

Title: Implementation of Biocontrol in an Educational Greenhouse

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Abstract: Consumers, retailers, and growers of bedding plants (spring flowers and vegetable starts) are concerned about the use of neonicotinoid pesticides and their impact on pollinator health. In some locations consumers demand that greenhouse growers stop the use of certain pesticides. This demand has reached greenhouse growers and spurred interest in the use of biocontrol in New York's Capital Region. The goal of this implementation project was to provide an understanding of the challenges and benefits of using biocontrol in greenhouse production to the major players in the bedding plant industry: consumers, growers, and educators. Specifically, I hoped to improve retailer and grower biocontrol communication to consumers, give consumers knowledge of biocontrol, and increase grower confidence applying biocontrol products. Biocontrol demonstration was implemented at the Schenectady County Horticulture Education Center (SCHEC) where educational workshops were held to explain what the biocontrol agents are, the packaging they arrive in, understand the complexity of biocontrol systems, and ask questions. Demonstrations focused on the biocontrol of western flower thrips (*Frankliniella occidentalis*), fungus gnats (Mycetophilidae sp. and Sciaridae sp.), and green peach aphids (*Myzus persicae*). Biocontrol of whitefly (Aleyrodidae sp.), mealy bug (Pseudococcidae sp.), and cabbage worm (Pieridae sp.) were also discussed.

Background and Justification:

Due to concerns about pollinator health, consumers are demanding that greenhouse growers stop the use of certain pesticide products. Products containing active ingredients in the neonicotinoid family have attracted substantial attention (Godfray et al. 2014). This demand has reached greenhouse growers and spurred interest in the use of biocontrol by potted ornamental and vegetable start growers in New York's Capital Region. Although, consumers demand reduced pesticide use, they do not necessarily understand and accept the alternative. In the transition to biocontrol, predatory mite bran and/or various packets of beneficial arthropods will be present on plants which changes the appearance of plants from the consumer's eye. Consumers of greenhouse grown annuals and perennials are the lynch pin for the use of biocontrol by growers. If consumers do not like how biocontrol looks on plants, they will not buy from growers who make the transition away from conventional pest management. Growers (and consumers) have an entomological and ecological learning curve as they get started with biocontrol. Therefore, outreach material and workshops will be offered for both consumers and producers. This implementation project addresses the NYS IPM priority to "promote pollinator health and conservation."

This project will implement biological control at the Schenectady County Horticulture Education Center (SCHEC) where educational workshops will demonstrate what the biocontrol agents are, the packaging they arrive in, and see a live example of how western flower thrips (*Frankliniella occidentalis*), fungus gnats (Mycetophilidae sp. and Sciaridae sp.), and green peach aphids (*Myzus persicae*) can be managed in a greenhouse producing annual bedding plants.

The success of biocontrol in greenhouses is not a new concept. However, research and outreach on organisms and implementation are ongoing (Gerben et al. 2014, Jandricic et al. 2011, Arthurs et al. 2009). As a member of two Cornell Cooperative Extension greenhouse tours this winter (LIHREC E-Gro Tour and Ornamentals PWT Rochester Tour/Meeting), I have seen that many greenhouse growers in New York State have adopted and embrace biocontrol as effective pest management. In response to the question, "How is your thrips population with biocontrol?" one grower in Rochester replied "What thrips?" It is clear that biocontrol is successful when it is implemented with arthropod identification skills and an understanding of how plants, beneficials, pests, and pesticides interact.

In general, growers in the Capital Region are behind the biocontrol trend with four growers (to my knowledge) beginning the transition from conventional to biocontrol pest management during the 2016 season. Growers in this region are hesitant to make the transition when they already have a system that works. This season's concern for bee health and the reciprocal demand for plants without pesticide residue from consumers will push growers to consider biocontrol for next season.

Seventy-seven percent of retailers and growers who completed my "2016 Bedding Plant Conference Survey" indicated that insect pest identification was information that they would benefit from most. Additionally, 54% of participants in the survey said that they would benefit from more information on pollination/bee health. The educational biocontrol demonstration will target major spring greenhouse pests: green peach aphid, Western flower thrips, and fungus gnats. Four species of bedding plant will be planted in the greenhouse and the appropriate biocontrol measures will be taken. Additional biocontrol agents will be purchased and used to show consumer and grower workshop attendees how they would be applied in a given situation. An *Aphidius colemani* banker plant system will be set up in the greenhouse. This is a more advanced yet effective management tool for green peach aphid and melon aphid (Van Driesche et al. 2008). Additionally, marigolds will be planted and used as trap plants for thrips. Although there are factsheets and supplier instruction on how to create and maintain a parasitic wasp colony and use marigolds as thrips trap plants, the rare consumer and few growers in the Capital Region have seen these plant mediated IPM systems in person, let alone know where to begin.

Finally, the goal of this implementation project is to educate consumers so that they have a better understanding of what bedding plant retailers and growers are doing to reduce their negative impact to pollinators, give retailers the outreach materials they need to communicate biocontrol to their customers and suppliers, and for growers to have improved confidence in applying biocontrol materials.

Objectives:

1. Implement successful green peach aphid and Western flower thrips biocontrol at SCHEC
2. Educate greenhouse plant consumers and growers on biocontrol systems and its relation to pollinator health.
3. Project evaluation of the success of biocontrol implemented in the educational greenhouse and knowledge received by participants.

Procedures:

Implementation. In August, biocontrol organisms were researched and ordered through Biobest. The greenhouse demonstration occurred from September 5 – October 21, 2016 in the 1,000sqft SCHEC greenhouse. During the first week of September, 100 pansy plugs from C. Raker & Sons, 50 lemon verbena and 50 nasturtium from Silverleaf Greenhouses were planted. Flats of ornamental kale (cane and collection F1 from Harris Seeds), oat, and marigold seeds were also planted this week. The greenhouse temperature did not drop below 65°F during the day and 50°F at night. Yellow sticky monitoring cards were distributed randomly among plants and replaced every other week. Insects caught on sticky traps were identified from sticky cards. A six-week biocontrol program was conducted beginning with thrips and fungus gnat management at planting and finishing with mealy bug and whitefly biocontrol (Table 1). Plants were overhead watered as needed (at least 3 times per week). Plants were fertilized with J.R. Peters, Inc. 20-20-20 general purpose fertilizer at a rate of 125ppm N through a D14 (14 GPM) dosatron every other week. Barley banker plants were planted every week. Once a barley container was large enough it was placed into the *A. colemani* – cereal aphid colony. Once marigolds were 4 inches tall, they were distributed throughout the greenhouse as a plant mediated thrips magnet.

Table 1. Biocontrol products ordered from Biobest over the six-week demonstration. The following are indicated: Week = products arrived and applied, Product = Biobest name, Quantity = number of individuals in the product, Species = biocontrol agent or vector, Cost = price of each product at quantity, Unknown as a Beginner = critical lessons learned, Only Works if You Also Order = additional product required for success.

Week	Product	Quantity	Species	Cost (USD)	Unknown as a Beginner	Only Works if You Also Order
1	ABS-Mini+Stake	500 sashets	<i>Amblyseius cucumeris</i>	80.00	keep moist, stake at planting	
1	Insidiosis-System	bottle of 500	<i>Orius insidiosus</i>	39.80	hard to establish	Banker plant or Nutrimac
1	Steinernema-System	50 million	<i>Steinernema feltiae</i>	22.50	start at planting	
1	Shipping			91.50		
2	Colemani-banker-system	1 barley + aphids	<i>Rhopalosiphum padi</i>	19.80	did not come with colemani	Aphidius-System (mummies)
2	ABS-System	bottle of 20,000	<i>Amblyseius cucumeris</i>	10.00	week 3 would be better	
2	T. brassicae-System	100,000 eggs on cards	<i>Trichogramma brassicae</i>	24.00	need a way to monitor	
2	Nutrimac	100 cards	sterile <i>Ephestia kuehniella</i>	25.00	banker plant would work better	Insidiosis-System
2	Shipping			84.00		
3	Colemani-banker-system	1 barley + aphids	<i>Rhopalosiphum padi</i>	19.80	established well	Aphidius-System
3	Aphidius-System	500 mummies	<i>Aphidius colemani</i>	19.00	established well	Colemani-banker-system
3	Steinernema-System	50 million	<i>Steinernema feltiae</i>	22.50	worked well every other week	
3	Shipping			73.00		
4	Amblyseius-System	bottle of 20,000	<i>Amblyseius cucumeris</i>	9.70	same thing as ABS	
4	Californicus-System	bottle of 2,000	<i>Amblyseius californicus</i>	20.30		
4	Phytoseiulus-System	bottle of 2,000	<i>Phytoseiulus persimilis</i>	22.90		
4	N. Californicus	bottle of 2,000	<i>Neoseiulus californicus</i>	36.10	not necessary, small pest population	
4	Shipping			35.50		
5	Aphidoletes-System	bottle of 1,000	<i>Aphidoletes aphidimyza</i>	26.50		
5	Chrysopa-MC-System	multicell of 500	<i>Chrysopa carnea</i>	25.90	very active	
5	Shipping			29.00		
6	Delphastus-System	bottle of 100	<i>Delphastus pusillus</i>	21.00		
6	Encarsia-System	5,000 on cards	<i>Encarsia formosa</i>	30.40	need a way to monitor	
6	Shipping			29.00		

2. Education

- a. Four workshops were held in September and October (weeks 2, 3, 5, and 6). Time during each workshop was spent walking and talking through how to manage the major greenhouse pests using biocontrol. The pests covered included western flower thrips, fungus gnats, two-spotted spider mites, green peach and melon aphids, mealy bugs, white flies, and lepidopterans of the Brassicaceae. For each pest, biocontrol options were discussed at their own station. Biocontrol application, storage, and function were demonstrated and discussed. If no reasonable biocontrol was available (e.g. mealy bugs),

alternative IPM tools were discussed. Workshops concluded with time to look at pests and beneficials under the compound microscope and time for additional questions.

- b. "Aphid Banker Plants 101: Culturing Aphids to Sustain Parasitoid Wasps" was created. The factsheet titled "Out with 'Neonics', In with Biology!" was deemed inappropriate to create at his time. Neonicotinoids are not the only impact on honey bees and more literature needs to be included for such a document. The factsheets titled "Getting Started with Biocontrol" and "Customer Biocontrol FAQ" were updated. These continue to be distributed at conferences and posted on our website.
- c. "Biocontrol On the Go" is a presentation that was created as a handout for workshop participants and also used as a presentation. This is also available on the Capital Area Agriculture and Horticulture website:
<http://blogs.cornell.edu/capitalareaagandhortprogram/capital-horticulture/>
- d. Workshop attendees were "gifted" the IPM Pocket Guide: Greenhouse Scout App for their Android or Apple phones if they wanted it.

3. Evaluation

- a. Online Qualtrics evaluation survey was available on paper after workshops and was emailed to participants to complete after the workshop.
- b. Follow up questions will be included in the January 2017 Bedding Plant Conference survey.
Question 1: Are you considering beginning a biocontrol program in your greenhouse, high tunnel, or field?
A. Yes, this spring. B. I'm considering it for the future. C. No
Question 2: If you wanted to start a biocontrol program, do you feel that you have the knowledge you need to succeed? Y/N
Question 3: If not, where do you need the most education?
A. Figuring out what to order, from whom, and when
B. I need a cost/benefit analysis
C. How to apply products
D. Biocontrol biology
E. Pesticide interactions with biocontrols
F. Other (please list)

Results and Discussion:

Implementation.

Because this was a demonstration project, more biocontrol products were ordered than necessary to manage the low pest populations present in the SCHEC greenhouse. Workshop and talk discussions during this project brought up interesting challenges and benefits. The first question that growers ask about biocontrol is usually "Is it expensive?" To provide some information on the subject, I had project invoices for each week available at all workshops. Shipping costs are shocking to all audiences. However, growers and consumers do understand that it is necessary to ship live insects quickly and with cold packs.

Both sashet and container *Amblyseius cucumeris* (predatory mites for thrips) were ordered to compare stake vs. shake application methods. The slow release and contained nature of the sashets was considered a benefit by both growers and consumers. However, keeping sashets moist but not so wet that an environment for disease is created, requires education. *Steinernema feltiae* application was easily digestible by both growers and consumers. The most common question about these predatory nematodes was "How do you know they are alive and working in the soil?" No western flower thrips were observed during the course of this project.

Ordering biocontrols from different companies will yield different products arriving in the mail. With banker plant systems, it is important to talk with representatives about what exactly is coming in each

product. It is easy to assume that a banker plant colony comes as one item but that is not always the case. For example, it is clear that *Orius insidiosus* (minute pirate bug generalist predator) is a tough biocontrol to start with. If a grower is going to use them, Orius should be ordered early and along with a food resource. Nutrimac cards were demonstrated in this project. However, an ornamental pepper banker plant system would be a self-sustaining establishment strategy. Similarly, barley (or oats) should be ordered with cereal aphids and *Aphidius colemani* parasitoids. It was not clear whether a “colemani-banker-system” would come with all three species or not. Because of this, *A. colemani* mummies were ordered in week three to supplement the original order. After the second round, the colony took off and worked very well. I would now recommend to growers that they start planting barley for an aphid banker plant system 2 weeks ahead of cash crop arrival. Green peach aphids were present in the greenhouse during this project but damage was not observed on plants. The successful establishment of *A. colemani* banker plants and *Chrysopa carnea* (lacewing) release in week 5 both helped to manage the population of green peach aphids.

Additional biocontrol organisms ordered and released emphasized the complexity of ecological systems for all audiences. The challenges associated with reducing neonicotinoid products for pollinator health, was discussed and pondered by participants. Once biocontrol begins, the attention that must be paid to pesticide interactions, was daunting to some. Overall, audiences now have a greater appreciation for how much is at stake and involved for a grower who transitions from pesticides to biocontrol. *Aphidoletes aphidimyza*, the predatory aphid midge, was released successfully and growers who attended workshops were intrigued by this predator. Eggs parasitized by *Trichogramma brassicae* for Lepidopteran management and sterile Mediterranean meal moth eggs for *Orius* as an alternative food resource, arrived on cards. Descriptions of these two products are promising, yet cabbage worms persisted on ornamental kale. Because one cannot see these eggs with the naked eye it was educational for consumers and students to see cards distributed throughout the greenhouse.

IPM, scouting, and planning concepts were discussed at the beginning of each workshop and at a spider mite management station. *Phytoseiulus persimilis* and *Amblyseius californicus* were shaken onto plants for two spotted spider mite discussion and demonstration. Participants were also reminded that although there is no quick fix in biology, these predatory mites can be applied where spider mite “hot spots” occur. Upon request from a large scale greenhouse grower at the week 5 workshop, whitefly management was the theme of the week 6 demonstration. *Delphastus pusillus* (predatory beetle) and *Encarsia formosa* (parasitoid wasp) were ordered and demonstrated. Questions about how to monitor the success of these biocontrols was discussed.

Education.

With small groups of attendees for each workshop, we were able discuss and address individual challenges. Growers brought in sticky traps from their own greenhouses which we were able to look at under the dissecting scope. Although new biocontrol orders arrived each week, there was not enough new material to create a true four-week course “series.” Therefore, each workshop was treated independently. In addition to the four planned workshops for growers and consumers, two hands-on greenhouse lectures were given for Mohanasen High School AP Biology classes. A lecture for Albany County Master Gardeners was also conducted due to their interest and role as consumers. Live Insect ecology and pest management piqued the interest of both audiences. The biology classes included students in grades 10-12. In total, 69 people were reached in person by all events held for this project (Table 2).

Table 2. Date, workshop title, and the number of attendees at each biocontrol event.

Date	Workshop Title	# Attendees
15-Sep	Start Early. Getting Started with Biocontrol for Growers	6
27-Sep	Biocontrol for the Public Eye	3
4-Oct	"Mid-Season" Biocontrol	4
7-Oct	Mohanasen High School AP Biology class 1: Biocontrol	16
11-Oct	Biocontrol for Growers, Educators, and Consumers	6
12-Oct	Demonstration with Betsy Lamb (via Zoom)	1
21-Oct	Mohanasen High School AP Biology class 2: Biocontrol	13
15-Dec	Biocontrol for Master Gardeners	20

Overall, master gardeners voiced their concern that consumers are turned off when insects are visible on plants, whether they are good or bad. One consumer asked “How do you know it isn’t going to spread to other house plants?” Upon reflection, I was able to successfully demonstrate the application of biocontrols that arrive in different types of packaging that included cards, paper, plants, vials, containers, and boxes. Consumers received “tip-of-the-iceberg” lessons in pest and biocontrol biology, predator-prey interactions, monitoring techniques, pesticide interactions, and the challenges associated with the transition to biocontrol. Growers gained an understanding of product costs, application instructions, reminders on attention to detail, and considered the integrity of one biocontrol compared to others. Personally, I found myself pitching banker plant systems because of their economical and sustainable functionality. These plant mediated IPM systems enhance the resiliency of greenhouse IPM programs.

Evaluation.

An online Qualtrics survey was made available for workshop participants to fill out. Responses were not collected from high school biology or master gardener lectures. When asked how well the workshop increased understanding of greenhouse biocontrol, attendees gave an average score of 9 on a scale of 1-10. Yet, only 36% reported that they are likely to start biocontrol next season. Few respondents indicated why they were hesitant to begin biocontrol. Those who did, indicated that it “seems too expensive” and that they “would like to hear from another grower about how biocontrol works for them.” One interesting observation (not statistically analyzed) is that several of the participants who rated the workshop as very informative, also indicated that they are not likely to start biocontrol next season. Participants thought that seeing the containers that biocontrols come in, understanding how each biocontrol is applied, and learning what the pests and biocontrol organisms are, were the most valuable. All seven audiences were interested in learning more about outdoor biocontrol. Two attendees reported that they would like to know more about how to raise their own nematodes and lady beetles. This indicates to me that they now understand the benefit of banker plants and see potential for a colony approach to biocontrol. Only one master gardener had seen evidence of biocontrol on a purchased plant and none reported seeing biocontrol practices advertised in the Capital Region (verbal discussion).

Locations: Project occurred in Albany and Schenectady counties. I continue to educate on this subject in Greene, Columbia, Rensselaer, Washington, Schenectady and Albany counties.

Resources Developed:

Biocontrol On the Go: a presentation of the demonstration project for continued use. A shorter version of this presentation was available as a handout at demonstration workshops.

Aphid Banker Plants 101: Culturing Aphids to Sustain Parasitoid Wasps: factsheet now available on the CAAHP blog

Consumer Biocontrol Flier: edited brief factsheet/statement for greenhouses using biocontrols to post on site for inquiring consumers

Getting Started with Biocontrol: edited factsheet which outlines the critical aspects of understanding biocontrol

“Biocontrol Workshop October 4th” Video: one minute video of Lily demonstrating a lacewing release was posted on the Capital Region Agriculture and Horticulture Program facebook page has received 284 views as of January 4, 2017. https://www.facebook.com/pg/CCECAHP/videos/?ref=page_internal OR https://www.facebook.com/pg/CCECAHP/videos/?ref=page_internal

Full Workshop Demonstration Video: recorded with Betsy Lamb via Zoom. Once edited, this recording will be posted on the Capital Area Agriculture and Horticulture website.

Literature Cited:

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Pictures of the Project



Orius insidiosus arrived in a bottle. They will not establish a population unless appropriate food is available. Nutrimac cards are one source of alternative food pictured here. Establishment of ornamental pepper plants prior to Orius arrival would likely be most effective.



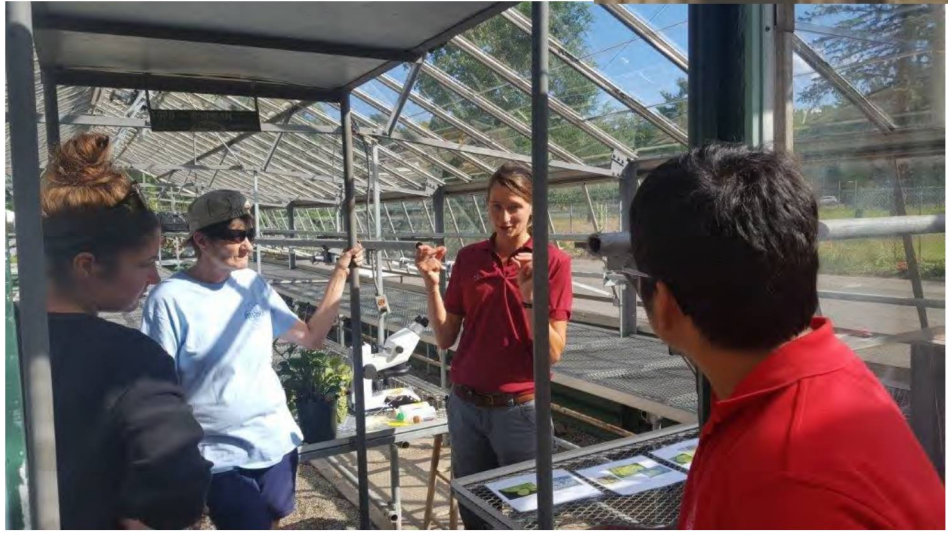
Black card has eggs parasitized by *Trichogramma*. These were used to target Lepidopteran eggs on ornamental kale. Yellow sticky cards were placed throughout the



Multi-cell delivery method of lacewing (*Chrysopa carnea*) larvae. This piece of cardboard has an individual cell for each larvae because they are so predacious.



Cucumeris predatory mite sashets placed into 4 inch pots that are not touching (above) and predatory nematode (*Steinernema feltiae*) station at SCHEC workshop (right).



Lily explaining the pests and biocontrols that workshop participants will see in the microscope at SCHEC.