LITERATURE CITED

Barletta, M. 1992. A new rockwool based growing medium for container plant production. Comb. Proc. Intl. Plant Prop. Soc. 42:149-151.

Bilderback, T.E. 1992. Use of composts in nursery potting substrates. Comb. Proc. Intl. Plant Prop. Soc. 42:376-380.

Bunt, A.C. 1976. Modern potting composts: A manual on the preparation and use of growing media for pot plants. The Pennsylvania State Univ. Press, Univ. Park, Pennsylvania.

Conover, C.A. and **R.T. Poole** 1977. Characteristics of selected peats. Univ. of Florida Ext. Ser. Bul. Vol. 14:7.

Dyke, M.J. 1994. The development of lignocell coir as a propagating medium. Comb. Proc. Intl. Plant Prop. Soc. 44:150-153.

Grapelli, A., U. Tomati, and **E. Galli.** 1985. Earthworm casting in plant propagation. HortScience 20(5):874-876.

Hartmann, H.T., D.E. Kester, and **F.T. Davies, Jr.** 1990. Plant propagation: Principles and practices. 5th ed. Prentice Hall, Englewood Cliffs, N.J.

Handreck, K. A., and **N.D. Black** 1994. Growing media for ornamental plants and turf. Rev. ed. Univ. of New South Wales Press, Randwick, New South Wales, Australia.

Landis, T.D., R.W. Tinus, S.E. McDonald, and **J.P Barnett** 1990. The container tree nursery manual: Volume two, containers and growing media. U.S.D.A., Washington, D.C.

Thomas, S.H. 1993. Compost helps media mixes fight diseases. Nursery Manager May 93:60-62.

Tilt, K.M. and **T.E. Bilderback** 1987. Physical properties of propagation media and their effects on rooting of three woody ornamentals. HortScience 22(2):245-247.

How to Use Biological Control to Manage Propagation Pests

Robin L. Rosetta
North Willamette Research and Extension Center, 15210 NE Miley Rd., Aurora, Oregon 97002

INTRODUCTION

Biological control is the suppression of pest populations by their natural enemies. This, of course, occurs naturally in our environment. It is quite a "bug eat bug" world out there. How do we utilize this occurrence to our benefit in our pest management programs? In order to successfully implement a biological control program in propagation systems, the pest management professional will need to hit the books. Applied biological control or 'biocontrol' is an information-intensive science and art. The science requires an intimate familiarity of both the pests and their natural enemies. The art of biocontrol is taking this information and transforming it into a practical and economical program suitable for a specific nursery location. In order to do this, biological control should be viewed in the broader context of integrated pest management (IPM).

IPM is a pest management strategy using multiple tactics to suppress a pest population below damaging levels. An IPM program includes several important aspects: pest identification, regular monitoring, action thresholds, and integrated

control tactics. Integrated controls include various tactics: cultural, physical, chemical, and biological.

GETTING STARTED

As with any new technique or skill, it is best to start small—limit the risk. Select one range, or crop, or even a few benches for your first attempt. If you're not currently monitoring, this is the first place to start. Dedicate time to scouting. It is too easy to skip the plant scouting when production is busy. Keep records. There is a wealth of information gained this way including cultivar sensitivity, timing of infestation, presence of beneficial organisms, and effectiveness of control measures. Scouting helps you to correct problems early increasing control options, such as spot applications, choice of lower toxicity chemicals, and problem elimination by roguing or pruning infested plants.

Correct pest identification is very important in biological control. Many natural enemies, especially the insect parasites, are very specialized. It may be necessary to identify the pest to the species level in order to choose the correct biological control agent. There are several good publications available (listed in the reference section) that will aid in identifying pests. County and state extension personnel and state nursery inspectors can facilitate pest identification as well.

Once the scouting program is well developed, begin eliminating pesticides that could impact the biocontrol agents you plan to release. In general, avoid long-residual, broad-spectrum insecticides such as pyrethroids. Explore the use of 'biorational' pesticides, such as insecticidal soap, horticultural oil, and botanical insecticides, e.g. neem products. Although many of these pesticides may be harmful to beneficials upon direct contact, they have limited residual activity, allowing beneficial agents to move into sprayed areas with minimal harmful impact. Of course, this applies to pests as well. Therefore, repeat applications may be necessary. There is limited information concerning pesticide compatibility with natural enemies. There are some charts available from insectaries, such as Applied Bionomics, the largest insectary in North America, or in the *Green Methods Catalog* from The Green Spot, a distributor for many insectaries.

After establishing a monitoring program and eliminating potentially harmful pesticide residues, the stage is set for implementation of biological control. Now the fun really begins. It is time to choose the biological control agent(s) for your pest complex.

TYPES OF BIOLOGICAL CONTROL AGENTS

There are three broad categories of biological control agents consisting of predators, parasites, and pathogens. Predators generally consume many insect or mite prey during their lifetime. They may be predatory as juveniles, or as adults, or both. Many are quite large such as lady beetles. They tend to move very quickly (a helpful trait if you must chase your dinner). Parasites, also known as parasitoids, are insect parasites of other insects. They lay their egg(s) on or inside another insect host. The egg then hatches and the larva consumes its host. Usually only one host is necessary for development of a parasitoid larva. The adult parasitoid continues the cycle. Many of the available parasitoids are very tiny wasps with extraordinary abilities to search out their hosts. Pathogens are the third category of biocontrol agents. Insect pathogens include fungi, bacteria, viruses, microsporidians, and parasitic nema-

todes. Most are applied as sprays or drenches and may have explicit requirements regarding humidity, temperature, or soil moisture. The most familiar pathogen to most growers is the bacteria, *Bacillus thuringiensis* var. *kurstaki*. This bacteria has a toxin that is released in the alkaline midgut of lepidopteran pests. There is a lot of interest in this area and quite a few new products are available or under development. The EPA is working to "fast-track" these pesticide registrations.

RELEASE STRATEGIES

There are three general release strategies in biological control: classical biological control, inoculative releases, and inundative releases. Classical biological control entails the importation and permanent establishment of natural enemies. This is usually conducted by state and federal agencies. A good example of this is the successful establishment of the parasite *Encarsia partenopea* for control of ash whitefly, *Siphoninus phillyreae*, in California. Inoculative releases consist of small releases of the natural enemy usually when pest populations are quite small. The desired end is that the introduced natural enemies will establish and reproduce, leaving the biocontrol agents and their progeny to suppress pest outbreaks. An example of this is the inoculation of the soil-dwelling predatory mite, *Hypoaspis miles*, onto greenhouse floors to suppress populations of fungus gnats. Inundative releases involve releases of large numbers of natural enemies to control a pest population as it nears damaging levels. This strategy is similar to our current pesticidal approach of chemical applications to control outbreaks. The application of Bt, *B. thuringiensis*, is an example of this type of release. The idea is to saturate susceptible plant material with the bacterial spores so they may be eaten by the pests. Repeated applications or releases are common. The large numbers of natural enemies and repeat applications may be expensive. In general, inundative releases are the least cost-efficient of the release methods.

SPECIFIC PEST CONTROL PROGRAMS

The following are some recommendations of biological control agents for several key propagation pests. The lists are not all inclusive and may change as more suitable candidates are discovered. Insectaries, like any other businesses, change their inventories as the market demands. Quality control varies greatly as do prices. It pays to shop around. *Suppliers of Beneficial Organisms in North America* is a very useful publication aptly described by its title. It is available for free from the California Department of Pesticide Regulation.

FUNGUS GNATS

Fungus gnats are small dipteran pests familiar to many who use yellow sticky cards in their monitoring program. The adults are generally considered nuisance pests. The larvae may cause direct damage and are implicated in the transmission of soil borne diseases, such as *Pythium* and *Fusarium*. Fungus gnats have several natural enemies including the predatory mite, *Hypoaspis miles*; parasitic nematodes, *Steinernema carpocapsae, S. feltiae, Heterorhabditis bacteriophora;* and the pathogen, *Bacillus thuringiensis* var. *israelensis*.

APHIDS

Aphids are key propagation pests due to their ability to cause direct damage, indirect damage in the form of honeydew and its associated black sooty mold, and their fast generation time. The most commonly encountered aphids in greenhouses tend to be the green peach aphid, *Myzus persicae*, and the cotton or melon aphid, *Aphis gossypii*. Biological control of aphids might include the parasitoids *Aphidius matricariae, A. colemani*, *Diaeretiella rapae;* the predatory midge, *Aphidoletes aphidimyza,* green lacewings *Chrysoperla carnea* or *C. rufilabris*, the predatory ladybug, *Hippodamia convergens,* and the pathogen *Beauveria bassiani.*

SCALE

Scale often occurs on cuttings from mother plants. There are two types of scale seen in propagation situations: hard scale and soft scale. Soft scale tends to be larger and produces honeydew while hard scale tends to be flatter and does not produce the honeydew. A good pictorial key is available from the California Department of Food and Agriculture. Natural enemies of scale include the predatory ladybugs*Rhyzobius lophanthae* and *Chilocorus nigritus*, and the parasitoid, *Metaphycus helvolus*.

LITERATURE CITED

Cherim, M.S. 1995 Green methods catalog. The Green Spot, Department of Bio-ingenuity, 93 Priest Road, Barrington, New Hampshire 03825

Dreistadt, S.H. 1994. Pests of landscape trees and shrubs: An integrated pest management guide. Division of Agriculture and Natural Resources, University of California, publication #3359

Gill, R.J. Color photo and host keys to the soft scales of California. State of California, Department of Food and Agriculture, Environmental Monitoring and Pest Management Branch, 1010 N Street, Room 161, Sacramento, California.

Hunter, C.D. 1994. Suppliers of beneficial organisms in North America. California Environmental Protection Agency, Department of Pesticide Regualtion, Environmental Monitoring and Pest Management Branch, 1010 N Street, Room 161, Sacramento, CA 95814-5604.

Johnson, W.T. and **Lyon, H.H.** 1991. Insects that feed on trees and shrubs. Comstock Publishing Assoc., Cornell University, Ithaca, New York.

Pirone, P.P. 1978. Diseases and Pests of Ornamental Plants. John Wiley and Sons, New York.

Sinclair, W.A., Lyon, H.H., and **Johnson, W.T.** 1987. Diseases of trees and shrubs. Comstock Publishing Assoc., Cornell University, Ithaca, New York.