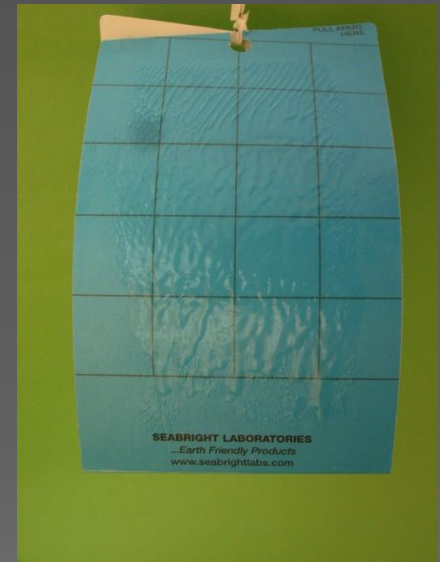


# Greenhouse IPM Programs for Insects & Mites



**Hummert**<sup>TM</sup>  
INTERNATIONAL

Dr. Steve Millett

# Pest Management Philosophy



Grant at Cold Harbor battle, VA 1864

**“The art of war is simple enough. Find out where your enemy is. Get at him as soon as you can. Strike him as hard as you can, and keep moving.”**

***Ulysses S. Grant***

# What is greenhouse IPM?

- \* System utilizing multiple methods
- \* Decision making process
- \* Risk reduction system
- \* Information intensive
- \* Biologically based
- \* Cost effective
- \* Site specific
- \* Multiple tactics:  
cultural, physical,  
genetic, biological, chemical



# What is greenhouse IPM?

- Know what pests you have
- Learn about the pest
- Be able to identify damage
- Monitor for the pests
- Determine threshold levels
- At low densities, use biological control and biorational pesticides
- High pest densities use conventional pesticides
- Use sparingly to protect beneficials





# The Art of War Sun Tzu 6<sup>th</sup> Century B.C.

- 13 chapters
- 13 aspects of warfare
- Definitive work on military strategy

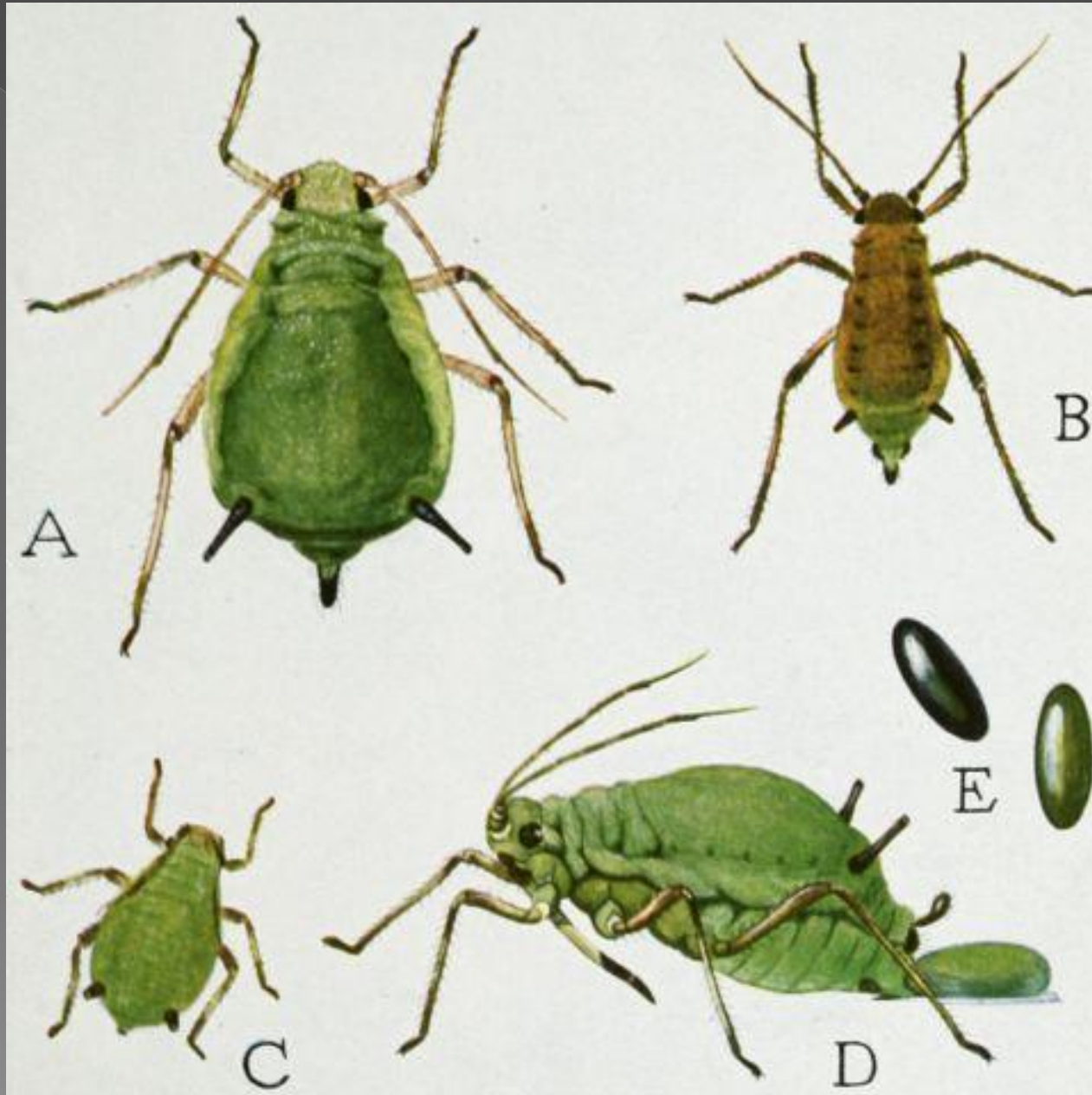




**4,400 species of aphids**



## The life stages of the green apple aphid (*Aphis pomi*)



# Aphid IPM

Order Hemiptera, Family Aphididae  
Melon/cotton aphid, *Aphis gossypii*  
Green peach aphid, *Myzus persicae*

## Green Peach Aphid

- Cornicles, tubelike appendages that protrude from the rear of the aphid
- Depression in the front of the head between the antennae and
- Long thin, translucent cornicles that extend beyond the tip of the body
- Yellowish green to rose pink
- Winged adults have a dark blotch in the middle of the abdomen





# Aphid IPM

## Melon Aphid

- Dark green with variations
- Cornicles are short, stout, & dark
- Red eyes
- Antennae to the middle of the abdomen
- Adults may/may not have wings
- Winged when crowded

**Melon aphids  
and mummies**



# Aphid IPM

## APHID DESCRIPTION

- Adults give birth to live young
- Start at 7 to 10 days old



Green peach aphid  
adult and young



Winged green peach  
aphid adult



# IPM For Aphids

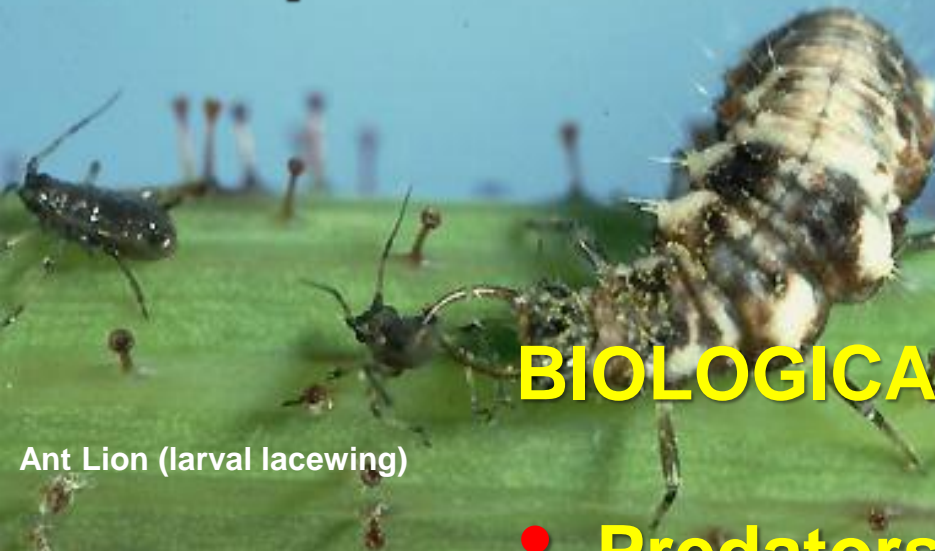
## DAMAGE

- Honeydew
- Black Sooty Mold
- Chlorosis stunting
- Vectors of viruses





# Aphid IPM



Ant Lion (larval lacewing)



Lady Beetle larva

## BIOLOGICAL CONTROL

- **Predators**
  - Lacewings (*Chrysoperla* spp.)
  - Midges (*Aphidoletes* spp.)
  - Lady Beetles
  - Syrphid fly



*Aphidoletes aphidimyza* larva



Syrphid fly larva



# Aphid IPM

## BIOLOGICAL CONTROL

- Parasitoids
  - *Aphidius* spp.
  - *Lysiphlebus testaceipes*
  - *Diaeretiella rapae*
  - *Aphelinus abdominalis*



*Aphidius* sp.

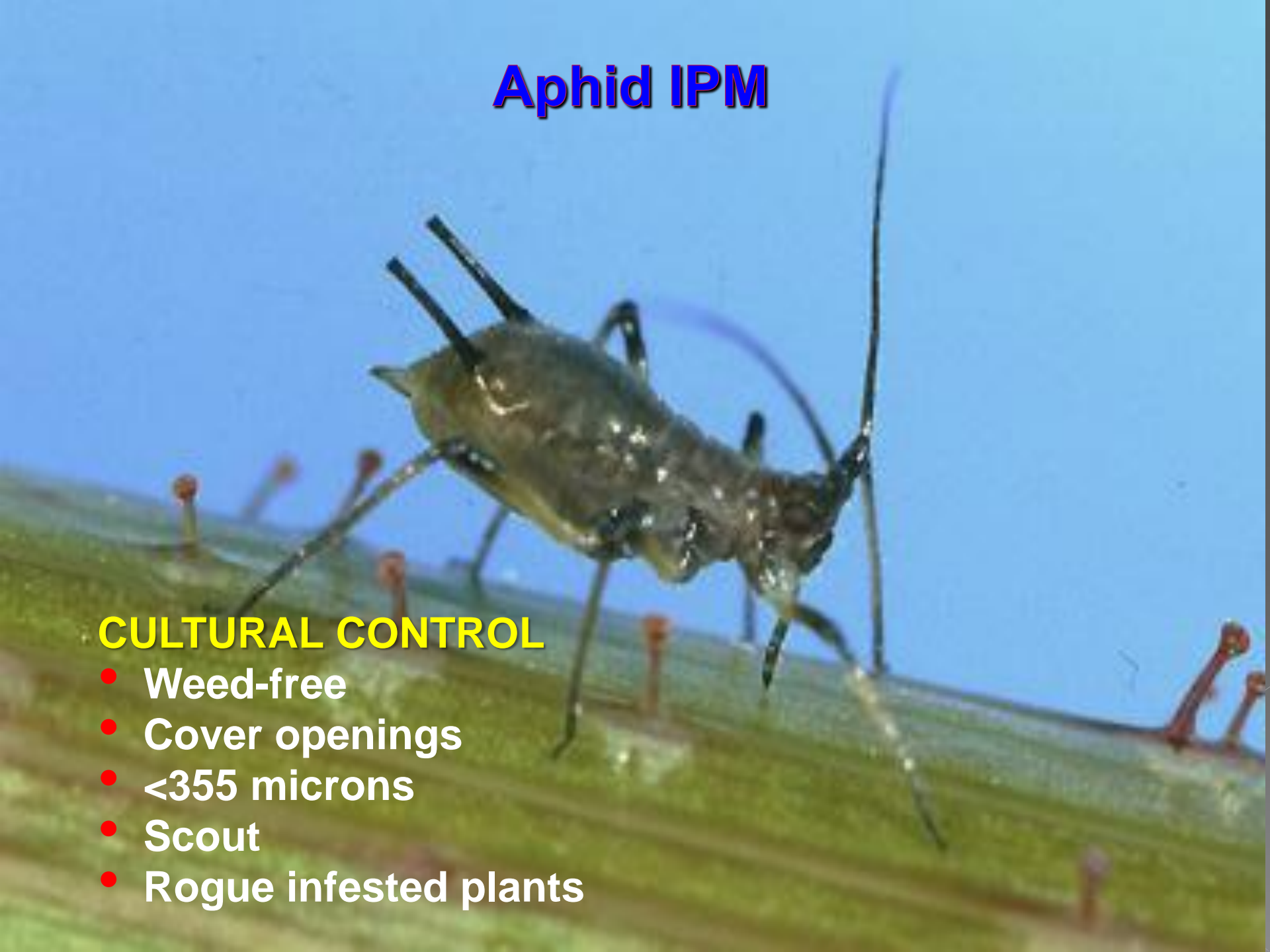


Wasp *Lysiphlebus testaceipes*

# Aphid IPM

## CULTURAL CONTROL

- Weed-free
- Cover openings
- <355 microns
- Scout
- Rogue infested plants



# Aphid IPM

## MONITORING and WHEN TO TREAT

- Yellow sticky cards
- Crowding produces winged aphids
- Check plants before high populations
- Melon aphids - vertical distribution on plants
- Green peach aphids cluster at growing points
- Check lower leaves
- Winged green peach aphids at lower densities
- One sticky trap per 10,000 square feet
- Treat at 5 to 10 aphids per card per week

# Aphid IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
biological	<i>Beauveria bassiana</i> (BotaniGard 22 WP) (BotaniGard ES)	4 12	Treat every 7 days while insects are active. Do not tank mix with most fungicides and wait 48 hours after application to apply a fungicide.
botanical	cinnamaldehyde (Cinnacure)	4	After 2 applications, rotate to an insecticide of different chemistry for 2+ applications. Don't apply to stressed/newly transplanted plants. Don't apply with irrigation system.
	pyrethrin/PBO2 (PT 1100 Pyrethrum TR)	12	An aerosol.
	pyrethrin/rotenone (Pyrellin EC)	12	



# Aphid IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
carbamate	methiocarb (Mesurol 75W)	24	Apply in 50 gal water. Repeat as necessary up to 4 applications/season. Do not apply with oil or foliar fertilizer. Don't apply with irrigation system
insect growth regulator	azadirachtin (Azatin XL Plus)	4	Must contact insect. Repeated applications as necessary. Aphid suppression only. Label permits low-volume application.
	azadirachtin (Ornazin 3%EC)	12	Do not exceed 22.5 oz/acre/application.
	pyriproxyfen (Distance)	12	Do not apply more than 2 times per cropping cycle or per 6 months. Do not use through any type of irrigation system.
	s-kinoprene (Enstar II)	4	Apply prebloom. Also-labeled for low volume use. Do not apply through any type of irrigation system.

# Aphid IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
neonico- tinoid	imidacloprid (Marathon 60 WP)	12	As above, but apply only as a drench.
	imidacloprid (Marathon 1G) (Marathon II)	12	Do not use more than once every 16 weeks. Alternate with insecticides that have a different mode of action to prevent resistance. Do not apply to soils that are water logged. Do not apply to plants intended as food crops.
oil	clarified hydrophobic extract of neem oil (Triact 70)	4	Do not spray plants under stress. Pest must be completely covered with spray-this material may not effectively control melon aphid because it is often on the underside of lower leaves. May cause injury to flowers. Do not use through any type of irrigation system.
	horticultural oil Ultra-Fine Oil SafTSide JMS Stylet Oil	4	Use as above for neem oil. Do not use with sulfur fungicides; check label for tank mix restrictions.

# Aphid IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
organo-chlorine	endosulfan (Endosulfan 3EC)	24	Check runoff restrictions. Chrysanthemums may exhibit phytotoxicity. Don't use through irrigation system or more than 3 lb ai/acre/season.
organo-phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system
	acephate (1300 Orthene TR)	24	An aerosol that is only for greenhouse use
	chlorpyrifos (DuraGuard ME)	24	
organo-phosphate/ pyrethroid	chlorpyrifos/ cyfluthrin (Duraplex TR)	24	An aerosol

# Aphid IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyrethroid	bifenthrin (Attain TR)	12	Check label. Fogger for greenhouse use only.
	bifenthrin (Talstar Flowable)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	cyfluthrin (Decathlon 20 WP)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	deltamethrin (DeltaGard)	12	Do not use through any type of irrigation system.
	fenpropathrin (Tame TR)	24	Aerosol
	fluvalinate (Mavrik Aquaflow)	12	Low-volume application. Also labeled for cutting dip at 5 fl oz/100 gal. Don't use through irrigation system.



# Aphid IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyrethroid	lambda-cyhalothrin (Scimitar)	24	Supplemental label for greenhouse and nursery use. Apply at 7-day intervals. Do not apply more than 52.4 fl oz of concentrate/acre/year. Do not mix with EC's or oils.
	permethrin (Pyganic)	12	May cause browning of petals. Marginal leaf burn may occur on salvia, diffenbachia and pteris fern. Low-volume application. Do not apply more than 2 lb a.i./acre/year.
pyridine	pymetrozine (Endeavor)	12	Do not use through irrigation system. Apply as foliar spray at 7-14 day intervals. For indoor use, do not use more than 100 oz.
soap	potash soap (Insecticidal soap) (M-Pede)	12	Must contact insect, so thorough coverage is important. Repeat weekly as needed up to 3 times. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

# Foliar-Feeding Mealybugs IPM

Order Hemiptera

Family Pseudococcidae

Citrus mealybug,

*Planococcus citri*

Longtailed mealybug,

*Pseudococcus longispinus*

## DESCRIPTION OF THE PESTS

- Slow-moving sucking insects
- Loose, waxy coating
- Lay eggs in ovisacs



UC Statewide IPM Project  
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# Foliar-Feeding Mealybug IPM

## DESCRIPTION

- Gives birth to live young
- Infestations occur under foliage and in dense foliage

## DAMAGE

- Remove sap from plants
- Chlorosis & decline
- Ovisacs & honeydew
- Black sooty mold
- Attracts ants
- Ants can infest other plants



Citrus mealybug



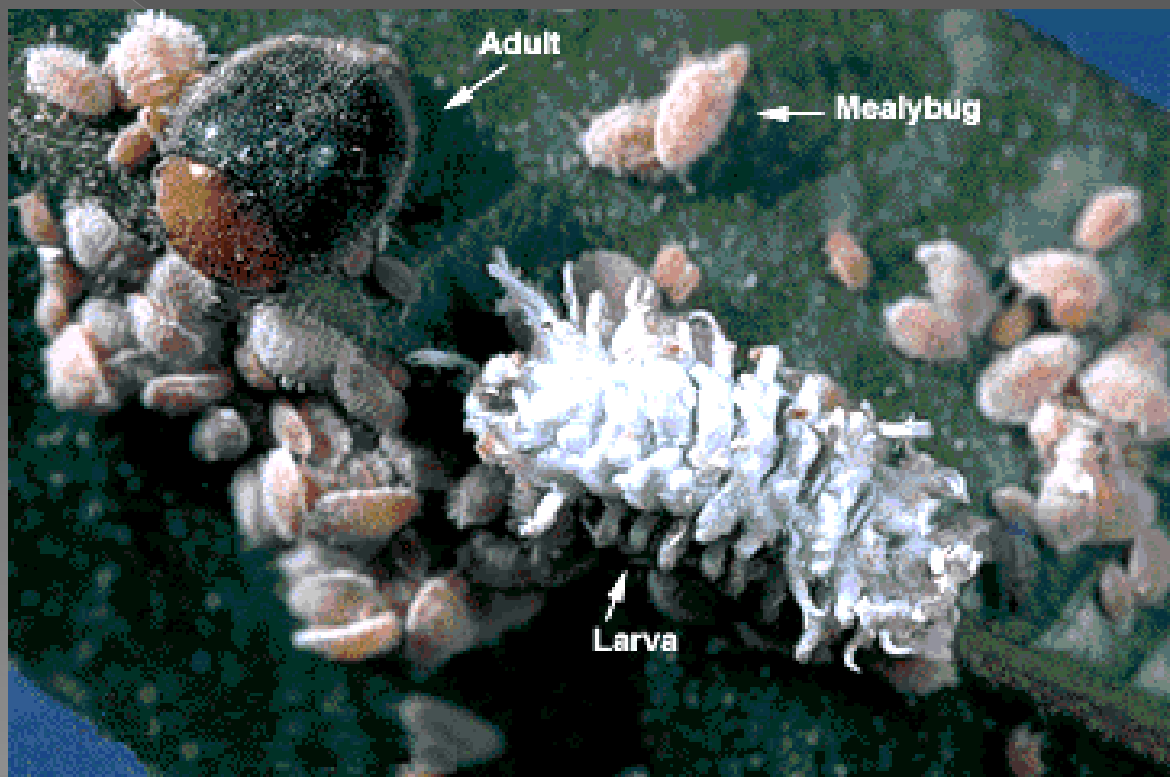
longtailed mealybug

# Foliar-Feeding Mealybug IPM

## BIOLOGICAL CONTROL

- *Cryptolaemus montrouzieri*, “mealybug destroyer lady beetle”
- Larval mealybug destroyers look like large, faster-moving mealybugs with chewing mouthparts
- Parasitoids
  - *Leptomastix dactylopii*
  - *Anagyrus pseudococchi*

*Cryptolaemus  
montrouzieri*





# IPM For Foliar-Feeding Mealybugs

## MONITORING and WHEN TO TREAT

- Inspect plants
- Look for honeydew and ants
- Well-established infestations are difficult to control
- Reproducing adults stop feeding
- Females' body or wax secretions help protect eggs or crawlers

Mealybugs on coleus





# Foliar-Feeding Mealybug IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
biological	<i>Beauveria bassiana</i> (BotaniGard 22 WP) (BotaniGard ES)	4 12	Treat every 7 days while insects are active. Do not tank mix with most fungicides and wait 48 hours after application to apply a fungicide.
botanical	pyrethrin/PBO2 (PT 1100 Pyrethrum TR)	12	An aerosol.
	pyrethrin/rotenone	12	

# Foliar-Feeding Mealybug IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
insect growth regulator	azadirachtin (Azatin XL Plus)	4	Must contact insect. Repeated applications as necessary. Only effective on immatures. Label permits low-volume application.
	azadirachtin (Ornazin 3%EC)	12	Do not exceed 22.5 oz/acre/application.
	s-kinoprene (Enstar II)	4	Apply prebloom. Low-volume use. Only effective on immatures. Do not apply through any type of irrigation system.
neonico-tinoid	imidacloprid (Marathon 60 WP)	12	As above, but apply only as a drench.
	imidacloprid (Marathon 1G) (Marathon II)	12	Do not use more than once every 16 weeks. Alternate with insecticides that have a different mode of action to prevent resistance. Do not apply to soils that are water logged. Do not apply to plants intended as food crops.

# Foliar-Feeding Mealybug IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
oil	clarified hydrophobic extract of neem oil (Triact 70)	4	Do not spray plants under stress. Pest must be completely covered with spray. May cause injury to flowers. Do not use through any type of irrigation system.
	horticultural oil Ultra-Fine Oil SafTSide JMS Stylet Oil	4	Use as above for neem oil. Do not use with sulfur fungicides; check label for tank mix restrictions.
organo- phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system.
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system.
	acephate (PT 1300 Orthene TR)	24	An aerosol that is only for greenhouse use.
	chlorpyrifos (DuraGuard ME)	24	

# IPM Program For Foliar-Feeding Mealybugs

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
organo-phosphate/ pyrethroid	<b>chlorpyrifos/ cyfluthrin (Duraplex TR)</b>	24	An aerosol.
pyrethroid	<b>bifenthrin (Attain TR)</b>	12	Check label. Fogger for greenhouse use only.
	<b>bifenthrin (Talstar Flowable)</b>	12	Label permits low-volume application. Do not use through any type of irrigation system.
	<b>cyfluthrin (Decathlon 20 WP)</b>	12	Label permits low-volume application. Do not use through any type of irrigation system.
	<b>deltamethrin (DeltaGard)</b>	12	Do not use through any type of irrigation system.
	<b>fenpropathrin (Tame TR)</b>	24	Aerosol



# IPM For Foliar-Feeding Mealybugs

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyrethroid	fluvalinate (Mavrik Aquaflow)	12	Low-volume application. Also labeled for cutting dip at 5 fl oz/100 gal. Don't use through irrigation system.
	permethrin (Pyganic)	12	May cause browning of petals. Marginal leaf burn may occur on salvia, diffenbachia and pteris fern. Low-volume application. Do not apply more than 2 lb a.i./acre/year.

Lance S. Osborne  
University of Florida



Longtailed mealybug

# Root Mealybug IPM

Order Hemiptera

Family Pseudococcidae

Root mealybug, *Rhizoecus* spp.

## DESCRIPTION

- Below-ground on roots
- Thin, uniform waxy coating
- No wax filaments

## DAMAGE

- Decline
- Visible when plants removed from pot



UC Statewide IPM Project  
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# Root Mealybug IPM





# Root Mealybug IPM

## CULTURAL CONTROL

- Rogue infected plants
- Control ants

## MONITORING and WHEN TO TREAT

- Look at root balls during decline
- Look for ants
- Rogue & discard
- Drench surrounding plants

No biological control as of yet



# Root Mealybug IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
botanical	pyrethrin/PBO2 (PT 1100 Pyrethrum TR)	12	An aerosol.
	pyrethrin/rotenone (Pyrellin EC)	12	
organo- phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system.
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system.

# Root Mealybug IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyrethroid	bifenthrin (Talstar Flowable)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	cyfluthrin (Decathlon 20 WP)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	fenpropathrin (Tame 2.4 EC)	24	Label permits low-volume application. Do not use through any type of irrigation system.
	fluvalinate (Mavrik Aquaflow)	12	Low-volume application. Also labeled for cutting dip at 5 fl oz/100 gal. Don't use through irrigation system.
	permethrin (Pyganic)	12	May cause browning of petals. Marginal leaf burn may occur on salvia, diffenbachia and pteris fern. Low-volume application. Do not apply more than 2 lb a.i./acre/year.



# Soft Scale IPM

Order Hemiptera

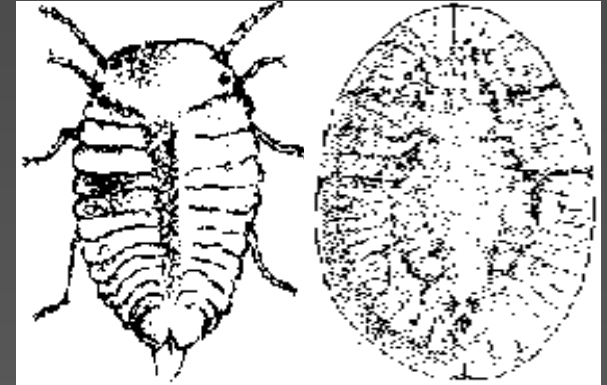
Family Coccidae

Brown soft scale, *Coccus hesperidum*

Hemispherical scale, *Saissetia coffeae*

Black scale, *Saissetia oleae*

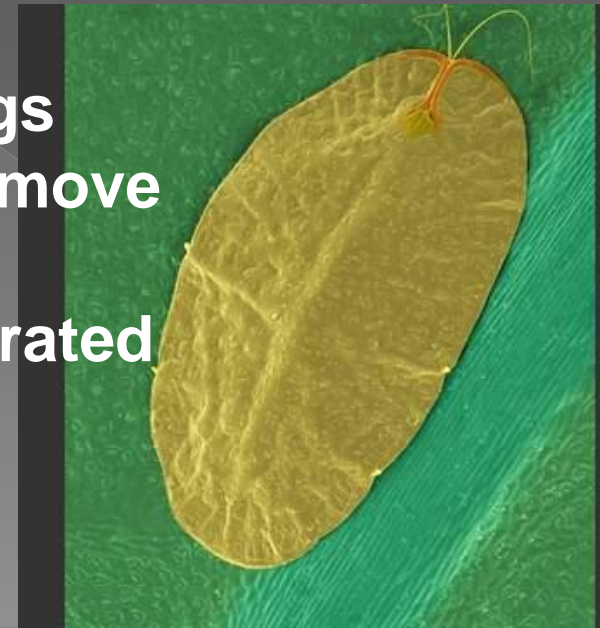
Green shield scale, *Pulvinaria psidii*



**Brown soft scale  
crawler (L) and adult  
female**

## DESCRIPTION

- Woody and foliage plants
- 1<sup>st</sup> nymphal instar = crawler with legs
- Later instars are attached & do not move
- Produce copious honeydew
- Protective covering cannot be separated from its body



# Soft Scale IPM



Brown soft scale

L.M. Vasvary, Rutgers Univ.

## DESCRIPTION

- Brown soft scale: flat in profile; yellowish green to brown to spotted or mottled to uniform brown
- Hemispherical scale: round, hard, brown, smooth and shiny.
- Black scale: globular, hardened, ridged
- Green shield scale: light yellow-green; produce mass of eggs in a cottony ovisac without mating (no males)







# Soft Scale IPM

## DAMAGE

- Removes sap
- Chlorosis
- Decline
- Ovisacs & honeydew disfigure
- Black Sooty Mold
- Ants may carry scales to uninfested plants

## BIOLOGICAL CONTROL

- Black scale parasite
  - *Metaphycus helvolus*
- Mealybug destroyer
  - *Cryptolaemus montrouzieri*
- Lady beetle
  - *Rhyzobius lophanthae*



# Soft Scale IPM

## CULTURAL CONTROL

- Seal greenhouse or screen
- Prune and discard heavily infested plant parts
- Control ants

## MONITORING and WHEN TO TREAT

- Scout for scale and ants
- Treatment when present
- Best to attack crawlers
- Multiple applications

Hemispherical scale



L.M. Vasvary

# Soft Scale IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
insect growth regulator	pyriproxyfen (Distance)	12	Do not apply more than 2 times per cropping cycle or per 6 months. Do not use through any type of irrigation system.
	s-kinoprene (Enstar II)	4	Apply prebloom. Low-volume use. Do not apply through any type of irrigation system.
neonico- tinoid	imidacloprid (Marathon 60 WP)	12	As above, but apply only as a drench.
	imidacloprid (Marathon 1G) (Marathon II)	12	Do not use more than once every 16 weeks. Alternate with insecticides that have a different mode of action to prevent resistance. Do not apply to soils that are water logged. Do not apply to plants intended as food crops.



# Soft Scale IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
oil	clarified hydrophobic extract of neem oil (Triact 70)	4	Do not spray plants under stress. Pest must be completely covered with spray. May cause injury to flowers. Do not use through any type of irrigation system.
	horticultural oil Ultra-Fine Oil SafTSide JMS Stylet Oil	4	Use as above for neem oil. Do not use with sulfur fungicides; check label for tank mix restrictions.
organo-chlorine	endosulfan (Endosulfan 3EC)	24	Check runoff restrictions. Chrysanthemums may exhibit phytotoxicity. Don't use through irrigation system or more than 3 lb ai/acre/season.

# INSECTICIDES

## Soft Scale IPM

Class	Pesticide (commercial name)	R.E.I.	Comments
organo-phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system.
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system.
	acephate (1300 Orthene TR)	24	An aerosol that is only for greenhouse use.
	chlorpyrifos (DuraGuard ME)	12	



Top and side  
views of  
hemispherical  
scale



# Whitefly IPM

Order Hemiptera

Family Aleyrodidae

**Greenhouse whitefly,**

*Trialeurodes vaporariorum*

**Silverleaf whitefly,**

*Benicia argentifolii*

## DESCRIPTION

- Adult 0.9 to 1.1 mm
- Four wings
- Sucking mouthparts
- Powdery waxy coating
- White wings
- Seven life stages: egg, four nymphal instars, pupal stage, and adult







UGA1243029

## DESCRIPTION of Greenhouse Whitefly

- Eggs inserted underside of leaf; circular pattern
- Eggs yellowish to purplish brown
- 1<sup>st</sup> nymphal instar = crawler
- Other instars = attached, immobile, on underside
- 4<sup>th</sup> instar = pupa, used for id
- GH whitefly pupae are oval w/ vertical sides (cakelike)
- Upper surface is a fringe of waxy filaments
- Can complete one generation in 21 to 26 days at 81°F

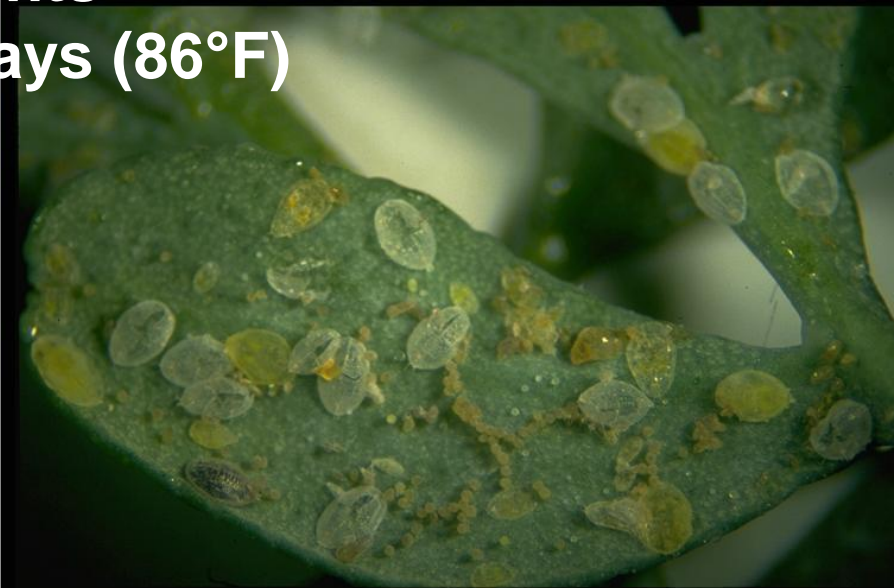
**Whitefly  
IPM**

## **DESCRIPTION of Silverleaf Whitefly**

- 0.8 to 1.0 mm long
- White, waxy coating < GHWF
- Eggs not laid in a circular pattern
- Eggs partially inserted into the leaf
- Eggs yellowish until hatching
- Pupae are ovoid
- Pupae slightly pointed hind end
- Pupae have red eye spots
- Pupa is flat w/o fringe of filaments
- Complete development in 16 days (86°F)



## **Whitefly IPM**





# Whitefly IPM

## DAMAGE

- Honeydew
- Black Sooty Mold
- Stunting
- Senesce
- White stem on poinsettia



Scott Bauer  
USDA ARS  
[www.insectimages.org](http://www.insectimages.org)

**Silverleaf whiteflies**

UGA1316008





## Whitefly IPM

### BIOLOGICAL CONTROL

- *GHWF - Encarsia formosa*, parasitic wasp
  - Weekly release (2-5 per plant for 9 weeks)
  - Low population
  - No systemic insecticide used
- *SLWF - Delphastus pusillus*, predator
- *SLWF & GHWF - Eretmocerus eremicus*

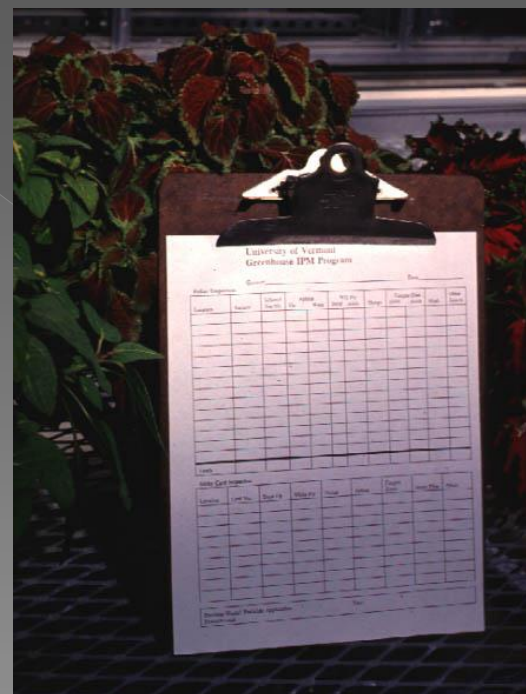
# Whitefly IPM

## CULTURAL CONTROL

- Weed-free
- Screens <405 microns
- Scout
- Treat or rogue infested plants

## MONITORING and WHEN TO TREAT

- Yellow sticky cards
- One per 1,000 sq. ft.
- Inspect for stages
- Underside of leaves





# Whitefly IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
biological	<i>Beauveria bassiana</i> (BotaniGard 22 WP) (BotaniGard ES)	4 12	Treat every 7 days while insects are active. Do not tank mix with most fungicides and wait 48 hours after application to apply a fungicide.
botanical	pyrethrin/PBO2 (PT 1100 Pyrethrum TR)	12	An aerosol.
	pyrethrin/rotenone (Pyrellin EC)	12	pyrethrin/rotenone (Pyrellin EC)
insect growth regulator	azadirachtin (Azatin XL Plus)	4	Must contact insect. Repeated applications as necessary. Low-volume application.
	azadirachtin (Ornazin 3%EC)	12	Do not exceed 22.5 oz/acre/application.



# Whitefly IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
insect growth regulator	diflubenzuron (Adept 25WP)	12	Whitefly suppression. May damage poinsettias if used over labeled rate. Also effective on fungus gnat larvae and lepidopteran larvae.
	novaluron (Pedestal)	12	Use no more than twice per year and don't exceed 52 oz/acre/year. Don't use on poinsettia.
	pyriproxyfen (Distance)	12	Do not apply more than 2 times per cropping cycle or per 6 months. Do not use through any type of irrigation system.
	s-kinoprene (Enstar II)	4	Apply prebloom. Also-labeled for low volume use. Do not apply through any type of irrigation system.
macrocyclic lactone	abamectin (Avid 0.15EC)	12	Low-volume application. Do not apply through any type of irrigation system.

# Whitefly IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
neonico- tinoid	imidacloprid (Marathon 60 WP)	12	As above, but apply only as a drench.
	imidacloprid (Marathon 1G) (Marathon II)	12	Do not use more than once every 16 weeks. Alternate with insecticides that have a different mode of action to prevent resistance. Do not apply to soils that are water logged. Do not apply to plants intended as food crops.
oil	clarified hydrophobic extract of neem oil (Triact 70)	4	Do not spray plants under stress. Pest must be completely covered with spray-this material may not effectively control melon aphid because it is often on the underside of lower leaves. May cause injury to flowers. Do not use through any type of irrigation system.
	horticultural oil Ultra-Fine Oil SafTSide JMS Stylet Oil	4	Use as above for neem oil. Do not use with sulfur fungicides; check label for tank mix restrictions.

# Whitefly IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
organo-chlorine	endosulfan (Endosulfan 3EC)	24	Check runoff restrictions. Chrysanthemums may exhibit phytotoxicity. Don't use through irrigation system or more than 3 lb ai/acre/season.
organo-phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system.
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system.
	acephate (1300 Orthene TR)	24	An aerosol that is only for greenhouse use.
	chlorpyrifos (PT DuraGuard ME)	24	
organo-phosphate/ pyrethroid	chlorpyrifos/ cyfluthrin (PT Duraplex TR)	24	An aerosol.



# Whitefly IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyrethroid	bifenthrin (Attain TR)	12	Check label. Fogger for greenhouse use only.
	bifenthrin (Talstar Flowable)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	cyfluthrin (Decathlon 20 WP)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	fenpropathrin (Tame 2.4 EC)	24	Label permits low-volume application. Do not use through any type of irrigation system.
	fluvalinate (Mavrik Aquaflow)	12	Low-volume application. Also labeled for cutting dip at 5 fl oz/100 gal. Don't use through irrigation system.
	permethrin (Pyganic)	12	May cause browning of petals. Marginal leaf burn may occur on salvia, diffenbachia and pteris fern. Low-volume application. Do not apply more than 2 lb a.i./acre/year.

# Whitefly IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyridazinone	pyridaben (Sanmite 75WP)	12	
pyridine	pymetrozine (Endeavor)	12	Do not use through irrigation system. Apply as foliar spray at 7-14 day intervals. For indoor use, do not use more than 100 oz.
soap	potash soap (Insecticidal soap) (M-Pede)	12	Must contact insect, so thorough coverage is important. Repeat weekly as needed up to 3 times. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.



# Thrips IPM

Order Thysanoptera

Family **Thripidae**

Western flower thrips, *Frankliniella occidentalis*

Greenhouse thrips, *Heliothrips haemorrhoidalis*

## DESCRIPTION

- Four featherlike wings
- Six stages: egg, 1<sup>st</sup> & 2<sup>nd</sup> instar, prepupa, pupa, adult
- Eggs inserted into tissue
- 1<sup>st</sup> & 2<sup>nd</sup> instars feed by piercing





# Thrips IPM

## DESCRIPTION

### Western Flower Thrips

- WFT
  - Pale
  - Intermediate
  - Dark
- Feed on flowers, buds, or growing tips
- Prepupa and pupal stages in the soil
- Females lay
  - male eggs if unmated
  - female eggs once mated
- One generation
  - 11 days (77° to 87°F)
  - 44 days (50° to 60°F)



# Thrips IPM

## DESCRIPTION

### Greenhouse thrips

- Adults are tiny, black, with whitish to translucent wings
- Nymphs are whitish to slightly yellowish in color
- Produce a globule of fecal fluid
- Globules increase in size and fall off
- Black fecal specks



Greenhouse thrips



# Thrips IPM

## DAMAGE

- WFT - flowers & GHT – foliage
- Streaking, spotting, and tissue distortion
- Leaf veins - outlining of the veins.
- WFT vector TSWV plus others
- GHT stipple the foliage – confused w/ mite



## Thrips Damage





# Thrips IPM

## BIOLOGICAL CONTROL

- minute pirate bug, *Orius* spp.
  - released at a rate of 2000 to 4000 per acre
- predatory mite, *Amblyseius cucumeris*
  - released at a rate of 10 to 50 mites per plant for each of 2 to 3 weeks
- predatory mite, *Hypoaspis miles*
  - soil-inhabiting predators released in the soil at planting
- *Thripobius semileteus*



# Thrips IPM

## CULTURAL CONTROL

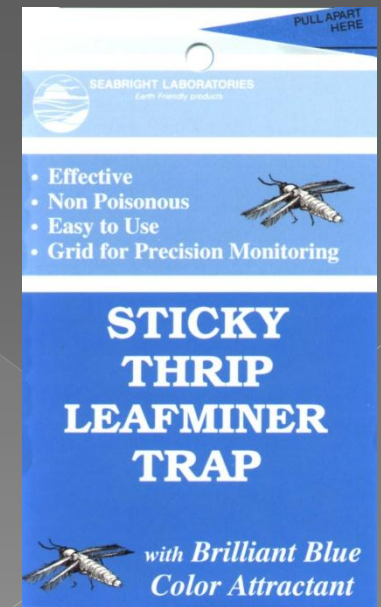
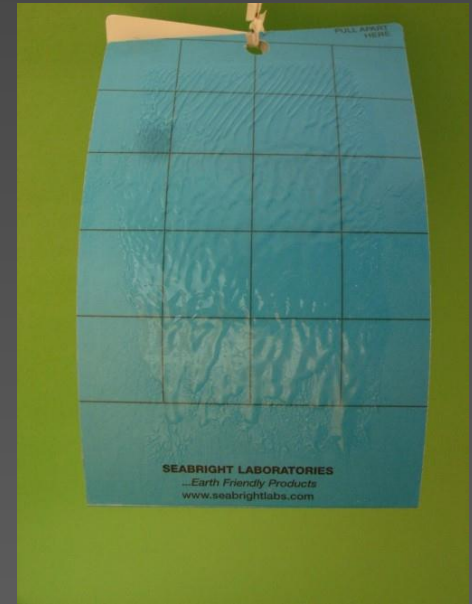
- Weed-free – alternate hosts
- Screens
- Cover openings
- Inspect incoming plants
- Rogue, destroy or treat infested plants



# Thrips IPM

## MONITORING and WHEN TO TREAT

- Blue sticky cards are most attractive to WFT
- Yellow cards are easier to read
- Vertically and upper 2/3 above leaves
- Raise as crop grows
- Most sensitive yellow or white flowers
- Eight traps per 100,000 square feet
- Threshold for roses is 25 to 50 thrips per card per week
- One card per 10,000 sq ft - 5 to 10 thrips per card per week





# Thrips IPM

Most insecticides must be applied at least two times, 5-7 days apart, for efficacy against WFT



UC Statewide IPM Project  
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White feeding scars and  
black excrement from  
greenhouse thrips

# Thrips IPM

## VIRUSES

- WFT vector
  - impatiens necrotic spot virus (INSV)
  - tomato spotted wilt virus (TSWV)



impatiens necrotic spot virus (INSV)



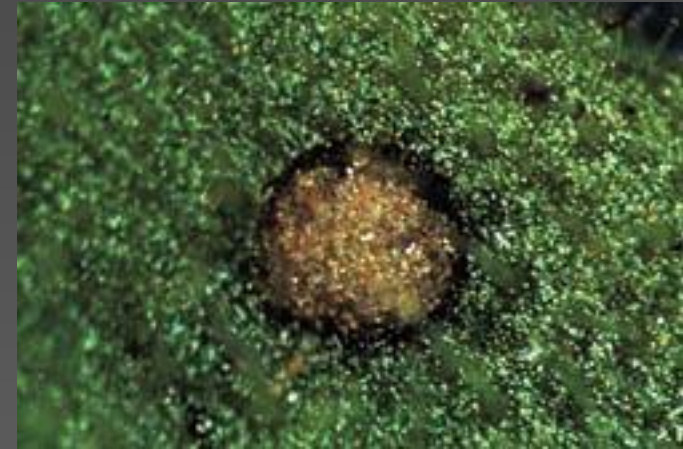
Begonia with tomato spotted wilt virus



# Thrips IPM

## VIRUSES

- Petunias indicator plants for WFT and tospoviruses
- Hypersensitive response: rapid death of plant tissues that also kills the invading virus
- Indicator cultivars
  - Calypso, Super Blue Magic, Blue Carpet, Cascade Blue, Summer Madness, Burgundy Madness, Red Cloud, Super Magic Coral



WFT lesions from feeding



# Thrips IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
biological	<i>Beauveria bassiana</i> (BotaniGard 22 WP) (BotaniGard ES)	4 12	Treat every 7 days while insects are active. Do not tank mix with most fungicides and wait 48 hours after application to apply a fungicide.
botanical	cinnamaldehyde (Cinnacure)	4	After 2 applications, rotate to an insecticide of different chemistry for 2+ applications. Don't apply to stressed/newly transplanted plants. Don't apply with irrigation system.
	pyrethrin/PBO2 (PT 1100 Pyrethrum TR)	12	An aerosol.
	pyrethrin/rotenone (Pyrellin EC)	12	

# Thrips IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
carbamate	methiocarb (Mesurol 75W)	24	Apply in 50 gal water. Repeat as necessary up to 4 applications/season. Do not apply with oil or foliar fertilizer. Don't apply with irrigation system
insect growth regulator	azadirachtin (Azatin XL Plus)	4	Must contact insect. Repeated applications as necessary. Label permits low-volume application.
	azadirachtin (Ornazin 3%EC)	12	Do not exceed 22.5 oz/acre/application.
	novaluron (Pedestal)	12	Use no more than twice per year and don't exceed 52 oz/acre/year. Don't use on poinsettia.
macrocyclic lactone	abamectin (Avid 0.15EC)	12	Label permits low-volume application. Do not use through any type of irrigation system.

# Thrips IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
neonico- tinoid	imidacloprid (Marathon 60 WP)	12	As above, but apply only as a drench.
	imidacloprid (Marathon 1G) (Marathon II)	12	Do not use more than once every 16 weeks. Alternate with insecticides that have a different mode of action to prevent resistance. Do not apply to soils that are water logged. Do not apply to plants intended as food crops.
nicotine	nicotine (Nicotine Smoke Generator)	see label	
oil	clarified hydrophobic extract of neem oil (Triact 70)	4	Do not spray plants under stress. Pest must be completely covered with spray-this material may not effectively control melon aphid because it is often on the underside of lower leaves. May cause injury to flowers. Do not use through any type of irrigation system.



# Thrips IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
organo-chlorine	endosulfan (Endosulfan 3EC)	24	Check runoff restrictions. Chrysanthemums may exhibit phytotoxicity. Don't use through irrigation system or more than 3 lb ai/acre/season.
organo-phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system.
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system.
	acephate (1300 Orthene TR)	24	An aerosol that is only for greenhouse use.
	chlorpyrifos (PT DuraGuard ME)	24	
organo-phosphate/ pyrethroid	chlorpyrifos/ cyfluthrin (PT Duraplex TR)	12	An aerosol.

# Thrips IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
soap	potash soap (Insecticidal soap) (M-Pede)	12	Must contact insect, so thorough coverage is important. Repeat weekly as needed up to 3 times. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.
spinosyn	spinosad (Conserve SC)	4	Do not apply more than 10 times in a 12-month period. Do not apply more than 3 times in a row without rotating to a different chemistry. Compatible with most beneficials, but highly toxic to bees and hymenopteran parasites. Direct contact can cause significant mortality to <i>Phytoseiulus persimilis</i> .
Pyridalyl	Pyridalyl (Overture)	12	<i>Thrips including WFT &amp; Chili thrips &amp; lepidopteran insects. Safe on beneficials 8 oz per 100 gallons</i>

# Fungus Gnat IPM

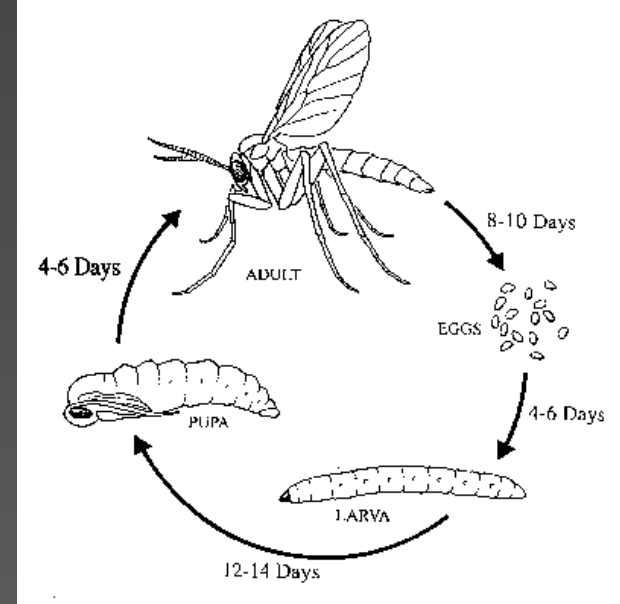
Order Diptera

Family **Sciaridae**

Darkwinged fungus gnats, *Bradysia* spp.

## DESCRIPTION

- 2-5 mm long
- Mosquito-like flies with dark wings
- Delicate legs, and long antennae
- Lay their eggs in soil & hatch 4 days later
- Four larval instars
- Larvae are clear, with visible internal organs
- Shiny black head capsules
- Feed on root hairs and algae then insides of roots
- High populations bore into roots & stems
- One generation may in 21 (72°F) to 40 (61°F) days





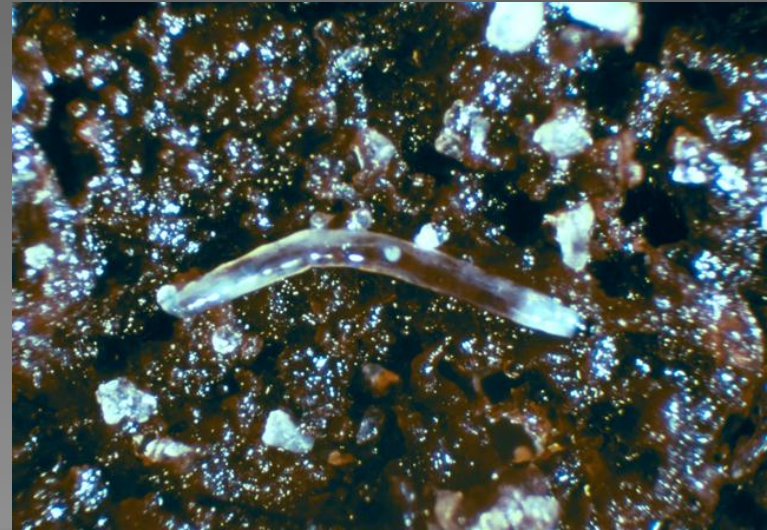
# Fungus Gnat IPM

## DAMAGE

- Larvae feed on roots & algae within 1 inch of surface
- Root feeding allows fungi to enter
- Wilting, necrosis
- Problem in propagation

## BIOLOGICAL CONTROL

- Nematodes (*Steinernema feltiae*)
- Soil-inhabiting predaceous mites (*Hypoaspis miles*)
- Bacteria *Bacillus thuringiensis* (Gnatrol)



# Fungus Gnat IPM

## CULTURAL CONTROL

- Weed-free
- Sanitation
- Attack algae
- Do not over-water
- Steam media





# Fungus Gnat IPM

## MONITORING and WHEN TO TREAT

- Yellow sticky cards
- Cubes or slices of potatoes pressed into soil
- Pyrethroids for adult knockdown
- Microencapsulated pesticides for larvae
- Apply drenches to top 1 inch of soil for larvae
- Foggers, aerosols, or sprays to control adults





# Fungus Gnat IPM

## INSECTICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
biological	<i>Bacillus thuringiensis</i> (Gnatrol)	4	Do not apply with fertilizers or fungicides containing copper or chlorine. Not effective on shore flies.
botanical	pyrethrin/PBO2 (PT 1100 Pyrethrum TR)	12	An aerosol.
	pyrethrin/rotenone (Pyrellin EC)	12	

Darkwinged Fungus Gnat



# Fungus Gnat IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
insect growth regulator	azadirachtin (Azatin XL Plus)	4	Must contact insect. Repeated applications as necessary. Label permits low-volume application.
	azadirachtin (Ornazin 3%EC)	12	Do not exceed 22.5 oz/acre/application.
	cyromazine (Citation 75 WP)	12	Certification training required to use this product. Also effective against shorefly larvae.
	diflubenzuron (Adept 25WP)	12	Apply as spray or drench to top 2 inches of soil.
	pyriproxyfen (Distance)	12	Do not apply more than 2 times per cropping cycle or per 6 months. Do not apply through any type of irrigation system.
	s-kinoprene (Enstar II)	4	Apply prebloom. Also labeled for low volume use. Do not apply through any type of irrigation system.

# Fungus Gnat IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
neonico- tinoid	imidacloprid (Marathon 60 WP)	12	As above, but apply only as a drench.
	imidacloprid (Marathon 1G)	12	Do not use more than once every 16 weeks. Alternate with insecticides that have a different mode of action to prevent resistance. Do not apply to soils that are water logged. Don't apply to food crops.
organo- phosphate	acephate (Acephate)	24	Do not use through any type of irrigation system.
	acephate (Orthene T, T&O Spray) 75WP	24	Chrysanthemums may exhibit phytotoxicity. Can stunt growth in roses. Don't use through irrigation system.
	acephate (1300 Orthene TR)	24	An aerosol that is only for greenhouse use.
	chlorpyrifos (PT DuraGuard ME)	24	



# Fungus Gnat IPM

## INSECTICIDES

Class	Pesticide (commercial name)	R.E.I .	Comments
pyrethroid	bifenthrin (Attain TR)	12	Check label. Fogger for greenhouse use only.
	bifenthrin (Talstar Flowable)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	cyfluthrin (Decathlon 20 WP)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	deltamethrin (DeltaGard)	12	Do not use through any type of irrigation system.
	fenpropathrin (Tame 2.4 EC)	24	Label permits low-volume application. Do not use through any type of irrigation system.
	permethrin (Pyganic)	12	May cause browning of petals. Marginal leaf burn may occur. Low-volume application. Do not apply more than 2 lb a.i./acre/year.

# Spider Mite IPM

Class Arachnida

Order Acari

Family Tetranychidae

Two-spotted spider mite, *Tetranychus urticae*



## DESCRIPTION

- Web-forming mites that pierce plant cells
- Two body segments and four pairs of legs as adults
- Adults have two large dark spots on the sides
- Lay round eggs that hatch into six-legged larvae
- The subsequent stages, the protonymph and deutonymph stages, are eight-legged
- Life cycle in 8 (77° to 95°F) to 28 (50° to 68°F) days
- Many generations per year and can rapidly increase in number

# Fungus Gnat IPM

## DAMAGE

- Stippling
- Webbing
- Chlorosis
- Stunted





# Spider Mite IPM

## BIOLOGICAL CONTROL

- Predatory mite - *Phytoseiulus persimilis*
- Lady beetle, *Stethorus* sp..

## CULTURAL CONTROL

- Weed-free
- Inspect, rogue, treat



# Spider Mite IPM

## MONITORING and WHEN TO TREAT

- Sticky cards do not work
- Scout plants
- 10X hand lens on underside of leaves
- May need a miticide and an ovicide



# Spider Mite IPM

## MITICIDES

Read and follow the instructions on the label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity.

Class	Pesticide (commercial name)	R.E.I.	Comments
botanical	cinnamaldehyde (Cinnacure)	4	After 2 applications, rotate to an insecticide of different chemistry for 2+ applications. Don't apply to stressed/newly transplanted plants. Don't apply with irrigation system.
carbamate	methiocarb (Mesurol 75W)	24	Apply in 50 gal water. Repeat up to 4 applications/season. Don't apply with oil or foliar fertilizer or with irrigation system
carboximide	hexythiazox (Hexygon 50WP)	12	No chemigation. Ovicidal/larvicidal action. Use only 1 time per crop or once a year.
carboxylic acid	bifenazate (Floramite)	12	Apply at least two alternative products between treatments of bifenazate. Primarily effective against motile stages but has some ovicidal activity.



# Spider Mite IPM

## MITICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
macrocyclic lactone	abamectin (Avid 0.15EC)	12	Label permits low-volume application. Do not use through any type of irrigation system.
oil	clarified hydrophobic extract of neem oil (Triact 70)	4	Do not spray plants under stress. Pest must be completely covered with spray-this material may not effectively control melon aphid because it is often on the underside of lower leaves. May cause injury to flowers. Do not use through any type of irrigation system.
	horticultural oil Ultra-Fine Oil SafTSide JMS Stylet Oil	4	Use as above for neem oil. Do not use with sulfur fungicides; check label for tank mix restrictions.

# Spider Mite IPM

## MITICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
organochlorine	endosulfan (Endosulfan 3EC)	24	Check runoff restrictions. Chrysanthemums may exhibit phytotoxicity. Don't use through irrigation system or more than 3 lb ai/acre/season.
	dicofol (Kelthane 50WP)	48	Low-volume use. Do not use through any type of irrigation system.
organtin	fenbutatin-oxide (Vendex)	48	
phenoxypyrazole	fenpyroximate (Akari)	12	Do not apply more than 10 gal spray/1000 sq ft/application. Do not exceed 48 oz/crop cycle or growing season, whichever is longer.

# Spider Mite IPM

## MITICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
pyrethroid	bifenthrin (Attain TR)	12	Check label. Fogger for greenhouse use only.
	bifenthrin (Talstar Flowable)	12	Label permits low-volume application. Do not use through any type of irrigation system.
	fenpropathrin (Tame 2.4 EC)	24	Label permits low-volume application. Do not use through any type of irrigation system.
	fluvalinate (Mavrik Aquaflow)	12	Low-volume application. Also labeled for cutting dip at 5 fl oz/100 gal. Don't use through irrigation system.
pyridazinone	pyridaben (Sanmite 75WP)	12	Use at least 2 different chemicals between applications of Sanmite. Do not use fertilizers containing boron or apply through any type of irrigation system. Do not exceed 10.67 oz/acre/application.



# Spider Mite IPM

## MITICIDES

Class	Pesticide (commercial name)	R.E.I.	Comments
soap	potash soap (Insecticidal soap) (M-Pede)	12	Must contact mite, so thorough coverage is important. Repeat weekly as needed up to 3 times. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.
spinosyn	spinosad (Conserve SC)	4	Miticidal activity is due mainly to surfactants and other inert ingredients. Not recommended for use against mites unless control is also needed for other pests (caterpillars, leafminers, thrips) against which the active ingredient in this product is effective. Do not apply more than 10 times in a 12-month period. Do not apply more than 3 times in a row without rotating to a different chemistry. Compatible with most beneficials, but highly toxic to bees and hymenopteran parasites. Direct contact can cause significant mortality to <i>Phytoseiulus persimilis</i> .

# Spider Mite IPM

## MITICIDES

Class	Pesticide (brand name)	R.E.I.	Comments
Napthoquinone	Acequinocyl (Shuttle-O)	12	Rapid knock-down & residual control of all stages of mites. Easy on beneficials. Translaminar
Phosphorylation inhibitors	Chlorfenapyr (Pylon)	12	Broad spectrum miticide with translaminar activity
Tetronic Acid	Spiromesfen (Judo)	12	Mites & whiteflies. Feeding stops in 1-2 days. Dead in 4 to 10 days. Residual 21 to 30 days

# Banker Plants

## Banker Plants for Biological Control in Greenhouses

Sarah K. Wong and Steven D. Frank  
Entomology Department, North Carolina State University

### Introduction to Banker Plants

**Banker Plant:** "a plant that directly or indirectly provides resources, such as food, prey, or hosts, to natural enemies that are deliberately released within a cropping system" (Frank, S D 2009)

### The Problem

The Western Flower Thrips (*Frankliniella occidentalis*), shown at top right of diagram, is the most economically damaging pest in commercial greenhouses worldwide. Thrips affect ornamental, nut flower, and vegetable crops by causing aesthetic damage to fruits and leaves. Thrips also transmit deadly plant viruses and can reduce plant yield and quality. Thrips are especially difficult to control because they hide inside flowers and developing parts of buds and leaves where they are not exposed to insecticidal sprays. In addition, isolated populations of WFT have developed resistance to all commercially available insecticides.

### The Minute Pirate Bug – *Oryzias insidiosus*

One of the most popular biological control agents on the market for thrips management. A generalist predator that eats soft-bodied insects such as thrips, spider mites, and aphids. Also feeds on pollen which increases reproduction, prolongs survival, and decreases development time.

### Black Pearl Pepper Banker Plant (BPPbp)

*Capiscum annuum* black pearl.  
A hardy pepper with a woody stem, bright purple flowers, and black glossy leaves.  
Can be encouraged to produce flowers year round by pinching the top, midline peppers.

### Acknowledgements:

Authors: Karyn, Steve Frank, Lili, John Frank, John and Dr. Frank Research Group, James D. Frank, John and Dr. Frank Research Group, Dr. Frank D. Frank, D. Frank and John Frank, Dr. Frank Research Group.

### Preliminary Observations:

Preliminary greenhouse studies have shown that *O. insidiosus* abundance is greater when flowers are present (Fig. 1).

From this observation, we see that BPPbp is a suitable vegetative substrate for *O. insidiosus*. BPPbp's have the potential to sustain multiple generations of *O. insidiosus* when most or all prey have been consumed.

This could reduce the need for repetitive releases of *O. insidiosus* for thrips suppression.

Average *O. insidiosus* adult abundance in the presence and absence of flowers over six weeks

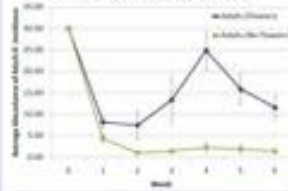


Figure 1. *Oryzias insidiosus* abundance over six weeks. 30 *O. insidiosus* were initially added to each BPPbp. A higher abundance of *O. insidiosus* was maintained on pepper plants with flowers (purple) than without flowers (green).

### Research Goals/Future Directions

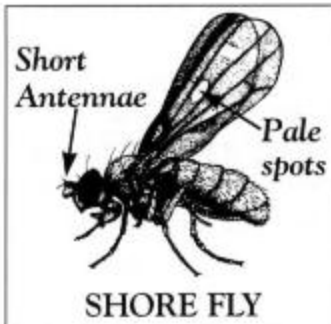
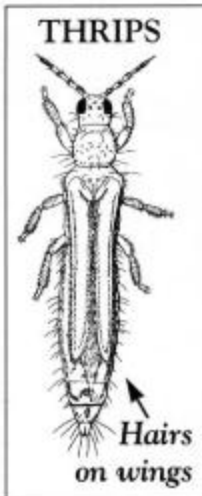
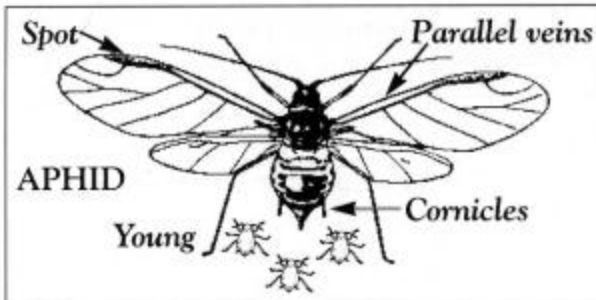
- 1) Determine how BPPbp plant affects *O. insidiosus* survival, development, and fecundity.
- 2) Determine how the BPPbp system works in a commercial greenhouse.
- 3) Optimize the BPPbp system for effective and sustainable thrips suppression in greenhouses.
- 4) Communicate to growers and scientists how the BPPbp system can be implemented in greenhouses for commercial and research purposes.



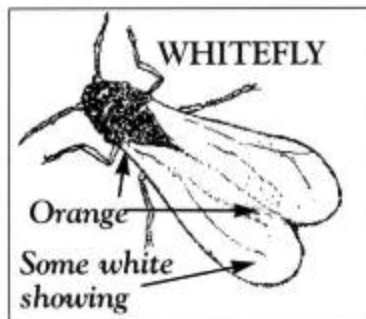
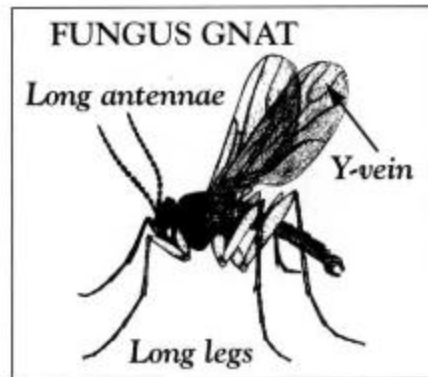
<http://mrec.ifas.ufl.edu/Iso/banker/Using-Bankers.html>



# Know thine enemy



From: Baker, J.R.  
1986. Insects on  
Sticky Traps 30(1)5-9.



Thank you and Questions Please