Each mite consumes 5 to 20 prey per day and algae or plant debris when prey is scarce. The entire life cycle is 7 to 11 days.

Release rates: 5,000 mites treats 500 to 1,000 plants; 10,000 to 25,000/per acre.

IPM: Cultural control

IPM Program For Thrips

CULTURAL CONTROL

- **Carefully inspect plants being brought in to start a new crop to ensure that they are free of thrips and other pests. A holding area where plants are kept for about 11 to 12 days is useful so that plants can be inspected for any infestations that may develop. Treat any infested plants if necessary.**

- **Blue sticky cards are most attractive to western flower thrips. However, yellow cards are easier to count and more commonly used for insect monitoring. Place yellow sticky cards vertically in the crop canopy, with the lower one-third of the trap in the leaves and the upper two-thirds above the leaves. As the crop grows, the traps will need to be raised. Three traps per cultivar is adequate.**

IPM Program For Thrips

CULTURAL CONTROL

- **Because western flower thrips and greenhouse thrips feed on a large variety of plant species, keep production areas free of weeds.**

- **Most commercially available screens have pore sizes slightly larger than the width of the western flower thrips thorax (145 microns), meaning that some winged adults can penetrate these openings. However, covering openings to the greenhouse with fine screens does exclude most thrips. Be sure that the ventilation system on an existing greenhouse can accommodate the reduced flow.**

IPM: Detecting virus

IPM Program For Thrips

MONITORING FOR VIRUSES

It is also important to monitor for viruses that western flower thrips vector, such as impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV) (both are tospoviruses).

It is difficult to diagnose tospovirus infections of greenhouse plants using visual symptoms alone because symptoms can vary. Tospovirus symptoms often mimic symptoms caused by other problems, such as nutritional deficiencies.

Tospovirus infections may be systemic (i.e., virus symptoms are spread throughout the plant) or non-systemic (i.e., the virus symptoms are confined to a specific part of the plant). Tospoviruses, however, may be present even though the plant shows no symptoms.

IPM Program For Thrips

MONITORING FOR VIRUSES

The symptoms of tospovirus infections in floral crops are:

- **Brown, black, or white spots**
- **Necrosis on the leaf petiole**
- **Yellow mottling or variegation**
- **Death of young plants or terminal meristems of older plants**
- **Brown or black cankers on the stem**
- **Stunting**
- **Veinal necrosis**
- **Concentric ring spots**
- **Mosaics**
- **Line or zonal patterns**

Begonia with tomato spotted wilt virus

IPM Program For Thrips

MONITORING FOR VIRUSES

Early warning is critical to the control of western flower thrips and to the prevention of tospovirus infections. Indicator plants are often used to detect thrips and virus problems. Indicator plants should meet at least one of the following criteria:

- **Indicator plants should be more attractive to pests than the producing crop**
- **Pests or pathogen must develop faster on indicator plants**
- **Indicators must show feeding damage or virus symptoms more readily**
- **Indicator plants should not contribute to the spread of the virus being monitored**

IPM Program For Thrips

MONITORING FOR VIRUSES

Petunia plants (*Petunia* x *hybrida*) are excellent indicators for presence of western flower thrips and transmission of tospoviruses because petunias are not systemically infected with either TSWV or INSV. In response to a tospovirus infection, petunias show a hypersensitive response: rapid death of plant tissues that also kills the invading virus.

The following petunia cultivars are excellent indicator plants:

- **Calypso**
- **Super Blue Magic**
- **Blue Carpet**
- **Cascade Blue**
- **Summer Madness**
- **Burgundy Madness**
- **Red Cloud**
- **Super Magic Coral**

Lesions on petunia leaves caused by feeding of western flower thrips

IPM Program For Thrips

MONITORING FOR VIRUSES

- **Remove flowers from indicator plants before placing them in greenhouses because petunia flower petals do not express local lesions and attract western flower thrips away from leaves.**
- **Flag indicator plants with blue pie pans or metal sheets to increase effectiveness since western flower thrips are most sensitive to blue colors.**
- **Look for feeding scars, which are whitish and have an irregular outline. Brown or black-edged lesions will develop on the edges of thrips feeding scars within 3 days if a tospovirus has been transmitted. If a tospovirus outbreak occurs in the greenhouse, look for patterns of injury that correlate with variations in air movement, humidity, and temperature.**
- **Control measures include removal of infected plants and controlling or excluding thrips.**

IPM Program For Thrips

MONITORING FOR VIRUSES

In addition to the use of indicator plants, there are several kits designed specifically to test for tospoviruses vectored by western flower thrips. The test kits are available from www.agdia.com.


windowbox.com

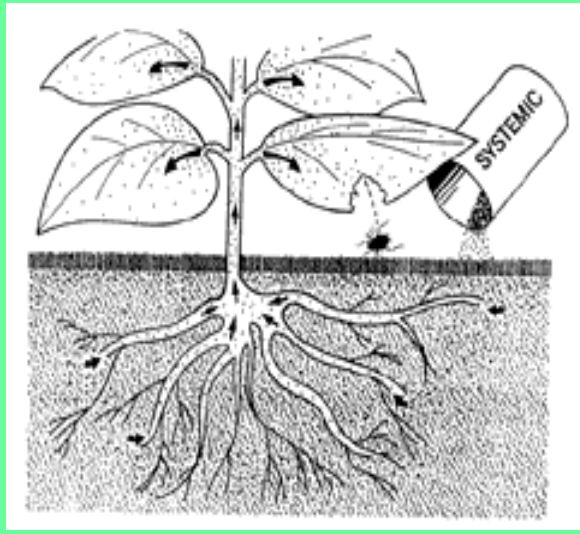
If you want to label a plant bee-friendly Do not use systemic insecticides.

Systemic insecticides move from soil and leaves into pollen and nectar.

Contact compared to systemic insecticides

Contact insecticides:

- Many used; sprayed on foliage
- Insect must eat leaf or walk on leaf to be killed
- Toxicity lasts 1-3 weeks
- Flowers that open after spraying do not contain insecticides.



Systemic insecticides:

- Uncommon; treated-seed, soil drench, trunk-inject
- Insect must eat leaf, pollen, or nectar to be killed
- Toxicity can least for months to years, unknown
- Flowers that open will have the insecticide in pollen and nectar for months to years, unknown

2014 MN State Bee labeling Law only applies to plants for sale that NEED to be designated as bee friendly.

1. Neonicotinoids can be used on plants that bees do not visit. They can be used on seasonal display plants, such as Christmas, Easter, and fall chrysanthemums.

2. If the plants need a bee-friendly label, then do not use neonicotinoids on these plants. Instead, use contact insecticides instead such as talstar, bifenthrin, pyrethroid; sevin, carbarly, carbamate.

Pesticides : toxicity / bees (LD_{50} ng/bee)

pesticide	®	Use	Dose g/ha	LD50 ng/ab	Tox/DDT
DDT	Dinocide	insecticide	200-600	27 000.0	1
thiaclopride	Proteus	insecticide	62,5	12 600.0	2.1
amitraze	Apivar	acaricide	-	12 000.0	2.3
acetamiprid	Supreme	insecticide	30-150	7 100.0	3.8
coumaphos	Perizin	acaricide	-	3 000.0	9
methiocarb	Mesurol	insecticide	150-2200	230.0	117
tau-fluvalinate	Apistan	acaricide	-	200.0	135
carbofuran	Curater	insecticide	600	160.0	169
λ-cyhalothrine	Karate	insecticide	150	38.0	711
thiaméthoxam	Cruiser	insecticide	69	5.0	5 400
fipronil	Regent	insecticide	50	4.2	6 475
imidaclopride	Gaucho	insecticide	75	3.7	7 297
clothianidine	Poncho	insecticide	50	2.5	10 800
deltamethrine	Décis	insecticide	7,5	2.5	10 800

Neonicotinoids are 5,000-10,000X more toxic than DDT to bees

LD50 DDT … 27,0000ng/bee
LD50 neonicotinoid insecticides
Imidacloprid ……..4 ng/bee….40 ppb
Clothianidin ……..4 ng/bee….40 ppb
Dinotefuran ……..4 ng/bee….40 ppb
Thiamethoxam …..5 ng/bee….50 ppb

aspirin 80mg=80,000microg=80,000,000ng