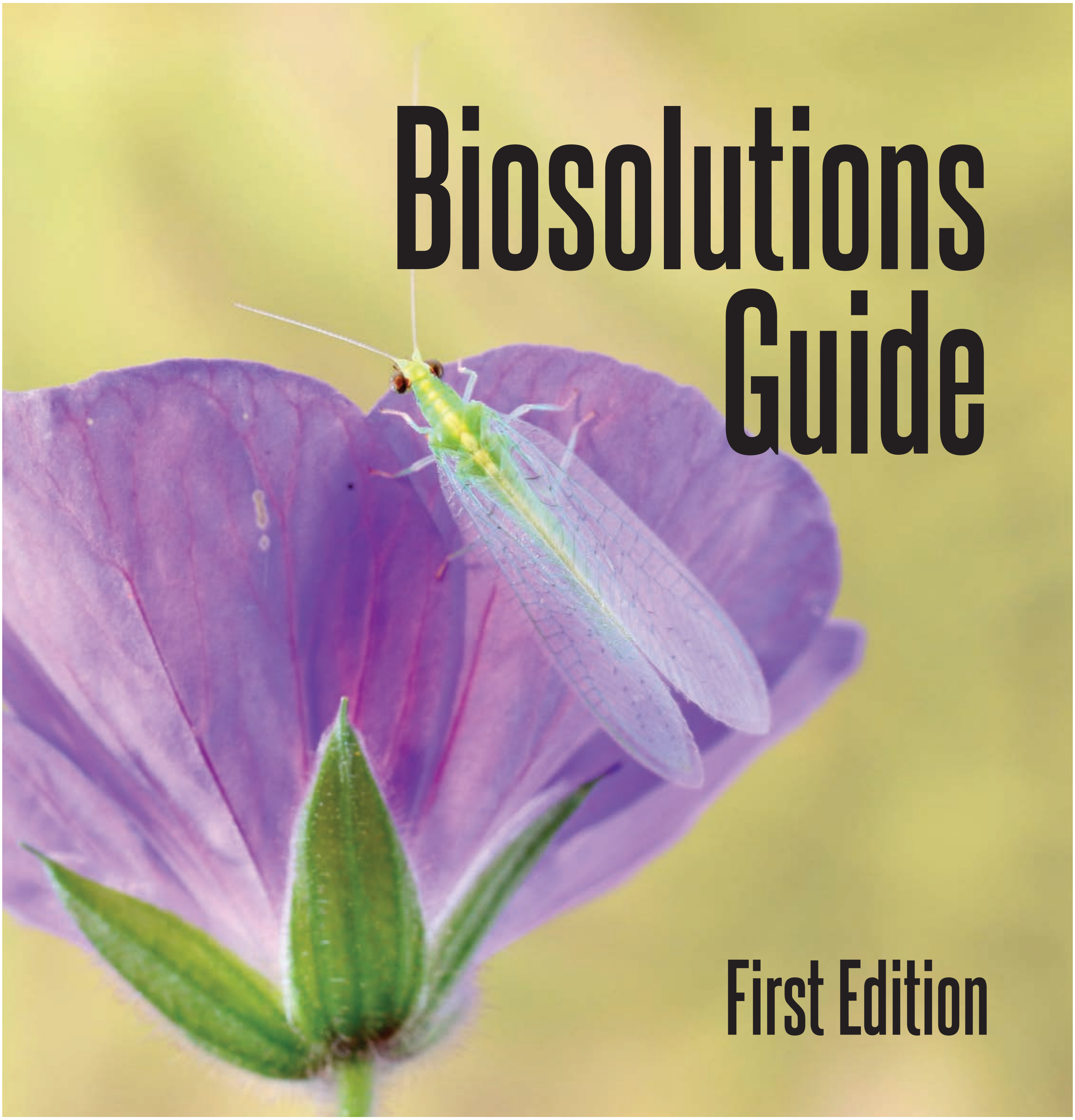
MAGAZINE • SINCE 1937
GROWERTALKS

Biosolutions Guide

First Edition



By Carlos E. Bográn, A.R. Chase, Paul Pilon and Suzanne Wainwright-Evans

ACTIVATE YOUR INTEGRATED PEST MANAGEMENT PROGRAM

Creating a well-rounded IPM program doesn't have to be complicated. Whether you're a new or returning biologicals user, there's a simple way to integrate them into your operation and power up your programs. This approach works alongside your existing programs in a production cycle, joining and synergizing what is already working at your operation.

Follow the template or customize it — take what you like and leave the rest.
Get ready for exceptional results.

IT'S NOT ROCKET SCIENCE — IT'S *BIO LOGICAL*

GETTING STARTED

1. Plan to start when pest pressure is low and pick one to two formulated biologicals for your most common pests.
2. Start with Foundational Fridays, every Friday: respond to changing pressure with rate adjustments.
3. You're already making conventional applications: if you want to add in macro-biological control agents (BCAs), shift conventionals to targeted chemistries and stagger your broad-spectrum insecticide applications, or use them only for rescue.

IPM PROGRAM GUIDE

We create chemistry

Use this guide to round out a solid IPM program harnessing the power of both biological and conventional chemistries.

FOUNDATIONAL FRIDAYS	CONVENTIONAL TUESDAYS	BENEFICIAL WEDNESDAYS
Dial down pest pressure	Elongate intervals between broad-spectrum or rescue applications	Prevent or delay pest resistance
Apply formulated biologicals	*Apply chemistries*	*Release BCAs*
Biological insecticides, like **Velifer® fungal contact insecticide/miticide**	Targeted insecticides and miticides, like **Sultan® miticide** **Ventigra® insecticide**	Insect and mite:
Beneficial nematodes, like **Nemasys® beneficial nematodes**** **Millenium® beneficial nematodes****	IGRs and MGRs	Predators
Biological fungicides	Oils and soaps, like **Ultra-Pure® oil***	Parasitoids
Other microbials	Fungicides and sanitizers	Pollinators
	Herbicides and PGRs	

BROAD-SPECTRUM CHEMISTRIES | Check compatibility and stagger or reserve for rescue applications

*OMRI Certified Organic
**Washington State Dept. of Agriculture Certified Organic

Visit **betterplants.basf.us** for more information.

Always read and follow label directions.
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It gives me great pleasure to be part of the first edition of the *GrowerTalks* Biosolutions Guide. My colleagues at Ball Publishing and I first talked about how beneficial a biosolutions supplement would be for the growers in our industry last summer and now this useful resource is a reality. Our vision was to provide invaluable information from industry experts, share efficacy tables for bioinsecticides and biofungicides, provide a list of biocontrol agents, and deliver a go-to resource on biosolutions products and how to use them. As you'll see, this supplement checks all of these boxes and more.

What are biosolutions? Biosolutions is the term used for any biologically based approach to managing insect pests, mites and diseases in greenhouses, nurseries and agriculture. Bioinsecticides, biofungicides (both referred to as biopesticides) and biological control agents (BCAs) are all examples of biosolutions. Biopesticides contain living organisms, are derived from naturally occurring microbes or consist of natural botanical extracts. BCAs (AKA natural enemies, beneficial insects or beneficials) are insects or mites (the good guys) used to control other insect or mite pests (the bad guys).

I've personally worked with biosolutions products on many fronts—as a grower, consultant and researcher—and feel that there's often confusion surrounding what they are and how they fit in with other practices, such as use in combination with biological control agents or in conjunction with traditional chemistries. As you'll learn in this guide, biosolutions products can not only be used along with other biosolutions products but can often be used in conjunction with other management approaches.

We partnered with some of the industry's leading experts to develop this resource. We're very proud to have worked with and share content from industry household names, including Dr. Ann Chase (Chase Agricultural Consulting), Suzanne Wainright-Evans (Buglady Consulting) and Dr. Carlos Bográn (OHP Inc.) Each is very passionate about what they do, experts in their professions and dedicated to sharing knowledge with growers.

Kicking off the guide, Dr. Bográn describes bioinsecticides, how they've been used for more than a century and how the use of bioinsecticides can often be complementary when used in conjunction with traditional chemistries or beneficials. Next, Dr. Chase discusses many of the myths and misconceptions that exist regarding biopesticides and then dives deeper into factors affecting biopesticides and how they can be used in conjunction with conventional pest management strategies. Last, but certainly not least, Suzanne describes how the use of beneficials in our industry has evolved over the past 30 years, sharing fun facts on several biological control agents and offering guidance on how to implement successful biocontrol programs.

Similar to how each of us approaches IPM (Integrated Pest Management) and greenhouse production differently, you'll soon see how each of our experts presents insights from different perspectives, albeit from an academic or scientific point of view. Each offers great information in this supplement that can be easily understood and implemented in greenhouses of any size.

Now, sit back and enjoy this supplement! We're hopeful this resource will provide you with a good grasp of what biosolutions products and biocontrol agents are currently available in the market, and establishes a basis for how they can be used in conjunction with one another, as well as alongside traditional pest management approaches.

Before getting to our first article, I thought it would be beneficial to provide you with a biosolutions glossary (on the following page) to introduce and cover some of the terminology our experts will be discussing in their awesome articles.

PAUL PILON
Director of Growing—Opel Growers, Hudsonville, Michigan
Editor-at-Large, *Perennial Pulse* e-newsletter

ON THE COVER: A green lacewing (*Chrysoperia carnea*) adult looking to deposit her egg in a pest. They're beneficial insects, but also beautiful pollinators.
Photo by Suzanne Wainright-Evans.

GROWERTALKS

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A Friend Remembered
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GreenProfit Supplement Enclosed

Biosolutions Glossary

Beneficial insects (beneficials)—Beneficial insects are insects including pollinators, natural enemies of pests and others that provide us with ecological and agricultural services. Insect natural enemies are predators and parasites, carnivore insects or mites that may be used as biological control agents.

Beneficial nematodes—Microscopic roundworms that are parasites of pests and used as biological control agents.

Biofungicide—Substances of natural origin used to prevent and manage plant diseases caused by fungal pathogens.

Bioinsecticides—Substances of natural origin used to kill, repel or inhibit the feeding, growth and reproduction of insect pests.

Biological control (AKA biocontrol)—The use of beneficial organisms to reduce the relative abundance of and damage caused by noxious organisms (pests).

Biological Control Agents—Predators, parasites and antagonistic organisms used to manage populations of noxious species (pests).

Biopesticides—Pesticides of natural origin including bioinsecticides, biofungicides, bioherbicides, etc.

Biosolutions—Biologically based tools and approaches to prevent or minimize damage to crops by insects, mites or plant diseases.

Ectoparasitoid—Parasitoids that develop outside and feed on their hosts.

Endoparasitoid—Parasitoids that develop inside and feed within their hosts.

Entomopathogenic—Organisms like fungi and bacteria capable of causing diseases in insects (insect parasites).

Insect—Group of invertebrates (arthropods) with three pairs of legs and three body regions: the head usually with antennae, the thorax commonly bearing wings and the abdomen.

Microbial pesticides—Microorganisms including bacteria, fungi and virus that are formulated and used to control or manage pests and diseases.

Mite—Group of invertebrates (arthropods) with four pairs of legs and two body regions: the cephalothorax and the abdomen. More closely related to ticks and spiders than insects.

Parasite—Organisms that live in or on another of a different species and benefits from its host.

Parasitoid (AKA insect parasites)—Insects that develop in or on their host (pest) thereby consuming and killing it.

Pesticides—Products that kill, prevent, reduce, destroy or repel a pest.

Pesticide compatibility—Short-term and long-term impact of a pesticide on biological control agents and microbial biopesticides.

Predator—An organism (insect or mite) that feeds on, consumes and kills multiple prey items during its lifetime.

Predatory—Refers to an insect, mite or other organisms that are predators.

Target pest—The noxious organism, insect mite, etc. that is the subject of a pest control activity.

Using Bioinsecticides in Your Greenhouse—Considerations

By **CARLOS E. BOGRÁN, Ph.D.**—Senior Technical Manager, OHP Inc.

Bioinsecticides are substances of natural origin that are used to kill, repel or inhibit the feeding, growth and reproduction of insect pests. The most commonly used bioinsecticides include botanical extracts from many vascular plant species and several microorganisms or their metabolites, most commonly including bacteria, fungi and viruses.

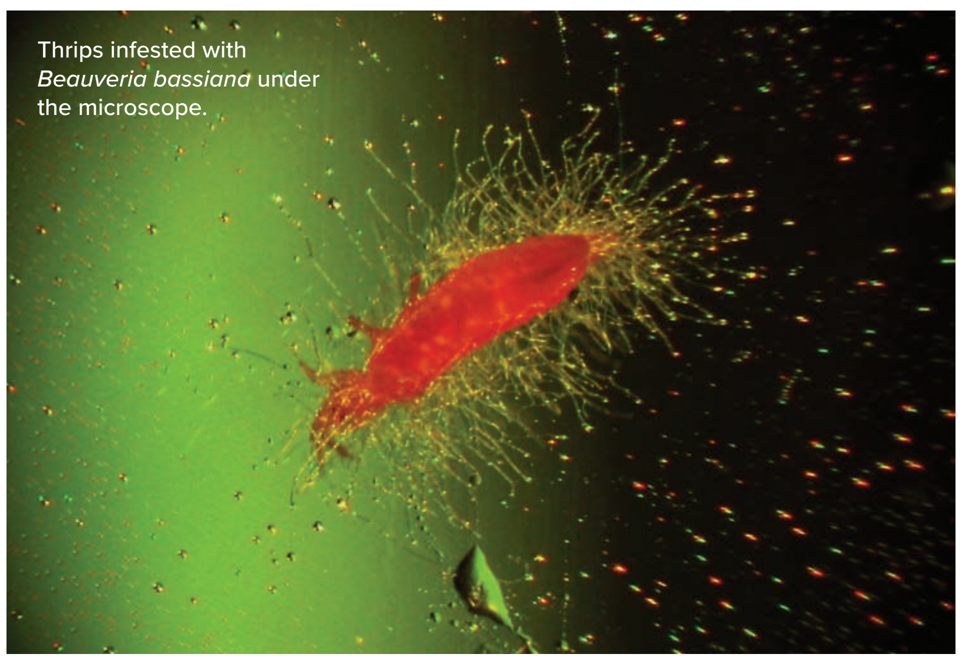
While conventional insecticides will likely continue to be a key component of integrated pest management (IPM) programs in the foreseeable future, bioinsecticides can be critical elements in moving modern horticulture production systems forward and responding to the ever-increasing demand for more sustainable approaches to agriculture. Bioinsecticides offer many of the practical and logistical advantages of conventional synthetic products without many of their associated environmental and health risks. Natural substances are commonly formulated into products that can be applied using the same equipment as other insecticides, they're highly compatible with many conventional chemistries and biological control agents (BCSs), and don't require major changes in production practices. When incorporated into insect pest control programs, bioinsecticides can reduce risks of developing insecticide resistance, keeping good products effective, and reducing worker exposure and environmental risks of the unilateral use of synthetic—and often more toxic—products.

The use of bioinsecticides for the control of economically important pests is nothing new, and in fact, started long before the discovery and deployment of synthetic insecticides. Crude extracts from the neem tree seeds and leaves have been used in traditional Indian medicine and agriculture for many centuries. The first indication of fungal spores being mass-produced and applied in the field for pest management dates back to 1888 when spores from the green muscardine fungus were used to control the sugar beet weevil in Eastern Europe. The full potential of the bacterium *Bacillus thuringiensis* for pest management in agriculture, however, wasn't realized until the 1940s.

Examples of bioinsecticides currently available for use in floriculture and nursery in the United States appear in Table 2 on page 10. Among the most widely used botanical bioinsecticides are pyrethrum and azadirachtin. Pyrethrum is a naturally occurring mixture of chemicals found in the flowers of chrysanthemums (*Tanacetum cinerariifolium*). Six compounds are recognized in pyrethrum, including Pyrethrin, Cinerin and Jasmolin, each in two distinct chemical versions (3 x 2 = 6). This biochemical diversity allows for broad spectrum of activity against key insect pests, but also reduces the risk of insecticide resistance development, relative to that of single compound pyrethroids, which are man-made synthetic analogs of pyrethrins with longer-lasting activity. Both act on contact, affecting the insect nervous system by disrupting sodium transport, leading to paralysis and death. Natural pyrethrins, however, are highly liable to degradation, particularly from natural sunlight, which makes them much safer to non-target organisms and the environment, and more compatible with BCAs.

Azadirachtin (AZA) is the main constituent of neem (*Azadirachta indica*) extracts used as bioinsecticides. It's a fairly large and complex molecule with multiple modes of action on target insect pests. This complexity in chemical structure and biological activity leads to a reduced risk of insecticide resistance development and allows for a very broad spectrum of activity on chewing and sucking insect pests.

AZA works on contact and ingestion of treated plant tissues by the insect. Feeding on AZA-treated foliage directly ▶



Thrips infested with *Beauveria bassiana* under the microscope.

affects insect defoliators; AZA can also be translocated from the roots into the plant foliage, providing systemic activity against many sucking insects. At relatively low concentrations, AZA interrupts normal insect development by disrupting the molting process; at higher concentrations, it acts as an anti-feedant and a repellent. AZA is thus active against all life stages of herbivore insect pests while being relatively safe on carnivore insect natural enemies used in biological control.

The spore-forming bacteria *Bacillus thuringiensis* (Bt) are highly specific to their insect hosts; different subspecies and strains of Bt are active against either Lepidoptera, Diptera or Coleoptera, but all Bt products work upon ingestion by disrupting the integrity of the insect gut membrane leading to sepsis and death within hours. The high selectivity of Bt products makes them relatively safe and compatible, but complicates their use in agriculture when crops are susceptible to several groups of insect pests. This is also the major challenge of the highly species-specific insect viruses, such as baculoviruses, which require using one product for each different pest species. Bacoulovirus-based products, however, are very useful in large-scale single-crop agricultural operations and forest production systems.

Several groups of fungal entomopathogens (insect parasites) are utilized in agriculture and are now some of the most widely used bioinsecticides. In all cases, the asexual spores of the fungus are formulated to keep their natural viability and work on contact. Upon contact, and under the appropriate temperature and relative humidity, the fungal spores attach to the insect cuticle, grow into the insect body and kill the insect via depletion of nutrients and release of toxins.


Whitefly infested with *Beauveria bassiana* under magnification.

For example, several strains of the entomopathogenic *Beauveria bassiana* and *Cordyceps fumosorosea* (previously known as *Isaria fumosorosea*) have been isolated and their host range, effectiveness against target pests and tolerance to environmental conditions vary extensively. This variability indicates that different strains may be better suited to different growing conditions or the microenvironments created by the different crop architectures or production systems.

Bioinsecticides are best used as components of insect management programs that include pest prevention and cultural control strategies, good sanitation and pest exclusion practices, sound pest/disease monitoring and plant health maintenance practices, and timely use of appropriate chemical and biological control tools. Because of their mode of action, bioinsecticide products work best in preventing crop injury and damage when pest population density is low to moderate and don't work as well in curing crops after pest densities have reached outbreak levels. GT

Table 1. Relative advantages and disadvantages of bioinsecticides compared to conventional synthetic insecticides.

Advantages	Disadvantages
Very easy to use in diverse production systems	Typically do not provide curative activity
No new application technology required	Each product may have a different use and evaluation protocol
Low pesticide resistance development risk	May require special handling and storage or shipping
May involve multiple modes of action, synergism	May not be available in all product distribution channels
Reduced environmental and health risks	Forecasting amount of product needed because they're living organisms
Provide new marketing opportunities	Typically used in larger quantities, more handling
Compatible with other chemical and biological control-based programs	May be more expensive, requiring more frequent applications

Bioinsecticides Efficacy Table

Table 2. Examples of common bioinsecticides used in floriculture and nursery in the U.S. and their target pests
(+ indicates some activity, +++ indicates high activity).

Active Ingredient or Organsim	Trade Name(s)	Use Rates	Application Methods	Use Sites	Aphids	Broad Mites	Caterpillars	Fungus Gnats	Mealybugs	Spider Mites	Thrips	Whiteflies
Azadiractin	Aza-Direct, Azatin O, Molt-X, Ornazin	4-16 fl. oz./100 gal.	S, D, F	GH, N, L	++		+++	++	+		+++	+++
Bacillus thuringiensis, subsp. *israelensis* Strain AM 65-52	Gnatrol WDG	3.2-26 oz./100 gal.	D	GH				Larvae ++				
Bacillus thuringiensis, subsp. *kurstaki* Strain ABTS-351	DiPel DF	4-16 oz./100 gal.	S	GH, N			++					
Beauveria bassiana Strain ANT-3	BioCeres WP	1.5-3.0 lb./100 gal.	S, D	GH, N	++			++	++		++	++
Beauveria bassiana Strain GHA	BotaniGard 22WP, BotaniGard ES, Mycotrol WPO, Mycotrol ESO	0.5-2.0 lb./100 gal.	S, D, F	GH, N, L	++		+	++	++	+	++	++
Beauveria bassiana Strain PPRI 5339	Velifer	3-13 fl. oz./100 gal.	S	GH	+				+	++	++	++
Burkholderia spp. Strain A396	Venerate CG	2-4 qt./100 gal.	S, D, F	GH, N	+		+++		+	+	+	+
Capsicum oleoresiin Extract, Garlic Oil, Soybean Oil	Captiva Prime	1-2 pints/100 gal.	S	GH, N			+			+	+	+
Chromobacterium subtsugae Strain PRAA4-1	Grandevo CG	1-3 lb./100 gal.	S, F	GH, N	++	+	++			++	+	++
Garlic Oil	Gemsei	40-55 oz./100 gal.	S	GH, N	++	+	++	+	+	+	++	++
Isaria fumosoroseus Strain FE 9901	Isarid, NoFly	16 oz./100 gal.	S,D, F	GH, N	+		+	Larvae +++	+	Eggs	Pupa ++	Nymph +++
Isaria fumosorosea Apopka Strain 97	Ancora, Preferal WG	14-28 oz./100 gal.	S, D, F	GH, N, L	+		+	Larvae +++	+	Eggs	Pupa ++	Nymph +++
Metarhizium brunneum Strain F52	Lalguard 52 OD	8-32 fl. oz./100 gal.	S, D, F	GH, N	+			++		+	++	+
Neem Oil (extract)	Triact 70	0.5-2 gal./100 gal.	S	GH, N, L	++	+	++	++	++	+++	++	++
Pyrethrins	PyGanic 5.0	16-32 fl. oz./100 gal.	S, D, F	GH, N	+++		++	++	++		++	++
Pyrethrins + Canola Oil	Pycana	1-2 gal./100 gal.	S, F	GH, N	+++	+	++	Adults ++	++	++	+++	++
Rosemary Oil	TetraCURB	32-256 fl. oz./100 gal.	S	GH, N	++	+		+	+	++	+	++

S = Spray
D = Drench
F = Fog
A = Aerosol

GH = Greenhouse
N = Nursery Production (Outside)
L = Landscape

+ some
++ good
+++ very good

Information as of June 2023.
The exclusion of trade names other than those listed in the table above is not intentional and does not imply that products not listed are ineffective.

Biofungicides: What to Consider

By **A.R. CHASE**—Chase Agricultural Consulting, LLC

Pythium root rot (on left).

We're hearing more today about biopesticides than ever before—especially if you're growing organically. But what if you aren't trying to grow crops with biopesticides, exclusively? They can definitely be used in a "conventional" production setting, as well; you just have to be mindful that the conventional products don't interfere with the biopesticides.

Most biopesticides are OMRI-listed and can include biological agents like bacteria, fungi and predatory mites and insects. They can also be extracts from a biological organism such as a plant.

You should be aware of some considerations before trying biopesticides in your operation. It might be simpler to convert completely to biopesticides, but it's rarely practical due to limitations in controlling a wide array of diseases. There are some facts you need to know to make the most successful use of any pesticide—biological or conventional.

Myths & misconceptions

Here are a few of the statements I've heard from a variety of growers, researchers and manufacturer representatives regarding biopesticides (especially those classified as true biologicals):

- Biopesticides don't work as well as synthetic or conventional products.
- Biopesticides don't have a good shelf life.
- Biopesticides aren't compatible with synthetic or conventional products.
- Applying biopesticides once is enough for the life of the crop.
- We don't know what biopesticides are doing. They're magic.
- Biopesticides are never phytotoxic and are inherently safe for the environment, plants and humans.

Each of these statements is wrong, at least as applied to some of the biopesticides registered today.

In contrast, the following characteristics are true for many biopesticides, including:

- Some biologicals or biopesticides must be used before the pest pressure arrives (at seedling, at planting in plug trays).
- Biopesticides should be used following (or sometimes with) chemical fungicides.
- Under high disease pressure, biopesticides may not perform well.
- Many things affect efficacy of biopesticides, including fertilizer, host plant, pathogens and even pathogen species.
- Being a better grower makes using biologicals (and really all) fungicides and bactericides more likely to succeed.

Although some products are biologicals, biopesticides and organics—not all biopesticides are biological and not all organic products are biopesticides. Table 1 on page 16 lists a few of the multitude of organic biopesticide products, including some biologicals (highlighted in the first column). Organic products that are best described as conventional (like copper and peroxide) aren't listed.

Biopesticides that aren't biological control agents (BCAs) act more like synthetic products, making them simpler to use in many cases. These products are typically a combination of a variety of chemicals they (biological agents) make in culture or are extracted from them (like plant extracts).

Biopesticides can be simple, but are more likely to provide a variety of direct and indirect effects. An example of direct effects would be lipopolysaccharides that destroy bacterial and fungal cells, for example *Bacillus*.

Indirect effects are those that such products trigger in the host— ▶

The biggest disease challenges for biopesticides (and conventional products as well)

There are a number of very challenging diseases for conventional products to control and they're difficult for biofungicides, as well. Some of these are listed below with the most effective biopesticides or biologicals and their level of control—none, some, good, very good and excellent. These efficacy summaries are based on reported trials for ALL crops—greenhouse, field edibles and ornamentals. Diseases for which you have many very good biofungicide choices (like bacterial leaf spot, powdery mildew and rust, as well as Pythium, Rhizoctonia and Phytophthora root rot) are not included.

- Anthracnose: MilStop (poor to good) or Triact 70 (some to good)
- Black root rot: Obtego (some to good) or LALSTOP K-61/MycoStop (none to good)
- Black spot on rose: NONE
- Cylindrocladium root/crown rot: NONE
- Downy mildew: MilStop (some to very good) or Regalia (none to very good)
- Fusarium root rot, crown rot, wilt: LALSTOP G46 (previously PreStop; very good to excellent) or RootShield Plus (none to very good)
- Phytophthora aerial blight: Camelot O (poor to good)
- Southern blight (Sclerotium): NONE

often referred to as SAR (systemic acquired resistance) factors. *Trichoderma, Bacillus* and some plant extracts have been proven to trigger plant defense responses.

One of the best examples of how much our knowledge has improved over the past 20 years is the understanding of T-22 (one of the BCAs in RootShield Plus). Here's a summary of the ways that researchers (often at universities here and internationally) have discovered they work. This particular summary was prepared by BioWorks Inc:

- *Excludes pathogens:* RootShield Plus takes up space in the rhizosphere and crowds out pathogens. It not only overtakes that space, it eats nutrients as well, causing pathogens to starve.
- *Shields roots:* Not only does RootShield Plus grow on the roots, it shields them from pathogens. It acts as a barrier that pathogens cannot get through.
- *Hunts and eats pathogenic fungi:* RootShield Plus seeks out, attacks and eats fungal pathogens.
- *Antagonizes pathogens:* RootShield Plus releases anti-pathogen substances, creating a zone that is inhospitable to pathogens.
- *Induces host resistance:* RootShield Plus, with its presence in the rhizosphere, signals the plant to accumulate defensive compounds, which gives the plant a better defense response in subsequent encounters with pathogens.

Sclerotinia blight on petunia.

Xanthomonas on Hedera (ivy).

Powdery mildew on rosemary.

What factors affect the use of biopesticides?

The answer is: exactly everything that affects how conventional products work, including: timing, rate and interval, inoculum pressure and crop, tank-mixing or alternation with conventional/synthetic fungicides, the potting medium, irrigation method and fertility regime, and finally, even the exact species of the pathogen causing the disease. This list is the same for biopesticides since what's being described is how the course of a plant disease is affected.

Dr. Mary Hausbeck and her team at Michigan State University performed extensive research with a few biologicals and a few conventional fungicides. They tested the ability of each product to control several species of Pythium on two crops (snapdragon and geranium). The best biological *OR* fungicide for one species of Pythium on geranium wasn't the same as the best for another species of Pythium on the same crop or even the same Pythium species on another crop. Consistency wasn't better for the conventional fungicides than for the biologicals. So the picture of choosing what biological or conventional products work best is based on what your crop(s) is and what the exact cause of the disease might be. Unfortunately, however, we don't know the exact product for a specific situation that would perform the best.

If the biopesticide is a biological control agent and alive, there are factors that must be considered to ensure their effective use. First, you must realize that everything that affects the crop or the plant pathogen can affect another living organism—the BCA. This includes water level, salinity, potting medium characteristics and, of course, conventional fungicides or bactericides. GT

Biofungicides Efficacy Table

Table 1: Examples of common biofungicides used in floriculture and nursery in the U.S. and their target diseases (+ indicates some activity, +++ indicates high activity).

Active Ingredient or Organsim	Trade Name(s)	Use Rates	Application Methods	Use Sites	Alternaria	Bacteria	Botrytis	Cercospora	Colletotrichum	Cylindrocladium	Downy Mildew	Fusarium	Phytophthora	Powdery Mildew	Pythium	Rhizoctonia	Rust	Sclerotinia	Sclerotiium	Thielaviopsis
Bacillus amyloliquefaciens Strain D747	Triathlon BA	0.5-6.0 qt./100 gal.	S, D	G, N, L	-/++	+++/++++	++/++++	+++		+++	-/+	-/++		+/+++	+	-/+++	-/++++	-	+	
Bacillus amyloliquefaciens ENV503 *Bacillus subtilis* Strain GB03	Companion	16-64 oz./100 gal.	S, D	G, N, L		-/++				-	-/+	-				-				
Bacillus amyloliquefaciens Strain F727	Stargus	0.5-4.0 qt./100 gal.	S, D	G, N	-/+++	-/+++	-/+++	+/+++	+++		-		+/+++		-	++		+/++++		
Bacillus amyloliquefaciens Strain FZB24	Taegro ECO	2.6-5.2 oz./100 gal.	S, D		-	-/++					-	+	-	+++	-	-				
Bacillus mycoides isolate J	LifeGard WG	4.5 oz./100 gal.	S	G, N	-/++	-/+	++	-/+++	-/+++		+/++							+		
Bacillus subtilis Strain QST 713	Cease	2-8 qt./100 gal.	S, D	G, N	-/++	+/+++	+/++	+/++++	-/++	-/++	-/+++	-/+	+	++/+++		-/+				
Clonostachys rosea Strain J1446	LALSTOP G-46	0.1% to 1%	S, D	G, N		-	+/++++		++			+++/++++	-	-/++++						-
Copper Hydroxide	Kalmor	0.5-2.0 lb./100 gal.	S, D	G, N, L	+++	+++/++++	+	+		+	+/+++		++++(foliar)			+	-			
Copper Octanoate	Grotto	0.5-2.0 gal./100 gal.	S	G, N	++/++++	++/++++	-/+	+/++	++		-/+++			+/++			-/++			
Extract of Neem Oil	Triact 70	0.5-2.0 gal./100 gal.	S	G, N, L	-/+	+	+/++	+/++	+/++		-/+			+++/++++			+++/++++			
Potassium Bicarbonate	MilStop SP	1.25-5.0 lb./100 gal.	S	G, N, L		-/++	-	+/++++	-/++		+/++++			+++/++++			+/+++			
Reynoutria sachalinensis	Regalia PTO	32-128 fl. oz./100 gal.	S, D	G, N	-/+	-/+++	-/+	+/+++	-		-/+++		-	-/+++				-		
Streptomyces Strain K61	LALASTOP K-61	40 g/100 gal.	S, D	G, N	-		-					-/++	-		-/++	-/++++		++/+++	-/+	-/++
Streptomyces lydicus WYEC 108	Actinovate SP	3-12 oz./100 gal.	S, D	G, N, L	-/+	-/+	-/+		-/+	+	-/+	-/++	+/+++	-/++	-/+++	-/++++	-/+	-/+	-/+	-
Swinglea glutinosa	EcoSwing	1.5-2.0 pints/100 gal.	S	G, N, L		-/++++	-/++				-/++			+/++++			+++/++++	+/++++		
Trichoderma asperellum Strain ICC 012 *Trichoderma gamsii* Strain ICC 080	Obtego	2.5-7.5 oz./100 gal.	D	G, N								-/++	-/++		-/++	-/+		-/++	-/+	+/++
Trichoderma Rifai Strain T-22 *Trichoderma virens* Strain G-41	RootShield Plus WP	3-8 oz./100 gal.	D	G, N, L						-/+		-/+++	++/++++			-/++++				-
Ulocladium oudemansii Strain U3	BotryStop	2-4 lb./acre	S	G, N		-/+++	+++/++++		-									-/++		

S = Spray
D = Drench
F = Fog
A = Aerosol

GH = Greenhouse
N = Nursery Production (Outside)
L = Landscape

- none
-/+ none to some range
+ some
++ good

+++ very good
+++/++++ very good to excellent
++++ excellent

Information as of June 2023.
The exclusion of trade names other than those listed in the table above is not intentional and does not imply that products not listed are ineffective.

30 Years in Biocontrol—Key Learnings

By **SUZANNE WAINWRIGHT-EVANS**—Buglady Consulting

I started working in the biocontrol field in Florida in the 1990s. To say it was a different time is an understatement. This was before we really had the Internet, Google or the ability to find any information we desire at our fingertips. In those days, information on commercial biological control was really only available from university resources that were very limited, and difficult to access. I remember one of the first talks I gave on biological control only five growers showed up and there was very little interest.

There was also very little, if any, pesticide compatibility information. The information we did have only came in a printed booklet from Koppert Biologicals in Europe. We would get a new book each year with the updated information, but it was very limited and based on European products.

It was also a time when pesticide resistance wasn't causing major issues in the ornamental market and people weren't as concerned about worker safety, resistance issues or the environment. It definitely was an uphill battle to convince growers that using the predatory mites to eat their two-spotted spider mites (TSSM—*Tetranychus urticae*) was a better way to go. I called on many growers trying to convince them and finally there was some interest.

Who was it? Tropical foliage growers who were grouping plants pot-tight. At the time, they were limited to translaminar and contact miticides. Because of the growing style, growers weren't getting good spray coverage in the middle and base of the plants. The predatory mites had the ability to get down into the plant canopy and into the nooks and crannies where growers weren't getting spray coverage. Growers also loved the benefit of not having to wear PPE in the summer heat. Additionally, when the plants were shipped, they were protected by the predatory mites that went with them.

A very forward-thinking grower, Ned Bradford of Bradford Botanicals, had flyers printed to go in each box, explaining how the predatory mites worked. Back then *persimilis* cost $20.00 for a bottle of 2,000 mites. If you think about it, biological control agents are one of the few things that are cheaper today than 30 years ago.

While Florida was dealing with TSSM, northern greenhouse vegetable and flower growers were dealing with Western Flower Thrips (WFT—*Frankliniella occidentalis*). The challenge they faced was, while they did have pesticides that could control the 1st and 2nd instars as well as adult thrips, there was nothing to kill the pupa in the soil. Over time, the WFT, even with a spray rotation program, developed resistance. Growers then started looking to use the predatory mite *Neoseiulus cucumeris* (today we know it at *Amblyseius cucumeris*) to help provide a control option to which the thrips couldn't develop resistance.

Around the same time, beneficial nematodes began to be considered an option to control WFT pupa in the soil. They were also being looked at for control of fungus gnat larvae. Back then, quality control of commercially beneficial nematodes was considered satisfactory if 50% of the product was alive. Even with those low numbers, it was a game changer to have an option to control thrips pupa in the soil. Today the nematode market has come a long way, with greatly improved quality, many suppliers, many species and different formulation options.

From the past and present to the future

As I think back on where we've been, it's hard not to think about where we're going. Recently, I see biocontrol adoption by growers speeding up, but sometimes I think we need to slow down a bit to ensure success. There's so much that we don't know and we need research to answer these questions. However, biocontrol research is complicated with many variables. In addition to lack of funding for research, it takes truly committed researchers to take the time to understand such challenging systems.

Another future concern is that most biological control agents used in the United States come from outside of the country. They've been developed for different growing conditions and styles. Looking over the border to Canada, researchers have been surveying for native beneficials and then developing ways to rear them. Most recently, Vineland Research & Innovation Centre has developed a production method for Anystis, also known as the whirligig mite. The technology was then transferred to Applied Bio-nomics Ltd. for commercial production. That's something I feel we need here in the U.S. We should use beneficials that are adapted to our specific environments, reared domestically, so growers can have better programs. Reduced transit times would also benefit product quality.

We also need to improve our understanding of pesticide compatibility related to beneficials. There are many places you can get compatibility information today, but most of the research merely looks at direct mortality. There are other considerations in play, such as the long-term impacts these chemistries have on factors like egg laying, sex ratio, longevity of the beneficial, as well as repellency.

We also need to understand the different formulations more completely because, often, the compatibility information is based only on the active ingredient and we know that inerts can impact beneficials. I'm not saying that pesticides are bad, but we just need to better understand how they fit into biocontrol programs. This way we can have pest programs using a truly integrated approach to manage the insects and mites that are always trying to outsmart us.

Creating a successful program

When I first walk into a greenhouse to help plan and develop a pest management program incorporating beneficials, I tend to just stop and look around at first. There are a lot of variables that go into putting a program together and there's not one easy map that everyone can follow. This is why many of us that have been working in this a long time get a little squirrely about giving advice over the phone without seeing the whole picture. Biocontrol programs need to be customized to get the most out of them.

After assessing the overall situation, I want to see the pest, identifying what it is down to specific species. This is more critical today than ever for a beneficial program, as well as pesticide spray programs. The newer pesticides are very targeted—gone are the days of broad-spectrum killing products. Many of these more targeted pesticides are often turning out to be much more compatible with beneficials. This allows programs to truly integrate all the tools in the toolbox.

A good example of this is the miticide Sultan (cyflumetofen). It's a very targeted miticide, going after all life stages of spider mites and false spider mites. It doesn't kill pest mites (like broad mites or russet mites), but it's very compatible in a predatory mite program.

Banker plants are being used in biocontrol programs to help build beneficial populations.

Orius insidiosus are very active beneficials. Right out of the bottle they're ready to start feeding on pests like thrips.

Green lacewing (*Chrysoperla carnea*) adults are beautiful pollinators. They fly around looking for pest populations so they can deposit their egg.

Biological control programs can be very targeted, too. Currently, we're dealing with a number of different thrips species in greenhouses and outdoor production. When it comes to western flower thrips (*F. occidentalis*) and onion thrips (*Thrips tabaci*) we have very good biocontrol agents to use. Unfortunately, I've recently seen more poinsettia thrips (*Echinothrips americanus*) on many different crops. This thrips cannot be controlled with commercially produced biocontrol agents; you have to spray for this pest thrips. I've seen costly mistakes made because either the wrong pesticide or wrong biological agent was applied—without taking the time to accurately identify the pest.

Once the pest is identified, I start the mental exercise of old-school integrated pest management. Can we control it with cultural or mechanical means? Do we have commercial biological control agents for it? What about microbial products? Do we need to use a conventional spray product? Also, is it economical? One thing often left out of IPM is economics. Making sure programs are economical so growers can stay in business is a very important part of this process.

If we decide that biological control is going to work well for the pest, we then have to look at the other pest issues in the crop. Will methods being used to control the other issues disrupt a beneficial program? This may include fungicides as well as insecticides. What about state and federal quarantine laws? Many growers are required by law to apply specific pesticides and we have to make sure those will be compatible with a biocontrol program. I also want to see the spray records for the last two months of any applications to the crop, just to make sure there's no surprise residue to interfere with the program. In a perfect world, we would have access to the spray records of any offshore cuttings, as well.

We also have to make sure the environment is right for the beneficial insect, mite or nematode. Often, we'll look in books, literature or scientific papers to find out the conditions in which the beneficials do well. The problem is beneficials don't always read the research and do what they're supposed to do. I see this a lot with temperature and humidity tables.

When I started, there weren't many beneficials on the market in the U.S. and most were coming from Europe. They'd been selected for the European growing environment. I was working in Florida, which has a very different climate than Europe. Since we had limited options, we went ahead and tried beneficials outside of their "optimal" temperature ranges. What we found is microclimates on leaves can provide a lot of humidity and lower temperatures to help compensate for less-than-ideal air temperatures. Also, in the heat of the day, beneficials can go down into the cooler parts of the canopy, but then come back up at night to work when it's cooler. Beneficials don't look at the time clock and only work 9:00 to 5:00—they can work for you 24/7. I think it's worth trying different beneficials to see how they perform in your growing environment even though it may not seem optimal, based on literature.

Sometimes BCAs can control a target pest, but might not be right for that crop. Take, for example, aphids. Often, parasitic wasps are used to control aphids in spring bedding plants and there may be a mummy here or there, which the consumer won't even notice … but in potted herbs or lettuce, which the customer was going to eat, this can be a problem. We cannot have aphid mummies on those crops because they would be too visible. You must know your crop and whether the beneficial is going to leave any signs it was there. Most beneficials don't leave visible traces, and many starve to death before the plants arrive at retail, but it's important to consider.

The biocontrol industry has come a long way in the last three decades and is making great strides every year. More growers are introducing biological products into their programs as companies continue to develop new products to sustainably manage pest issues. New, softer-targeted chemistries are being developed by many manufactures to ensure they work well in an integrated pest management program. We're seeing more microbial pesticides that tend to be compatible with most beneficials. Taken together, all of these advances bode well for our industry. GT

To learn more about beneficial insects, mites and nematodes, consider these additional resources:

"Knowing and Recognizing—The biology of pests, diseases and their natural solutions" (Koppert Biological Systems, 2017)

"Biological Control in Plant Protection: A Colour Handbook" 2nd Edition (Neil Helyer, 2014)

"Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control" (University of California, 1999)

Fast Facts on the Most Commonly Used Beneficials

By **SUZANNE WAINWRIGHT-EVANS**
—Buglady Consulting

Phytoseiulus persimilis

- Predatory mite
- Feeds on two-spotted spider mites (TSSM)
- Female only needs to mate once to lay fertile eggs for the rest of her life
- Higher female-to-male ratio in populations
- Faster life cycle than TSSM
- Used heavily in tropical foliage, roses and other crops prone to TSSM issues

Neoseiulus californicus

- Predatory mite
- Feeds on TSSM, but can survive on thrips, other mites, mold and nectar
- Better on lower populations of TSSM than *persimilis*
- Color can vary depending on diet
- Must mate and have offspring
- Female can lay around 50 eggs in her life

Phytoseiulus persimilis has been used for decades to control TSSMs in many crops.

Photo by Suzanne Wainwright-Evans

Neoseiulus cucumeris

- Predatory mite
- Feeds on western flower thrips (WFT), onion thrips, broad mites, other mite species and pollen
- Introduced in 1985 to control thrips in peppers
- Current strain sold is from New Zealand
- Mating is necessary for offspring
- Most effective on 1st instar WFT (can consume about six per day)
- Look for eggs on underside of leaves, in domatia
- Color can vary, depending on diet
- More suitable for moderate climates
- Backbone of many floriculture biological control programs for spring color and other thrips-prone crops

Amblyseius swirskii

- Predatory mite
- Feeds on WFT, onion thrips, broad mites, other mite species, whitefly eggs and crawlers (and pollen)
- First released in the U.S. in 1983
- Mating is necessary for offspring
- Most effective on 1st instar WFT (can consume about four per day)
- Can eat 10 whitefly eggs per day
- Look for eggs on underside of leaves, in domatia
- Color can vary depending on diet
- Often used in warmer climates
- Used often in poinsettia, gerbera and spring color programs

Aphidius colemani emerging from the body of a dead aphid. These dead aphid hosts are referred to as "aphid mummies."

Photo by Suzanne Wainwright-Evans

Aphidius colemani

- Wasp parasitoid of smaller aphid species like green peach aphid (*Myzus persicae*) and melon aphid (*Aphis gossypii*)
- Naturalized worldwide
- Females only need to mate once for life and can lay 300 eggs
- Egg to adult takes approximately 14 days
- The adults can live for about 10 days
- Creates golden mummified aphids, but there are other genera of aphid parasites that have golden mummies
- Susceptible to hyperparasites

Aphidius ervi

- Wasp parasitoid of larger aphid species like the potato aphid (*Macrosiphum euphorbiae*) and foxglove aphid (*Aulacorthum solani*)
- Native to Europe and introduced into the U.S. in 1959
- Females can lay approximately 100 eggs, laying most of them the first three days after emergence
- More aggressive than *colemani*, causing disruptions in aphid colonies
- Egg to adult takes approximately 14 days
- Creates golden mummified aphids, but there are other genera of aphid parasites that have golden mummies
- Susceptible to hyperparasites

Lacewing larvae are very aggressive predators feeding on many pest insects and mites.

Photo by Suzanne Wainwright-Evans

Orius insidiosus

- Minute pirate bug, generalist predatory bug
- Feeds on many arthropods, as well as plant material (no damage to plant), but most known for control of thrips
- Needs pollen in its diet
- Introduced into the Netherlands in 1988
- Used for decades as a commercial biological control agent in the U.S.
- Adults can live two to three weeks
- Immatures can resemble thrips, but with red eyes
- Females can lay approximately 125 eggs, inserted into plant tissue
- Needs 12 hours of light to prevent going into diapause
- Strong fliers and actively search out new prey
- Often used in conjunction with pepper banker plant systems

Chrysoperla carnea

- Green lacewing, generalist predatory insect
- Adults feed on pollen, nectar and honeydew while larvae are predatory
- Wide host range, but known for feeding on aphids
- Larva feed by grabbing prey with mandibles, injecting saliva and then sucking the contents out
- Adults and larvae tend to be nocturnal
- 75% of its prey will be eaten in the larval instar before pupating and becoming an adult
- Adult females can lay approximately 400 eggs
- Egg to adult time varies greatly by temperature
- Can be cannibalistic
- Used in many crops as a spot treatment for aphids

Orius insidiosus is an excellent generalist predator, but most often used for thrips control.

Photo by Suzanne Wainwright-Evans

Encarsia formosa

- Wasp parasitoid of greenhouse whitefly (WF, *Trialeurodes vaporariorum*) and silverleaf WF (*Bemisia tabaci*)
- Used in greenhouses since 1972
- Faster life cycle than WF
- Population almost all female
- Females can lay up to 150 eggs in lifetime
- Turns WF pupa black
- Control levels vary between plant species, leaf hairs can slow searching
- Host-feeds, eats three to four L1 per day
- Used often in poinsettia and gerbera programs, as well as vegetable starts prone to whitefly

Eretmocerus eremicus

- Wasp parasitoid of silverleaf WF (*Bemisia tabaci*) and greenhouse WF (*Trialeurodes vaporariorum*)
- Native to Southwestern U.S.
- Used for WF control since 1994
- Must mate to produce female offspring
- Female can lay up to 200 eggs in her life
- Turns WF pupa yellow
- Control levels very between plant species, leaf hairs can slow searching
- Host-feeds, 20 to 30 L1 per day
- Used often in poinsettia and gerbera programs, as well as veggie starts prone to whitefly

Stratiolaelaps scimitus, formally known as *Hypoaspis miles*, is an excellent soil predator that many growers use to control fungus gnats and WFT pupa.

Photo by Suzanne Wainwright-Evans

Stratiolaelaps scimitus

- Soil-dwelling predatory mite
- Naturally occurring in the Americas
- Lives in top layer of soil feeding on thrips pupa, fungus gnat eggs and larvae, springtails, and others
- High tolerance for starvation
- Females can live approximately 100 days
- Often used in propagation and is the base of many biocontrol programs

Dalotia coriaria

- Rove beetle
- Soil-dwelling predatory beetle
- Spends most of its life in the soil, but can fly
- Feeds on thrips pupa, fungus gnat eggs and larvae, springtails, and others
- Immature beetles and adults are predatory
- At high populations, they can be cannibalistic
- Often used in propagation and are the base of many biocontrol programs

Steinernema feltiae

- Beneficial nematode
- Control of thrips pupa in soil, fungus gnats and other soil-dwelling insects
- Uses ambushing behavior to catch prey
- Symbiotic bacteria inside of nematode kills the insect host
- Compatible with many pesticides
- Often used in propagation, poinsettias and crops prone to fungus gnats (or for thrips species that pupate in the soil) GT

Aphidoletes aphidimyza is a midge that, in its larval stage, feeds on aphids. It's easily recognizable by the larva's orange color.

Photo by Suzanne Wainwright-Evans

Using Bioinsecticides in Conjunction With Biological Control Agents

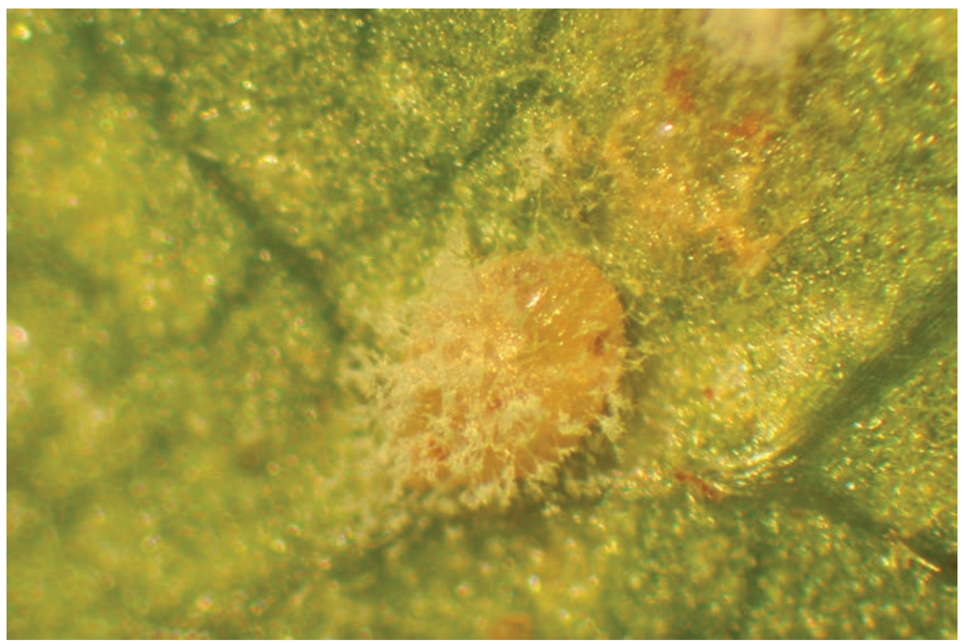
By **CARLOS E. BOGRÁN, Ph.D.**—Senior Technical Manager, OHP Inc.

Most bioinsecticides are compatible with conventional insecticides, but also compatible with natural enemies used in augmentative biological control, which involves multiple biological control agent (BCA) releases during the crop season.

Compatibility with natural enemies is a function of the nature of the bioinsecticide, and the biology and behavior of the specific biological control agent. For example, many adult predators and parasitoids spend a significant amount of time cleaning and grooming themselves using their legs and antennae. This behavior helps them avoid contamination and infection by naturally occurring pathogens, but also avoids any negative impact of biopesticide applications.

Immature life stages of parasitoid wasps and flies often occur inside the insect host where they're protected from direct contact with bioinsecticide sprays. In many cases, female parasitoids can detect and avoid entomopathogen-infected hosts (pests) preferring to oviposit on healthy, unparasitized hosts.

Biopesticides are also more quickly degraded by the environment (temperature, UV light, oxygen) than conventional synthetic insecticides. This leads to a much shorter window of activity/toxicity and reduces the risk of direct contact between the active ingredients in a bioinsecticide and the released biological control agents. Bioinsecticides may be relatively less compatible with inoculative biological control programs that rely on single natural enemy release at the beginning of the crop season or conservation biological control programs that rely on the natural colonization and reproduction of biological control agents.



The concurrent use of bioinsecticides and augmentative releases of biological control agents is also complementary because it represents the sum of a density-independent pest mortality factor (insecticide application) and a density-dependent pest mortality factor (biological control agent), which translates into more effective long-term pest population suppression.

In general, it's better to apply the bioinsecticide *before* the release of the selected biological control agent to take full advantage of both pest mortality factors. Special care must be taken when using broad-spectrum fungicides/bactericides immediately before or after microbial bioinsecticide applications, as these products may negatively affect the survival of the entomopathogens and lead to reduced impact on the pest population. Bioinsecticides of plant origin are generally less prone to incompatibility issues with conventional or biological fungicides/bactericides, but it's always important to read and understand compatibility information provided on the product labels.

In summary, the effective use of bioinsecticides in floriculture and nursery requires a basic understanding of the pest(s) and its life cycle, and the nature of the natural substances to select and use the right product at the right time and under the right environmental conditions. The more we understand the biology and ecology of all agents involved, the crop, the pest and their mortality factors, the more we'll be able to move horticultural production into a safer and more sustainable future. GT

Whitefly infested with *Beauveria bassiana* under magnification.

Using Biofungicides in Conjunction With Conventional Chemistries

By **A.R. CHASE**—Chase Agricultural Consulting, LLC

You're now juggling the needs of three living organisms and trying to produce a crop (in addition to living organisms). I once heard an entomologist state that for one of the mycopathogens of insects to work the grower must keep the plants at very high relative humidity for at least 24 hours. My thoughts immediately jumped to: Well, won't that make Botrytis happy?

In that regard, using a biological control agent (BCA) to control a disease cannot require that you actually change conditions and end up promoting the disease. Fortunately, most of the living BCAs have been formulated to work well in our growing systems without unduly favoring the plant pathogen.

What should you know when adding a biopesticide to a conventional program?

■ *What is the disease target?* If you have Pythium root rot, and use a product that works on Rhizoctonia only, then you just wasted your money. Always get a lab diagnosis.

■ *What are the best conventional and biofungicide products for that disease?* If you use any product that's only marginally effective, it will reduce the efficacy of the entire program, even when you use high-efficacy conventional products. Check with experts. No single product works best on all diseases. Some biopesticides for root disease control work better in soil (field crops) than in our soilless media.

■ *Is the biofungicide alive?* If you use a biopesticide or BCA living fungus or bacterium and rotate with a fungicide that kills it, then it stands to reason your control will be decreased. If the biofungicide (even a biological) doesn't need to be alive to work, then you don't have to worry about killing it. Check with your suppliers to see if such products are sensitive to other bactericides or fungicides in your program.

Years ago, we found out that the *Bacillus* in Cease wasn't very sensitive to copper and could actually be tank-mixed with copper without damaging its efficacy. The explanation I was given included the fact that the chemicals the *Bacillus* created while producing Cease would work with or without the living bacterium present. In this case, tolerance to copper and the efficacy of the chemicals it made were each responsible for the efficacy of Cease.

■ *Does it have special concerns (temperature, storage conditions, sensitivity to fungicides or insecticides)?* BotryStop previously had a storage recommendation for refrigeration. If this product is stored it in a hot shed and it dies, then it obviously won't work. Fortunately, the manufacturer, BioWorks, has improved the formulation, and going forward, it will be safely stored at room temperature, making BotryStop easier and more likely to be successful. Most responsible BCA producers have tested common fungicides and insecticides for safety on their particular BCA. Check manufacturer websites to be sure.

Table 1. A few examples of different types of biofungicides (OMRI-listed).

Biological Control Agents	BCAs (don't need to be alive)	Plant Extracts	Chemical Biopesticides
BotryStop	Cease, Stargus, Taegro, Triathlon BA	EcoSwing	Grotto (Camelot O)
LALSTOP G-46 (PreStop)		Regalia	Kalmor (Kocide 3000 O)
LALSTOP K-61 (MycoStop)		Triact 70	Microthiol Disperse
Obtego, RootShield Plus			MilStop
			ZeroTol, Oxidate

Table 1 shows some categories of biopesticides. Those in the column to the far left are living BCAs and cannot randomly be mixed with conventional products without checking for compatibility. The next column includes BCAs that don't have to be alive for effectiveness. They make complex groups of chemicals during their production and, in essence, act more like conventional products.

The third column shows plant extracts that are clearly chemicals naturally produced by a plant (at least originally). The final column (to the far right) shows some biopesticides that are actually inorganic chemicals (copper, sulfur, potassium bicarbonate, and the combination of hydrogen peroxide and peroxyacetic acid). The farther to the right in the table, the less complicated it will be for you to use such biopesticides in a conventional system.

Some possible biopesticide/conventional programs

At the risk of irritating virtually all manufacturers, I'll share a few examples of possible programs incorporating effective biofungicides into effective conventional programs. I also suggest that you read the product label and follow all of them carefully and completely. *Using a product on a disease or crop that is not listed on the label is still not legal.*

Bacterial leaf spots (Pseudomonas and Xanthomonas):

- Triathlon BA or Cease
- Copper, i.e., Grotto (Camelot O), Kalmor (Kocide 3000)

(Note: If you choose Camelot O or Kalmor, you could be approved 100% organic.)

Poinsettia production for root disease control:

- RootShield Plus using an eight-week treatment interval—apply immediately after transplant
- Subdue Maxx/Medallion drench apply monthly starting at eight weeks and alternate with Segway O/thiophanate methyl tank mix or Empress Intrinsic

Sclerotinia blight:

- Astun or a FRAC 7/11 combination (such as Broadform, Mural or Pageant Intrinsic)
- LALSTOP G-46
- Stargus

Powdery mildew:

- Avelyo (or Eagle)
- FRAC 7/11 combination (such as Broadform, Mural or Pageant Intrinsic)
- Regalia
- MilStop

Always read labels and follow them. They have been (and will probably always be) the law. GT

In conclusion

I hope you enjoyed the first edition of the Biosolutions Guide. It's the first of (hopefully) many to come.

As you learned from Dr. Carlos Bográn, using biological methods for managing pests and diseases isn't new and dates back as far as the late 1800s. With that in mind, each of our experts discussed how the use of biopesticides and biological control agents has evolved more recently over the past two decades. There was once a time (not too long ago) where biological controls seemed out of reach, impractical and not cost effective. But, currently, these approaches are more readily available, practical in just about every greenhouse business and can be used cost effectively.

After reviewing this supplement prior to publication, I found it fascinating how each of our experts approached their individual content. Their viewpoints and voices are meaningful and effectively reflect the diversity and individuality of the grower community as a whole, especially when it comes to biologicals. Each did a wonderful job providing the history and evolution of biopesticides and biological control agents, and provided invaluable insights for implementation into pest management programs.

I particularly like the practicality of the efficacy tables. With the rapid development and acceptance of biopesticides, it's not currently feasible to compile fully comprehensive tables that include all products. Biosolutions are a lot like technology—changing rapidly. We developed these tables to include the most widely used products labeled for greenhouse and/or nursery applications, and effective at controlling the target pests or diseases displayed in the tables.

The efficacy results listed in the biofungicide table from Dr. Ann Chase are derived entirely from research results. The bioinsecticide table is derived primarily from research, but also incorporates actual greenhouse experiences and findings. These tables will be extremely useful for greenhouse professionals in strategic planning and decision-making processes. BCA expert Suzanne Wainright-Evans helped explain the life cycles and key actions of a range of different species in her "Fast Facts" list that clearly shows the potential of BCAs in commercial horticulture. Her experience is not only scientific but also rooted in real-world greenhouse situations.

All of you face different challenges and must utilize different tools to accomplish pest management goals. As Dr. Chase points out in her article, applying a product that doesn't control the intended targeted pest or disease is both a waste of time and money. Having efficacy tables at your disposal is very valuable as you build your biosolutions programs. I personally opt to use products with very good to excellent efficacy ratings when low pest or disease pressure is present, while finding it acceptable to use products with good to very good efficacy when applications are applied preventatively or before any problems are detected.

As we've learned in this guide, using biologicals doesn't always mean *only* using biological approaches, but instead can often integrate very effectively into other management strategies. There are opportunities and limitations when using biosolutions products and BCAs during production. The key is to have a good understanding of how these products work and how they might complement or adversely affect other management strategies currently in place at your operation.

I trust you found the information provided in this guide inspiring, as well as valuable. Please return to this resource as you navigate the world of biologicals. Since we anticipate biosolutions will continue to develop at a rapid pace in the future, *GrowerTalks* is committed to leading the biologicals discussion and bringing innovative growers, researchers and market leaders to the forefront. We'll continue to publish and distribute articles, newsletters, biosolutions guides and multimedia content to our readers, listeners and viewers throughout each year moving forward.

Lastly, I encourage readers, manufacturers and researchers to contact us with new products, efficacy data and research results so we can pass these critical tools along to growers. If you have any information you'd like to share, please contact *GrowerTalks* Senior Editor Bill Calkins at bcalkins@ballhort.com.

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