Feb 22 , 2018, Profit by enhancing biocontrol in greenhouse/nursery. landscape, and turf

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Switching to biocontrol 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

What is IPM?

What is 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

When should biological control be used?

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

When using biological control agents, 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.

Greenhouse:Olympic Horticultural Products

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 are biorational insecticides?

Endeavor, pymetrozine insecticide
Stops mouthparts from siphoning in aphids, scales, does not kill biocontrol agents

What are biorational insecticides?

- **Use insecticides compatible with good bugs.**
- **Use at low pest density.**
- **Tell the good bugs from bad. Recognize beneficial insects/biocontrol agents**

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 has assigned IRAC numbers for each chemical class to rotate classes of insecticides and prevent resistance**

- **Carbamates, class 1A**

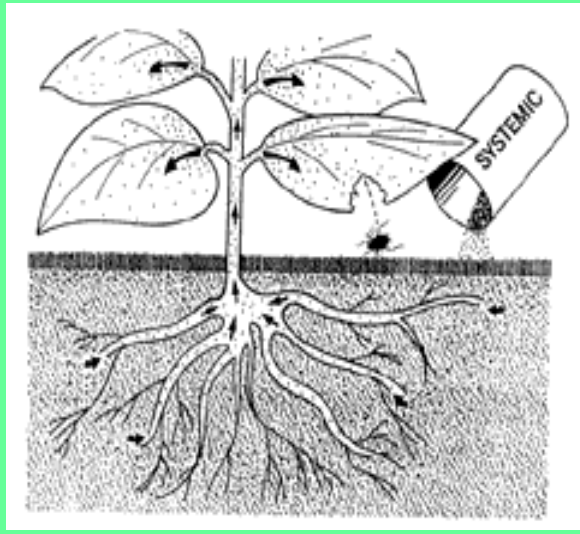
- **Organophosphates, class 1B are in the same group as the mode of action (cholinesterase inhibition) is the same.**

- **Neonicotinoid class, 4A**

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**

Toxicity to Pollinators of Insecticides Bulletin,
Vera Krischik , Dept Entomology, UMinnesota
http://cues.cfans.umn.edu/

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			
		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	Common name	Trade names	LD 50*	Toxicity to honeybees**		
			ug/ bee	Non	Mod Toxic	H ly
Carbamates	carbaryl methomyl	Sevin, Lannate	0.014 0.816			x x
Neo nicotinoids	imidacloprid thiamethoxam clothianidin dinotefuran Imid/bifenthrin	Merit, Marathon Flagship, Meridian Arena, Aloft Safari Allectus	0.004 0.004 0.005 0.023			x x x x

Organophosphates	acephate	0.1082			x
	chlorpyrifos	0.06			x
	dimethoate	0.038			x
	malathion	0.16			x
	phosmet	0. 1			x
Pyrethroids	bifenthrin	0.1			x
	cyfluthrin,	0.001			x
	fenpropathrin	0.05			x
	lambda-	0.038			x
	cyhalothrin	0.029			x
	permethrin	0.065			
	resmethrin				

Botanical	pyrethrin	Pyganic	0.15			x
IGR	diflubenzuron	Adept,	25	x		
	tebufenozide	Dimilin	234	x		
		Confirm				
	azadirachtin	AzaDirect	2.5		x	
	buprofezin	,Azatin	163	x		
	pyriproxyfen	Talus	100	x		
		Distance				
	novaluron	Pedestal	150	x		
	cyromazine	Citation	25	x		
JH	s-kinoprene	Enstar II	35	x		

Miticides	acequinocyl	Shuttle	>100	x		
	extoxazole	TetraSan	200	x		
	fenpyroximate	Beethoven	162	x		
	fenbutatin-oxide	Mach II	3982	x		
	halofenozide		100	x		
	clofentezine, hexythiazox	Ovation Hexygon	111 200	x x		
	bifenazate	Floramite, Sirocco	7.8		x	
	pyridaben	Sanmite	0.024			x
	chlorfenapyr	Pylon	0.12			x

Pyridine carboxamide	flonicamid	Aria	60	x		
Pyridine azomethines	pymetrozine	Endeavor	158	x		
Other	Bacillus thuringiensis	Bt/Dipel	na	x		
	soaps	Surround, M-Pede		x		
	horticultural mineral oils	Monterey Oil			x	

Biorational inseticides are compatible with biocontrol

Acelepryn, chlorantraniliprole for grubs in soil and on landscape plants.

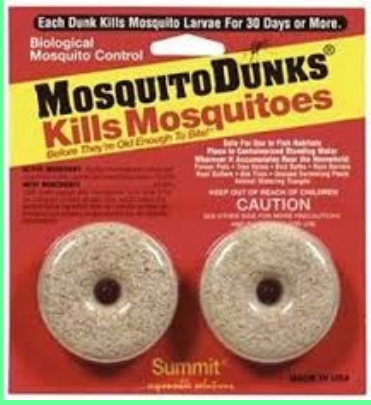
Spinosad for caterpillars and sawflies

Neem oil, soaps, and oils for aphids

Imidacloprid or dinotefuran for borers.

Pymetrozine stops siphons

Biorational inseticides are compatible with biocontrol



- BT is a protein crystal that puts an hole in the insect's gut wall after ingestion.
- BT kurstaki, moth larvae, Dipel, Javelin
- BT aizawai, moth larvae and suckers, Xentari
- BT tenebrionis, beetle larvae, Trident
- BT galleria, grubs, Grubgone
- BT israelensis, fly larvae, Aquabac

- Bifenthrin, grubs, Grub B Gone Ortho
- Chlorantraniliprole, conserves beneficials, grubs, Grub Ex Scotts

Biorational insecticides: Beauveria bassiana is a fungus

- ***Beauveria bassiana*** **is a fungus which causes a disease. When spores of this fungus come in contact with the cuticle (skin) of susceptible insects, they germinate and grow directly through the cuticle to the inner body of their host. Here the fungus proliferates throughout the insect's body, producing toxins and draining the insect of nutrients, eventually killing it.**

- **Unlike bacterial and viral pathogens of insects,** ***Beauveria*** **and other fungal pathogens infect the insect with contact and do not need to be consumed by their host to cause infection.**

Azadirachtin

- From Indian neem tree, *Azadirachta indica*
- *Active* against thrips.
- Caterpillars and aphids
- Biodegrades in sun.
- More effective on young larvae.
- Works best at temperatures, greater/equally to 70F

Pyrethroids/Pyrethrins/Pyrethrum

- Pyrethroid, Talstar
- South African daisy, *Tanacetum cinerariafolia*
- *Requires PBO, piperonyl butoxide synergist, PyGanic*

What is biocontrol?

Recognizing beneficial insects/biocontrol agents

When should biological control be used?

Biological control is most effective when enemies 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 greenh

What is greenhouse biological control?

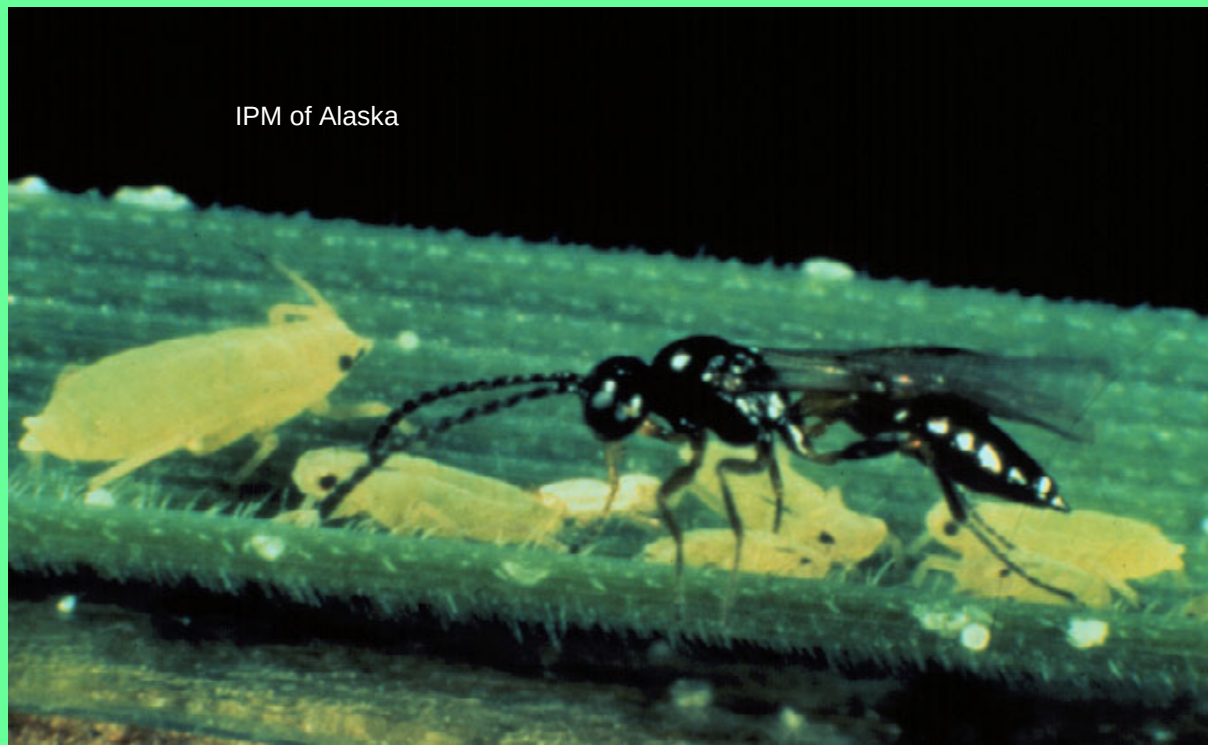
- **Classic biological control**
- **Conservation biocontrol**

- **Augmentative biological control involves periodic releases of biological control agents. This is the type of biological control most likely to be used in greenhouses.**

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

Ohio State University

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. Feed with cat food and honey water before releasing.

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.

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

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
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.

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

Order Coleoptera
Family Coccinellidae

Adults and larvae feed on scales.

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*)

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

Order Coleoptera
Family Coccinellidae

Adults and larvae feed on scales.

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 Predator (*Delphastus pusillus*)

Order Coleoptera
Family Coccinellidae

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

Thrips Parasitoid (*Thripobius semiluteus*)

Order Hymenoptera
Family Eulophidae

This parasitic wasps attacks greenhouse thrips.

Thripobius semiluteus **stalking immature thrips prey**

Thrips Predator (*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.

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.

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.

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 Destroyer (*Stethorus* spp.)

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

Right: *Stethorus* eggs in mite colony

IPM of thrips

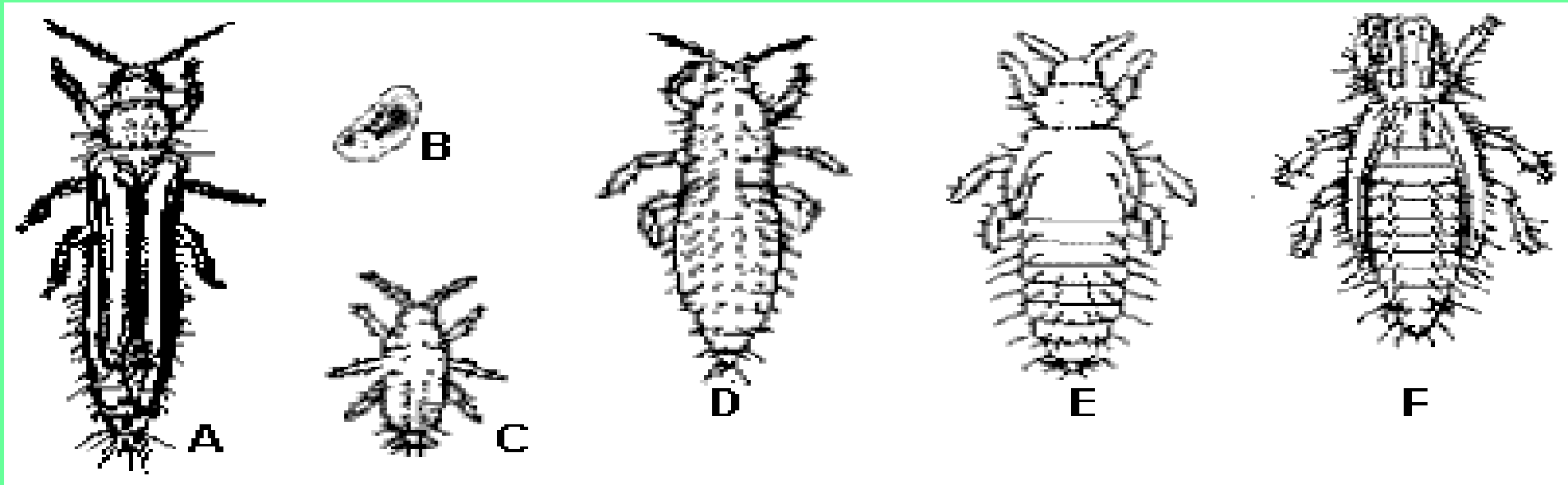
First properly identify the pest as life history differs among the species

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

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. WFT vectors tomato spotted wilt virus and other viruses.**

- **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.**

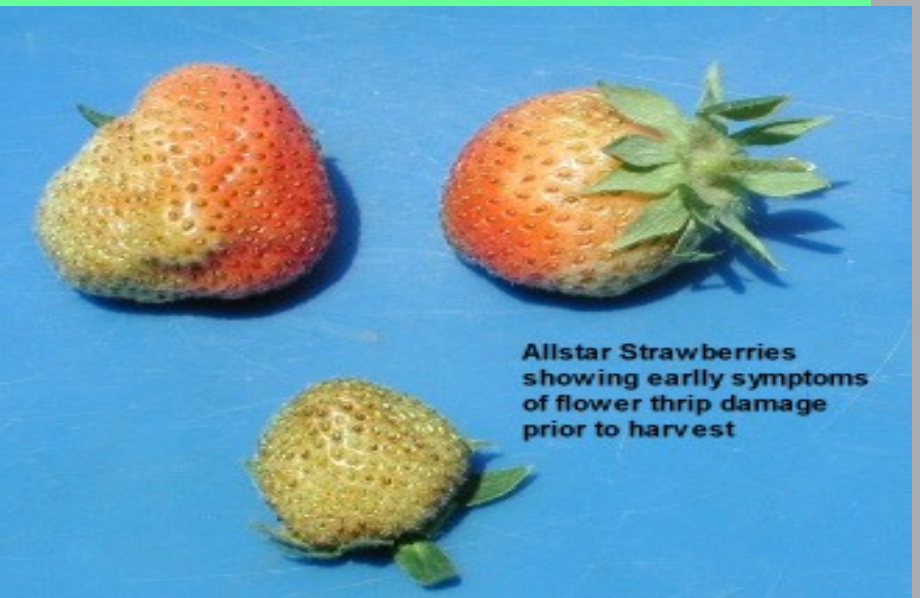
IPM Program For Thrips

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

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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 Program For Thrips


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University of California

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

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.

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University of California

Biocontrol

Release the proper biocontrol and use insecticides compatible with good bugs

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

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**

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University of California

Detecting virus

At arrival test plugs and plants for virus using a quick test

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

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.

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.

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

If you want to label a plant bee-friendly
Do not use systemic insecticides.
Use contact insecticides that will not last more than 5 wks in the GH and do not move from leaves to pollen and nectar.