Understanding Biological Control in Greenhouses

Many factors are important in establishing successful biological control programs in greenhouses. Implementing such programs requires commitment, patience, and a thorough knowledge of the life history and requirements of both the biological control agent(s) and the pest(s). There are few easy answers or short cuts to success, and extra effort is required to make these programs work. Understanding the role of the biological control agent supplier, the grower's commitment, and the limitations of the biological control agents is necessary to ensure success.

Supplier Issues

Ordering—The starting point for any biological control program is the supplier. It is the supplier's responsibility to deliver an order on time and to make no mistakes in the shipment contents. If the shipment is delayed (for any reason) or the contents are wrong, it can adversely affect the program. When beginning most biological control programs, a release schedule is determined for the biological control agents. If disrupted, this may reduce the ability of the agent(s) to successfully control the pest population. Receiving the correct number of agents is another important issue. If you are being under- supplied, it can also reduce the agents' ability to overcome the pest population. Be sure to inspect each shipment carefully before releasing any biological control agents.

Agent Condition upon Arrival—Biocontrol agents may be dead or in poor condition upon arrival. If dead, the release schedule can be upset (as above). If in poor condition, the agents may not perform up to their capabilities. There appears to be a lack of knowledge regarding agent shipment by some companies. It is preferable to have orders shipped in the quickest possible manner, usually overnight if possible.

The supplier is a key participant in the equation of establishing a successful biological control program. A good supplier is knowledgeable and reliable. Be sure to check all orders for accuracy and agent viability. Don't hesitate to call the supplier if you feel there is a problem.

Grower Issues

There will certainly be changes in a system if biological control agents are used. Growers must realize that certain sacrifices may have to be made and/or there may have to be changes from the normal routine. There can be no partial commitments to a biological control program; if the decision is made to use biological control agents, then all necessary adjustments must be made.

Pest/Injury Threshold Expectations—The two most important psychological barriers growers must overcome when implementing biological control programs relate to pest numbers and plant injury. Biological control agents are not pesticides and will not work like them. Unlike many conventional pesticides, biological control agents will not achieve a 100% reduction in pest numbers. Consequently, you may have to tolerate slightly more damage to a crop. Acceptance of a tolerable level of pests and plant injury are critical in making biological control programs work.

Crop Needs vs. Biological Control Agent Needs—Most growers are aware that each crop has certain environmental conditions (temperature, humidity, light, etc.) which are favorable for optimal growth. Not surprisingly, most biological control agents have optimal temperature ranges which allow them to successfully out-compete a pest. You must balance crop needs and biological control agent needs by providing an environment that allows the crop to grow and also allows the biological control agent to perform at a rate which

controls the pest. When selecting a biological control agent for use in a particular crop, make sure the biological control agent is compatible with conditions in which the crop is grown.

Multiple Pest Complexes—Dealing with several pests in a crop simultaneously presents the need for many decisions. It is important to balance the crop and biological control agent needs to provide a conducive environment for each. How do you maintain a favorable environment for the crop and several biological control agents, all of which may have different needs? There is no easy solution. One approach is to use the biological control agent(s) that have the best chance of succeeding in the particular crop environment and control the remaining pest(s) with alternatives that won't harm the biological control agents you are using. Other plans could involve attacking the pest that is most damaging or that has the best chance of successful control with biological control. A crop with a single pest is ideal for biocontrol. However, that is rarely the case so adjustments will need to be made.

Pest Exclusion—It is very important to limit the number of pests that enter the greenhouse from outdoors. Broken windows, open doors, and/or unscreened vents can allow additional pests to enter. Sudden increases in pest numbers can upset any balance you may have achieved between the biological control agent(s) and pest(s). Excluding additional pests will not only be a big aid in reducing overall pest numbers, but by having lower numbers, the chances for successful biocontrol are increased dramatically.

Biological Control Agents Being Perceived as Pests—If biological control agents remain on crops at the time of sale, it may adversely affect sales. Consumers don't know the difference between pests and beneficial organisms, and may not care. Using sprays to clean-up crops before sale will certainly eliminate this problem. However, pesticide use may make reintroduction of biological control agents difficult. (This will generally not be a problem, but something that should be kept in mind when selecting agents for a particular crop.)

Production Time Loss—In making sure that the released agents survive, certain practices may need to be altered. For instance, certain agents are released by setting them in containers on the ground. If overhead watering fills the dishes, the agents will die. Thus, watering practices may need to be changed to accommodate this problem. In addition, hanging materials that contain the biocontrol agents directly on the crop is a common release method. In cutting crops for flowers, these materials may have to be moved or reattached and if numbers are high, this could be time-consuming. This again is probably a minor issue, but something that should be thought about when starting a biological control program.

Biological Control Agent Issues

Pesticides and Biological Control Agents—Conventional pesticides and biological control agents don't mix. Direct contact as well as residues on containers, benches, fixtures, etc., will adversely affect the biological control agents. If conventional pesticides are used during a biological control program, most biocontrol agents will die. In addition, depending on the pesticide, it may take up to 12 weeks after application before you can safely introduce or reintroduce any biological control agents. If you are considering starting a biological control program, be sure to check all records to determine dates and specific pesticides that may have been previously applied.

Biorational pesticides (insecticidal soaps, horticultural oils, insect growth regulators, etc.) are often compatible with biological control agents. They can be used to control pests prior to agent release, and then used to supplement a control agent(s). Information is available listing pesticides and their effect on biological control agents (see table). Be sure to consult this or a similar reference prior to applying any pesticide.

Biological Control and Pest Levels—Because biological control agents do not work like conventional pesticides, certain levels of pests will remain on the crop. Biological control agents are meant to keep pest

populations at acceptable (non-damaging) levels, not eliminate the population. Additionally, biological control agents will not work as fast as pesticides and thus patience is necessary. Noticeable reductions in pest levels will usually take several weeks. This is an important reason to start biological control programs while pest populations are low. Once pest densities are high, biological control agents will be unable to keep the pests from causing crop injury. Plan ahead and introduce biological control agents while pest populations are at a low level.

Biological Control Agent Release Rates—Specific rates for release of most biological control agents have not been worked out. Suppliers will give rates based on the information you supply regarding your crop and pest. It is very important that you have accurate information on all aspects of your crop and pest densities. This will allow the suppliers to make more accurate estimates of what is needed. Working with a knowledgeable supplier is important. If a supplier can't adequately answer your questions, call another company.

Cost—Biological control programs typically cost more (often significantly more) than conventional pesticide programs. In addition to biological control agent(s), significantly more labor in the areas of scouting/monitoring is required than when simply applying a conventional pesticide. How much more biological control programs cost than conventional pesticide programs will depend on such things as the biological control agent used, crop, and the acreage to be treated. As we learn more about biological control, efficiency will be increased, and costs reduced. A financial commitment must be made to biological control programs, or program success will be limited.

Scientific Data—Most scientific studies have concentrated on only a few biological control organisms (e.g. Encarsia formosa). In addition, many studies are done on a small scale, in controlled conditions. More work is now being done in implementing biological control programs in large scale, commercial situations. This will increase general knowledge and make programs more successful and cost effective in the future.

Using biological control is not easy and often requires much more effort than conventional control programs. To make things more efficient, keep the following in mind:

1. Know program limitations: It is important to understand that biological control agents are not chemicals, and you can’t expect fast, 100% control of your pests, and that accepting certain levels of crop damage is a given.

2. Understand your pest complex: The pests you have, their population levels, options for control, and environmental compatibility needed to aid the biological control agents' control of the pest(s).

3. Patience, Patience, Patience!

This data is compiled from various sources, including the International Organization for Biological Control (IOBC) working group on pesticides, and from commercial growers' field results over a number of years. Results will vary depending on temperature, crop, and type of greenhouse cover. Pesticides with residuals over 14 days should rarely be used as they may disrupt biological control programs for an entire season. Contact your biocontrol supplier if in doubt before purchasing or applying any chemical.

Note: Although some compounds, particularly sulfur sprays or dusts, are not directly toxic, they have been found to interfere with biological control programs and repeated use will be detrimental. Never use wetting agents or spreader stickers as these are themselves toxic to biocontrol agents.

Table 1. Effect of Chemicals on Biological Control Agents

Pesticide		Effect on Biological Control Agent[1]				
Trade Name Application[2]	**Common Name**	***Encarsia aphidius***	***Persimilis***	***Cucumeris hypoaspis[3]***	***Aphidoletes***	***Orius[4]***
Afugan	pyrazofos	H (28)	H (0)	H (1)	H (21)	H
Agrimycin	streptomycin	S	S	S	S	S
Ambush	permethrin	H (70)	H (14)	H (30)	H (70)	H
Apex	methoprene	I (0)	I (0)	I (0)	H	?
Apollo	clofentezine	S	S	S	S	S
Applaud	buprofezin	H (3)	S	S	H (7)	S
Avid	abamectin	H (14)	H (14)	H (14)	H (14)	?
Azatin	azadarachtin	H	H	H	H	H
B-Nine	daminozide	S	S	S	S	?
Basamid	dazomet	S	S	S	S	S
Baygon	propoxur	H (60)	H (14)	H (60)	H	H
Bayleton	triadimefon	S	?	?	?	?
Benlate, DR	benomyl	S	H (14)	H (14)	S	I
Benlate, S	benomyl	S	H (14)	H (7)	S	H
Botran	DCNA	S	S	S	S	S
Bravo	chlorothalonil	S	S	S	S	S
Captan	captan	S	S	S	S	S
Copper	copper	S	S	S	S	S
Cycocel	chlormequat chloride	S	S	S	S	S
Cygon	dimethoate	H (60)	H (60)	H (60)	H (14)	H
Daconil 2787	chlorothalonil	S	S	S	S	S
DDVP, F	dichlorvos	H (7	) H (3)	H (3)	H (3)	H (7)
Decis, FS	deltamethrin	H (84)	H (>30)	H (>30)	H (>30)	H
Decis, S	deltamethrin	H (84)	H (>30)	H (>30)	H (>30)	H
Derris	rotenone	H (14)	H	H	H (14)	H
Dibrom F	naled	H (7)	H (3)	H (3)	H (7)	H (3)
Dimilin	diflubenzuron	S	S	S	S	S
Dipel	*Bacillus thuringiensis*	H (3)	S	S	I	?
Dithane	maneb	I	S	S	I	?
Dursban	chlorpyrifos	H (42)	H (3)	H (42)	H (14)	H
Enstar	kinoprene	S	S	S	S	S
Epsom salts (.5%)	Mg SO_4	S	S	S	S	S
Fixed copper	copper oxychloride	S	S	S	S	S
Formaldehyde	formaldehyde	H	H	H	H	H
Fungailor	imazalil	I	H (3)	I	H	?
Funginex	triforine	S	I	S	I	I
Gardona	tetrachlorvinphos	H (70)	H (70)	H (70)	H (70)	I
Insecticidal Soap	fatty acid salts	H (0)	H (0)	H (0)	H (0)	M
Karathane	dinocap	I (7)	I (3)	I	S	?
Kelthane	dicofol	H (14)	H (14)	H (30)	H (4)	I

Kumulus	sulphur	I (7)	I (7)	I (7)	I	I
Lannate	methomyl	H (70)	H (>42)	H (>42)	H (>42)	H
Lindane	lindane	H (70)	H (42)	H (42)	H (70)	H
Lorsban	chlorpyrifos	H (42)	H (7)	H (42)	H (7)	H
Malathion	malathion	H (70)	H (14)	H (14)	H (70)	H
Manzate	maneb	H (14)	I (7)	I	I	H
Manzate 200	mancozeb	I	H	I	H	H
Meltatox	dodemorph acetate	I (7)	I (7)	I (7)	I	I
M-Systox-R	oxydemeton methyl	H (70)	I	I	I	?
Micro-Niasul	sulphur	I	I	I	I	?
Mitac	amitraz	H (21)	H (21)	H (21)	H (14)	I
Morestan	oxythioquinox	I	H (14)	H (14)	I	?
Nicotine F	nicotine sulfate	I (3)	I	H (1)	H (1)	H
Nimrod	bupirimate	I (0)	H (3)	I (0)	I (0)	I (0)
Oil	refined oils	H (0)	H (0)	H (0)	H (0)	H
Omite	propargite	I (7)	H (0)	H	I	I
Orthene	acephate	H (84)	H (30)	H (30)	H (84)	H
Parathion F	parathion	H (60)	H (14)	H (30)	H (60)	H
Pentac	dienochlor	H (3)	H (14)	H (14)	S	?
Phosdrin	mevinphos	H (14)	H (14)	H (14)	H (14)	H
Pirimor	pirimicarb	I (3)	I (3)	I (3)	H (7)	M
Plant Fume 103	sulfotep	H (70)	H (70)	H (70)	H (70)	H
Pyrethrum	pyrethrins	H (7)	H (7)	H (7)	H (7)	H
Resmethrin	resmethrin	I (3)	H (4)	H (4)	H (4)	?
Ridomil	metalaxyl	I	I	I	I	?
Rovral	iprodione	S	S	S	S	S
Rubigan	fenarimol	S	I (0)	I (0)	S	?
Sevin	carbaryl	H (30)	H (14)	H (30)	H (30)	H (30)
Sulfur	sulphur	I	I (7)	I (7)	I	?
Sulfur F	sulphur	I (3)	I (7)	I (7)	S	I
Temik	aldicarb	H (84)	H (3)	H (80)	H (84)	H
Thiodan	endosulfan	H (4)	H (4)	H (4)	H (14)	H
Thiram	thiram	I (14)	I (2)	I (2)	I (2)	?
Trumpet	bendiocarb	H (21)	H (21)	H (21)	H (21)	H
Trumpet, FS	bendiocarb	H (20)	I	I	H (20)	?
Vendex	fenbutatinoxide	I	I	I (0)	S	S
Vydate	oxamyl	H (70)	H	H	H (70)	H
Zineb	zineb	I	I	I	I	I

[1]H (3) = harmful for # of days: I = intermediate; S = safe or negligible effect; ? = no data, presume toxic.
[2]Applications are all foliar sprays unless indicated as: F = fumigant; FS = floor spray; DR = drench.
[3]Sprays will affect foliage-inhabiting *Cucumeris* more than the soil dwelling *Hypoaspis*. Drenches with nonsystemic pesticides will affect Hypoaspis more than *Cucumeris*.
[4]There is little information on the sensitivity of *Orius* to pesticides.

Table used with the permission of Jim Matteoni, B.C. Horticultural Center, Kwantlen University College, Surrey, B.C. and Don Elliott, Applied Bio-nomics, Sydney, B.C.