IPM in the Greenhouse Series

Using Biocontrol Agents in the Commercial Greenhouse

Oklahoma Cooperative Extension Service • Division of Agricultural Sciences and Natural Resources

F-6713

Linda A. Topliff
Extension Associate—Greenhouse IPM

Kenneth N. Pinkston
Extension Entomologist

Sharon L. von Broembsen
Extension Plant Pathologist

Michael A. Schnelle
Extension Ornamentals/Floriculture Specialist

Michael D. Smolen
Extension Water Quality Specialist

Pest control in the commercial greenhouse has evolved from a fairly routine and unimaginative chore to a complex, multifaceted one. Environmental concerns, restricted labeling of pesticides for greenhouse use and pest resistance have caused growers to seek alternative forms of pest management. Integrated pest management (IPM) offers growers alternatives to pesticides for pest control. Total abandonment of pesticides is not the focus of an IPM program. IPM is a holistic approach to managing diseases, insects and mites in the greenhouse. It combines many components, including judicious pesticide usage, that when employed, will decrease pesticide usage. Some of these components include sanitation, cultural practices, scouting, "softer" chemicals, physical barriers, record keeping and biological control agents.

One component of IPM that is receiving increasing attention is the use of biological control agents, also called biocontrol agents. Simply put, a biocontrol agent is any life form used to control or eradicate another. Biocontrol agents used in the greenhouse include insects, mites, bacteria, fungi and nematodes. These bioagents may be predatory, parasitic, pathogenic or work by antibiosis. Predaceous insects and mites function by consuming several prey over the course of their development. They are free living, and the predators are usually as large or larger than their prey (the pest species). Predators may be generalists (feeding on a wide variety of prey) or specialists (feeding on only one or a few related species). Common predators include lady beetles, lacewings, true bugs such as *Podisus* (Spined Soldier Bug) and *Orius* (Minute Pirate Bug), preying mantids, spiders, midges including *Aphidoletes*, mites such as *Phytoseiulus* and *Amblyseius*, and beneficial nematodes such as *Steinernema carpocapsae.*

True insect parasites are generally much smaller than their hosts. As they develop, parasites usually weaken but rarely kill their hosts. The majority of parasite-like forms being used in biocontrol programs are most appropriately referred to as parasitoids. In contrast to true parasites, many parasitoids are almost the same size as their hosts, and their development always kills the host insect. In contrast to predators, parasitoids develop on or within a single host during the course of their development.

Most parasitoids are highly host-specific, laying their eggs on or into a single developmental stage of only one or a few closely related host species. They are often described in terms of the host stage(s) within which they develop. For example, there are egg parasitoids, larval parasitoids, larval-pupal parasitoids (eggs are laid on or into the larval stage of the host, and the host pupates before it dies), pupal parasitoids and a few species that parasitize adult insects.

The vast majority of parasitoids are small to minute wasps, but a few species of flies and beetles are also parasitoids. Some of the parasitoids/parasitic wasps utilized in greenhouses include *Trichogramma, Encarsia, Leptomastix,* and *Aphelinus.*

Pathogens (disease causing organisms) such as bacteria, fungi and protozoans can also be used to manage greenhouse pests. These organisms either infect the pests directly or are ingested by the pests. The pests become diseased and stop feeding, fail to reproduce and/or die. *Bacillus thuringiensis*, a bacterial pathogen used to control insects such as leaf feeding Lepidoptera and fungus gnats, and *Nosema locustae,* a protozoan used to control insects such as grasshoppers outside greenhouses, are two examples of pathogenic biocontrol agents. Some fungal biocontrol agents which are incorporated into potting mixes to control soilborne plant pathogens not only parasitize the target fungi but also produce antibiotic compounds that inhibit them and plant pathogenic bacteria. *Gliocladium virens* (GL-21) is a fungal biocontrol agent that has recently become available for greenhouse use.

Many growers try to achieve "zero pest tolerance" by using pesticides. The development of resistance to

Amblyseius barkeri, **a predatory mite sold for control of thrips in greenhouses. (Photo by: Marion Herbut)**

Enlarged view of *Amblyseius*, predatory mite with thrips.

Enlarged view of *Phytoseiulus persimilis*, a spider mite predator. (Photo by: Jack Scott)

View of sweet potato whitefly pupa parasitized by *Encarsia formosa*. (Photo by: Marion Herbut)

View of greenhouse whitefly pupa parasitized (black) by *Encarsia formosa.*

Greatly enlarged view of *Encarsia formosa.*

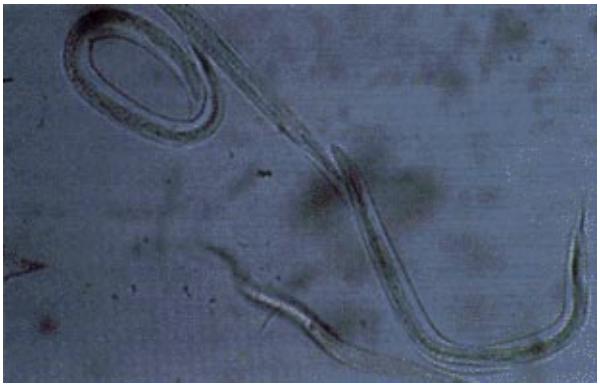
Enlarged view of predatory midge, *Aphidoletes aphidimyza* and aphid.

Tiny parasitic wasp, *Aphidius matricariae*, and parasitized aphids that have turned into hard, brown shells (mummies). Note holes/flaps at rear of mummies where the wasps have emerged.

Adult mealybug destroyer, *Cryptolaemus montrouzieri,* and enlarged view of the larva of this lady beetle. Note how much the larva resembles a mealybug.

Parasitic wasp, *Metaphycus helvolus*, that has been used to control some species of scale insects.

Parasitic nematodes, *Steinernema carpocapsae*. Shows size relationship to infected black vine weevil larva.



Enlarged view of *Steinernema carpocapsae*.

Photographs courtesy of Marilyn Steiner, Entomologist, IPM Biological Sciences, Alberta Environmental Centre, Alberta, Canada

pesticides within a traditional chemical control program is making this less of a possibility. Growers should be aware that zero pest tolerance is not practical using biocontrol agents; however, pest populations can be kept below economic thresholds. Once the biocontrol agents are well established, outbreaks rarely occur because the agents and pests are in balance at low levels. If the pest population becomes too low or is eradicated, biocontrol agents starve or move on and must be replaced.

The choice of which biocontrol agent to use depends upon the pest present. Most biocontrol agents are very host specific and cannot be used as a "broad spectrum" treatment. Knowing which pests are present and their populations are the keys to a successful program (refer to OSU Circular E-909, "Commercial Greenhouse Pests"). Therefore, scouting and monitoring for pests on a routine schedule is necessary. Employees must be able to identify both pest and biocontrol agent in all life stages and estimate population changes through the use of indicator plants and sticky traps. Detailed records must be gathered to make pest management decisions. For more information about scouting, refer to OSU Extension Facts No. 6711, "Scouting and Monitoring for Pests in the Commercial Greenhouse."

Biocontrol agents should be introduced into a program after all other components are in place—sanitation, scouting, record keeping, etc. A strong commitment of sufficient time and money must be made if biocontrol agents are to be effective. Refer to OSU Extension Facts No. 6710, "Integrated Pest Management for Commercial Greenhouses: A General Overview of IPM Principles and Practices." Purchase biocontrol agents from reputable dealers; for example, many dealers belong to the Association of Natural Biocontrol Producers (ANBP). A selected list of suppliers of biological control organisms is given in Table 1.

A problem that may be encountered when initiating a biocontrol agent regime is the presence of pesticide residues. It is best to start small in an area that has not been treated with residual chemicals, such as a new section or small propagating house. It is better to start small to avoid expensive mistakes. Up to a year is usually needed for most people to learn to manage a biological control program. Start in a greenhouse separated from the rest of the production ranges to avoid infiltration by chemicals, especially fumigants. Table 2 lists the effects of some insecticides and fungicides on biological control agents.

The grower must decide what crop to commit to biocontrol and which biocontrol agent will be needed. Some biocontrol agents can be used successfully together; however, if biocontrol is a new concept in the greenhouse, it might be better to limit biocontrol agents to only one at a time. After deciding which agent to use, educating oneself on its unique requirements is essential. Most suppliers are willing to provide information on their products and many trade journals have articles about biocontrol agents. Some of the major biocontrol agents now in use are discussed in this fact sheet.

There are several factors to remember when starting a biological control program. Start small; commit one crop or a portion of a large one to biocontrol, and learn along the way. Choose the proper biocontrol agent for the pest present and purchase them from reputable dealers. Learn to identify both pest and agent and their life stages. Use proper scouting and record-keeping techniques. Learn to live with a few "bugs." Zero pest tolerance is not possible (or desirable) with biological control. Above all, be patient; biological control depends upon the development of a balanced system which takes time to evolve. Remember, no single pest control method is 100% effective. This applies to biological as well as chemical pest control. Expecting miracles will only cause disappointment.

Encarsia formosa

This tiny parasitic wasp is used primarily to control greenhouse whitefly. It should be introduced as a preventative or at low pest population levels for best results. The wasps lay their eggs in the third and fourth instars of whitefly larvae. *Encarsia* are sold as parasitized whitefly pupae stuck to small cards. The cards are easy to hang on plants below the canopy, out of direct sunlight. Release rates should average 1 wasp for every 1 to 4 plants per week for 4 to 6 weeks. Higher release rates may be needed for older, and thus larger, plants.

Encarsia has also been tried for sweet potato whitefly control but with less success. Release rates are higher, 4 to 5 *Encarsia* per plant for the first 3 weeks, then 1 per plant for 6 weeks. Greenhouse whitefly pupae that have been parasitized turn black, and sweet potato whitefly pupae turn a straw color. When 70 to 80% of the plants contain parasitized pupae, releases may be discontinued.

The wasps do best when daily temperatures exceed 72° F. At lower temperatures, the whiteflies reproduce too fast for the *Encarsia* to control them, so it is not advisable to release them when day temperatures are below 72° F and the night temperatures are below 59° F, as often is the case in winter. April releases have been successful for some growers. *Encarsia* lay more eggs in bright light; however, sodium halide lights may kill *Encarsia* that fly into them. The wasps tend to migrate to drier parts of the greenhouse. *Encarsia* are readily available from numerous suppliers. To check viability of the wasps, a small portion of each shipment should be set aside in small containers, such as sealed plastic bags or yogurt cups, and emergence observed.

Delphastus pusillus

Another biocontrol agent effective against whiteflies is *Delphastus pusillus.* Both the larvae and adults

Table 1. A Selected List of Suppliers of Biological Control Agents*

Applied Bio-Nomics Ltd.
11074 West Saanich Rd
Sidney, British Columbia
Canada V8L 3X9
604-656-2123
HM,PP,AA,CM,EF,HC,OT

Beneficial Insectary
14751 Oak Run Rd
Oak Run CA 96069
916-472-3715
PP,SC,EF,Cvs,OT

Bio-Agronomics
PO Box 1013
Clovis CA 93613
209-297-9288
PP,HC,OT

Bio Ag Services
4218 W Muscat
Fresno CA 93706
209-268-2835
PP,CM,OT

Bio Ag Supply
710 South Columbia
Plainview TX 79072
806-293-5861
FAX 806-296-0431
SC,AA,CM,Cvs,EF,HC,OT

Biofac, Inc.
PO Box 87
Mathis TX 78368
512-547-3259
OT

Biotactics Inc.
22412 Pico St
Grand Terrace CA 92324
714-783-2148
FAX 714-681-7915
PP,OT

Bozeman Bio-Tech
Box 3146
Bozeman MT 59772
406-587-5891
PP,SC,Cvs,EF,HC,OT

Buena Biosystems
PO Box 4008
Ventura CA 93007
805-525-2525
PP,CM,Cvs,HC,OT

Foothill Ag
Research, Inc.
510 W Chase Dr
Corona CA 91720
714-371-0120
PP,CM,Cvs,EF,HC,OT

Gardens Alive!
5100 Schenley
Lawrenceburg IN 47025
812-623-3800
BT,PP,SC,Cvs,EF,HC,OT

Garden-Ville of Austin
6266 Hwy 290 W
Austin TX 78735
512-892-0002
SC,Cvs,HC,OT

Hydro-Gardens, Inc.
PO Box 9707
Colorado Spgs CO 80932
800-634-6362
PP,SC,AA,CM,Cvs,EF,OT

IPM Laboratories
Main St
Locke NY 13092-0099
315-497-3129
PP,SC,AA,CM,Cvs,EF,OT

M & R Durango, Inc.
PO Box 886
Bayfield CO 81122
800-526-4075
FAX 303-259-3857
SC,CM,OT

Natural Pest Controls
8864 Little Creek Dr
Orangevale CA 95662
916-726-0855/also FAX
PP,SC,CM,Cvs,EF,HC,OT

Nature's Control
PO Box 35
Medford OR 97501
503-899-8318
FAX 503-899-9121
PP,SC,AA,CM,Cvs,OT

Plant Sciences,
Inc. (KOPPERT)
342 Green Valley Rd
Watsonville CA 95076
408-728-7771
FAX 408-728-4967
PP,AA,CM,Cvs,EF,OT

PRAXIS
PO Box 360
2723 116 Ave
Allegan MI 49010
616-637-2793
HM,PP,SC,AA,DP,OT

Rincon-Vitova
Insectaries, Inc.
PO Box 95
Oak View CA 93022
805-643-5407
800-248-2847
HM,PP,SC,AA,EF,HC,OT

The Beneficial
Insect Company
244 Forrest St
Fort Mill SC 29715
803-547-2301
PP,SC,CM,Cvs,EF,HC,OT

Tri-Cal Biosystems
PO Box 1327
Hollister CA 95024
408-637-0195
HM,PP,SC,AA,CM,EF,HC,OT

Unique Insect
Control
5504 Sperry Dr
Citrus Heights CA 95621
916-961-7945
PP,SC,CM,Cvs,EF,HC,OT

Key to Beneficial Organisms:

AA = *Aphidoletes aphidimyza*
Cvs = *Chrysoperla* species
HC = *Hippodamia convergens*
PP = *Phytoseiulus persimilis*
BT = *Bacillus thuringiensis*
DP = *Delphastus pusillus*
HM = *Hypoaspis miles*
SC = *Steinernema carpocapsae*
CM = *Cryptolaemus montrouzieri*
EF = *Encarsia formosa*
OT = Other biocontrol organisms

* This list is only a selected list of suppliers of beneficial organisms. Many other reputable dealers are available.

Table 2. Toxicity of Selected Pesticides Against Biological Control Organisms[1]

Key: H = Harmful; M = Moderately Safe; S = Safe; - = No Data Available

Pesticide Trade Name	Pesticide Common Name	Encarsia formosa	Phytoseiulus persimilis	Aphidolete aphidimyza	Amblyseius mckenziei	Chrysoperla carnea
INSECTICIDES/MITICIDES						
Ambush	permethrin	H	H	H	H	M
Avid	abamectin	M	M	M	M	
Bladafum	sulfotepp	H	H	-	-	-
DDVP	dichlorvos	H	H	H	H	H
Diazinon	diazinon	H	H[2]	H	H	H
Dibrom	naled	H	H	H	H	-
Dipel	B.T.	S	S	S	S	S
Dursban	chlorpyrifos	H	H	-	-	-
Dycarb	bendiocarb	H	H	-	-	-
Enstar	kinoprene	S	-	-	-	-
Gnatrol	B.T.	S	S	S	S	S
Kelthane	dicofol	H	H	-	-	M
Lindane	lindane	H	H[3]	-	-	-
M-Pede	insect. soap	H	H	H	H	-
Malathion	malathion	H	H	-	-	H
Margosan-O	azadirachtin	S	S	-	-	-
Orthene	acephate	H	H	-	-	-
Pentac	dienochlor	H[2]	H[2]	H[2]	H[2]	-
Sunspray	petroleum oil	H	H	-	-	-
Thiodan	endosulfan	H	H	-	-	M
Vendex	fenbutatin-oxide	S	S	S	S	-
FUNGICIDES						
Agri-Mycin	streptomycin	S	S	S	S	-
Bravo	chlorothalonil	S	S	S	S	-
Chipco 26019	iprodione	M[2]	M[2]	S	S	-
Dithane	mancozeb	S	H[2]	S	S	-
Karathane	dinocap	M	S	M	-	-
Kocide	fixed copper	S	S	S	S	-
Orthocide	captan	S	H[2]	S	S	-
Maneb	maneb	S	S	S	S	-
Subdue	metalaxyl	S	S	S	S	-
Sulfur	sulfur	S[4]	S[4]	S[4]	S[4]	-
Truban	etridiazole	S	S	S	S	-

1. This list is intended as a guide, and is not a recommendation for use. It is not a complete list of chemicals registered for greenhouse use.
2. Some sources list this chemical as safe for this biocontrol organism.
3. Some sources list this chemical as moderately safe for this biocontrol organism.
4. Safe when applied as a fumigant.

of this small black lady beetle feed on whitefly eggs, larvae and adults. It should be used in conjunction with *Encarsia*. It has been effective against *Bemisia tabaci,* the sweet potato whitefly. Availability, however, is limited.

Phytoseiulus persimilis

This predatory mite is widely available for the control of spider mites. They are shipped mixed with vermiculite or bran. Check quality by shaking some vermiculite on white paper and looking for tiny orange mites moving around. Better results are generally obtained using locally produced predators, as these often arrive in better condition than imported ones due to shorter shipping time.

Care must be taken when releasing the *Phytoseiulus*. Sprinkle vermiculite on every infested leaf. Order enough for one mite per infested leaf. They become established in the crop in about one week. Beneficial mites prefer moderate temperatures and humid conditions (60-90% relative humidity).

Spider mites have been successfully controlled by releasing 10 predators per plant. *Phytoseiulus*has also

been used on *Gypsophila* (Baby's Breath) and has been effective from two to seven months.

Exercise care when using miticides near *Phytoseiulus*. Abamectin (Avid ®) will indirectly kill beneficial mites that feed on treated spider mites.

Other beneficial mites that are available include: *Phytoseiulus longipes, Amblyseius californicus* and *Galendromus occidentalis*. Each of these species is suited to a different environmental condition that should be considered when ordering. For example, *Phytoseiulus persimilus* does best in fairly humid conditions under 85° F. There is a strain of *P. persimilus* adapted to high temperatures that tolerate temperatures over 100° F with lower humidity. *P. longipes* can handle temperatures over 100° F and has the lowest relative humidity requirement of commercially available predatory mites—40% at 70° F (higher relative humidity required at higher temperatures). *Amblyseius californicus* tolerates slightly warmer temperatures than *Phytoseiulus persimilus* with lower relative humidity requirements. Most dealers are willing to assist growers in selecting the proper biological control agent for their greenhouse environment.

Steinernema (=Neoaplectana) carpocapsae

These beneficial nematodes attack numerous insects in the soil. A moist environment and appropriate application rates are the two main requirements for success. The nematodes can be supplied in a spray concentrate or a moist granular carrier. A smaller hybrid strain of *Steinernema* is especially suited to the warmer environment of the greenhouse. Apply 70,000 per sq. ft. of soil surface, preferably in the evening. Some growers apply them using injector systems or diluting them with water and using a pump sprayer, hose-end sprayer, watering can or pail. They will survive in oxygen-rich water, such as produced by nutrient film technique systems, but may "drown" if left in standing water for more than a few hours.

Amblyseius cucumeris and *A. barkeri (=mckenziei)*

These thrips predators are widely available. They are tan-orange mites that are similar in appearance to spider mites. They prey on Western flower, onion, broad and cyclamen thrips. They are best used as a preventative measure in ornamentals, before any evidence of thrips occurs. They prey only on the larval stages of the thrips, and they cannot control an established thrips population.

These predators are relatively inexpensive. They are received in containers of loose bran which is easily sprinkled on the foliage of the plant. A suggested release rate is 10 to 100 per m^2 weekly. Other sources suggest an introduction rate of one predator per ft^2, followed on a monthly schedule.

Amblyseius spp. preform best in warm, dry weather. They enter diapause and are not effective between September and March unless night temperatures remain above 70°F.

Hippodamia convergens

Both the adult and immature ladybug (ladybird) beetles feed on aphids and spider mites. Ladybugs do not always provide successful, long-term control; however, they are useful to "knock down" an infestation. Availability is good, except during the early summer months when supplies may be sold out.

Ladybugs may be kept in the refrigerator for several weeks and released one handful at a time. They are usually thirsty when released, so plants should be misted prior to release. Since ladybugs have a strong dispersal instinct, spraying them with diluted soda pop will cause their wings to stick together and keep them from flying. Releasing them in the evening is also helpful.

Aphidoletes aphidimyza

Aphidoletes aphidimyza is a predatory midge commonly known as the aphid predator. The tiny orange larvae of this predator attack and kill aphids. The adults resemble tiny mosquitoes. They are effective against many species of aphids, but not against the melon aphid.

The midges are shipped in the pupal stage, mixed in either small bags of vermiculite or peat moss. Cut a one inch hole in the top of the bag and place it at the base of an aphid-infested plant. Keep the vermiculite or peat damp but not saturated. Adults will emerge in seven to ten days. Adults fly at night and lay eggs in aphid colonies. Since only the larval stage attacks aphids, overlapping generations must be maintained. Repeat the application in two weeks. Suggested release rate is one cocoon per 10 ft^2 of greenhouse or a target level of 1 larvae per 15 to 20 aphids.

Short days will cause *A. aphidimyza* to enter diapause. Lighting with 80 to 100-watt bulbs at night will prevent diapause. The optimum temperature for the midge is 73° F.

This predator works especially well on long season crops such as lilies, roses and chrysanthemums and in greenhouses with in-ground beds or gravel floors because it pupates in the soil.

Cryptolaemus montrouzieri

This beneficial lady beetle is known as the mealybug destroyer or mealybug predator. It prefers warm temperatures (72-77° F) and is not effective during the winter months. The adult and larva are predaceous and attack mealybugs and scales. Release rates vary with pest population, approximately 2 per m^2 or 2 to 5 per

infested plant. Release at various infestation sites. Repeat releases may be necessary. Citrus mealybugs may also be controlled by *Leptomastix dactylopii.* This parasitic wasp prefers sunny environments with warm temperatures of 74 to 80° F. Control takes one to three months.

Chrysoperla (=Chrysopa) carnea and *C. rufilabris*

Lacewings are generalist predators. They will attack almost any soft-bodied insect. They are best known for attacking aphids and each larva can kill 30 to 50 aphids per day. In some species adults are predaceous, while in other species only the larvae are predaceous. Only the larvae of the two species commonly available, *Chrysoperla carnea* and *C. rufilabris*, are predaceous.

Lacewings are usually shipped in the egg stage, packed in bran or rice hulls. At 80° F they will hatch in about four days. They hatch with a voracious appetite and will often resort to cannibalism if no other food source is available. They will attack and eat other biological control agents. Each larva will feed for about three weeks, pupate and emerge as an adult about one week later.

Hypoaspis (=Geolaelaps) miles

The nymphs and adults of this inconspicuous brown soil mite are voracious predators of fungus gnat larvae. They will also eat thrips pupae in the soil. This predator is widely available. They are shipped in vermiculite and should not be cooled before application, but stored at room temperature.

Hypoaspis has a short life cycle and reproduces quickly; therefore, only a few per plant are needed. One quart will treat 500 to 1000 ft^2 of growing area. Apply $^1/_4$ teaspoon to every other plant. Only one application is needed, but if plant materials are shipped out and replaced regularly, weekly or monthly treatments are advisable. Vermiculite containing mites should be sprinkled directly on the media, over flats, plug trays, capillary mats and floors. The mites are compatible with *Steinernema carpocapsae* (beneficial nematodes) and with most pesticides, except insecticidal drenches. Mites should be applied while fungus gnat populations are low.

Bacillus thuringiensis

Bacillus thuringiensis (Bt) is a bacterial pathogen which has been formulated into a number of "microbial insecticides." Most Bt strains are highly effective for control of leaf feeding Lepidoptera. Recently, a new strain has been developed for control of fungus gnat larvae. Since it is a larvicide, it will not immediately reduce adult populations. This product is sold under the brand name Gnatrol® .

Gnatrol ® should be applied three times, one week apart. Apply as a soil drench, two to eight teaspoons per gallon of water. Saturate soil to a depth of at least two inches. Bt has a long shelf life.

Bt products are exceptionally safe and have specific activity, which make them compatible with biological control agents.

Gliocladium virens

Gliocladium virens (GL-21) is a beneficial fungus that can be incorporated in the growing media to suppress the major fungal genera (*Pythium* and *Rhizoctonia*) responsible for damping-off diseases of greenhouse crops. Available under the name GL-21 Microbial Fungicide® , it is non-toxic to people or other beneficial organisms. There are no reentry requirements, handling risks or chemical odor from plants treated with GL-21. Available in a prilled form, it is incorporated uniformly into the soil or soilless growing media. Prills should be added at a rate of 1 to 1.5 lbs. per cubic yard of growing media. Incubate one to two days before seeding or transplanting. It is important that the prills be uniformly incorporated into the media to provide the best performance possible.

Conclusions

Biological control agents are an important part of integrated pest management systems. Their use must be coordinated with other types of pest management, chemical and mechanical. Care must be taken when considering which agents to utilize. Pest species must be carefully identified; pest populations must be low enough so that bioagents are not overwhelmed; temperature, humidity and lighting of the greenhouse must be considered; and previous pesticide usage must be taken into account before biocontrol agents are introduced. Strict attention to these requirements will help make integrated pest management a reality in the commercial greenhouse.

The authors would like to acknowledge Marilyn Steiner of Alberta Environmental Centre, Alberta, Canada, and Michael Morton of Hydro-Gardens Inc., Colorado Springs, CO, for their assistance in obtaining photographs for this publication.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Charles B. Browning, Director of Cooperative Extension Service, Oklahoma State University, Stillwater, Oklahoma. This publication is printed and issued by Oklahoma State University as authorized by the Dean of the Division of Agricultural Sciences and Natural Resources and has been prepared and distributed at a cost of $ 2,628.89 for 4,650 copies. #5812 0193 TD.