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PEST MANAGEMENT

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An Essential Part of Your Future

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Biopesticides are registered and regulated plant protection products that are defined by the EPA and Canada's PMRA as "… certain types of pesticides derived from natural materials such as fungi, bacteria, viruses, plants, animals and minerals." Biopesticides are then divided into three classes depending upon the active ingredient contained or expressed. Two are of importance to the greenhouse sector:

- Biochemical pesticides
- Microbial pesticides

In this article, the focus is on the use of biochemical and microbial biofungicides registered for management of foliar and soilborne diseases and their broader contribution to plant health and productivity.

Why consider using a biofungicide?

Biofungicides are a great fit in IPHM due to their inherent features and the value they bring to the program—proven efficacy and performance, safety and compatibility—and they have unique modes of action (MOA), which is important in resistance management. In addition, most biofungicides have short re-entry intervals (REI) and pre-harvest intervals (PHI), so they can be applied with minimal disruption to day-to-day crop management activities. It's important to remember, though, what they are not: They are not curative. Rather, they're best used in a preventative manner, ideally starting in propagation, and as part of an integrated solution applied into a production system that supports their success, i.e., other components of the system do not compromise their efficacy. And, yes, they can be used in programs that include conventional pesticides, either as tank mix partners or in rotations.

The disease triangle provides a simple way of understanding what's required for a plant pathogen to infect a host. First, a virulent pathogen must be present at high enough levels to infect healthy plants. Second, to develop, that inoculum needs a susceptible host. And, finally, environmental conditions must be favorable for disease development to occur (like temperature and humidity levels). Infection will only occur if all three elements are concurrently satisfied. If we eliminate or reduce any one of them, we significantly reduce the likelihood of disease developing and spreading within a crop.

*Pictured: Enhanced root development and health following application of A) RootShield PLUS (BioWorks, left) on Romaine lettuce (control: grower standard, right); and B) in greenhouse pepper following application of RootShield PLUS (*Trichoderma harzianum *T-22 and* T. virens *G-41). Note healthy white roots growing through the coco medium.*

Recognizing we can't control the weather, what can we do to protect plants? Good agronomic and sanitation practices are fundamental, including environmental management when crops are grown indoors. Beyond that, we can reduce pathogen levels using chemical or biological fungicides (biofungicides) or both. We can also reduce plant susceptibility to specific diseases through use of resistant varieties, and by increasing a plant's ability to tolerate and recover from abiotic (environmental) stress, as stressed plants are more prone to pathogen infections.

Biofungicides for foliar diseases

Both biochemical and microbial biofungicides are available for common foliar pathogens, such as Botrytis and powdery mildew. Bacterial products based on *Bacillus* (for example, Cease, Stargus, Rhapsody, Double Nickel, Serifel) and *Streptomyces* (for example, Actinovate, Mycostop, Lalstop K61) species primarily work by antagonism. These products contain viable spores, but activity resides in the bioactive metabolites produced by the bacteria during fermentation, that are included in the formulations. These metabolites physically disrupt cell membranes and cell walls of actively growing fungi and bacteria, causing the cells to collapse and die.

The saprophytic fungus, *Ulocladium oudemansii* U3 strain (BotryStop WP), works by antagonistic competition. *Ulocladium* colonizes dead, damaged and senescing plant tissues, and out-competes Botrytis for resources at these sites, preventing the disease from getting a foothold on a plant and building inoculum levels in the crop. As the fungus grows on the plant tissue, it also secretes enzymes that degrade pathogen cell walls, providing an additional MOA. This product also works well against bacterial leaf spot (BLS) diseases (caused by Xanthomonas and Pseudomonas) on many plants, likely due to a very similar MOA, with the fungus colonizing leaf tissue compromised by the bacteria and effectively enclosing the disease and preventing its further development and spread.

Several foliar products classified as biochemical fungicides have a physical mode of action. Potassium bicarbonate (like MilStop SP and Kaligreen) is a well-known remedy for powdery mildew and Botrytis. Bicarbonate-based products work by desiccating fungal spores and actively growing hyphae on the leaf surface on contact, destroying cell membranes, leading to cell death. An application also raises the pH of the leaf surface, creating conditions that are unfavorable for fungal growth. Polyoxin D is a naturally occurring compound produced by *Streptomyces cacaoi* var. *asoensis*. Polyoxin D is very water soluble, so it's formulated as a zinc salt (Polyoxin D zinc salt, such as OSO) to provide longer residual activity on a leaf. Polyoxin D works by inhibiting the formation of chitin. Chitin is a vital component of fungal cell walls, so the product prevents fungal growth.

Botanical extracts derived from giant knotweed (Regalia) or *Swinglea glutinosa* (EcoSwing), as well as some *Bacillus* species (such as *B. mycoides* and LifeGard), have no direct effect on pathogens, but when applied to plants, stimulate production of antimicrobial proteins and other compounds that inhibit plant pathogens, thereby enhancing the plant's own natural defenses against infection.

Microbial biofungicides for soilborne diseases

Microbial biofungicides will prevent infection by common root diseases such as Fusarium, Pythium, Rhizoctonia, Phytophthora and Thielaviopsis. We know that infection by one may pre-dispose a plant to infection (and death) by another, so the availability of products with the capacity to control a broad range of diseases is clearly advantageous. That's another benefit provided by the microbial biofungicides that are registered for soil application. Most are based on fungi like *Trichoderma* and *Clonostachys*, or bacteria, like *Bacillus* and *Streptomyces*. *Streptomyces* and *Bacillus* species colonize the rhizosphere, the thin layer of soil or growing substrate that surrounds the plant root, whereas *Trichoderma* species colonize the root surface itself. All utilize sugars and other root exudates to grow. While several different species are represented in the registered products, they provide protection via a combination of competition, antagonism, parasitism and their capacity to induce plant resistance. However, not all strains have multiple MOA.

Let's consider the MOA of *T. harzianum* T-22, one of the two strains in RootShield PLUS, as an example to understand how these microbes work. As the fungus grows around the plant root, it competes with pathogens for resources (such as sugars and space) at the root surface and prevents them from establishing (competition). Actively growing T-22 also secretes metabolites that inhibit germination and growth of pathogens (antagonism). This fungus can also parasitize and "consume" pathogens in the soil.

Lastly, as the fungus grows, other biochemicals it produces are detected by the plant roots; this activates metabolic pathways in the plant that result in the upregulation of plant defense genes, so the plant is primed to defend itself against pathogen attacks (induced resistance). Having multiple MOA means that it's difficult for diseases to develop resistance to these microbial biocontrol agents, making them ideal standalone products and excellent rotational partners in resistance management programs. Some metabolites produced by the fungus work as phytohormones, stimulating root growth and development.

Application essentials

Think of it this way: You need to put the right product in the right place at the right time, using the right equipment to be successful. Incorrect timing and poor coverage are primary causes of biopesticide failure. But isn't that true of all fungicides, whether conventional or biological? Here are a few things to consider:

Product selection. First off, make sure that the products you're considering using are registered. There are many microbial products out there, but relatively few are EPA-registered. Educate yourself on the different types of biofungicides that are available for foliar and soilborne disease control. Ask questions of the manufacturers so you select the best product for your crop and needs. Consider the application equipment you have available and where you're looking to utilize the material. Although biofungicides share many characteristics, they're also different. Familiarize yourself with the label and the recommendations around product use, rates and re-application intervals. Ask for data to support claims and understand how products interact with other crop inputs and the environment.

Timing. Biofungicides provide the best protection when applied proactively, *before* disease symptoms are observed in the crop. Few work curatively (there are some exceptions—potassium bicarbonate products like MilStop-SP, for example, can be applied at preventative or curative rates) and they all work best when

disease pressures are low to moderate. This is true for foliar and soilborne diseases.

In greenhouse crops, applications of microbial biofungicides to protect plants against root diseases should begin in propagation. When plants are dying in propagation, it's too late to remediate the disease(s). It's better to protect roots from the get-go and the plants will thank you for the added benefits these products bring. (Note: Growers can also apply biofungicides after a recent chemical application to lower pressure. Or, if compatible, mix a biological with a chemical for curative, then preventative, protection.)

As with any fungicides, biofungicides need to be re-applied while disease pressures persist. Foliar diseases spray intervals are often similar across crop types and will be influenced by disease pressures or the onset of weather conditions that are conducive for disease development. This is also true for soilborne diseases, but the type of growing medium used also affects the interval between treatments. Timing varies for plants grown in peat, coco or rockwool media, and even hydroponics.

Application. Different terms are used on labels to describe how products should be applied. It's important to understand what these terms mean to use spray or other application equipment correctly to achieve the desired outcome in terms of getting a biofungicide where it needs to be, whether that equipment is even appropriate for that product and whether that method of application is actually on the label—application by dipping or fogging, for example, aren't approved methods of delivery for many biofungicides. Performance is then a product of the equipment selected, how well it's maintained and calibrated, and how well the applicator uses that equipment.

A wide range of equipment can be used to apply biopesticides, from simple backpack sprayers to more advanced hydraulic, low-volume and electrostatic sprayers. While the sprayers utilize different methods to produce and deliver spray droplets onto the plant, in all cases, the goal is to get thorough coverage of all plant surfaces and good penetration of the plant canopy by those spray droplets. For most foliar biofungicides, "spray to glisten" (meaning apply a light coating of spray droplets to leaf surfaces) or "to wet" (leaves are wet, but no runoff) are often recommended spray practices. The goal should always be to avoid runoff. We can get significantly better coverage if we use a sprayer that generates fine droplet sizes. Smaller droplets also move deeper into the canopy and provide superior coverage over all surfaces. Selection and use of the right spray equipment for the product and targeted use are essential to achieving the desired end result.

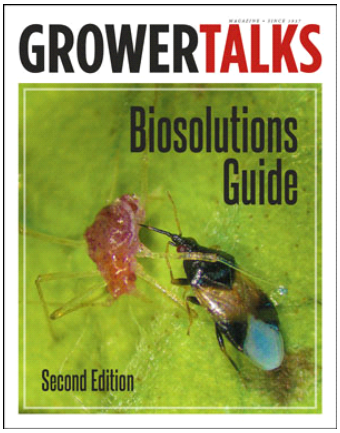
Drenching via a Dosatron-type system or through the driplines is the most common method used to apply WP or liquid formulations of biofungicides for soilborne diseases. It's worth emphasizing again that early application allows the microbes, that can, to establish on and protect the young roots, with products re-applied at different stages of the production cycle to provide ongoing protection. Critical to efficacy again, though, is coverage, ensuring that the biofungicide is applied in sufficient water to move the spores though the growing medium and into contact with the roots. Granular formulations of these biofungicides can be directly incorporated into the growing medium prior to use, so that the granules, and hence the inoculum, are evenly distributed throughout the medium and available to roots as they grow through the medium. As an alternative, granular biofungicides that grow can be top-dressed onto the media. When watered, the spores are moved into the medium, and will germinate and grow on the roots to defend the plant and reduce plant stress.

A final word of caution

There's no shortage of microbial products that claim to protect plants from disease or sources for them, including several multi-strain products that allegedly contain bacteria and/or fungi that are the same as those

in registered plant protection products. But are they? Take a closer look at the label on your *EPA-registered biofungicide*. It'll tell you what species of bacterium or fungus it contains, and the strain number.

For example, *Trichoderma harzianum* T-22; *T. virens* G-41; *T. asperellum* T-34; *Streptomyces griseoviridis* K-61, *S. lydicus* WYEC 108; *Bacillus amyloliquefaciens* MBI600, D747 and F727; *B. subtilis* QST713. These specific strains have proven capacity to control plant diseases and deliver other plant health benefits. There are many isolates of *Trichoderma*, *Bacillus* or *Streptomyces*, but a name is just that—a name. Strains are key and numbered strains in registered products distinguish them from other isolates with the same name.



The Biosolutions Guide

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