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Bio-Fungicides

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Biological control of plant disease can be defined as " the involvement of the use of beneficial microorganisms, such as specialized fungi and bacteria, to attack and control plant pathogens and the diseases they cause. So what are these "specialized fungi and bacteria" that can attack and control plant pathogens? These specialized fungi and bacteria are microorganisms that are part of the normal microbiological environment of most "healthy" soils. They are not genetically engineered. In their native habitat these beneficial microorganisms compete with other microorganisms for space and food. In some cases they are parasitic on other microorganisms and/or they produce toxic substances that kill other soil-inhabiting microorganisms such as Pyhtium sp., Phytophthora sp., Rhizoctonia sp., and other plant pathogens. Scientists are well aware of these beneficial microorganisms and have studied them for many years. They have shown that these beneficial microorganisms play a vital role in the make up of the soil environment and are part of the normal checks and balances that make up a "healthy" soil.

Many beneficial fungi and bacteria have been isolated from the soil and tested in private and university-based laboratories as to their ability to control plant pathogens. Recently, some of the more promising of these beneficial fungi and bacteria have been further developed and marketed to ornamental plant growers as an alternative to the traditional chemical-based fungicides.

The purpose of this article is to allow the reader a better understanding of the current crop of beneficial organisms (biofungicides). I will discuss how they work, and most importantly their advantages and disadvantages when compared to traditional chemical fungicides.

How They Work. There are four different mechanisms by which beneficial or biocontrol agents interact with other microorganisms. Most biocontrol agents apply only one of these four mechanisms, however, some may employ more than one. Also for the purpose of this article I will refer to the plant pathogen as the target organism.

1. Direct Competition. In this case the biocontrol agent out-competes the target organisms for nutrients and space. This is typically a fungus or bacteria that grows very fast and overwhelms the target organism with sheer numbers. The target organism is suppressed due to lack of food and space. The target organism may not die- out completely, however, it's population becomes so low it is no longer a legitimate threat to the host plant. In order for this type of biocontrol agent to be most affective the environmental conditions must favor the growth and reproduction of the biocontrol agent.

2. Antibiosis. With antibiosis, the biocontrol agent produces a chemical compound such as an antibiotic or some type of toxin that kills or has some sort of detrimental effect on the target organism. Many microorganisms produce antibiotics and toxins. Some of the more common antibiotics that we humans use to warrant-off infections came originally from common soil-inhabiting fungi and bacteria. In some cases antibiosis can be accompanied with other detrimental mechanisms. Antibiosis is one the of the most affective methods of controlling microorganisms.

3. Predation or Parasitism. This is the mechanism that most of us envision when we think of biocontrol agents. In this case the biocontrol agent attacks and feeds directly on the target organism or the biocontrol agent produces some sort of toxin that kills the target organism and then the biocontrol agent feeds on the dead target. Like Direct Competition, the environment must favor growth and development of the predator or parasite since populations need to be high enough to overwhelm the target organism.

4. Induced Resistance of the Host Plant. Scientists have known for decades that once a plant is infected with a pathogenic microorganism, that infection triggers some sort of biochemical reaction in the infected host plant that helps keep it from being infected with further pathogens (super infection). The infected plant becomes more "resistant" to other infections. Plants do not have immune systems to protect them from infection as we do, however, they do have physiological and biochemical systems that help inhibit infection and spread of pathogens within tissues of the affected plant. Some biocontrol agents are known to trigger these mechanisms and in the case of induced resistance, host plants are purposely inoculated with this agent in an effort to trigger this resistant response. The microorganism that triggers the response is usually not a severe pathogen of the host. If it were, it would defeat the whole purpose. Induced resistance is little understood and is currently a very exciting area of research throughout scientific community.

Advantages and Disadvantages of Using Biological Control Agents

Even though it appears as if these biocontrol agents are the cure-all, there are distinct advantages and disadvantages in using these products when compared to traditional chemical controls.

Advantages

- If used properly they help reduce the use of chemical-based fungicides. This is good for the environment and is one of the most important reasons to consider their use.
- They help reduce the risk of developing pathogen resistant to traditional chemicals. Due to the overuse of certain chemical fungicides, some common plant pathogens such as *Pythium* sp. and *Botrytis* sp. have become resistant to these fungicides. This is less likely to happen with biocontrol agents because the beneficial organism co-evolves along with the target organism and adapts to the changes. Something a chemical can not do.
- In most cases they are safer to use. Most biocontrol agents have very low or no toxicity to humans and other mammals. This is a tremendous benefit in this day and age.
- They tend to be more stable than chemical pesticides if stored properly. These are living organisms and must be stored as such. If they spoil they are no longer affective.
- In most cases they have lower re-entry interval (R.E.I.) times. This is a significant factor especially when it is necessary to enter the production facility immediately following application.
- In most cases they are less phytotoxic. Because they are "natural" they are less likely to cause toxic effects on the host plant. Especially is mistakes are made and rates are miscalculated.

Disadvantages

- Biocontrol agents tend to be more difficult to implement when compared to chemicals. Since most of these products have to be implemented prior to the onset of disease, greater preparation by the user is necessary. Biologicals work best in greenhouses that routinely scout for diseases and insects and detect problems early.
- In most cases they have a narrower target range. Most are not broad spectrum products. Identification of the correct target organism is imperative.
- They may not work as quickly as chemicals. Since their populations need to take time to build-up they can take more time to be affective. That is why it is necessary to apply them prior to the onset of severe disease outbreak.
- These products do not eradicate the pathogen or rescue the host from infection. They have to be administered prior to the onset of disease. In most cases at preplant.
- They may have a shorter shelf live if not stored properly. Remember these are living organisms and don't take well to extremes in temperatures.
- In most cases biocontrol products are more expensive to use. This includes both time and money. They may be a bit more expensive to

purchase initially and they take more time to initiate, if used properly.

- They may not be compatible with the use of other chemical fungicides and bactericides. The product label should be checked to see what chemicals the product is compatible. Many of these beneficials are fungi and some of the more common greenhouse fungicides have the potential to kill these beneficial microorganisms.

The Products

Currently there are close to 40 commercial products that are marketed as biological controls worldwide. Not all of these are available in the United States. Greenhouse floriculture and perennial production there are about a half dozen products that are currently popular (**Table 1**.) Of these PlantShield appears to be the most widely used. Plantshield is the T-22 strain of the soil inhabiting fungus *Trichoderma harzianum* (TH). TH's mode of action against the target organism is multifaceted. It uses both antibiosis and predation against many common soil-inhabiting fungi that cause root and crown rots such as Pythium, Rhizoctonia, Fusarium, and Sclerotinia. It appears to be one of the most popular biofungicides in the greenhouse industry and can be an asset to a disease management program if used properly.

Keys to Successful Use of Biocontrol

In order for any of these biological control agents to work for you, two simple rules MUST be followed. First off, all of these products MUST be used in conjunction with standard disease cultural controls. Cultural controls include, growing plants in a well drained media, not over watering, keeping the greenhouse relative humidity below 85%, practicing strict sanitation, and making sure that the nutrient and pH conditions of the host plant a within the ideal range for proper growth and development. This will help assure that the environment is favorable for the growth and development of the beneficial organism. Secondly, All of these biocontrol products MUST be applied at preplant or prior to the onset of disease. In most cases they will not rescue plants that are already infected. If you abide by these two critical conditions, the likelihood of you having success with a biocontrol agent is good. If you don't, they won't work. Manufactures that have traditionally been the source of chemical fungicides will be producing and marketing biofungicides. Growers need to be aware of what products are available, the way they work, and their limitations. It will be a while before we see a biofungicide that controls Pythium sp. as good as Subdue did. However, under the proper growing conditions biofungicides can be a viable alternative to chemicals.

Table 1. Common Floriculture Biological Control Products and Their Uses.

Product Name*	Contents	Target Organisms
AQ10	M-10 isolate of the fungus *Ampelomyces quisqualis*	powdery mildew**
Companion	GB03 isolate of the bacterium *Bacillus subtillis*	root rot pathogens***
Galltrol-A	Strain 84 of the bacteria *Agrobacterium radiobacter*	crown gall disease
Mycostop	Strain K61 of fungus *Streptomyces griseovidiris*	many root, stem and leaf pathogens***
PlantShield	Strain T-22 of the fungus *Thrichoderma harzianum*	root rot pathogens****
SoilGard	Strain GL-21 of the fungus *Gliocladium virens*	*Rhizoctonia* & *Phytium* sp

* in alphabetical order
** only on selected ornamental crops
*** *Fusarium* sp., *Alternaria* sp., *Phomopsis* sp., *Botrytris* sp., *Pythium* sp., and *Phytophtora* sp.
**** *Pythium* sp., *Rhizoctonia* sp., and *Fusarium* sp.

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