

# 2023 Cannabis Conference



**Las Vegas, NV**  
**August 17, 2023**



**Got Pests? Learn The Best Strategies  
For Preventing And Mitigating Pests**

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# Overview: What To Expect

\* Identification Of Pests

\* Scouting

\* Sanitation

\* Biological

\* Biopesticides

\* Questions And Discussion





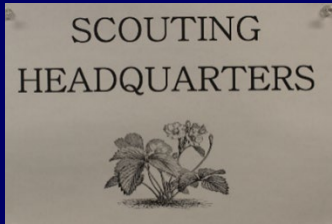
**Dealing With Pests In The “Front End” (Early In Production) Will Mitigate Having To Deal With Pests On The “Back End” (Later In Production): **Proactive Approach!****



**Once The Crop Is In Reproductive Mode (Phase) Then Options Are Limited Regarding Managing Insect And/Or Mite Pest Populations**

# Key Plant Protection Strategies That Need To Be Implemented To Prevent Or Mitigate Pest Problems

\* Identify insect and mite pests



\* Scout crop regularly

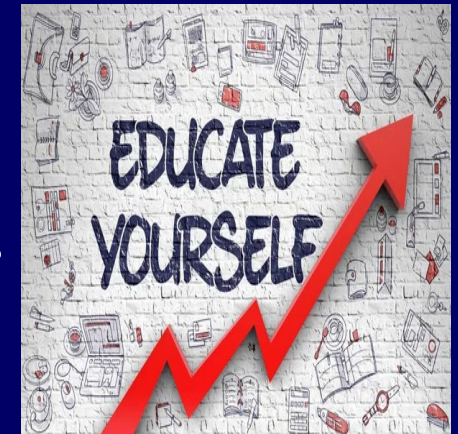


\* Implement sanitation practices

\* Establish a biological control

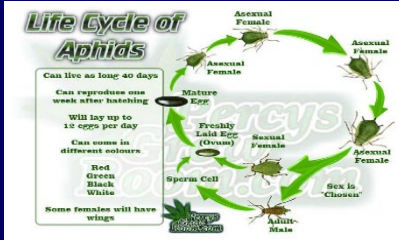
program

\* Educate yourself

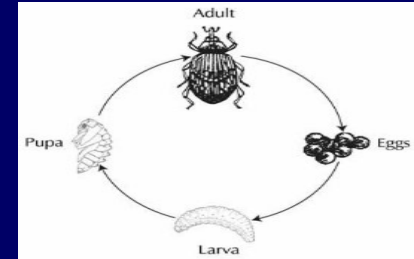


# Questions That You Need To Know

## Associated With Insect And Mite Pests



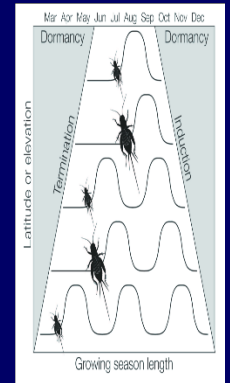
\* What is the life cycle?



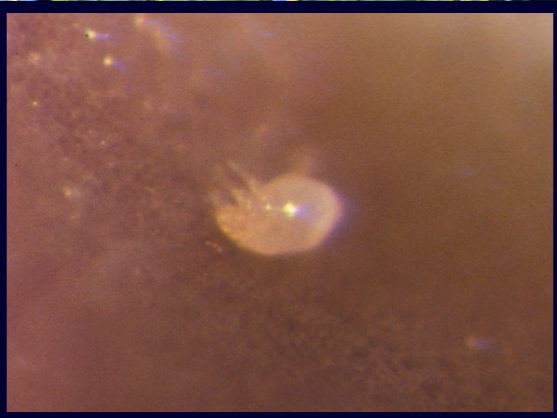
\* How many generations are there per year/cropping cycle?



\* What is the feeding damage?



\* What life stages are susceptible to biological control agents or pesticides?



# Insect And Mite Pests Of Cannabis Crops



\* Aphids (foliar-feeding)

\* Thrips



\* Twospotted spider mite

\* Hemp russet mite



\* Broad mite

\* Root aphids



\* Root mealybugs

\* Whiteflies



\* Fungus gnats





# Pests of Cannabis

## & How To Fight Back



### Cannabis Aphids

*Phorodon cannabis* - Similar in lifestyle to many of the other sap-sucking aphids in that they give live birth to multiple generations of females. If left unchecked, their numbers can quickly escalate and seriously impact plant growth, as well as vector virus.  
**Scouting Hint:** Check your fruity strains! Many of these aphids have moved from field production to indoor production in the last year.

#### Biocontrols:

Aphidoletes, Aphidius spp., Lacewings, Ladybugs and other native predators.



### Root Aphids

*Rhopalosiphum* spp. - Most commonly referred to as the Rice Root Aphid (which may vary in color but is often olive-red). Root Aphid infestations sometimes cause confusing symptoms that resemble nutrient deficiencies in the foliage.  
**Scouting Hint:** These pests feed on fresh root-hairs near drain holes of containers. When they sprout wings they end up in buds!

#### Biocontrols:

**Curative:**  
Drench with Botanigard/MAOX  
**Preventative:**  
PFR-97, Grandevo, Dalotia spp.



### Thrips

*Frankliniella occidentalis* - Known as Western Flower Thrips. Although poor fliers, they find their way eventually into most operations. Control is important, as this pest vectors viruses and diseases, but they are easy to control with natural solutions.  
**Scouting Hint:** Feeding damage on leaves is often confused with spider mites. Their rasping mouthparts leave silvery lines of dead plant cells.

#### Biocontrols:

*A. cucumeris*, *A. swirskii*, *Stratiolaelaps* spp., *Orius* spp., *Dalotia* spp., SF Nematodes



### Fungus Gnats

*Bradysia* spp. - Fungus Gnat larvae in the soil are damaging to root health, but adults (pictured) spread progeny and must also be controlled. Regular monitoring is the key to success, and the specifics of soil medium will dictate the best mechanisms for biological control. Unchecked, the winged adults will lead to contamination in indoor growing systems. **Scouting Hint:** Use sticky cards to monitor for adults.

#### Biocontrols:

**Curative:** Knockdown Drenches, PFR-97  
**Preventative:** *Stratiolaelaps* spp., *Dalotia* spp., SF & GH Nematodes



### Two-Spotted Spider Mites

*Tetranychus urticae* - Early preventative measures are key in order to avoid considerable plant stress and damage. One female can lay up to 20 eggs per day and can live for up to 4 weeks, contributing greatly to their proliferation.  
**Scouting Hint:** Feeding damage appears as stippling on leaves as they puncture plant cells. Unchecked, webbing develops, making curative biological control difficult.

#### Biocontrols:

Stethorus beetles, *P. persimilis*, *M. longipes*, *A. andersoni*, *A. fallacis*, *N. californicus*, *G. occidentalis*

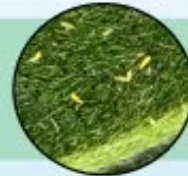


### Broad Mites

*Polyphagotarsonemus latus* - Broad Mites feed on plant juices by depositing toxic saliva, causing malformations and stunted growth. These translucent microscopic pests (adults measure 0.1-0.2mm) can be hard to spot, so determining level of infestation is difficult.  
**Scouting Hint:** Sample plants adjacent to those visibly damaged, as it can take weeks for damage to become visible and populations are known to relocate.

#### Biocontrols:

*A. swirskii*, *A. andersoni*, *N. californicus*, *A. fallacis*, *A. cucumeris*



### Hemp Russet Mites

*Acalaps cannabisicola* - Specific to Cannabis, they have evolved with this crop and can be insidious and difficult for growers to characterize. Ongoing preventative measures are imperative, as control is difficult. They feed on leaves and flower trichomes, causing populations to explode mid to late flowering and severely impacting cannabinoid values.  
**Scouting Hint:** Search for yellowing or deformation of growth.

#### Biocontrols:

*A. andersoni*, *G. occidentalis*, *N. californicus*, *A. fallacis*, *A. cucumeris*



### Powdery Mildew

*Podosphaera xanthii* - This fungal infection spreads quickly when humidity fluctuates. White fungal spots can spread rapidly, making controlling environmental conditions imperative. Left uncorrected, testing failures follow. Sanitation, hygiene, airflow and human movement need to be addressed.  
**Scouting Hint:** Monitor areas with cool temperature, high humidity and stagnant air closely.

#### Biocontrols:

Cease, Millstop (or Kalgreen), Actinovate, ZeroTol, Sil Matrix, Procidic 2



### Botrytis

*Botrytis cinerea* - Also known as "gray mold", Botrytis is a fungal disease seen near harvest time under moist conditions, particularly in dense buds. Air exchange is critical in arresting the spread of this airborne pathogen. Largely an environmental problem, this disease can quickly destroy a crop at harvest.  
**Scouting Hint:** Closely monitor crowded, humid areas for brown and gray discoloration.

#### Biocontrols:

Cease, Millstop (or Kalgreen), Actinovate, Zerotel, Sil Matrix, Procidic 2

\* Regulations on products vary by state. Please check your local restrictions.

Contact Sound Horticulture for further information, and allow our experts to assist you in designing the perfect biocontrol system for a fruitful harvest!

Additional Photography Courtesy: Rachel Thripas, Benjamin Disher PhD, University of Florida (Fungus Gnat)



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# Reproductive Capacity Of Certain Insect And Mite Pests Impacts Your Ability To Effectively Manage Insect And Mite Pest Populations: **‘Numbers Game’**



**Aphid**



**Twospotted Spider Mites**



**Aphid Reproduction (Parthenogenesis):  
'Numbers Game'**

# **‘Many’ Aphids Can Be Produced In A ‘Short’ Period Of Time**



**In 5 Generations, A Single Green Peach Aphid May Give Rise To  
13,552,028 Individual Aphids (Harrison, 1969)**

# Aphids On Underside Of Cannabis Leaf





**Twospotted Spider Mite Feeding Damage On Cannabis Leaves**

# The First Item Associated With Plant Protection Is To Establish A Reliable And Coordinated Scouting Program.





**Scouting Is Important In Determining The Presence And Trends Associated With Insect And Mite Pest Populations**



Scouting For Insect And Mite Pests Using The **Beat Method**, Which Will Help Determine Presence Or Absence Of Insect And/Or Mite Pests

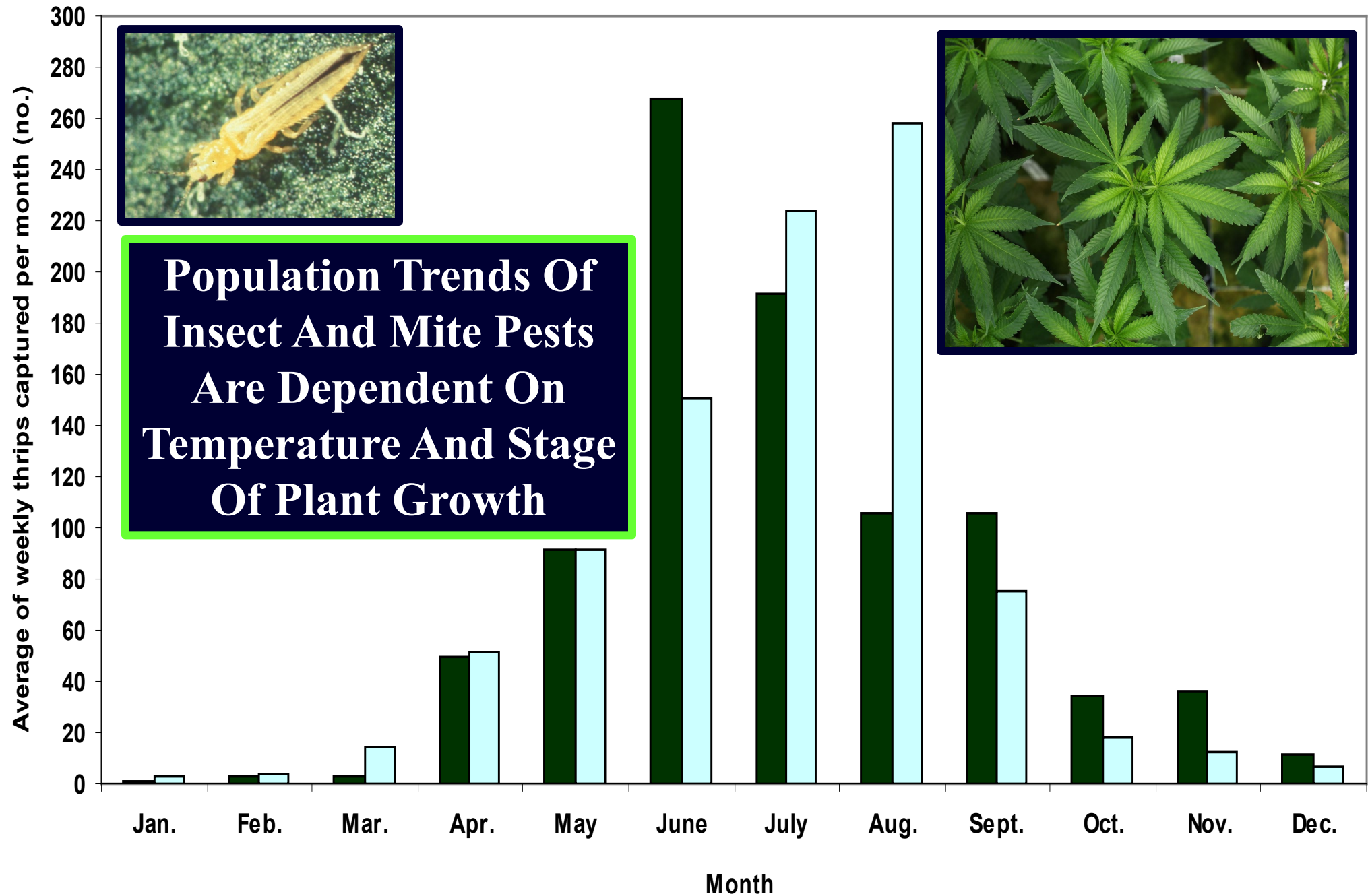




**Insect And Mite Pests Are Typically Located On Leaf Undersides.  
So, Look Under Leaves For The Presence Of Insect And Mite Pests**

**Use A 10- Or 16-Power Hand Lens To Observe Insect And Mite Pests On The Underside Of Leaves Or On A White/Black Sheet Of Paper When Scouting**





Mar - 4	4/1		0					
Apr - 1	4/9		0		0		Marigolds	
Apr - 2	4/14		24					
Apr - 3	4/21		13		17			
Apr - 4					21			

3 E

mo/wk	Date	Thrips	WF	Mites	F. Aphids	Aphids	Plant	Treatment
Mar - 1	3/13						<del>Marigolds</del>	
Mar - 2	3/17						Cali	
Mar - 3	3/24						<del>Bidens</del>	
Mar - 4	4/1	0						
Apr - 1	4/9	0					Callie	
Apr - 2	4/14	20			21			
Apr - 3	4/21	13			9			
Apr - 4								

4 E

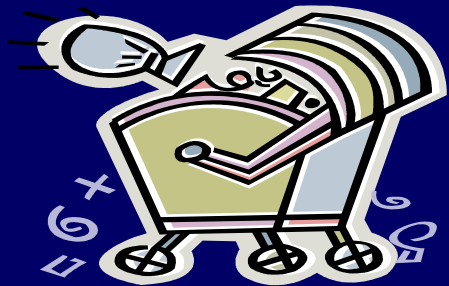
mo/wk	Date	Thrips	WF	Mites	F. Aphids	Aphids	Plant	Treatment
Mar - 1	3/13						<del>Vinca Vine</del>	
Mar - 2	3/17							
Mar - 3	3/24							
Mar - 4	4/1	0					Callie	
Apr - 1	4/9	0						
Apr - 2	4/14	28			20			
Apr - 3	4/21	10			11			
Apr - 4								

**Record-Keeping Data Sheets**



**This Is What Can Happen If You Do Not Scout Regularly For Insect And Mite Pests, Such As; Twospotted Spider Mite, *Tetranychus urticae***

**The First Line Of Defense  
Against Insect And Mite  
Pests, And Plant Diseases  
Involves Implementing  
Appropriate Sanitation  
Practices**



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Greenhouse Management / November 2015

## Sanitation: the first line of defense

Features - Pest & Disease

Proper practices can reduce insect and mite pests and disease difficulties.

November 24, 2015

Raymond Cloyd







## Greenhouse sanitation is the first step in managing pests and pathogens

Following these simple sanitation protocols may help greenhouse businesses prevent pest outbreaks.

September 8, 2014 - Author: [Kristin Getter, Michigan State University Extension](#), Department of Horticulture

In light of recent floriculture disease outbreaks during the last two production years (see these [Michigan State University Extension](#) articles: "[Impatiens downy mildew: Outbreaks reported in Michigan and nearby states](#)" and "[Common questions and answers about tobacco mosaic virus](#)"), now may be a good time to review your greenhouse sanitation protocols.



# **Fundamentals Of Greenhouse Sanitation**

- \* Place all debris into refuse containers with tight-sealing lids or dispose of debris into dumpsters or 'compost piles.'
- \* **Eliminate algae from benches and floors.**
- \* Remove undesirable plants (weeds), and plant and growing medium debris.
- \* **Dispose of old stock plants or any left-over plant material.**
- \* Clean plant containers thoroughly if they are to be re-used.

# Top Five Sanitation Tips

1. **Throw Away Dead Plants**

2. **Pick-Up All Plant And Leaf Litter**

3. **Clean Filters**

4. **Use Filtered Water**

5. **Clean Bench Surfaces, Tools, And Containers**

**Top Five Sanitation Tips**  
**Sanidad: Los 5 consejos más importantes**

- Throw away dead plants in a garbage bin with a cover, and empty the garbage bin frequently.



Tire las plantas muertas en un bote de basura con tapa. Desocúpelo frecuentemente.
- Do not leave parts of the plant or leaf litter behind.



No deje tiradas hojas o partes de las plantas.
- Clean your filters. (If using self-cleaning water filters, check to make sure they are working properly.)



Limpie los filtros. (Si son filtros que se limpian solos, reviselos y asegúrese de que están trabajando correctamente.)
- Use filtered water on plants and surfaces to reduce disease inoculum.



Use agua filtrada en plantas y superficies para reducir enfermedades.
- Clean surface of benches, tools, and pots with chlorine bleach or other sterilizing agent.



Limpie la superficie de bancas, las herramientas y los recipientes con cloro u otro desinfectante.

syngenta

Implementing A **Proper Sanitation Program** Can Reduce Problems With Insect And Mite Pests, And Plant Pathogens (Fungi And Bacteria)



# Concrete Flooring Can Alleviate Problems With Algae And Weeds



# Extension Publication

## Sanitation Insect Pest Management In Greenhouse Production Systems (MF3592 September 2021)

<http://bookstore.ksre.ksu.edu/pubs/MF3592.pdf>



Sanitation is a component of a plant-protection program that involves maintaining a clean work environment by removing weeds and disposing of plant and growing-medium debris. When performed with insecticide applications or the release of biological control agents (parasitoids and predators), sanitation helps alleviate insect pest problems and prevent damage to ornamental and vegetable crops grown in greenhouse production systems.

This publication provides information on three sanitation practices that will help greenhouse producers minimize problems with insect pests: weed management, disposal of plant and growing medium debris, and algae management.

### Weed Management

Weeds may harbor insect pests including aphids, leafhoppers, mealybugs, thrips, and whiteflies. Weed seeds can enter greenhouses via wind currents through vents, doors, and sidewalls. In addition, weed seeds can be transported on plant material, tools, equipment, and personnel. Weeds growing under benches (Figure 1) or in containers can



Figure 1. Weeds underneath bench in greenhouse. (Photo: Raymond Cloyd)

serve as hosts for insect pest populations that can damage crops. The weed species, growth stage (vegetative vs. flowering), and density of weeds in the greenhouse influence the types and numbers of insects present.

Weeds can harbor diseases such as viruses, which are transmitted by aphids, leafhoppers, thrips, and/or whiteflies. These pests feed on weeds before moving to the main horticultural crops. For example, weeds located under benches or in planting beds or containers may harbor the tospoviruses, *Impatiens necrotic spot virus* and *Tomato spotted wilt virus*, that are transmitted by western flower thrips, *Frankliniella occidentalis*, adults. Weeds that serve as a source of *Impatiens necrotic spot virus* are presented in Table 1.

Weeds should be removed from all areas within the greenhouse. In addition, weeds should be removed from around the greenhouse perimeter (at least five feet) to alleviate problems with insects that vector viruses. Removing weeds that serve as hosts for both insect pests and viruses reduces the potential for insect pests to migrate into a greenhouse, attack the main crops, and transmit plant viruses.

Table 1. Common name and scientific name of weeds that serve as a source of *Impatiens necrotic spot virus*.

Common name	Scientific name
Annual sow thistle	<i>Sonchus oleraceus</i>
Bittercress	<i>Barbarea vulgaris</i>
Burning nettle	<i>Urtica urens</i>
Chickweed	<i>Stellaria media</i>
Field bindweed	<i>Convolvulus arvensis</i>
Gill-over-the-ground	<i>Glechoma hederacea</i>
Jewelweed	<i>Impatiens capensis</i>
Common lambsquarters	<i>Chenopodium album</i>
Little mallow	<i>Malva parviflora</i>
Nettleleaf goosefoot	<i>Chenopodium murale</i>
Common purslane	<i>Portulaca oleracea</i>
Shepherd's purse	<i>Capsella bursa-pastoris</i>
Shortpod mustard	<i>Hirschfeldia incana</i>
Wood sorrel	<i>Oxalis spp.</i>

# Types Of Biological Control Agents

- Parasitoids

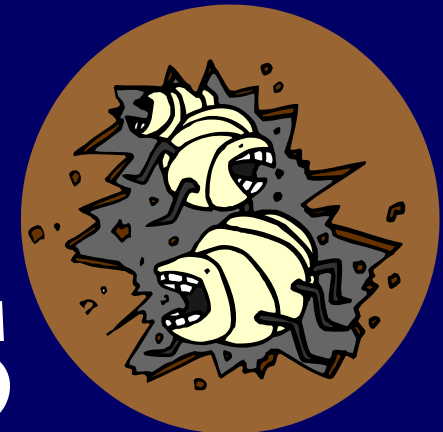


- Predators



- Beneficial

Nematodes



**Parasitoid**



**Predatory Mite**



**Beneficial Nematodes**



**Types Of  
Biological  
Control Agents**



# A Wide-Variety Of Biological Control Agents, Such As; Parasitoids And Predators Are Commercially Available From Distributors Or Suppliers

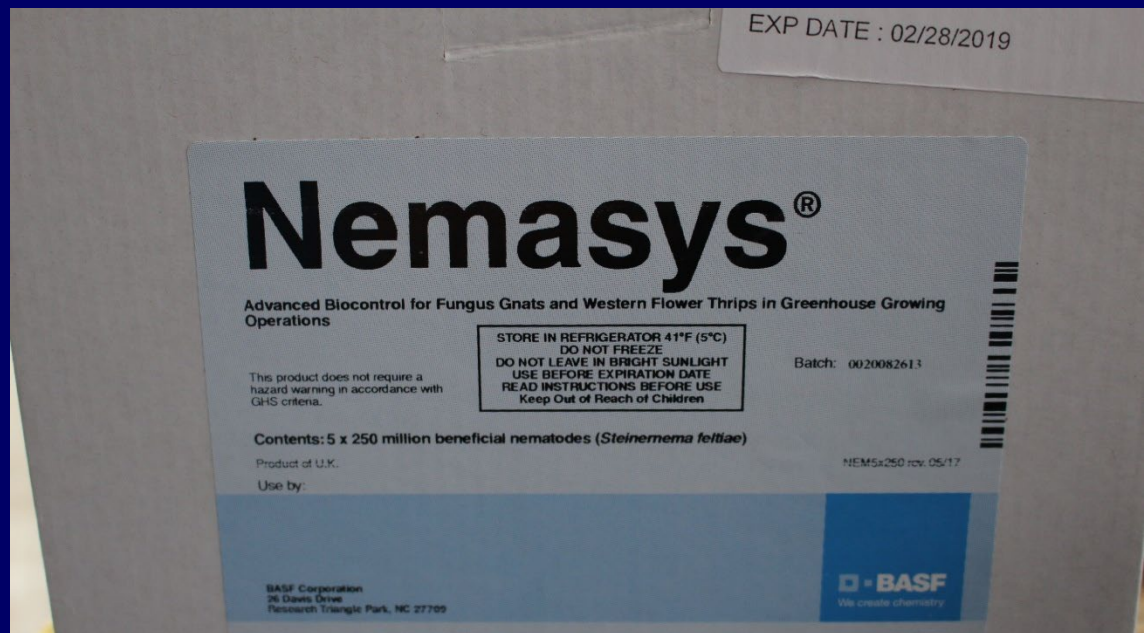




**Aphid Parasitoid (*Aphidius ervi*)**



**Container Of Rove Beetles (*Dalotia coriaria*)**

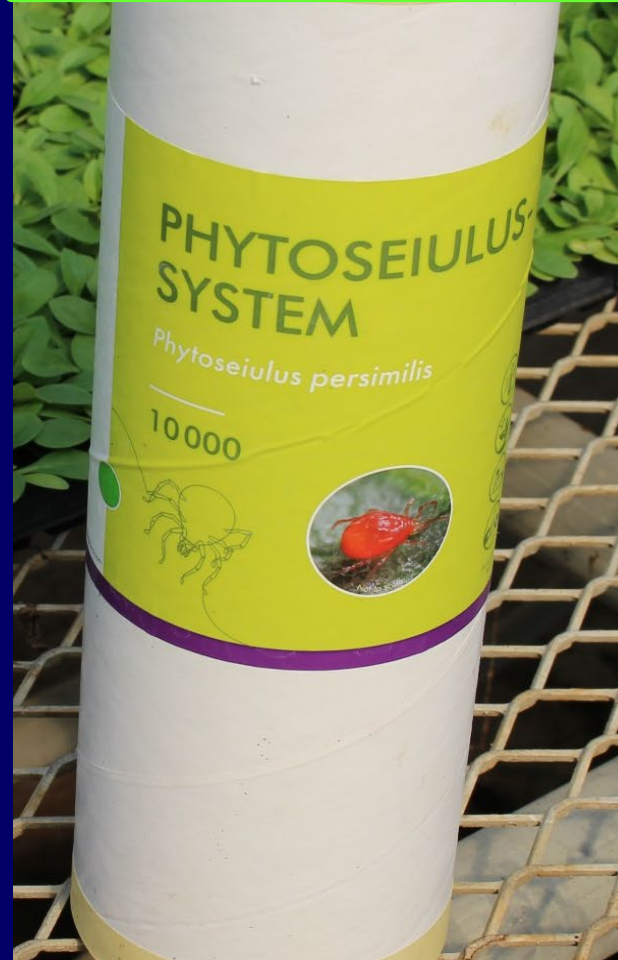


**Beneficial Nematode (*Steinernema feltiae*)**

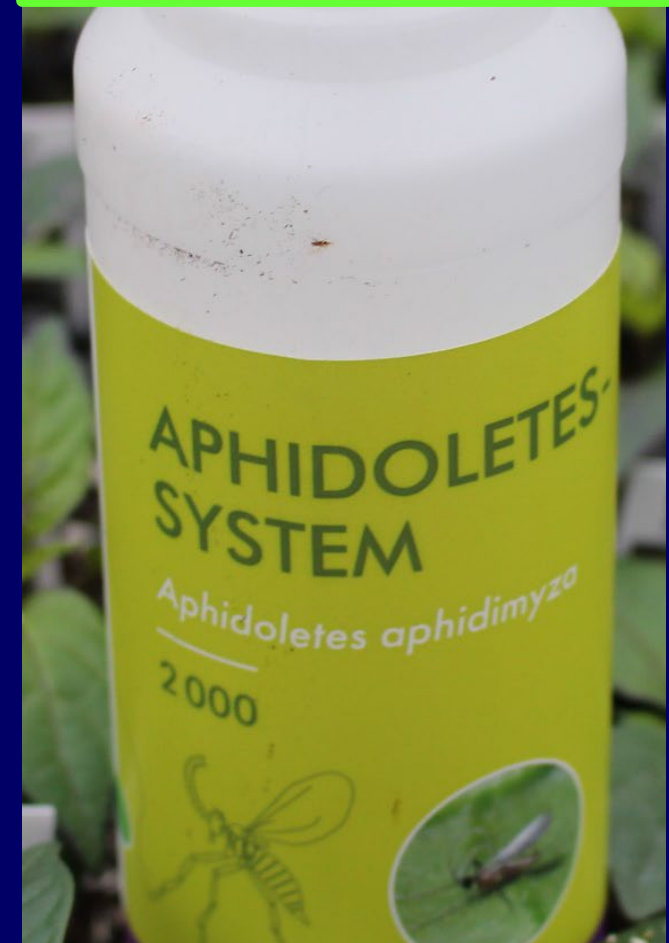
*Chrysopa carnea*



*Phytoseiulus persimilis*



*Aphidoletes aphidimyza*



**Containers Of Different Biological Control Agents**

**Table 1. Predators and Parasitic Wasps Commercially Available for Insect Pest Management in Fruits and Vegetables**

Target Insect	Biological Control Agent	Common Name	Mode of Action	Examples of Suppliers & Products	
				Koppert Biological Systems	Syngenta-Bioline
<b>Aphid</b>	<i>Adalia bipunctata</i>	Lady beetle	Predator	Aphidalia	Adalline b
	<i>Aphidoletes aphidimyza</i>	Gall midge	Predator	Aphidend	Aphidoline
	<i>Chrysoperla carnea</i>	Lacewing	Predator	Chrysopa	Chrysoline c
	<i>Episyrphus balteatus</i>	Syrphid fly	Predator	Syrphidend	-
	<i>Aphelinus abdominalis</i>	Parasitic wasp	Internal parasite	Aphlin	Apheline
	<i>Aphidius colemani</i>	Parasitic wasp	Internal parasite	Ahipar	Aphiline c
<b>Leafminer</b>	<i>Dacnusa sibirica</i>	Parasitic wasp	Internal parasite	Diminex	Dacdigline
	<i>Diglyphus isaea</i>	Parasitic wasp	Internal parasite	Miglyphus	Digline i
<b>Mealy bug</b>	<i>Anagurus pseudococci</i>	Parasitic wasp	Internal parasite	Citripar	-
	<i>Leptomastix dactylopii</i>	Parasitic wasp	Internal parasite	Leptopar	-
	<i>Coccidoxenoides perminutus</i>	Parasitic wasp	Internal parasite	Planopar	-
	<i>Cryptolaemus montrouzieri</i>	Predatory beetle	Predator	Cryptobug	Cryptoline m
<b>Caterpillars</b>	<i>Hypoaspis aculifer</i>	Predatory mite	Predator	Entomite A	-
	<i>Macrolophus caliginosus</i>	Predatory bug	Predator	Mirical	Macroline
	<i>Trichogramma brassicae</i>	Parasitic wasp	Internal parasite	Tricho-strip	Tricholine
<b>Spider mite</b>	<i>Macrolophus caliginosus</i>	Predatory bug	Predator	Mirical	Macroline
	<i>Amblyseius californicus</i>	Predatory mite	Predator	Spical	Amblyline
	<i>Feltiella acarisuga</i>	Gall midge	Predator	Spidend	-
	<i>Phytoseiulus persimilis</i>	Predatory mite	Predator	Spidex	Phytoline
<b>Thrips</b>	<i>Hypoaspis miles</i>	Predatory mite	Predator	Entomite m	Hypoline m
	<i>Amblyseius swirskii</i>	Predatory mite	Predator	Swirski-mite	Bugline s
	<i>Orius insidiosus</i>	Predatory bug	Predator	Thripor - I	Oriline i
	<i>Orius majusculus</i>	Predatory bug	Predator	-	Oriline m
<b>Whitefly</b>	<i>Eretmocerus eremicus</i>	Parasitic wasp	Internal parasite	Ercal	Eretline e
	<i>Eretmocerus eremicus</i> + <i>Eretmocerus mundus</i>	Parasitic wasp	Internal parasites	Bemimix	-
	<i>Encarsia formosa</i>	Parasitic wasp	Internal parasite	En-Strip	Encarline
	<i>Encarsia formosa</i> + <i>Eretmocerus eremicus</i>	Parasitic wasp	Parasite premix	Enermix	-
	<i>Amblyseius swirskii</i>	Predatory mite	Predator	Swirski-mite	Bugline s

# COMMONLY USED PREDATORY MITES FOR GREENHOUSE BIOLOGICAL CONTROL



*Neoseiulus (Amblyseius) cucumeris*

- Target pest: Thrips immatures, spider mites.
- Tan-yellowish; survives on pollen and spider mites in the absence of thrips.



*Phytoseiulus persimilis*

- Target pest: Spider mites (all stages).
- Bright red-orange; fast-moving; very high predation rate.



*Hypoaspis miles & Hypoaspis aculeifer*

- Target pest: Fungus gnat and thrips larvae and pupae; shorefly larvae.
- Dark tan above, light tan below; soil-dwelling.



*Neoseiulus (Amblyseius) californicus*

- Target pest: Spider mite, broad mite, cyclamen mite.
- Pear shape; clear to pale yellowish-orange; slower predation rate; also survives on pollen.



*Neoseiulus (Amblyseius) fallacis*

- Target pest: Spider mite, russet mite, European red mite, cyclamen mite.
- Pear shape; clear until it feeds on prey; high predation rate; survives on pollen without prey.



*Amblyseius swirskii*

- Target pest: Thrips larvae and whitefly eggs and immatures.
- Whitish; high predation rate; works in cool winter months; can survive on pollen.

# Biological Control Agents For Aphids: **Parasitoids** *(Aphidius colemani, Aphidius ervi, Aphidius matricariae, and Aphelinus abdominalis)*

Table 1. Commercially available aphid parasitoids and the aphid species they will attack.

Parasitoid	Aphid Species			
	Green Peach Aphid	Melon/Cotton Aphid	Potato Aphid	Foxglove Aphid
<i>Aphidius ervi</i>			X	X
<i>Aphidius colemani</i>	X	X		
<i>Aphidius matricariae</i>	X	X		
<i>Aphelinus abdominalis</i>			X	X

## Western Flower Thrips Life Cycle

What Life Stages Do Biological Control Agents Prey Upon?

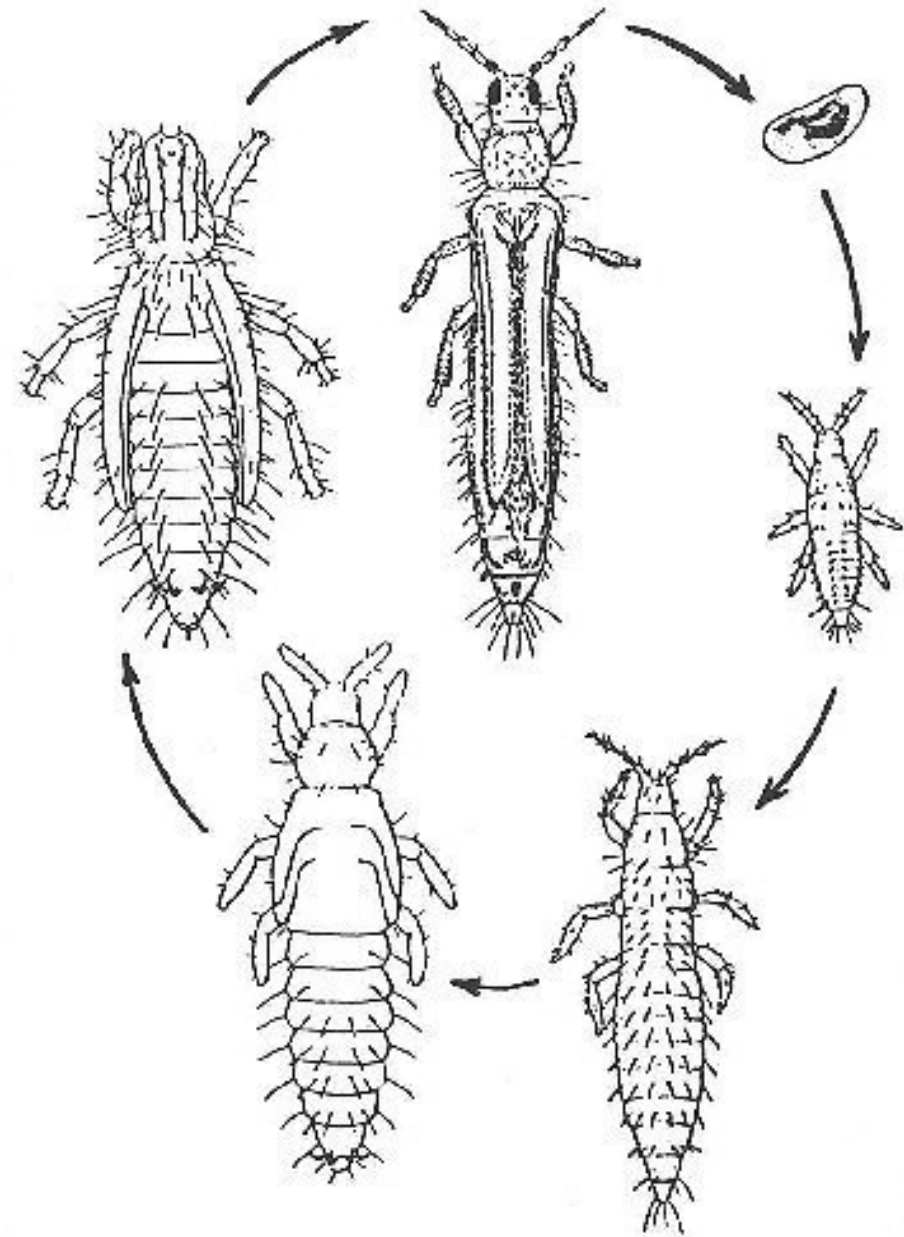
\* *Neoseiulus (Amblyseius) cucumeris*: 1<sup>st</sup> Instar Larva

\* *Amblyseius swirskii*: 1<sup>st</sup> (and maybe 2<sup>nd</sup>) Instar Larva

\* *Orius insidiosus*: 1<sup>st</sup>, 2<sup>nd</sup> Instar Larvae, and Adult

\* *Stratiolaelaps scimitus*  
(‘*Hypoaspis miles*’): Pupae

\* *Dalotia (Atheta) coriaria*: Pupae





**Releasing Predatory Mites Among A Crop  
Using Sachets**



# What are Biopesticides?

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations.

[View a list of biopesticide active ingredients.](#)

On this page:

- [Classes of biopesticides](#)
- [Advantages of using biopesticides](#)
- [How EPA encourages the development and use of biopesticides](#)
- [For more information](#)

# Biopesticides

- Biopesticides are types of pesticides that are derived from natural materials; such as, animals, plants, bacteria, and certain minerals.

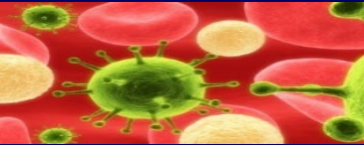




- Biopesticides are categorized into three major classes:

- Microbial pesticides
- Plant-incorporated protectants
- Biochemical pesticides



# Biopesticide Classes

- Microbial pesticides (or mycoinsecticides): consist of a microorganism as the active ingredient (e.g. fungus, bacterium, virus, or protozoa) that is highly selective in activity against specific target insect pests. 
- Plant-incorporated protectants: substances that plants produce based on genetic material that is incorporated into plants. 
- Biochemical pesticides: naturally occurring substances such as semiochemicals that control insect pests by non-toxic mechanisms (e.g. insect sex pheromones). 

Bacteria

Bacillus thuringiensis

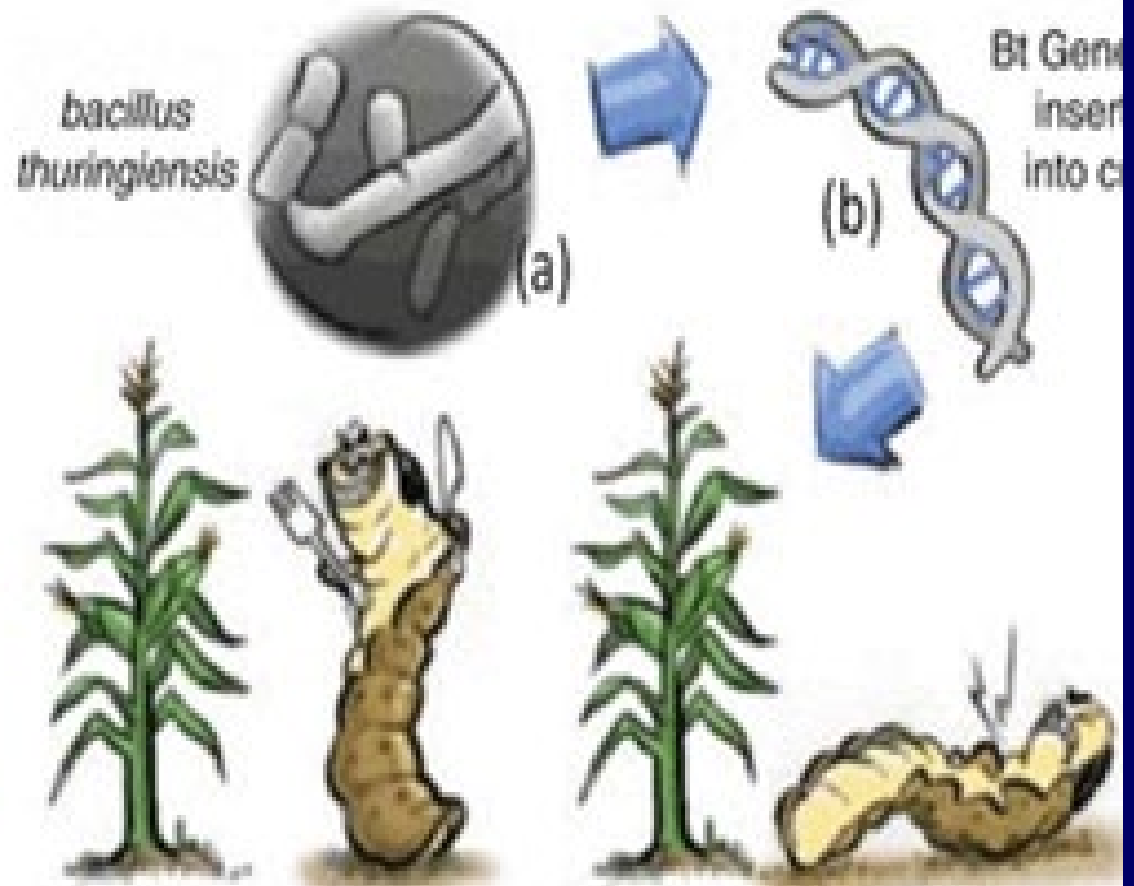
## Plant Incorporated protectants (PIP)

Microbial  
Pesticides

Biopesticide:

Biochemical  
Pesticides

Biological Control  
Agent



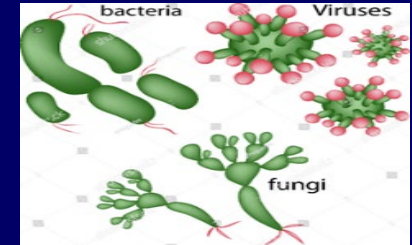
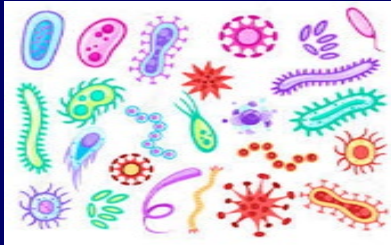
# Characteristics Of Biopesticides



- \* Narrow target pest activity
- \* **Complex modes of action**
- \* Timing of application is critical
- \* **Limited residual activity (persistence)**
- \* Safe to environment and humans
- \* **Influenced by environmental conditions (temperature, relative humidity, day length, and light intensity)**

# Advantages Of Biopesticides

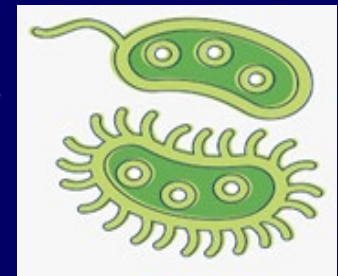
\* Less toxic than conventional pesticides



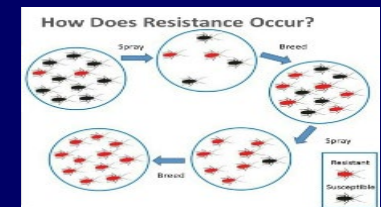
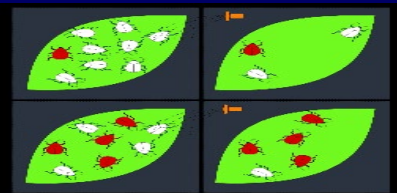
\* Narrow-spectrum of pest activity



\* Short residual activity

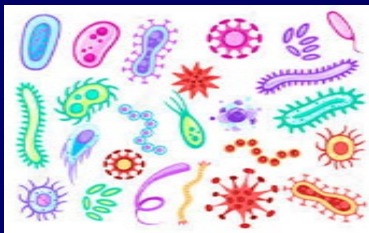


\* Less susceptible to resistance development



# Disadvantages Of Biopesticides

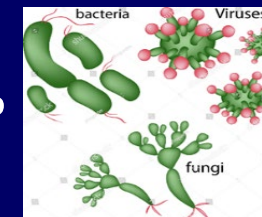
\* Slower rate of kill compared to conventional pesticides



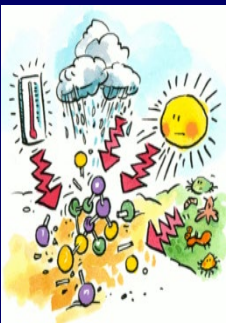
\* **Narrow-spectrum of pest activity**



\* Short residual activity or persistence in the environment



\* **Susceptible to unfavorable environmental conditions**



# General Characteristics Of Microbial Pesticides

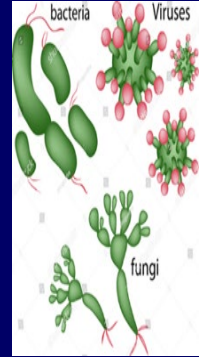
- Short-residual activity.
- Sensitive to ultra-violet (sunlight) degradation and rainfall.
- Primarily active on the young (immature) stages of insect pests.
- Less harmful to biological control agents such as parasitoids and predators compared to conventional pesticides.
- In general, low mammalian toxicity.
- Usually takes longer to kill insect pests.

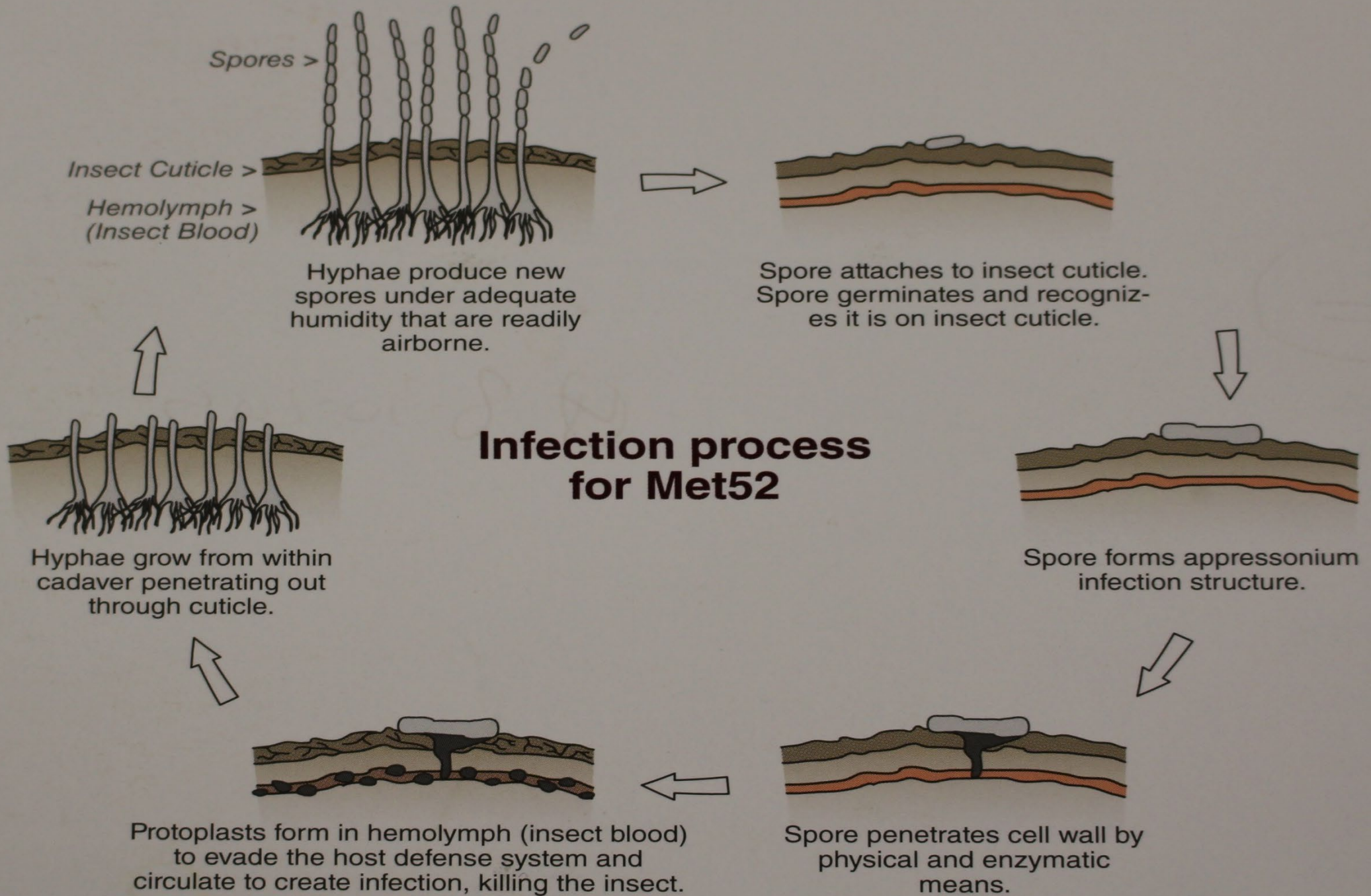




# Difference Between Bacteria And Fungi

- **Bacteria**: have to be consumed (stomach poison) to be effective. Cause septicemia, which results in death of insect pests.
- **Fungi**: can directly penetrate through the insect cuticle and initiate an infection. Use a combination of enzymes and mechanical pressure to penetrate the insect cuticle. The entomopathogenic fungus grows into and proliferates within the hemolymph (blood or body cavity) of an insect pest. Death occurs within 4 to 7 days.

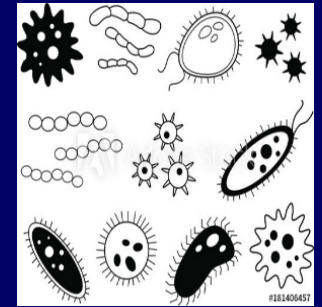




# Commercially Available Microbially-Based Entomopathogenic Fungi



\* *Beauveria bassiana* Strain GHA  
(BotaniGard/Mycotrol)

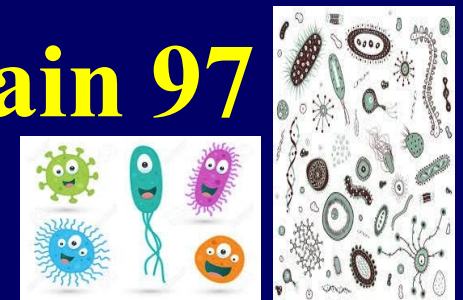
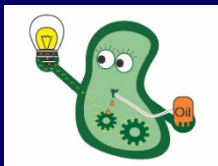


\* *Beauveria bassiana* strain PPRI 5339 (Velifer)

\* *Isaria fumosoroseus* Strain FE 9901 (NoFly)



\* *Isaria fumosorosea* Apopka Strain 97  
(Ancora)



\* *Metarhizium brunneum* (=anisopliae) (Met52)



For use in controlling Whitefly, Aphids, Thrips, Psyllids, Mealybugs, Leafhoppers, Weevils, Plant Bugs, Borers and Leaf-feeding Insects in Field, Agronomic, Vegetable and Orchard Crops; Grasshoppers, Mormon Crickets, Locusts and Beetles in Rangeland, Improved Pastures and Agronomic Crops; Whitefly, Aphids, Thrips, Psyllids and Mealybugs in Vegetables and Ornamentals grown in Indoor/Outdoor Nursery, Greenhouse, and Shadehouse.

Active Ingredient: <i>Beauveria bassiana</i> Strain GHA .....	10.9%*
Inert Ingredients: .....	89.1%
Total: .....	<u>100.0%</u>

\*Based on the weight estimate of  $4.78 \times 10^{-12}$  grams per spore.  
Mycotrol O contains  $2 \times 10^{13}$  viable spores per quart.

**KEEP OUT OF THE REACH OF CHILDREN**

**Store between  
40°F and 85°F**

**CAUTION**

**SHAKE WELL**



# Mycotrol<sup>®</sup> WPO

WETTABLE POWDER MYCOINSECTICIDE

For use in controlling Whitefly, Aphids, Thrips, Psyllids, Weevils and Mealybugs in Ornamentals and Vegetables, Indoor/Outdoor Nursery, Greenhouse, Shadehouse, Commercial Landscape, Interiorscape and Turf.

Active Ingredient: <i>Beauveria bassiana</i> Strain GHA.....	22.0%*
Inert Ingredients:.....	78.0%**
	Total 100.0%

\*Based on the weight estimate of  $4.78 \times 10^{-11}$  grams per spore.

\*\*Contains petroleum distillates.

MYCOTROL WPO contains  $2 \times 10^{13}$  viable spores per pound.

**KEEP OUT OF THE REACH OF CHILDREN**

**Store between  
40°F and 85°F**

## CAUTION

See additional precautionary statements and first aid statements in attached booklet.



### LAM INTERNATIONAL CORPORATION

117 S. Parkmont; P.O. Box 4109-Butte, MT 59702; Ph: (406)782-2386; Fax: (406) 782-9912  
EPA Registration Number 82074-2 EPA Establishment Number 65626-MT-02

Edition:  
Net Contents: One Pound

Lot No.:  
Expiration Date:





We create chemistry

SPECIMEN

# Velifer™

## Fungal Contact Insecticide/Miticide

**Oil Dispersion Spore Concentrate of *Beauveria bassiana* strain PPRI 5339**

**For biological control of the labeled piercing and sucking insect or mite pests in enclosed commercial greenhouses on ornamentals, fruits, vegetables, herbs and spices, including vegetable, fruit, herb, and spice transplants for the consumer market**

**Active Ingredient:**

*Beauveria bassiana* strain PPRI 5339\* ..... 8.00%

**Other Ingredients:** ..... 92.00%

**Total:** ..... 100.00%

\*Velifer contains a minimum of  $8 \times 10^8$  viable spores per mL.

EPA Reg. No. 71840-22

EPA Est. No. 67064-ZAF-001

**KEEP OUT OF REACH OF CHILDREN  
CAUTION/PRECAUCIÓN**

It is a violation of federal law to use this product in a manner inconsistent with its labeling. **DO NOT** apply this

**Velifer™** is a broad spectrum biological insecticide/miticide used for biological control of aphids,

2

mealybugs, mites, thrips, and whiteflies on ornamentals, fruits, vegetables, herbs, and spices grown in enclosed commercial greenhouses. This includes commercial production of fruit, vegetable, herb, and spice transplants for the consumer market.

The use of additives or spray adjuvants is not required when making an application of **Velifer**. Always test proposed tank mixes on a small group of representative plants prior to large-scale use.

When tank mixing **Velifer** with any other product

See inside for full instructions



# BioCeres<sup>®</sup> WP

**BIOLOGICAL MYCOINSECTICIDE**

**WETTABLE POWDER | AGRICULTURAL CROP USE**

Active Ingredient: *Beauveria bassiana* strain ANT-03.....20.0%  
Other Ingredients:.....80.0%  
Total:.....100.0%

Contains a minimum of  $1 \times 10^6$  cfu/gram.

EPA Est. No.: 89600-CAN-001

EPA Reg. No.: 89600-2

V1-091515 1610-0

Manufactured by:

Anatis Bioprotection Inc.

278, rang Saint-André

St-Jacques-le-Mineur, Québec J0J 1Z0, Canada

**KEEP OUT OF REACH OF CHILDREN  
CAUTION**

#### FIRST AID

<b>If in eyes</b>	<ul style="list-style-type: none"><li>• Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.</li><li>• Call a poison control center or doctor for treatment advice.</li></ul>
<b>If inhaled</b>	<ul style="list-style-type: none"><li>• Move person to fresh air.</li><li>• If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.</li><li>• Call a poison control center or doctor for further treatment advice.</li></ul>
<b>If swallowed</b>	<ul style="list-style-type: none"><li>• Call a poison control center or doctor immediately for treatment advice.</li><li>• Have person sip a glass of water if able to swallow.</li><li>• Do not induce vomiting unless told to do so by the poison control center or doctor.</li><li>• Do not give anything by mouth to an unconscious person.</li></ul>

#### HOTLINE NUMBER

Have the product container or label with you when calling a poison control center, doctor, or other person for treatment. You may also contact 1-800-222-1222 for emergency medical treatment information.

Store between 45°F and 85°F

Net Weight: 1 lb.





# Wettable Powder Mycoinsecticide

For Greenhouse Use Only

**ACTIVE INGREDIENT:**

<i>Paecilomyces fumosoroseus</i> strain FE 9901 .....	18.0%*
Inert Ingredients.....	82.0%
Total.....	100.0%

\* Contains a minimum of  $2 \times 10^9$  colony forming units of *Paecilomyces fumosoroseus* strain FE 9901 per gram (Dry Weight Basis)

**KEEP OUT OF REACH OF CHILDREN  
CAUTION**

See back panel for additional precautionary statements

**FIRST AID**

**If inhaled:**

- Move person to fresh air.
- If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.
- Call a poison control center or doctor for treatment advice.

**If on skin or clothing:**

- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15 – 20 minutes.
- Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

EPA Reg. No.: 73314-6  
EPA Est. No.: 73314-TX-001

Net Contents: 2-lbs (912 g)

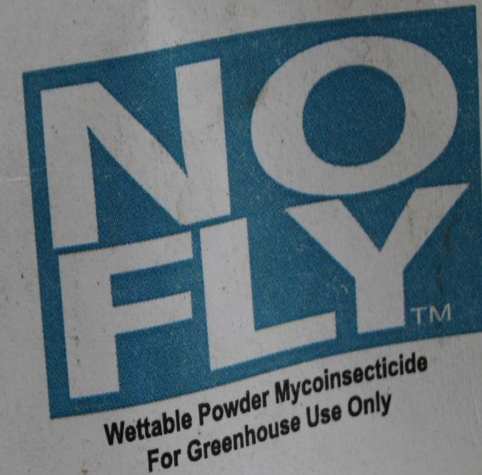
**Manufactured by:**  
Natural Industries, Inc.  
12320 Cutten Rd  
Spring, TX 77066

Lot Number:  
Best If Used By: 3 months from  
manufacturing date



May be used in organic production.

For use in controlling Whitefly, Aphids, Thrips, Psyllids, Mealybugs, Leaf hoppers, Plant bugs, Weevils, Grasshoppers, Mormon Crickets, Locust, Beetles and Fungus Gnats on non-food crops and ornamentals in greenhouse.



**ACTIVE INGREDIENT:**

<i>Paecilomyces fumosoroseus</i> strain FE 9901, blastospores .....	18.0%
Inert Ingredients.....	82.0%
Total.....	100.0%

\*Based on the weight estimate of  $4.0 \times 10^{12}$  grams per blastospore  
NoFly™ WP contains  $2 \times 10^9$  colony forming units of *Paecilomyces fumosoroseus* strain FE 9901

**KEEP OUT OF REACH OF CHILDREN  
CAUTION**

See back panel for additional precautionary statements

**FIRST AID**

- Move person to fresh air.
- If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.
- Call a poison control center or doctor for treatment advice.

# PFR-97™ 20% WDG

## MICROBIAL INSECTICIDE

For the Control of insect pests on Ornamental Plants Grown in Greenhouses and Nurseries.

Do not apply to food crops.

This bag will treat up to 0.3 acre when used at the highest application rate.

**Active Ingredient:**

*Paecilomyces fumosoroseus* ..... 20%\*

**Other Ingredients:** ..... 80%

**Total** ..... 100%

\* Contains 1 x 10<sup>9</sup> CFU/g Apopka Strain 97 (ATCC 20874) (equivalent to 0.014% technical grade active ingredient)

**KEEP OUT OF REACH OF CHILDREN  
CAUTION**

Net Contents: 1 pound

EPA Reg. No. 70051-19

EPA Est. No. 70051-CA-001

Lot No:

03 2011  
90820831

# ANCORA™

Microbial Insecticide

## FOR ORGANIC PRODUCTION

For control of insect and mite pests on vegetables, fruits, ornamental plants grown in greenhouses or other cover, or in nurseries.

### ACTIVE INGREDIENT:

*Isaria fumosorosea* Apopka Strain 97 (ATCC 20874)  
(formerly *Paecilomyces fumosoroseus*) . . . . .

20%\*

### OTHER INGREDIENTS: . . . . .

80%

### TOTAL: . . . . .

100%

\*Contains  $1 \times 10^9$  CFU/g (equivalent to 1.4% technical grade active ingredient)

EPA Reg. No. 70051-19-59807

EPA Est. No. 70051-CA-001

**KEEP OUT OF REACH OF CHILDREN**  
**CAUTION**

## GREENHOUSES (AND OTHER COVER), NURSERIES, AND LANDSCAPES *(continued)*

### Foliar (Spray) Application

For control of whiteflies (*Bemisia* and *Trialeuroides* spp.), aphids, thrips, spider mites, leafminers (*Liriomyza* spp.), citrus leafminers, mealybugs, psyllids, and plant bugs (*Lygus* spp.)

Apply to plants using pressurized spray equipment (such as backpack sprayer, tractor-mounted spray boom, hand-held spray gun or wand) mist-blower, cold fogger, electrostatic, or other applicator.

Spray sufficient volume to achieve thorough coverage of leaves, flowers, fruit, and other above-ground plant parts with minimal run-off.

### Soil Application

To control black vine weevil and other root weevils, crown weevils, thrips pupae, rootworms, wireworms, Coleoptera grubs and larvae, Lepidoptera caterpillars and larvae

**Drench application:** Apply suspension as a drench of 4 fluid ounces per pot for pots up to 6" diameter, or 8 fl oz for pots up to 12" diameter. For pots larger than 12" in diameter, apply 1 pint of drench per pot.

**Soil surface spray:** Spray the suspension on the soil surface. If targeting rootfeeding insects, follow immediately by sufficient water from a watering can, hose, or overhead sprinkler irrigation to carry the spores into the root zone.

**Chemigation: ANCORA** may also be applied through drip or trickle chemigation. Mix in water as described above and apply using standard injection equipment to introduce into the irrigation lines. See the "Chemigation Instructions" below for additional information.

**Soil injection against root-feeding insects:** The **ANCORA** suspension may be injected directly into the soil surrounding roots using pressurized shank or other injector. Inject in sufficient volume of water to wet the entire root zone.

# Met52<sup>®</sup> EC

bioinsecticide

**ACTIVE INGREDIENT**

*Metarhizium anisopliae* Strain F52\* 11.0%

**OTHER INGREDIENTS\*\*** 89.0%

Total 100.0%

\* Contains 5.5 x 10<sup>9</sup> Colony Forming Units (CFU)/gram of Met52 EC based on 5 x 10<sup>10</sup> viable conidia per gram of active ingredient.

\*\* Contains petroleum distillates

**KEEP OUT OF REACH OF CHILDREN**

**CAUTION  
PRECAUTIONARY STATEMENTS**

**HAZARDS TO HUMANS AND DOMESTIC ANIMALS**

Causes moderate eye irritation. Harmful if inhaled, absorbed through skin, or swallowed. Avoid contact with skin, eyes, or clothing. Avoid breathing dust. Wash thoroughly with soap and water after handling, and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

Batch Code/Expiry Date:



**Net Contents:**  
1.06 quarts (1L)



**Novozymes Biologicals Inc.**  
5400 Corporate Circle  
Salem, VA 24153  
1-800-245-4104

EPA Establishment Number: 085238-CAN-001  
EPA Registration Number: 70123-10  
Made in CANADA 13059 0414

FIRST AID	
<b>IF IN EYES:</b>	Hold eye open and rinse slowly and gently with water for 15–20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
<b>IF INHALED:</b>	Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or doctor for advice.
<b>IF ON SKIN OR CLOTHING:</b>	Take off contaminated clothing. Rinse skin immediately with plenty of water for 15–20 minutes. Call a poison control center or doctor for advice.
<b>IF SWALLOWED:</b>	Call a poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.
HOT LINE NUMBER	
Have the product container or label with you when calling a poison control center or doctor or going for treatment. For emergency information on this pesticide product (including health concerns, medical emergencies, or pesticide incidents), call the National Pesticide Information Center at 1-800-858-7378, 6:30 AM to 4:30 PM Pacific Time (PT), seven days a week. During other times, call the poison control center at 1-800-222-1222.	
NOTE TO PHYSICIAN	
Contains petroleum distillate. Vomiting may cause aspiration pneumonia.	



Ornamental plants and grasses: shrubs, vines, trees, lawn, bedding plants, poinsettia, etc.		drench	40–80 fl. oz./100 gal.
	thrips, weevils, mites, whiteflies	foliar	8–32 fl. oz. (0.5 pt.–1 qt.) /100 gallons, spray to wet but avoid runoff.

# Commercially Available Microbially-Based Entomopathogenic Bacteria



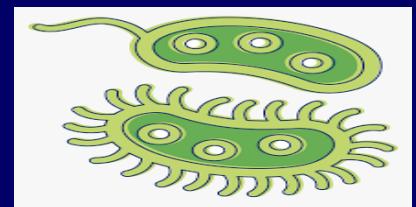
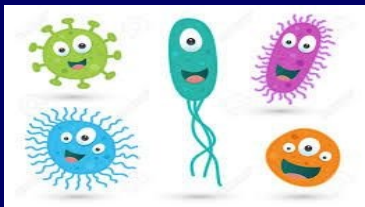
\* *Bacillus thuringiensis* subsp. *israelensis*  
(Gnatrol)



\* *Bacillus thuringiensis* subsp. *kurstaki* (Dipel)

\* *Chromobacterium subtsugae* Strain PRAA4-1<sup>T</sup>  
(Grandevo)

\* Heat-killed *Burkholderia* spp. Strain A396  
(Venerate)





*Bacillus thuringiensis* subsp. *kurstaki* (Btk)  
 Product (Dipel): **Only Kills Caterpillars**



# Gnatrol® WDG

BIOLOGICAL LARVICIDE

FOR ORGANIC PRODUCTION

### Active Ingredient:

*Bacillus thuringiensis*, subsp. *israelensis*, strain

AM 65-52 fermentation solids and solubles . . . . . 37.4%

Other Ingredients . . . . . 62.6%

Total . . . . . 100.0%

[Potency: 3000 International Toxic Units (ITU) per mg].  
Equivalent to 1.36 billion ITU/lb.

The percent active ingredient does not indicate product

## 2.0 PRECAUTIONARY STATEMENTS

### 2.1 HAZARD TO HUMANS (AND DOMESTIC ANIMALS) CAUTION

Harmful if inhaled. Avoid breathing dust. Remove contaminated clothing and wash before reuse. Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling.

### 2.2 Personal Protective Equipment (PPE)

Applicators and other handlers must wear:

- Long-sleeved shirt and long pants
- Waterproof gloves
- Shoes plus socks

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

Mixer/loaders and applicators not in enclosed cabs or aircraft must wear a dust/mist filtering respirator meeting NIOSH standards of at least N-95, R-95, or P-95. Repeated exposure to high concentrations of microbial proteins can



***Bacillus thuringiensis* subsp. *israelensis* (Bti) Product (Gnatrol): Only Kills Fungus Gnat Larvae**



# **GRANDEVO**<sup>®</sup>

**BIOINSECTICIDE**



**Active Ingredient:**

*Chromobacterium subtsugae* strain PRAA4-1<sup>T</sup> and  
spent fermentation media\* .....

30.0%

**Other Ingredients:** .....

70.0%

**Total:** .....

100.0%

\*Contains not less than 1,000 Cabbage Looper Killing Units (CLKU)/mg.

Note: The percent active ingredient does not indicate product performance and potency measure.

**Ornamental Plants – Ground application only to non-blooming plants**

**1.40 to 4.19 Tablespoons of GRANDEVO CG per 1,000 square feet**

Loopers, tobacco budworm, omnivorous looper, omnivorous leafroller, diamondback moth, armyworms, ello moth, lo moth, oleander moth, and azalea caterpillar

**2.79 to 4.19 Tablespoons of GRANDEVO CG per 1,000 square feet**

Whiteflies, aphids, thrips, azalea lace bug, *Lygus*, and mites



# VENERATE®

## BIOINSECTICIDE

## XC

**Active Ingredient:**

Heat-killed *Burkholderia* spp. strain A396 cells and spent fermentation media\* ..... 94.46%

**Other Ingredients:** ..... 5.54%

**Total:** ..... 100.00%

\*Contains not less than 1,500 Beet Armyworm Killing Units (BAWKU)/mg. Note: The percent active ingredient does not indicate product performance and potency measurements are not federally standardized.

## Flowers, Bedding Plants and Ornamentals

1-4 quarts of VENERATE XC per acre or 1-4 quarts of VENERATE XC per 100 gallons of water

Armyworms, Azalea caterpillar, Diamondback moth, Ello moth, Lo moth, Loopers,

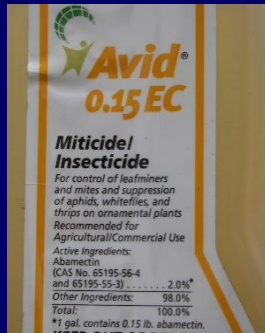
Oleander moth, Omnivorous leafroller, Omnivorous looper, Tobacco budworm

2-4 quarts of VENERATE XC per acre or 2-4 quarts of VENERATE XC per 100 gallons of water

Aphids, Azalea lace bug, Lygus, Mites, Thrips, Whiteflies

# Plant-Incorporated Protectants

\* *Streptomyces avermitilis*  
[Abamectin (Avid)]



\* **Azadirachtin (Azatin, Molt-X)**

\* *Saccharopolyspora spinosa*  
[Spinosad (Conserve)]





**Ornamentals (Herbaceous and Woody) Growing Outdoors, in Nurseries (Including Conifer Seed Orchards), or in Greenhouses**

Pests	Conserve SC fl oz/gallon	Conserve SC fl oz/100 gallons	Conserve SC fl oz/acre
chrysomelid leaf feeding beetles, such as: elm leaf (1) viburnum leaf (larvae) willow leaf (1) European grapevine moth lepidopterous larvae, such as: azalea caterpillar bagworm beet armyworm cabbage looper California oakworm cankerworm diamondback moth eastern tent caterpillar fall webworm Florida fern caterpillar geranium budworm gypsy moth light brown apple moth oblique banded leafroller oleander caterpillar orange striped oakworm spruce budworm tussock moths (hickory, whitemarked) western tent caterpillar winter moth yellownecked caterpillar (2) sawfly larvae, such as: European pine pear redheaded pine shore fly thrips (exposed) in greenhouse settings, such as: (3) chilli Cuban laurel western flower	0.06 (1.77 mL)	6 (177 mL)	24 (709.8 mL)
dipterous gall midges pinyon spindlegall thrips (exposed) in outdoor settings, such as: (3) chilli Cuban laurel western flower	0.1 (2.96 mL)	11 (325.3 mL)	44 (1301 mL)

Pests (Cont.)	Conserve SC fl oz/gallon	Conserve SC fl oz/100 gallons	Conserve SC fl oz/acre
dipterous leafminers, such as: serpentine (4) emerald ash borer (5) lewis mites Nantucket pine tip moth spider mites, such as: spruce two-spotted (6) (see 6 below for mite suppression/control expectations)	0.2 (5.92 mL)	22 (650.6 mL)	88 (2602 mL)

Numbers in parentheses ( ) refer to Pest-Specific Use Directions

# The Impact of Beneficial Fungi on Natural Enemies



*The use of entomopathogenic fungi is a common practice in greenhouse production. What factors influence their direct and indirect effects on pests?*

BY RAYMOND A. CLOYD

Entomopathogenic or beneficial fungi are relatively ubiquitous worldwide and are commonly used in greenhouse production systems to suppress populations of different insect pests, such as aphids, thrips and whiteflies.

Entomopathogenic fungi, in general, infect the insect cuticle by means of enzymatic degradation and/or mechanical pressure. Once inside the host, the entomopathogenic fungus distributes throughout the haemocoel, which is the primary body cavity that contains circulatory fluids. Death normally occurs in three to 14 days after the conidia (spores) of the entomopathogenic fungus contact the host.

Death may be caused by mechanical damage via spore penetration, resulting in water loss, and/or poisonous toxins produced by the entomopathogenic fungus. Mortality is generally dose-dependent, with higher conidia concentrations leading to faster kill and enhanced mortality rates of insect pests.

## FACTORS THAT IMPACT ENTOMOPATHOGENIC FUNGI

There are a number of pesticides containing entomopathogenic fungi as the active ingredient that are commercially available for use in greenhouse production systems, including: *Beauveria bassiana* Strain GHA (BotaniGard: BioWorks Inc.), *Metarhizium anisopliae* Strain F52 (Met52: Monsanto BioAg Inc.), and *Isaria fumosorosea* Apopka Strain 97 (Ancora: OHP Inc.). Direct effects associated with entomopathogenic fungi involve acute mortality or survival (longevity), over a specified time period, of the life stages of natural enemies such as the egg, larva, nymph, pupa or adult. Indirect effects may

biological parameters that may be indirectly affected by exposure to entomopathogenic fungi include: host acceptance, reproduction, foraging behavior, sex ratio, and host emergence (for parasitoids).

The integration of natural enemies and entomopathogenic fungi may be influenced by food availability and avoidance factors. For instance, any changes in host population numbers due to applications of an entomopathogenic fungus may reduce availability of food sources, thus indirectly affecting subsequent natural enemy populations. In addition, predators may avoid consuming hosts that are infected by entomopathogenic fungi.

Entomopathogenic fungi produce volatiles or odors after infecting hosts, which may mask the volatiles emitted by hosts that are used by predators to determine their location. In all three instances prey search time increases, predation rates decrease, and efficacy associated with regulating pest populations is reduced.

Subsequent factors that also need to be considered in regards to the direct and indirect effects of entomopathogenic fungi on natural enemies are: 1) host treated with an entomopathogenic fungus may not be acceptable as a food source for parasitoids or predators; 2) parasitoids may avoid laying eggs into hosts already infected by an entomopathogenic fungus (Figure 1); 3) entomopathogenic fungi may be able to outcompete immature parasitoids developing inside hosts; 4) parasitoids may become infected by an entomopathogenic fungus while developing inside an infected host; 5) during searching, parasitoids and predators may encounter free conidia of entomopathogenic fungi on plants and consequently become

# Take Home Points To Consider

\* Correctly identify insect and mite pests.

\* **Scout your crop to detect insect and mite pest infestations early.**

\* Determine extent of potential damage, and assess spatial (space) and temporal (time) distribution.



\* **Implement sanitation practices.**



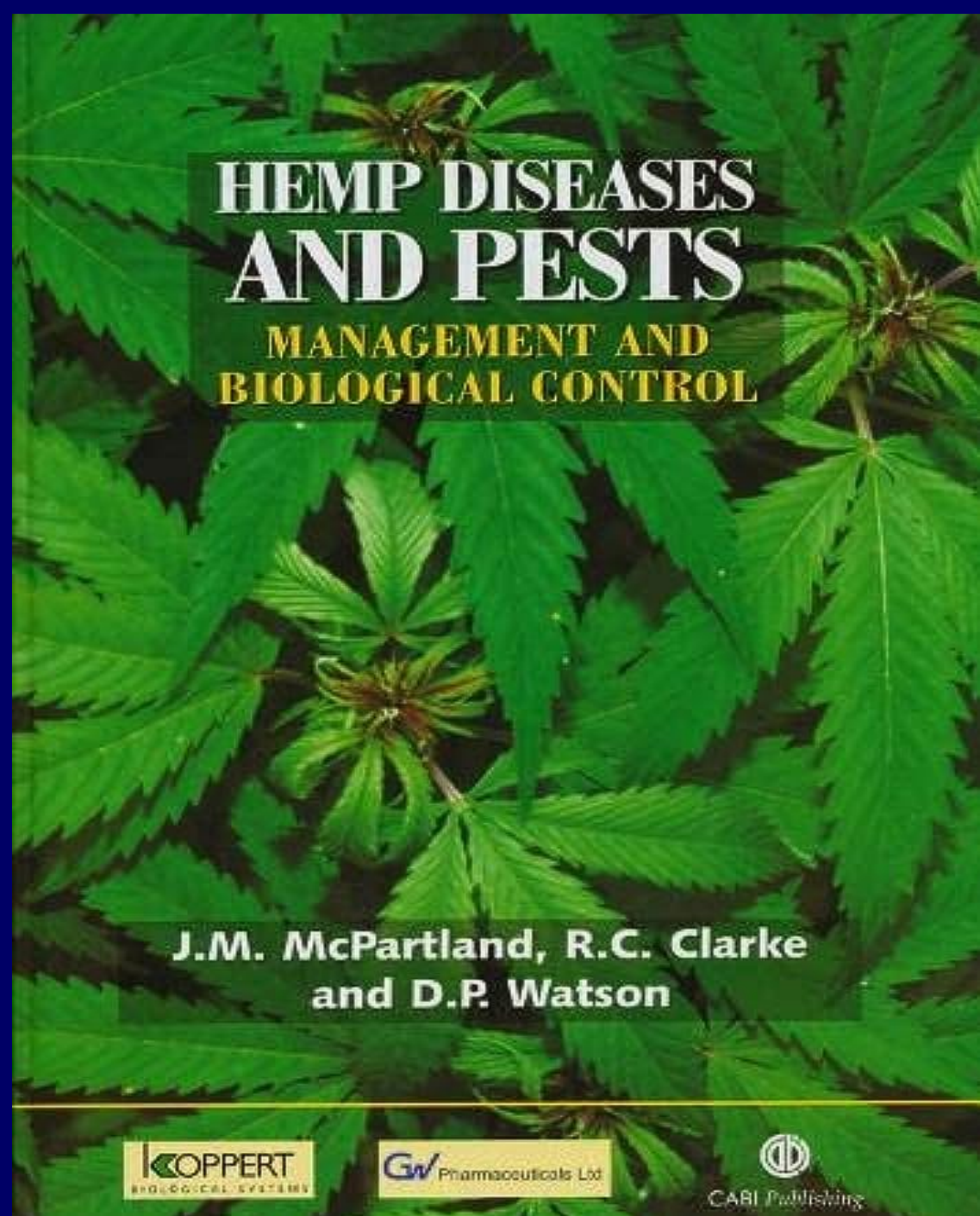
\* Release appropriate biological control agent.

\* **Conduct quality assessments of all biological control agents released.**

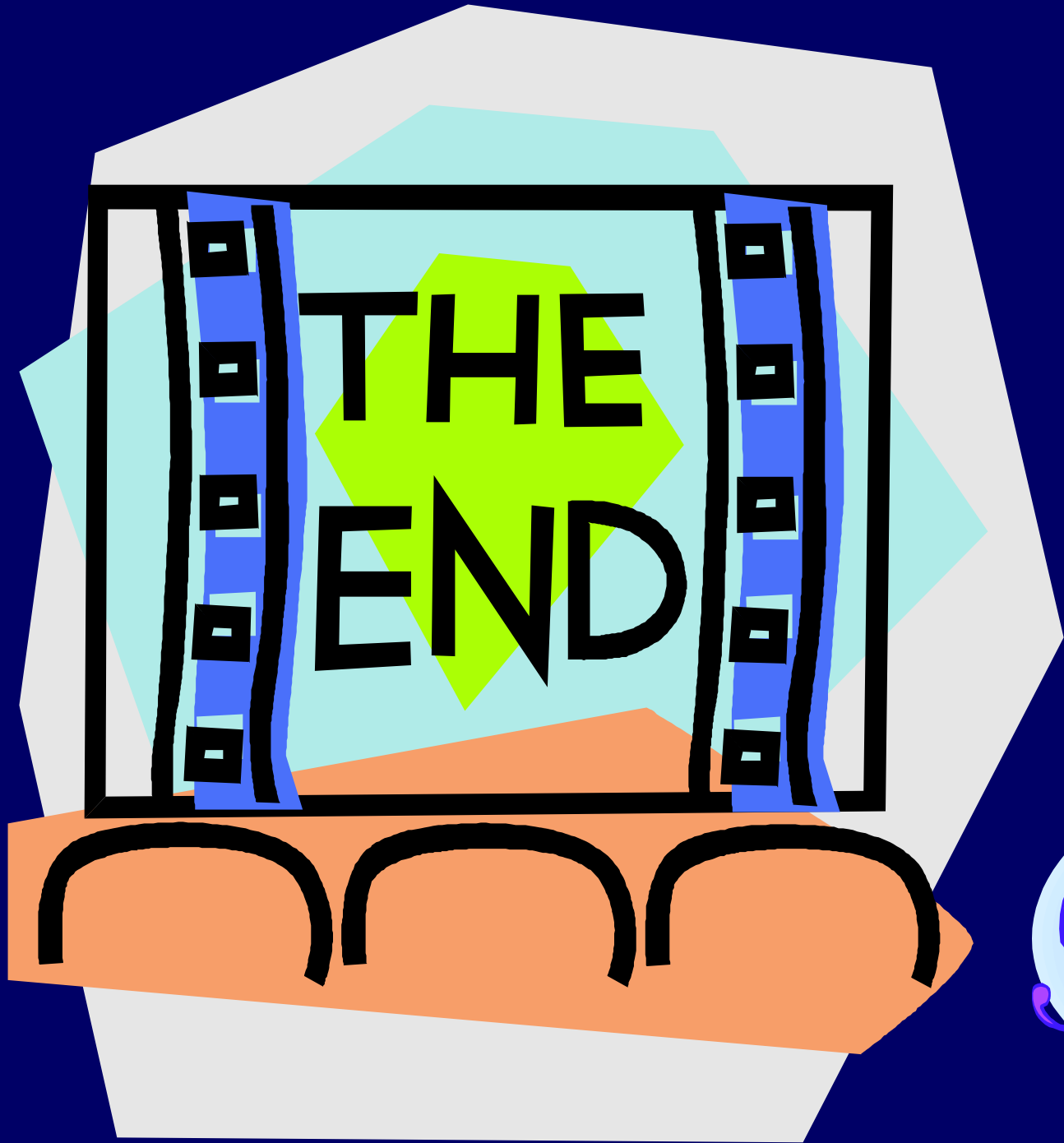
\* Keep detailed records (documentation) of pest occurrence throughout the growing season to track population trends of insect and mite pests.

\* **Contact your state extension entomologist if need be.**

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# Thank You For Your



# Attention!



# I Hope You All Learned Something!

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What?

Where?

Which?

Any Questions?

When?

How?

Why?

