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by JOHN FRANCIS

The NATURAL Choice

"Planting" or applying very small, dormant propagules of beneficial microbes to your rooting medium results in a population of organisms that provide many benefits, including protecting your plant roots from disease. While the "crop" doesn't produce a plant of aboveground beauty or utility, using some biological fungicides can result in hairy, disease-free, vigorous roots, which to a grower are beautiful things!

This article focuses on biological or microbial fungicides for root disease control. These fungicides have been in the industry for years, and many growers have successfully reaped the benefits of excellent root health and — with some products — lowered overall costs to keep root diseases under control.

There are strengths and weaknesses for any product, and this applies to biological or microbial fungicides, as well, which I'll address. Understanding how they "work" is helpful because all of this work is done at a microscopic level, which, by the way, is where the pathogens do their work. Along with understanding how they function, there are some factors for success that — if you haven't tried microbial fungicides or didn't have success before — can expand your understanding.

When you are approached with a new product to trial, the first level of evaluation is to determine if it is an EPA-registered product. Registered products have at least been screened for a basic level of efficacy against root diseases. If the product is registered in California, data was submitted showing proven efficacy for the diseases and crops listed. Currently, the more commonly used biological fungicides are either bacterial or fungal organisms.

Biological or microbial fungicides can be effective and cost-efficient tools in your overall root disease prevention program.

Why consider biological fungicides? Biological or microbial fungicides can be effective parts of your overall root disease prevention program, complementing any efforts of sanitation, cultural practices and pesticides. Biological fungicides can also eliminate or reduce the use of chemical fungicides. Besides saving money, there is the issue of resistance management from microbials that — due to unique and often multiple modes of action — can prevent attack by resistant populations of a pathogen. Rotating a biological fungicide between chemical applications can extend their usefulness before resistance develops, as well as reduce the overall use of chemicals. Biological fungicides fit well into the "clean plants" concept of input history or pedigree of the crop where every material used in or applied to the crop is listed.

For organic or sustainable growers, microbials integrate well and become an essential part of overall sustainability efforts. Also, plants can be treated without any slowdown or setback due to mild root phytotoxicity reactions from some chemical drenches and, therefore, biologicals are softer on tender plant material. Many biological fungicides are labeled for edible crops (such as vegetables and herbs) and have either a short or no restricted entry interval. Additionally, most are compatible with biocontrol agents, such as predatory mites and insects.

Strengths and weaknesses. Strengths of some microbial fungicides include no resistance development, extended disease control from one application, gentler to plant material, lower toxicity and a better perception of sustainability. There are additional factors growers need to consider when evaluating whether to use a particular biological root fungicide. For example, some of the weaknesses cited for

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Some microbial pest-control agents

Product/type/restricted entry interval (REI)	Primary source	Organism	Formulation/ reapplication
Actinovate (bacterium) [REI-1]	Natural Industries Inc.	*Streptomyces lydicus* (WYEC 108)	Powder (season-long)
Actino-Iron (bacterium) [REI-4]	Natural Industries Inc.	*Streptomyces lydicus* (WYEC 108)	Granular (season-long)
CEASE (bacterium) [REI-4]	BioWorks Inc.	*Bacillus subtilis* (QST 713)	Liquid (3 to 4 weeks)
Companion (bacterium) [REI-4]	Growth Products Ltd.	*Bacillus subtilis* (GB03)	Liquid (2 to 4 weeks)
Mycostop (bacterium) [REI-4]	Verdera Oy	*Streptomyces griseoviridis* (K61)	Powder (2 to 6 weeks)
PlantShield HC (fungus) [REI-0]	BioWorks Inc.	*Trichoderma harzianum* strain T-22	Powder (10 to 12 weeks)
RootShield (fungus) [REI-0]	BioWorks Inc.	*Trichoderma harzianum* strain T-22	Powder or granules (10 to 12 weeks)
SoilGard 12G (fungus) [REI-0]	Certis USA LLC	*Gliocladium virens* strain GL-21	Granules (1 to 4 weeks as needed)

Fungicide cost comparison

Comparison showing how costs are reduced using RootShield WP versus a typical chemical root drench fungicide

Weeks of control	Thiophanate-methyl fungicides (low cost)	Thiophanate-methyl fungicides (high cost)	RootShield WP cost
1	$17	$40.78	$16.67
2			
3			
4			
5	$34 (2nd application)	$81.56 (2nd application)	
6			
7			
8			
9	$51 (3rd application)	$122.34 (3rd application)	
10			
11			
12			

• Cost comparison provided by BioWorks Inc.

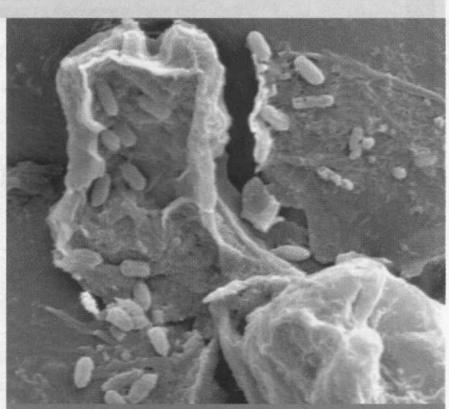
microbials are short shelf life (compared to chemicals), special storage condition requirements, frequent applications, lack of rapid results and concern over chemical compatibility.

Frequency of application is important — labor costs increase with every application — and ranges from one week to all season. For products that claim season-long control, it is important to get a definition of "season" from the product supplier. Some biologicals benefit from refrigeration to extend their shelf life. The expectation of rapid results can be overcome with understanding and using biologicals appropriately — as preventive, not curative.

Using biological fungicides, such as RootShield granules, can result in disease-free, vigorous roots.

How sensitive a microbial fungicide is to other chemical inputs is information you will need to obtain from the supplier. Some bacterial products, for example, are sensitive to applied foliar fungicides containing copper or to irrigation water containing biocides, such as chlorine and hydrogen dioxide/peroxide materials.

A biological product also needs to be resistant to chemical fungicide drenches, which are sometimes required if incoming plant material is possibly infected with a pathogen, during high stress periods or when pathogen inoculum loads rise to overwhelming levels. A biological product should be easy to use and easy to mix with practical rates; it shouldn't have complicated application methods or wait times. Most important, selection of a suitable product involves matching the disease-control spectrum with what you are encountering in your production.



A fungal spore is damaged by CEASE, a biological fungicide that contains the strain of the bacterium *Bacillus subtilis* (QST 713).

How do they work? The main principle of activity for biological fungicides is high numbers. Introduce a high enough population of good organisms and you overwhelm the bad or ineffective organisms. Various modes of action are claimed for both types of biological fungicides (bacterial and fungal) and include:

- competitive exclusion, which is when the applied organism outcompetes the pathogens for ideal colonization sites on the root system and for nutrients that are released or leaked from the roots;
- mycoparasitism, which is when the

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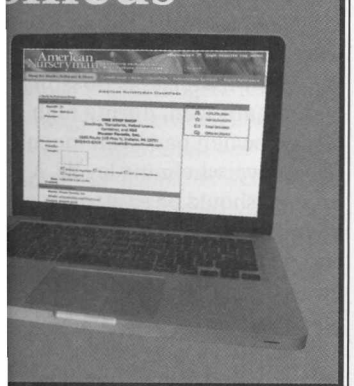

good guys eat the bad guys;
- antagonism, which usually results from metabolites that repel the root pathogen;
- disruption of pathogen cell membranes with metabolites, including lipopeptides; and
- production of antibiotic agents and anti-fungal enzymes, which can kill or repel pathogens — this mode of action is often short-lived.

Factors for successful use. The following are factors to keep in mind in order to be successful with microbial fungicides.
- A key consideration for any biological fungicide is to understand that it is preventive only. It must be *applied early* — well before pathogen infection occurs.
- Use microbial fungicides throughout the production cycle, starting with stock plants, in propagation and while finishing the crop.
- It is critical that you use a living biological fungicide. If you get a trial sample from a salesperson or purchase your first product, observe proper storage conditions and expiration dates — don't apply a dead, expired product and expect results. Apply an appropriate drench volume, remembering that it is a numbers game of good guys versus bad guys.
- If you are trying a microbial root fungicide for the first time, compare it to your present standard practice. Have controls with no treatment and one with reduced chemical fungicide applications, in addition to your usual way of doing things.
- Observe reapplication intervals, and reapply at recommended rates to keep the numbers up.
- Lastly, remember that just like chemical fungicides, biological fungicides are not a "silver bullet," nor "bulletproof."

Why don't researchers always get great results? Some research reports show poor results for microbial fungicides. Of course, products vary in their effectiveness, but I have seen proven products reported as ineffective when growers have used them successfully for years.

While many factors are involved, some researchers are more used to testing chemical fungicides than biologicals. Often, a protocol developed for a chemical *eradicant* is used to test a *preventive* product. This can involve artificially high pathogen inoculant loads. Also, some testing protocols don't allow enough time for the biological fungicide to adequately colonize the root system prior to introducing the disease inoculum. Often, research involves worst-case testing, which

These *Coreopsis* (top) and *Echinacea* plugs were protected by RootShield WP, a wettable-powder biological fungicide for greenhouse, nursery and vegetable crops.

PHOTOS COURTESY OF BIOWORKS INC.

favors the pathogen, thus overwhelming the biological fungicide. This is usually unrealistic and can be far worse than the disease problems growers usually face in real production environments.

Cost-effectiveness. Whether a product is cost-effective depends on the particular product and its characteristics. One of the most important factors is how effective the product is at controlling your particular disease problem. Next comes the reapplication interval. On a long-term crop, a product applied every two to four weeks is going to cost more by crop finish than one lasting 12 weeks from one application when you add up material, plus labor. Proper cost evaluation involves calculating the overall cost for the entire crop cycle or the cost per unit of production, such as a plug, pot or flat, not the cost per package or pound of product. Other, more intangible effects on cost-effectiveness are worker safety, speed of plant establishment and maintaining sustainability standards.

With careful selection of a biological fungicide — by being aware of the product's characteristics, proven track record and understanding the factors for effective use — excellent root disease control can be maintained in all types of plant production.

John Francis is director of marketing and technical services for BioWorks Inc., Victor, NY. He can be reached at (800) 877-9443 or jfrancis@bioworksinc.com.