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Biocontrol for Propagation Greenhouses

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INTRODUCTION

Biological control utilizes living organisms including insects, mites, fungi, or bacteria to control problem pests, and diseases. Utilizing beneficial control agents (BCAs) as insect and disease control procedures requires a different approach compared to pesticides and fungicides. To be successful, growers and managers need to deploy these BCAs early in the crop cycle, and not after an outbreak occurs. BCAs are used preventatively in most cases, and should be used when crops are young, pest numbers are low, and damage has not reached a critical level.

Bio control has been used extensively on greenhouse vegetable crops. Plants such as pepper and tomato when produced in greenhouses will often be longer term production cycles than many ornamentals grown as plugs or starter plants. Since only the fruit needs to be blemish free, these crops actually have a higher threshold for insect damage. Pesticides can be effective, but laws for pesticides are stricter than with ornamentals. Frequently pollinator insects will be part of the production system, and these beneficials are more compatible with BCAs than with many chemicals.

Some of the advantages in using BCAs over chemicals would include worker exposure to pesticides is reduced, reduced potential for spray injury, REI would be short to non-existent, minimum equipment needs for application, potential environmental (or green) marketing, and reduced selection pressure for resistance. Customers of the operation would also have lower exposure. Challenges would include rate of control, as BCAs will not work as quickly as a chemical, greater need for understanding the pest and the BCA life cycle, understanding the environmental requirements for success. Shelf life and handling can also be a challenge, as these beneficials need strict control of temperature in shipping and storage. One of the best management practices, would be to start on a limited basis, using one greenhouse. As experience is gained then it is possible to expand use to other greenhouses or facilities (Stack et al., 2016).

An increasing number of BCAs are on the market, and the sources for these organisms are expanding as well (Bale et al., 2008; van Lenteren et al., 2018).

Companies such as Creek Hill Nursery, North Creek Nurseries, Terra Nova Nurseries, and Longwood Gardens use biocontrol strategies for propagation and production. The Penn State (PSU) Flower Trials also utilizes biocontrol in both greenhouse production and in the PSU Flower Trials in the Field. We do use conventional pesticides but prefer to use bio control for the health of the pollinator insects and beneficials that are on the property.

BIO FUNGICIDES

Bio Fungicides are an effective control of pathogens when used preventatively prior to infection. RootShield® and RootShield® Plus have been used for a considerable time to control root rot diseases in greenhouse and nursery applications. This BioWorks® product controls *Pythium, Rhizoctonia, Fusarium, Thielviopsis, Cylindrocladium,* and *Phytopthora.* The active ingredient is *Trichoderma harzianum* (Figure 1), which are naturally occurring fungi. In RootShield® plus, there are two species (*T. harzianum* and *T. virens)* which work effectively against these problem diseases. Applied as a soil drench at potting, the *Trichoderma* fungus colonizes root systems and then prevents pathogens from attacking root systems (Dicklow, 2014).

A newer product with increased shelf life is now being sold by Marrone® Bio-Innovations, called Bio-Tam®. Bio Tam® contains *T. asperellum, and T. gamsii,* and will also control *Sclerotinia, Armillaria, and Rosellina* (Bogash, 2018). Both of these products are successfully used in the Penn State Flower Trials for production of the entries tested. In five years, there have been less than twelve containerized plants exhibiting root injury from root rot pathogens out of the thousands of containerized plants grown. RootShield® plus is added to the potting media when formulated, and the four and ½-in. pots which are planted in the final containers all are drenched with RootShield or Bio Tam® after plugs are planted in the 4.5-in. pots.

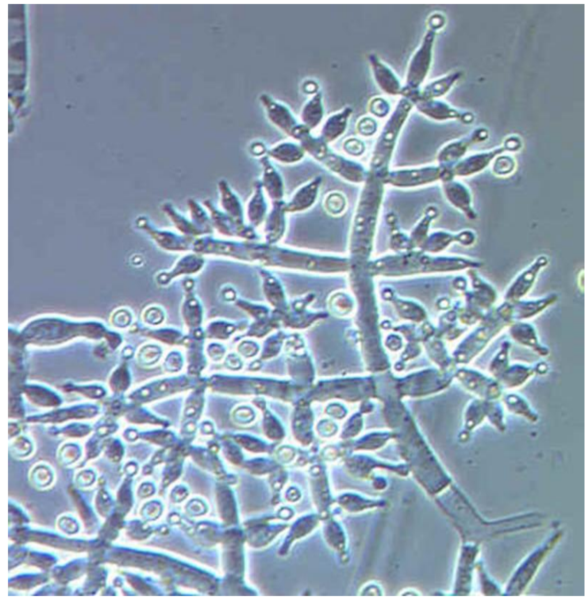

Figure 1. *Trichoderma*, Photo credit: Wikimedia.

Actinovate® SP has also been used successfully at the PSU Experiment station in Manheim, Pennsylvania. This bio fungicide has filamentous structure and works to control Powdery mildew, downy mildew, White mold, *Phytomatotricum,* and *Alternaria* as a foliar spray. Used as a root drench, it will control *Pythium, Phytopthora, Rhizoctonia*, and *Fusarium* (Stack et al., 2016).

Cease® (*Bacillus subtilis*). Cease®, and Stargus® are two products which have *Bacillus,* as the active ingredient. Both of these bio fungicides are used as protectants and should be applied before there is a pathogen present. The bacteria create a protection against infection and block the potential pathogens from entering the plant. Cease® has been successful in preventing infection by *Xanthomonas* with begonias at the PSU Flower Trials. Rotating this product with a copper fungicide has been a successful strategy in most growing seasons. Other products that utilize *Bacillus* work on the same principal and create barriers against bacteria and fungi (Dicklow, 2014).

Contans®, a product that contains *Coniothyrium minitans* works against *Sclerotinia* spp and attacks the apothecia and the sclerotia bodies that are part of white mold's biology. White mold has increased in Pennsylvania cut flower and high tunnel production recently, Contans® is labeled for greenhouse and field production.

Newly introduced in 2017, Botrystop™ (Bioworks®) is labeled for *Botrytis*, *Monilinia*, and *Sclerotinia* and aggressively outcompetes pathogens for nutrients in dead or dying tissue. As with the other bio fungicides listed, this one has a four-hour REI, and can be applied to a wide range of plants. Bio fungicides are successful control agents by parasitism, by rhizosphere competence, by antibiosis, induced metabolic change and plant growth promotion (Dicklow, 2014; Raudales and McGehee, 2017).

INSECT BENEFICIAL CONTROL AGENTS

Pest management in greenhouses has evolved into a complex process, using many of the tools in an IPM management toolkit. Using biocontrol agents (BCAs) has increased recently and BCAs would include predators, parasitoids, and parasites (Topliff et al., 2007). BCAs can be specialists or generalists depending on their diets. Aphids such as potato aphid, and green peach aphid are generalists, and attack a wide range of plants. *Aphis nerii* (milkweed aphid), *Chrysanthemum* aphid, and *Heliopsis* aphid (*Dactynotus*), are specialists working on a small group (*Asclepias* or *Heliopsis*) of plants (Figure 2). Similarly, BCAs can be specialists or generalists.

Figure 2. (A left) *Aphis nerii* on *Asclepias*, (B right) *Heliopsis* aphid.

Insects such as green lacewings, or lady bird beetles are generalists, and feed on a wide range of prey insects. *Aphidius ervi* is a specialists BCA, and only attacked the larger forms of aphids (Cloyd, 2015). *Hippodamia* is a generalist and will feed on a wide host range (Aristizabel and Arthurs, 2014). As aphids can build up rapidly due to asexual reproduction, prompt action in deploying BCAs is important (Chowder, 2007). An inundative release could be successful when numbers are building up rapidly, as with chrysanthemum aphid. May species of Lady bird beetles are present in the USA, and most of these are generalists. During the pupal stage of the life cycle, the lady bird beetle is vulnerable to attack from other species (such as dragonfly, assassin bugs, parasitic wasps, and ants) (Aristizabel and Arthurs, 2014).

Aphidoletes is a delicate midge which attacks aphids, and operates during long days, biting aphids on their knees and injecting a toxin (Stack et al., 2016). The wasp *Aphelinus* works well on potato aphid, and foxglove aphid, and can tolerates higher temperatures than *Aphidius* (Stack et al., 2016). Syrphid flies are excellent aphid predators in the larval stage, and while the adults feed on nectar and pollen, these populations can build up in the presence of diverse flowering plants. *Lobularia* plants provide good nectar and pollen sources for sustaining Syrphid fly populations (Shepherd et al., 2002). Green lacewings are also a generalist predator, and in the larval stage are very quick acting, but these insects usually require repeat applications to be successful (Stack et al., 2016). Aphid mummies indicate the presence of *Aphidius* wasps, which are tiny insects that are parasitoids of aphids. The hardened aphid exoskeleton is a hollow shell after the wasp has eaten its way out of the aphid (Stack et al., 2016). *Aphidius colemani* attacks the smaller aphids, like green peach or melon aphids. *Aphidius ervi* attacks larger aphids such as potato or foxglove and is about twice as large as *A. colemani* (Stack et al., 2016). *Aphidius* can be maintained in greenhouses using a banker system (Figure 3A). Plants of oats, barley, or other grassy species can be grown to rear Bird Cherry Oat Aphid which will feed exclusively on grass plants (Figure 3B). These plants are then deployed in the greenhouse to provide a food source for the wasps. When pest aphids drop below sustainable thresholds, the bird cherry oat aphid will sustain the *Aphidius* population (Wollaeger et al., 2015; Cloyd, 2015).

Figure 3. (A left) Banker system, (B right) grassy species can be grown to rear Bird Cherry Oat Aphid which will feed exclusively on grass plants.

A good reference guide is a big help in managing the BCAs in propagation greenhouses, and the New England Greenhouse Floricultural Guide is an excellent choice for in depth information on insect and disease challenges (Stack et al., 2016) (Figure 4). *Lepidoptera* larvae (caterpillars) have been successfully managed at the Penn State Flower Trials using Dipel® DF, or one of the other *B. thuringiensis* products. At the Penn State Flower Trials, we have been concerned with

Tobacco bud worm, and the Virginia tiger moth (or yellow wooly bear), due their predilection for petunia flowers. Naturally occurring predators such as wheel bugs, assassin bugs and birds also contribute to control in this outdoor setting.

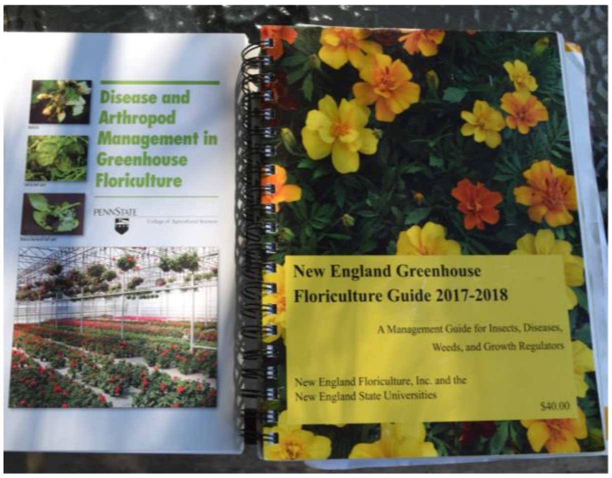

Figure 4. New England Greenhouse Floriculture Guide 2017–2018.

Two spotted spider mites are typically found on the lower leaf surfaces of plants. These mites have shown resistance to a number of miticides, but good BCA solutions are available for control (Stack et al., 2016). One of these BCAs *Phyoseiulus persimilis* is an excellent control and moves rapidly through the plant canopy (Wollaeger et al., 2015; Cloyd, 2015). These mites work well at moderate temperatures, and consume eggs, nymphs, and adult Two Spotted Spider Mites (Cloyd, 2015). At temperatures over 80 °F using *Neoseiulus* or *Galendromus* mites could be a preferable control strategy (Stack et al., 2016).

Thrips have been showing resistance to a number of insecticides and are often difficult to control. One of the reasons for this is their behavior in plant canopies. Thrips tend to be found in flowers and buds making them hard to get good chemical coverage. This cryptic behavior of thrips makes it hard to get good control with insecticides (Greer and Diver, 2000). Fortunately, several good BCAs are available for control. Pirate bugs (*Orius* spp.) are excellent consumers of thrips especially the western flower thrips (*Frankliniella occidentalis*) (Stack et al., 2016). At the PSU Flower Trials, we have been using pirate bugs for four years, and the population continues to maintain itself without additional pirate bug releases. These BCAs do a fair job in controlling thrips, but in 2018 additional support was required. To accomplish this, *Steinernema feltiae* were deployed through the injector system to assist with control of the soil borne stages of thrips life cycle. *Amblyseius swirskii*, was also applied in August, at 1 sachet/plant. All three of these control methods worked very well in concert to drop the thrips levels by 75-80%.

While we used sachets of the *Amblyseius swirskii*, they can be applied to flats and plug trays by shaking the mites out of the shipping container or using an air blast delivery system (Dogramaci, et al., 2013). To assist with pirate bug support, both Black Pearl and Purple Flash ornamental peppers are placed in the trials program to provide a nectar and pollen source for the pirate bugs. These two bankers (or support plants) have been placed in each bed of the trials. Research has shown that both Black Pearl and Purple Flash do a good job providing flower nectar and pollen for the pirate bugs to feed upon (Wong and Frank, 2011; Waite, 2012).

Fungus gnats are frequently problematic in many propagation systems. The larval stage feeds on newly developing roots in mist or fog propagation systems (Stack et al., 2016). While a number of chemical control products are available, the use of *Steinernema feltiae* has become the preferred control procedure for many operations. Applications of *Steinernema* on a 14 to 21-day interval provides effective control (Stack et al., 2016). Dissolving the packet of *Steinernema* in water and applications through the injector system, watering can, or pressure sprayer provides good coverage. *Hypoaspis miles*, and rove beetles also provide control the fungus gnat populations in flats and plug trays. These BCAs work on the soil borne insect populations and can be compatible with some chemical (Cloyd et al., 2010).

CONCLUSIONS

BCAs are being utilized successfully at an increasing rate in propagation greenhouses and nurseries in the USA (Stack et al., 2016).

While challenges can be increased compared with conventional chemical use, the BCAs are a good alternative choice for propagators and producers of ornamental plants (van Lenteren et al., 2018). Using BCAs will take more time especially for scouting, but the benefits to consumers, employees, and the environment are significant (Bale, et al., 2008) (van Lenteren et al., 2018). Using BCAs in both propagation greenhouses, and at the Penn State Flower Trials, have shown to be successful approaches to insect and disease control.

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Some useful websites:

- Association of Natural Biological Producers: http://www.anbp.org/
- Biobest Biological Systems: https://www.biobestgroup.com
- Side Effects Manual: https://www.biobestgroup.com/en/side-effect-manual
- Biological Control: A Guide to Natural Enemies in North America: http://www.nysaes.cornell.edu/ent/biocontrol/)
- Buglady Consulting – Biological Control Services: http://www.bugladyconsulting.com
- Koppert Biological: www.koppert.com
- New England Greenhouse Update: www.negreenhouseupdate.info
- University of Massachusetts Extension, Greenhouse Crops and Floriculture Program: http://www.umass.edu/umext/floriculture/

- University of Vermont, Entomology Research Laboratory: http://www.uvm.edu/~entlab/Greenhouse%20IPM/greenhouseipm.html

- IPM Laboratories New York: https://www.ipmlabs.com/plant-pest-management

- Penn State University Nematodes: https://ento.psu.edu/extension/factsheets/parasitic-nematodes

- Penn State University Broad Mites: https://extension.psu.edu/broad-mites-an-example-of-using-biocontrols-for-management

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