XI. BIOLOGICAL CONTROL

Biological control is an option that some growers are now incorporating into their pest management programs. This chapter describes insect and mite natural enemies, biopesticides (insect toxins or pathogens packaged and sold as pesticides), and fungal antagonists. Table 19 lists biological control agents that are available for bedding plant pests. The order of pests in the table is the same order followed in the pest descriptions in this chapter.

A list of natural enemy suppliers can be obtained from the California Environmental Protection Agency, Division of Pesticide Regulation (916-324-4100). Biological control is a rapidly changing field, so check with a supplier or a university specialist for new developments before starting.

Many biological control products such as these are available. They are pesticides and users must follow the label directions. Photo: R. Way

Table 19. Biological control agents available for bedding plants

Pest Problem	Biological Control Agents	Common Name or Trade Name
Western flower thrips	*Neoseiulus cucumeris* *Orius insidiosus* *Iphiseius (=Amblyseius) degenerans* *Hypoaspis miles* *Beauveria bassiana*	Cucumeris Insidious flower bug Naturalis-O, BotaniGard®
Fungus gnat	*Hypoaspis miles* *Bacillus thuringiensis israelensis* *Steinernema feltiae*	 Gnatrol Nemasys, Scanmask
Green peach aphid	*Aphidius matricariae*	
Green peach aphid and Melon/cotton aphid	*Hippodamia convergens* *Aphidoletes aphidimyza* *Chrysoperla rufilabris* *Aphidius colemani* *Beauveria bassiana*	Convergent lady beetle Aphid midge Green lacewing Naturalis-O, BotaniGard®
Two-spotted spider mite	*Phytoseiulus persimilis* *Mesoseiulus (=Phytoseiulus) longipes* *Neoseiulus (= Amblyseius) fallacis* *Neoseiulus californicus*	Persimilis

Table 19—*Continued*

Pest Problem	**Biological Control Agents**	**Common Name or Trade Name**
Broad mite	*Neoseiulus barkeri*	
Citrus mealybug	*Cryptolaemus montrouzieri* *Leptomastix dactylopii*	Crypts, mealybug destroyer
Long-tailed mealybug	*Chrysoperla rufilabris*	Green lacewing
Greenhouse whitefly	*Encarsia formosa* *Delphastus pusillus* *Beauveria bassiana*	Naturalis-O, BotaniGard®
Silverleaf whitefly	*Eretmocerus eremicus* (=*californicus*) *Delphastus pusillus* *Beauveria bassiana*	Naturalis-O, BotaniGard®
Caterpillars	*Bacillus thuringiensis kurstaki*	Dipel, MVP, MVP II
Damping off (*Pythium* spp., *Rhizoctonia solani*)	*Gliocladium virens* GL-21 *Trichoderma harzianum* Rifai strain T-22 (KRL-AG2)	SoilGard™ 12G RootShield™ 1.15G
Leafminers	*sa sibirica* *Diglyphus isaea*	
Pythium and Rhizoctonia root rot	*Gliocladium virens* GL-21 *Trichoderma harzianum* Rifai strain T-22 (KRL-AG2)	SoilGard™ 12G RootShield™ 1.15G

You *must plan* before undertaking any biological control project because natural enemies are living organisms that function differently from more familiar pest control tactics. Since these organisms do not act as quickly as pesticides and sometimes must be shipped in a stage that does not attack pests, they generally cannot be used as rescue treatments. Pest populations should be at low levels when natural enemies are released. Effective natural enemies should keep a low population from building. The use of natural enemies must be carefully monitored and evaluated, so it's best not to undertake it unless a scouting program is already in place.

Start by using biological control for one pest problem in a limited area of the greenhouse. Practice by ordering a small quantity of natural enemies before you make your first release, so you are familiar with the process of receiving the shipment and assessing its viability. As you gain experience and confidence, expand to larger areas and to several pests.

Important issues that must be considered before any biological control program is initiated are cost, compatibility with pesticides, the need for appropriate environmental conditions, mode of action, and efficacy. These topics are discussed below. In addition, you should keep in mind the location of a reputable supplier and release rates and timing. Communicate with your supplier about release rates and other specifics.

Cost

Biological controls tend to cost more than pesticides, although this is changing as the demand for natural enemies increases and newer, more expensive pesticides are developed. Cost of natural enemies might be offset by their advantages, such as limited or nonexistent reentry intervals and reduced health, environmental, and phytotoxicity risks.

Compatibility with Pesticides and Other Natural Enemies

Many pesticides are capable of affecting harmful *and* beneficial insects, mites, fungi, nematodes, or bacteria. Although some natural enemies and pesticides can be used together, many cannot. If you will be releasing biological controls, the entire pest management program will usually need to shift toward methods compatible with natural enemies. In some cases, there is no information about compatibility between specific natural enemies and specific pesticides. Fortunately, this situation is slowly changing. We are gaining practical knowledge as more growers use natural enemies. Consult your supplier or the Koppert side effects list (see bibliography) for specific compatibilities.

Pesticide residues in the greenhouse can affect natural enemies. Wood and soil absorb pesticides as they are applied and the chemical residue can be picked up by natural enemies as they walk across greenhouse surfaces. Volatilization of pesticide residues over time can harm beneficials. A greenhouse with many wooden structures and a history of pesticides with long residuals may not be the best location in which to use natural enemies.

In general, an insecticidal soap or horticultural oil is safe once it has dried, although it can kill beneficials if it contacts them as a spray. Fungicides are often compatible with insect natural enemies, and insect growth regulators are fairly compatible as well. Fungicides usually aren't compatible with insect fungal pathogens, and should be applied 48 hours before or after the insect pathogen is applied. There are some exceptions to these guidelines, so consult your supplier for more information.

Synthetic pyrethroids are particularly harmful to most natural enemies, whereas natural pyrethrum has a shorter residual time and is not as detrimental. Organophosphates and carbamates are also generally harmful to natural enemies and have a long residual. Many of the newer reduced-risk pesticides have better compatibility with natural enemies. Some are compatible immediately, whereas others are safe once the spray has dried. Again, consult the Koppert

Side Effects List for information on compatibilities of specific pesticides and natural enemies.

Pesticide residues remain in sprayers and pose a risk to natural enemies that are applied with a sprayer, such as insect pathogens and nematodes. It is a good idea to dedicate a sprayer to application of biopesticides and natural enemies. It is also important to consider compatibility of natural enemies with each other. For example, some insect pathogens may not be compatible with certain arthropod predators and parasitoids. Generalist predators, such as *Orius*, may eat certain natural enemies.

Viability of Natural Enemies

Reputable natural enemy suppliers work hard to ensure that the agents they sell are healthy. Despite this, problems occasionally develop in production or shipping. It is a good practice to examine natural enemies when they arrive at the greenhouse to make certain they are alive. Part of the shipment should be held for a day in containers that will prevent escape of the natural enemy. Live material should be shipped to arrive within one to two days; it should arrive at the greenhouse at a time of day when someone will be there to receive it. Keep the package out of extremes of sun, heat, or cold, and refrigerate it if specified by the supplier.

Predators and parasitoids that are shipped as mobile stages (e.g., predaceous mites and some wasps, such as aphid parasitoids) should be inspected upon arrival to determine if they are actively moving. A microscope or hand lens may be needed to see them. Natural enemies that are shipped as eggs or pupae should be checked for viability by placing a small sample in a clear, airtight, dry container, keeping the container in a shaded, unsprayed area for two to three days, and carefully looking for active larvae or adults.

Environmental Conditions

As living organisms, natural enemies require specific environmental conditions to be effective. For example, *Orius* and *Aphidoletes* enter a type of dormancy called diapause when day lengths shorten in the fall and winter; low relative humidity and high temperature is unfavorable to *Persimilis*. Discuss the environmental requirements of each biological control agent with the supplier. In addition, keep in mind that environmental conditions during shipping, storage, and release are important. For example, winged natural enemies should be released away from yellow sticky cards and at dusk, after the vents are closed.

Mode of Action

Insect and mite natural enemies work by eating, parasitizing, or poisoning their prey, while fungal antagonists compete with and displace plant-pathogenic fungi. These activities are dependent on the environmental conditions in the crop, the life stage of the insect or mite pest, and crop stage.

Natural enemies usually do not kill as quickly as pesticides, and some insects continue to feed while they are being killed, so *biological control must be started when pest populations are low.* They are often most effective at keeping a low pest population low, rather than reducing a large pest population. Some natural enemies will starve once they have eliminated their prey, so additional releases will be required if pests return. Others can switch to alternative food sources until the preferred prey returns. Biological control often seeks to maintain a balance between pest and natural enemy populations. However, in short-term crops with little tolerance for pest damage (such as bedding plants) it is desirable to make repeated releases to reduce pest population to negligible levels, rather than trying to establish a balance.

Evaluation of Efficacy

Begin your evaluation of efficacy by checking the survival of natural enemies when you receive them. Suppliers usually send a description of what to look for with the shipment. Open the container and assess the health of the natural enemies (see above section). Notify the supplier immediately if the shipment is of poor quality.

You should evaluate the effectiveness of biological control agents as part of routine scouting. Although optimum release rates and timing for many natural enemies are not known, careful evaluation will suggest where recommended release rates can be adjusted to fit a particular situation. Suppliers and university biological control specialists can help.

Performance evaluation depends on the mode of action of the natural enemy—how it kills, as well as how quickly it does so. Predators often begin feeding soon after release, whereas it may take two to four weeks for parasitism to become apparent. If insect or mite numbers have not dropped by two to three weeks after the release, or if populations rise quickly a few days after the release, consider other measures.

In many cases involving predators, the dead insects or mites are not visible, so evaluation is based on a drop in the pest population or observation of active natural enemies. Signs of parasitism often are visible, however, and an estimation of percent parasitism can be an important evaluation tool. The papery skins of aphid mummies caused by *Aphidius colemani* and *Aphidius matricariae*, the amber SLWF pupae parasitized by *Eretmocerus eremicus* (= *californicus)* or the black GHWF pupae parasitized by *Encarsia formosa* are all visible. Sometimes you can observe insects infected by pathogens. Infected whitefly nymphs may turn reddish orange when infected by *Beauveria bassiana.* Under humid conditions, life stages infected by fungal pathogens may be covered with white, powdery mycelia.

Predation or infection of soil-inhabiting insect life stages will be difficult to determine. If they can be located for observation, nematode-infected fungus gnat larvae will appear a cloudy white to yellow. *Hypoaspis miles*, the fungus gnat and thrips predator, is occasionally seen on potato disks. Look for a drop in the number of adult fungus gnats on yellow sticky cards or a drop in the number of larvae on potato disks to evaluate fungus gnat biological control.

Fungal antagonists can be evaluated accurately only in the laboratory. Regular root system inspection will show whether the roots are remaining free of disease. Leave some flats or pots untreated so the effect of the treatment on crop growth can be assessed.

Biological Control of Specific Bedding Plant Pests

Western Flower Thrips

Several options are available for thrips biological control.

Neoseiulus cucumeris (Cucumeris) is a predatory mite that feeds on first instar thrips larvae. The mite is distributed in the greenhouse in one of two ways: sprinkled onto the crop from a container that holds a mixture of Cucumeris mixed in a bran carrier, or in paper bags that are placed every 25 to 30 square feet on the bench so that the bags touch the plant canopy. The bag contains bran and a bran mite that serves as a food supply for Cucumeris, which reproduces in the bag and emerges over a six-week period to feed primarily on first instar western flower thrips (WFT). They are most effective when the temperature is higher than 70°F and the greenhouse humidity is high. Use these preventatively.

Place bags in the greenhouse even if thrips are not present so predators are in place before thrips arrive, and so predator populations can increase before thrips populations. Replace one-quarter to one-half of the bags every three weeks to maintain a viable supply of predators. Cucumeris will feed on pollen and can increase to large numbers on pollen-producing crops such as peppers. Avoid wetting the bags since high moisture can cause the bran to rot. Slugs and mice occasionally feed on the bags. Cucumeris is adversely affected by most insecticides but is compatible with insect growth regulators (IGRs).

Iphiseius* (= *Amblyseius*) *degenerans is another predatory mite used for thrips biological control. It has been demonstrated to effectively manage WFT on sweet peppers, an excellent source of pollen. It is also reported to be drought resistant. Limited studies have shown this mite to be more effective than Cucumeris against WFT in greenhouse vegetables. It is adversely affected by most insecticides other than IGRs.

One species of ***Orius*** is sold for thrips biological control. Members of this species attack all stages of thrips by sucking out their body fluids. They enter a type of dormancy called diapause during short days (eight hours or less of daylight), so they are effective only in spring and summer. They sometimes bite people who are handling plants. *Orius* biological

control agents are distributed over the leaves directly from the shipping container. They will feed on pollen (especially gerbera, chrysanthemum, and pepper) in the absence of thrips, spider mites, or aphids, and can also be cannibalistic. They are adversely affected by most insecticides.

Beauveria bassiana is an insect pathogen sold as the biopesticides Naturalis-O and BotaniGard®. The fungal spores land on the insect's cuticle (skin), germinate, and develop into hyphae, which penetrate the cuticle of the insect to create an infection. Uninfected thrips may pick up spores as they walk across an infected insect and spread the infection. Unlike most insect pathogens, *Beauveria* functions at relative humidities as low as 45 percent. It is adversely affected by many fungicides.

Fungus Gnat

Several options are available for fungus gnat biological control, all directed against the larvae.

Hypoaspis miles is a soil-dwelling predatory mite that feeds on fungus gnat larvae. It is packaged in sawdust that is distributed over the soil surface or incorporated into the media before planting. These mites will reproduce in the greenhouse, so one application is often sufficient. They are active when soil temperatures are above 50°F, and are most effective in pot-to-pot spacing or flats, both of which permit easy mite dispersal. If fungus gnats are already numerous, these predatory mites should probably be used in conjunction with either Gnatrol or nematodes when they are released, as it may take several weeks for *Hypoaspis miles* populations to reach an effective level. They will feed on alternative prey (such as thrips pupae) in the absence of fungus gnat larvae. Pesticides running onto the soil surface may have an adverse effect on *Hypoaspis*.

Bacillus thuringiensis israelensis is an insect pathogen that is sold under the trade name Gnatrol. This subspecies of the bacterium is specific to certain larvae in the order Diptera, the flies. The bacteria must be ingested by the fungus gnat larva, after which a lethal protein crystal is released into the insect gut. Feeding stops within a few hours, but death can take several days, The bacteria do not leave the larva to infect other fungus gnats.

This material is most effective when young fungus gnat larvae are actively feeding; older larvae must feed longer to ingest a lethal dose. One to three applications may be needed, depending on fungus gnat levels. This material should not be tank-mixed with fertilizer concentrates (but dilute solutions may be applied at the same time) or with any compound containing more than 100 ppm copper or chlorine. It has a shelf life of one year when stored under refrigeration, and is compatible with most pesticides.

Steinernema feltiae is a nematode—a microscopic worm-like organism. Nematodes are mixed with water and applied through an injector or a sprayer under low pressure with the filters removed. Nematodes move through the media on a film of moisture and enter the fungus gnat larva through body openings, where they release bacteria whose toxin kills the larvae within one to two days. The nematodes reproduce within the larva and can go on to infect other fungus gnats. Adequate soil moisture is required for the nematodes to move through the soil and find their hosts. One application is sometimes sufficient, especially if used in conjunction with Gnatrol. They are not compatible with nematicides.

Green Peach Aphid and Melon/Cotton Aphid

There are several biological controls for both of these aphids. They must be used when aphid populations are low, since aphids can multiply rapidly and will develop faster than they can be killed.

Hippodamia convergens (convergent lady beetle) is a predatory beetle that is often released for aphid biological control. Both adults and larvae prey on aphids, but may switch to other insects, honeydew, or nectar when aphids are not present. They sometimes reproduce if food supply and day length are suitable. If eggs or larvae are not observed, additional releases may be necessary. Adults should be preconditioned by your supplier to minimize migration when they are released. Adults may be able to tolerate some pesticides.

The green lacewing ***Chrysoperla rufilabris*** is more adapted to humid areas than ***Chrysoperla carnea***, so it is used in greenhouses. The adults feed on nectar, pollen, and honeydew. The larvae feed on aphids as well as other greenhouse pests, including mites and whiteflies. They are very cannibalistic and must be released in ways that minimize encounters with other lacewing larvae, which means dispersing them as widely as possible. All lacewing life stages can be purchased from insectaries, but eggs or larvae are preferable

because adults will leave to search for food before laying eggs. Releasing larvae rather than eggs may reduce cannibalism. These insects do not tolerate most pesticides, although insecticide-resistant lacewings have been developed in the laboratory.

The aphid midge, ***Aphidoletes aphidimyza*** is another aphid predator used in greenhouses. The midge larvae bite aphids on their legs, inject a toxin, and extract body fluids. The adults feed on honeydew, and are rarely seen because they are short-lived and active at night. They are effective summer predators but will enter diapause under short days unless supplemental lighting is provided. They are shipped as pupae, so they must pass through the adult and egg stages before they begin aphid predation. They are not compatible with some pesticides.

Aphidius colemani is a parasitic wasp that attacks green peach and melon/cotton aphids in the greenhouse. The wasp lays an egg in the aphid nymph or adult, and the developing larva feeds within the aphid, causing its skin to turn brown and papery. These are called aphid mummies, and an adult parasite emerges from them. Mummies can be seen among a population of aphids, so parasitism can be estimated. Count only mummies without an exit hole to avoid re-counting old mummies.

Aphidius matricariae is a parasitic wasp similar to *A. colemani* and favors the green peach aphid. It kills aphids in the same way as *A. colemani*, and percent parasitism can be counted the same way as well. Adults of this species feed on nectar or honeydew.

The insect pathogen ***Beauveria bassiana,*** sold as Naturalis-O or BotaniGard™ is also used against aphids. It is most effective against adults because the rapidly developing nymphs shed their skins before the fungus can penetrate, necessitating several applications for adequate control.

Two-spotted Spider Mite

The predatory mite ***Phytoseiulus persimilis*** is used for biological control of two-spotted spider mite (TSSM). It works best at moderate temperatures (70–85°F) and high humidity (70–90 percent). Plants that are close enough to touch will facilitate predator movement among plants and will promote high humidity within the canopy. It is important to release Persimilis when TSSM levels are low; the recommended rate is one predator per ten TSSM. The onset of cool, short days in late fall and winter can cause TSSM to turn orange. They should not be confused with the rapidly moving predatory mites, which are slightly larger than TSSM, bright orange, and pear-shaped. Most pesticides are toxic to Persimilis, although it can tolerate some fungicides, IGR insecticides, avermectin, and residues of insecticidal soap and horticultural oil.

Mesoseiulus* (= *Phytoseiulus*) *longipes is another predatory mite used for biological control of TSSM that is more tolerant of low humidity (40–50 percent). Release the predators when TSSM populations are low.

Broad Mite

The predatory mite ***Neoseiulus barkeri*** is available for broad mite. Not much is known about the use of this mite as a biological control agent, although limited research has demonstrated that it will attack the broad mite. It will also feed on WFT.

Mealybug

Three natural enemies of mealybugs can be purchased commercially. The mealybug's waxy coating and cryptic feeding habits can hinder chemical control; therefore, biological control can be an important part of a mealybug management program.

Cryptolaemus montrouzieri is a beetle that consumes all stages of the citrus mealybug. It is released as an adult and is most effective around 80˚F. Under favorable conditions (temperature above 68˚F and an ample food supply), *Cryptolaemus* will reproduce in the greenhouse. It will feed on scale insects or immature whiteflies if mealybugs are not present. It is effective when mealybugs are plentiful, but usually will not eliminate a population. Using it in combination with *Leptomastix dactylopii* for citrus mealybug will ensure better control. Place cotton balls in the crop to provide additional egg-laying sites.

Leptomastix dactylopii is a parasitic wasp that attacks citrus mealybugs and has limited effectiveness against other mealybug species. It prefers to lay its eggs in larger mealybugs, i.e., third and fourth instars and female adults. *Cryptolaemus* will feed on newly parasitized mealybugs but will

leave them untouched as the parasite reaches maturity. Both of these natural enemies are adversely affected by pesticides.

The green lacewing, ***Chrysoperla rufilabris***, has been used against mealybugs in interiorscapes, where repeated releases are required. Its effectiveness in the greenhouse has not yet been demonstrated.

Leafminer

Two commercially available parasitoids attack leafminer larvae and are generally released on a preventative basis, before leafminers become problematic. In chrysanthemum, time releases to control leafminers within 40 days of crop initiation, before marketable foliage is present.
Some people believe *Dacnusa* works best under the cooler conditions of winter and spring and is most effective at finding leafminers when populations are low. *Diglyphus* is may be most effective at warmer temperatures, establishing only when leafminer populations have reached a critical threshold. Combinations of chemical control early, followed by biological control at the end of the crop, may be the best approach in ornamental crops.

Whitefly

Development of biological control methods for greenhouse whitefly (GHWF) and silverleaf whitefly (SLWF) has been the subject of a great deal of research; the result has been the commercialization of several predators, parasitoids, and pathogens. All whitefly parasitoids attack nymphs (also known as whitefly scales), while predators and pathogens affect all stages. Parasitoids kill by parasitism and host feeding, which occurs when a female wasp punctures the body of a whitefly and feeds on the body fluid that seeps out. She may also lay an egg in the same nymph. Regular releases are often made on short-term crops, and much mortality occurs through host feeding rather than parasitism. Measures of parasitism should not be used exclusively to measure effectiveness of whitefly parasitoids.

Encarsia formosa is a parasitic wasp that attacks GHWF and SLWF. It is most effective against GHWF, but has been used with limited success on SLWF. These wasps parasitize immature whiteflies; third and fourth instars are preferred, but they will host feed on smaller instars. Whiteflies of all life stages are often present in a crop at the same time, so regular, weekly releases are usually made until all whiteflies have been controlled.

Encarsia is shipped as parasitized whitefly pupae glued to cards that are placed in the greenhouse, usually once per week. Place the cards face down, as close to the center bottom of the plant as is possible. Because whitefly nymphs are located on leaf undersides, inverting the cards mimics the orientation from which the wasps normally emerge. In addition, the wasps fly in an upward spiral as they emerge, so placing the cards near the center bottom ensures that they will encounter nymphs as they fly upwards. Your supplier can suggest a release rate based on plant size and density. These wasps are most effective at about 80˚F and 50–80 percent relative humidity. They cannot tolerate most pesticide applications or residues, but soap, oil, most insect growth regulators, and Avid are compatible, as are fungicides.

Eretmocerus eremicus* (= *californicus) is a parasitic wasp used for SLWF control, although it will also attack GHWF. These wasps parasitize immature whiteflies; all immature stages may be killed by host feeding, while second and third instars are preferred for parasitism. Because all life stages of whitefly are typically present in a crop, regular releases are usually made until all whiteflies have been controlled.

Pupae of this parasite are either glued to cards (as with *Encarsia formosa)* or are mixed with a sawdust carrier. Batches of the pupae can be divided and placed in release cups from which *Eretmocerus eremicus* adults emerge. The cups are distributed uniformly throughout the greenhouse. Place these cups as close to the center of the plant as possible to increase the encounter rate between wasps and immature whiteflies. The suggested release rate is one to three wasps per plant per week, but your supplier may suggest a different rate based on plant size and density.

These wasps are very attracted to yellow sticky cards, so use fewer cards than normal when they are being released. The wasps cannot tolerate most pesticide applications or residues, but soap, oil, most insect growth regulators, and fungicides are compatible.

Delphastus pusillus is a predatory beetle that feeds on all stages of whitefly. Both larval and adult beetles are predaceous. They are most successful against high populations

and are typically released in whitefly "hot spots" and in conjunction with other whitefly biological controls. They will reproduce in the greenhouse if they are able to consume large numbers of whiteflies. They should not be released near yellow sticky cards, as they are attracted to them.

Beauveria bassiana is an insect pathogen sold as the biopesticides Naturalis-O and BotaniGard®. The fungal spores germinate and develop into hyphae, which penetrate the cuticles of the whiteflies to create infections. Uninfected whiteflies may pick up spores as they walk across an infected insect, thus spreading the pathogen. Infected whiteflies may turn an orange brown color. Unlike most insect pathogens, *Beauveria* can infect at relative humidities as low as 45 percent. It is not compatible with fungicides.

Caterpillars

Bacillus thuringiensis kurstaki is an insect pathogen that is sold as the biopesticides Dipel, MVP, and MVP II. This subspecies of the bacterium is specific to insects in the order Lepidoptera, the butterflies and moths. The bacteria must be ingested by the caterpillar, after which a lethal protein crystal is released into the insect gut. Death can take several days, and the bacteria do not leave the larva to infect other caterpillars. This material is most effective when small larvae are actively feeding; older larvae must feed longer to ingest a lethal dose. One to three applications may be needed, depending on caterpillar population and development. It has a shelf life of one year when stored under refrigeration, and is compatible with most pesticides.

Plant Pathogens

***Gliocladium virens* GL-21** is a naturally occurring soil fungus sold as SoilGard™ 12G. It is antagonistic to plant pathogenic fungi such as *Pythium* and *Rhizoctonia*, and helps to prevent the damping off diseases they cause. The SoilGard™ 12G fungus colonizes the root zone as new roots grow, making it difficult for other fungi to become established. Once pathogens are present, it has little effect, so it cannot cure diseased plants. The material is mixed with the growing medium and left to sit for a day before planting. Fungicides should not be used at planting, but may be used later on.

***Trichoderma harzianum* strain T-22 (KRL-AG2),** sold as RootShield 1.15G, is based on another naturally occurring soil

fungus that is an antagonist of *Pythium* and *Rhizoctonia*. It is only active when soil temperatures are above 50˚F. It can be incorporated into the soil prior to planting or applied as a drench after planting. Fungicides may be used with this product.

When using biological control against plant pathogens, always leave some flats or pots untreated and label them "untreated" so the effect of the treatment on crop growth can be assessed. Accurate evaluation of fungal antagonists can be accomplished only in the laboratory, but regular root system inspection will show whether the roots are remaining free of disease. BioWorks, the manufacturer of RootShield, will help you with the evaluation of this product (315-781-1703).