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The key to using biological-control agents to manage pests and diseases in a nursery setting is understanding the fundamentals of this natural option.

Taking a Stroll with BIOCONTROL

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Nursery growers often have negative thoughts when they hear somebody suggest biological control as a management option. This misunderstanding may be in part the fault of extension entomologists and plant pathologists not adequately demonstrating the role natural control plays in nursery crops. Naturally occurring biological-control agents are at work every day in your nursery, keeping arthropods and plant pathogens under control. If it were not for these agents, nursery growers would be spraying constantly for insects and diseases.

There are many definitions for biologi cal control, with the most common being "the control of a pest by the introductior of a natural enemy or predator." This statement only is partially correct.. A better way to think about biological contro would be: "the control of a pest by another biotic, or living, agent." Natural enemies include predators, parasites, parasitoids fungi, bacteria, viruses and even verte brates, such as birds. There are two bio logical-control approaches that growers can use — conservation biological control and augmentation biological control.

Conservation biological control. Conservation biological control is the manipulation of growing practices for the conservation of natural enemies. This method is the most important biological-control practice and easiest for growers to implement. A range of natural enemies is found in ornamental nurseries. These organisms are well-adapted to the host plants and pests in your nursery. Developing production practices that conserve these organisms generally is simple and cost-effective. With relatively little effort, the activity of these natural enenes can be conserved.

A method of conservation biological control that you may be practicing already to manage root diseases is the utilization of composted materials. Composted materials are capable of harboring beneficial fungi. However, there are no standards of tests that are readily available to ensure the materials you use contain these beneficial biologicals.

The use of pesticides can kill beneficial predators, parasites and microbes, as well as pests. They can cause outbreaks of secondary pests or rapid resurgence of pests that initially were suppressed. By avoiding the use of nonselective pesticides and using pesticides that kill only the target pests, you may protect natural enemies in your nursery. Most of the newer insecticides only target a few pest species and oftentimes will list the natural enemies that are not killed by the product.

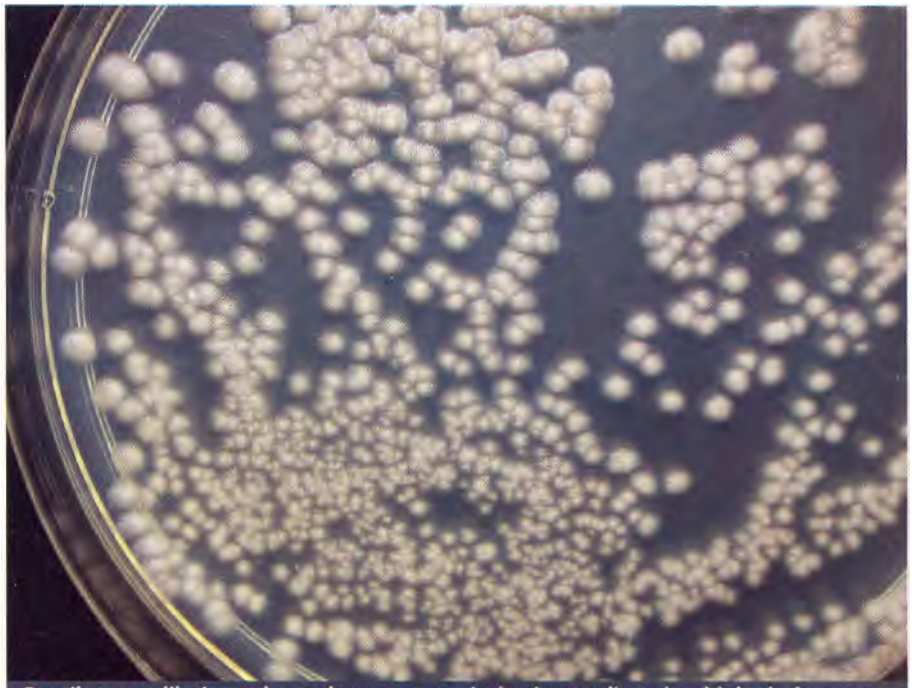
Many of the natural enemies easily are seen when scouting, including spiders, lacewings, lady beetles, ground beetles, rove beetles, syrphid flies, flower flies, hover flies, true bugs (such as minute pirate bugs, big-eyed bugs and damsel bugs) and predatory mites. However, many important natural enemies rarely are seen, such as parasitic wasps and flies, beneficial nematodes, bacteria and fungi. The active stage of the parasites is the immature stage, which is inside the insect. Nematodes also are internal. Bacteria and fungi are too small to be seen by the naked eye.

Augmentation biological control. Augmentation biological control is the release of natural enemies all at once or over time to suppress pest populations. Releasing natural enemies for controlling certain pests can be very effective in greenhouses and interiorscapes. A well-known example is the control of the two-spotted spider mite by releasing predacious mites, such as *Phytoseiulus persimilis.* To date, the use of augmentation biological control in the nursery has been difficult to implement. Outdoor releases of biological-control agents are affected by unpredictable environmental conditions. Furthermore, if other pests (such as insects, mites or pathogens) are unaffected by the released organism, pesticides used to control these pests often eliminate the natural enemy that was released.

The application of microorganisms in a manner similar to conventional pesticides is a type of augmentation. These products are referred to as "microbial insecticides." Several products available contain varieties of the bacterium *Bacillus thuringiensis,* which controls certain caterpillars, beetles and flies, but does not affect other arthropods. Microbial insecticides are relatively slow-acting and are most effective if applied when pest numbers are low and pests are in early stages of development.

Purchasing and releasing natural enemies for control of insect and mite pests are an attractive alternative to the potential hazards associated with chemical insecticides (such as toxic effects on nontarget organisms, development of pesticide resistance and persistence in the environment). Furthermore, releasing natural enemies, such as lady beetles, is educational and fun for children and adults alike. However, consumers sometimes are disappointed with the level of pest control achieved by releasing natural enemies. Successful use of natural enemies requires the use of appropriate species under proper conditions. A better understanding of this method of biological control can help improve your chances of success.

Commercial products available for use in augmentation biological control include microbial insecticides containing living pathogens (bacteria, fungi and viruses) and multicellular animals (nematodes, parasites and predators). Other



Paecilomyces lilacinus, shown here on a semiselective medium, is a biological antagonist of nematodes.

Hunter flies are a new beneficial insect that has entered the US market. The adult fly feeds on small, flying insects.

Biological-control agents for disease

Biological-control agents for disease are classified into two groups by area of action: aboveground parts (foliage) and belowground parts (roots).

Area of action	Trade name	Active ingredient	Type of agent	Mode of action
Above ground	Taegro Sonata Biofungicide Rhapsody Serenade	*Bacillus* sp. (various species and strains)	Bacteria	Competition, antibiosis
	PlantShield HC RootShield Granules T22 Planter Box	*Trichoderma harzianum* (various species and strains)	Fungi	Competition, mycoparasitism
Below ground	MeloCon WG	*Paecilomyces lilacinus* strain 251	Fungus	Mycoparasitism
	Actinovate SP	*Streptomyces lydicus* strain WYEC 108	Bacterium (actinomycete)	Mycoparasitism, induced resistance*

* There is some speculation that *S. lydicus* strain WYEC 108 is capable of inducing resistance in plants, but it has not been well-documented.

Lady beetles are among our most beneficial insects. They feed on aphids, immature scale insects, mealybugs, mites and other soft-bodied insects.

products occasionally used with biological-control agents include synthetic honeydew, flowers to attract and conserve beneficial insects in and around pest-prone or pest-infested sites and traps that use colors or scents as attractants.

Modes of action. Biological-control agents used to suppress plant diseases are applied in an augmentative fashion. They suppress disease pathogens using one or more of the following modes of action: competition, antibiosis, mycoparasitism and/or induced resistance.

Some biological-control agents are selected for their vigor and ability to compete successfully for space and nutrients, thus outcompeting the pathogens. However, one should be reminded that biological-control agents are organisms — and they have their preferences. If conditions do not exist for conducive growth of the biological-control agent, then the agent will be ineffective. One of the limitations in the search for new biological-control agents is their ability to be active in a wide range of environmental conditions.

Many microorganisms produce biochemicals as a weapon against their competition. These chemicals commonly are known as antibiotics or antimicrobials. Some biological-control agents are selected for their ability to produce chemicals that are harmful to pathogens. But keep in mind that because biological-control agents are living organisms, they only will produce these chemicals under specific growth conditions. One of the challenges in searching for new biological-control agents is finding ones that always have the ability to produce antimicrobials or to produce those antimicrobials in a wide range of growing conditions.

Some microorganisms just love to prey on others. They are selected for their ability to seek out and destroy pathogens. As with previous challenges, finding a biological-control agent that would be consistent in its ability to prey on pathogens over a large range of environmental conditions almost is impossible. Thus, the conditions limit the activeness of the biological-control agent.

In some cases, a biological-control agent can mimic a pathogen. The agent does it in such a way that plants are capable of detecting it and responding to it by enacting some defenses. The reaction is called induced resistance, by which the plant is resistant to certain plant pathogens. This mode of action has been attributed in many cases to "elicitors." These elicitors can be parts of the biological-control agent or chemicals that are produced by the biological-control agent. Nowadays, there are products that are isolated from living organisms that can react to induced resistance, hence taking out the living agent in the biological control.

To simplify our understanding of biological-control agents for diseases, we can separate them into two groups: those that go to work on plant parts above the soil line and those that suppress pathogens below the soil line (chart, above).

Biological controls for diseases. Currently, there are few biological-control solutions available to the nursery industry for managing plant diseases. Careful decision-making and planning must be taken into account to ensure that growth condi-

tions exist for the biological-control agent to thrive so that best results can be achieved. As with any biological-control agent, there is a lag time prior to any results being observed. This gap can be attributed to the fact that the biological-control agents need to multiply and reach a critical population under a conducive environment in order for them to act in a manner to suppress their target pathogens. That having been said, biological controls for plant disease are best used in a preventive manner. Biological-control agents that have a chance to establish themselves tend to exclude or suppress the pathogen, thus providing a chemical-free approach to producing plants.

Companies selling products and promoting their use should provide the consumer with directions on how to store and use their products, as well as support their claims of product performance. Insectaries and brokers — the companies producing and marketing parasites and predators — assure the delivery of viable natural enemies of the stated species or strain. They usually do not guarantee results from releases of these biological-control agents even when used as directed.

Microbial pesticides (bacteria, fungi and viruses) are regulated like pesticides by the EPA under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). However, multicellular animals (such as arthropod predators, parasites and nematodes) are not registered or regulated by the EPA under FIFRA.

Users who purchase and release natural enemies must be aware of legal and biological limitations of augmentation biological-control methods. Just restricting frequent use of broad-spectrum insecticides often will allow a diverse group of naturally occurring beneficial organisms to survive — sometimes profoundly impacting pest population densities. As the cost of natural-enemy products continues to decrease and delivery systems and methods are improved, the economic feasibility of using these methods in commercial pest control undoubtedly will improve.

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