# Augmentative Biocontrol

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# What Is Augmentative Biocontrol?

In augmentative biocontrol, a grower or pest manager applies living organisms to manage a pest (Stenberg et al. 2021). Augmentative biocontrol is different from classical biocontrol and conservation biocontrol, as it typically requires recurring application of the biocontrol species. Augmentative biocontrol can be an *excellent* tool in your pest management toolbox depending on your crop and pest species.

## Using This Resource

The goal of this resource is to help you implement your own augmentative biocontrol program, meeting you where you are. The process is broken into several steps, each building upon the last. Feel free to explore the whole site or to choose the starting point that best matches your needs.

**This website focuses on the following crop systems and biocontrol agents:**

- Indoor growing (greenhouse vegetables, floriculture, and ornamentals)
- Biocontrol agents that are:
    - insect parasitoids
    - insect and noninsect arthropod predators
    - entomopathogenic nematodes

**The following fall under the broad umbrella of *bioprotective* resources, but are not addressed in this resource:**

- Biopesticides
- Bioactive products
- Biofertilizers
- Biostimulants

- Entomopathogenic fungi and viruses
- RNA interference

# The “ABCs” of Augmentative Biocontrol

## What Augmentative Biocontrol CAN Do

The benefits of augmentative biocontrol are many and include:

- Reduced pest pressure from certain types of pests
- Reduced reliance on pesticides, which may reduce costs and risks, such as pesticide resistance, loss of available products, human and environmental health
- Use of the whole integrated pest management toolbox
- *Sustainable* pest management – opportunity to be more creative and insightful and learn more about your system
- Excellent advertisement opportunities to demonstrate sustainable practices

## What Augmentative Biocontrol CAN’T Do

Nothing is a true “silver bullet” (solve all) in pest management (including pesticides!). While augmentative biological control can aid in controlling pests, situations can arise that require additional tools. Augmentative biological control cannot:

- Completely eradicate all pest problems in your system
- Guarantee that you will never need to use pesticides again
- Be a onetime release and never thought of again
- Work for every crop or in all environmental conditions
- Work with every pesticide – systems need to be adapted or timed specifically to work in each situation

## Upcoming Research and Crop Availability

While this guide focuses only on indoor augmentative biocontrol, researchers are working on adapting the systems for outdoors. Dispersal of biocontrol agents is one of the limiting factors to outdoor use, and work includes tractor-mounted applicators and the application of environmentally resistant stages, such as insect pupae. Labor may be another limiting factor, and researchers are investigating opportunities for automated application. Current research on outdoor crops includes:

- Sweet Corn
- Peppers
- Citrus
- Strawberries
- Lettuce
- Turf
- Manure Fly Control
- Theme Parks

## Common Terms and Concepts Associated With Augmentative Biocontrol

Different terms for augmentative biocontrol have been developed that sometimes can be confusing. This glossary should help you navigate resources and conversations about biocontrol.

- **Augmentative Biocontrol** – human application of mass-reared biocontrol agents, temporarily augmenting their population densities in a targeted area. Sometimes referred to as inundative biological control or

inoculative biological control, which are subcategories referring to whether the released organisms will reproduce or not (Source: Stenberg et al. 2021).

- **Bioprotection** – protection provided by all tools of biological origin for management of pests, pathogens, and weeds. This is an umbrella term that includes all types of biological control and protection from other nonliving substances (Source: Stenberg et al. 2021).
- **Integrated Pest Management** – an effective and environmentally sensitive approach to pest management that relies on a combination of commonsense practices (Source: United States Environmental Protection Agency)
- **Sustainable Pest Management** – a holistic, whole-system approach applicable in agricultural and other managed ecosystems and urban and rural communities that builds on the concept of integrated pest management (IPM) to include the wider context of the three sustainability pillars, including human health and social equity, environmental protections, and economic vitality (Source: California Department of Pesticide Regulation)

# Step-by-Step Overview of Augmentative Biocontrol

The goal of this resource is to guide you through the steps that are needed to integrate a successful augmentative biocontrol program into your pest management program, no matter your level of understanding. The overview below can help you to work your way through the process of building a successful augmentative biocontrol program, no matter your starting point.

Read through these questions to determine what step you should start at, and then **click on a step** to navigate to resources that will guide you through this process.

**Step 1: Assess Your Current Pest Management Program & Needs**

- Do you use integrated pest management (IPM), and how well is it functioning?
- What pests do you currently have, and are they compatible with augmentative biocontrol?
- What species and cultivars of crops do you grow and how might they affect biocontrol outcomes?
- What pesticides are used, and are they compatible with biocontrol agents?
- Do you have effective systems for monitoring, identification, communication, and recordkeeping?

**Step 2: Manage Your Expectations of Augmentative Biocontrol**

- Are you aware that augmentative biocontrol is not a quick fix or silver bullet?
- Have you considered that outcomes may be less immediate or measurable than with pesticides?
- Are you ready to adapt your existing systems (scouting, timing, inputs) to accommodate biocontrol?
- Have you thought about how you'll measure "success" beyond eradication?
- Are you committed to iterative learning and long-term improvement?

**Step 3: Build Your Augmentative Biocontrol Toolbox & Network**

- Do you have connections with other growers using biocontrol that you can learn from?

- Have you identified trustworthy biocontrol suppliers and shipping partners?
- Have you drafted a budget that includes both onetime and recurring costs?
- Do you have SOPs for receiving, storing, and releasing biocontrol agents?
- Are your staff prepared for recordkeeping, quality checks, and weekly reviews?

**Step 4: Prepare Your Facility and Staff**

- Have you developed a clear delivery and deployment schedule for biocontrols?
- Have all staff been trained in pest ID, scouting, and the goals of the program?
- Is your facility equipped for proper storage and handling of live agents?
- Do you have clear protocols in place for release methods and post-release scouting?
- Have you considered how you'll communicate your use of biocontrols to customers (e.g., signage, FAQs)?

**Step 5: Begin Augmentative Biocontrol in One Crop**

- Are you starting with a crop that's well-suited to biocontrol and low risk?
- Have you conducted pre-release scouting to establish a pest baseline?
- Are you maintaining regular records on pest levels, releases, and observations?
- Are you performing quality control checks before and after releases?
- Have you scheduled weekly team check-ins to assess progress and troubleshoot issues?

**Step 6: Scaling and Strengthening Your Biocontrol System**

- Are you keeping up with new research, suppliers, or tools that could improve your program?
- How will you evaluate whether a supplier relationship is still meeting your needs?
- Are there opportunities to scale to more crops or introduce additional agents?
- How are you building internal expertise (e.g., staff skills, in-house SOPs)?

- Are you prepared to critically evaluate new technologies before adopting them?

**Step 7: Review and Improve Systems Annually**

- Are pest levels acceptably managed across your facility?
- Do your scouting and monitoring records show trends or gaps worth addressing?
- Are staff confident and consistent in applying the biocontrol program?
- Where are the bottlenecks or inefficiencies in your current approach?
- What updates to your tools, budget, or partnerships might improve next year's success?

# Step 1: Assess Your Current Pest Management Program & Needs

## Overview

In order to implement a new pest management system, you will need to step back and assess how your current pest management system works and look for any inefficiencies and areas to improve. If you have not built an integrated pest management system yet, it is strongly recommended to do so. Here are some broad questions to ask yourself:

## Do You Use Integrated Pest Management?

Having an integrated pest management system in place is crucial for best outcomes when using augmentative biocontrol. The following pieces should be built into your operations:

### Monitoring System & Identification

Employees need to be trained to know the symptoms of plant stress and the common pests and issues for each system they are working in. Some systems to develop include:

- Scouting regularly and systematically (e.g., weekly, in the same order)
- Recording data the same way each time (e.g., physical or digital datasheets)
- Pests, diseases, and other issues are identified properly

### Communication, Recordkeeping, and Assessment

It is crucial to develop a system to communicate potential pest problems in a facility, ensuring that issues found during scouting are linked to information about how problems were dealt with and how well it worked. Ideas for communication include:

- Issues (e.g., pests, disease) are always recorded with the date, zone/area, etc.

- Control measures (e.g., pesticide use, plant removal, biological control) are linked to the issue incidence
- Time is set aside each week to discuss issues, control measures, and how well they worked
- Information is reviewed annually to look for trends across time (this way you can anticipate annual or event-based issues that may arise)

### Putting It All Together

Having a system and keeping records can help you learn, adapt, and predict future problems.

### Integrated Pest Management Resources

- Critical Questions To Help You Manage Persistent Pest Problems – UVM Entomology Research Laboratory: www.uvm.edu/~entlab/High Tunnel IPM/Factsheets/Critical Questions to Manage Persistant Pest Problems Aug 2019.pdf

## What Pests Do You Have? Are They Compatible With Augmentative Biocontrol?

Knowing the actual pest species that you are dealing with is ABSOLUTELY crucial to a successful augmentative biocontrol program (or any pest management program!).

**Factors to consider:**

- Price or value of the crop
- Production scale/area of cultivation
- Availability of the biocontrol agent
- Plant factors (see below, e.g., trichomes)

The table below emphasizes the importance of accurately identifying the pest species before considering augmentative biocontrol as a management strategy. Not all pests, such as thrips or aphids, behave the same way.

Some species can be controlled by a variety of biocontrol agents, while others may only respond to one specific agent, or none at all, especially if certain agents are not available in your region. Please note that this table is not exhaustive and may not include all available biocontrol agents. It represents agents currently known to be available for purchase in the United States.

| Pest | Pest Group | Can Be Controlled By | Biocontrol Agent Count |
|---|---|---|---|
| **Green peach aphid (*Myzus persicae*)** | Aphids | *Aphidius colemani*, *Aphidoletes aphidimyza*, *Chrysoperla* spp., *Hippodamia convergens*, *Adalia bipunctata*, *Orius insidiosus* | 6 |
| **Foxglove aphid (*Aulacorthum solani*)** | Aphids | *Micromus variegatus*, *Hippodamia convergens*, *Aphelinus abdominalis*, *Chrysoperla* spp., *Aphidius ervi*, *Orius insidiosus* | 6 |
| **Melon/Cotton aphid (*Aphis gossypii*)** | Aphids | *Orius insidiosus* | 1 |
| **Imported cabbageworm (*Pieris rapae*)** | Caterpillars | *Trichogramma* spp. | 1 |
| **Cabbage looper (*Trichoplusia ni*)** | Caterpillars | *Trichogramma* spp. | 1 |
| **Diamondback moth (*Plutella xylostella*)** | Caterpillars | *Trichogramma* spp. | 1 |
| **Fungus gnats (*Bradysia* spp.)** | Fungus Gnats & Flies | *Stratiolaelaps scimitus*, *Steinernema feltiae*, *Dalotia coriaria* | 3 |
| **Shore flies (*Scatella stagnalis*)** | Fungus Gnats & Flies | *Dalotia coriaria*, *Steinernema carpocapsae*, *Hexacola neoscatellae* | 3 |
| **Garden fleahopper (*Halticus bractatus*)** | Hoppers (Hemiptera) | *Anagyrus pseudococci* (now *A. vladimiri*) | 1 |
| **Potato leafhopper** | Hoppers (Hemiptera) | None known | 0 |
| **Aster leafhopper** | Hoppers (Hemiptera) | None known | 0 |
| **American serpentine leafminer (*Liriomyza trifolii*)** | Leafminers | *Diglyphus isaea*, *Dacnusa sibirica* | 2 |
| **Serpentine leafminer (*Liriomyza brassicae*)** | Leafminers | None known | 0 |

## Know Your Free Biocontrols!

Sometimes certain species may find their way into your facility (e.g., plug flies from cultivators) and understanding which species you see are really important. They have even developed resistance to pesticides in some instances. These organisms can find their way into your greenhouse through:

- Plug flies from cultivators
- Open greenhouses

The top five friends:

- Hunter flies
- Syrphid (hover) flies
- Snout mites (Bdellidae)
- *Aphidius* spp. and other aphid parasites
- Lacewings (green and brown)
- Ladybird (ladybug) beetles

## What To Do When You Can't Figure Out an Identification?

Don't fret, insect and other small noninsect arthropods can be extremely difficult to identify, and there is a learning curve. Depending on your location, the following are likely to be available for free or for a low fee. To find these in your location, an internet search should get you to these services if you copy/paste the bullet point into a search engine and add your state or location:

- **State University Insect or Pathogen Identification Services** – Typically offered through cooperative extension services, often with mail-in options available for convenience.
- **State Agency Departments** – Various departments or divisions may offer pest identification services, including Agriculture, Plant Health, Pesticide Control, Agricultural Experiment Stations, Plant Industry, Environment, Sustainability, Pest Detection, Invasive Species, Nursery, etc. To find the appropriate service in your area, we recommend visiting your state's Department of Agriculture website and navigating from there. Look for sections dedicated to Integrated Pest Management programs, best management practices for growers, and other relevant resources.
- **Private Laboratories (Paid for Service)** – You can find insect identification labs by searching online for "insect identification testing laboratory" or by consulting your supplier. You may need to browse several results, as many structural pest companies may appear in the search. For a reliable vetting process, consider asking your supplier or peers for recommendations.
- **USDA ARD Systematic Entomology Laboratory Insect & Mite Identification Service** – A trusted resource for insect and mite identification from the USDA Agricultural Research Service.
- **Biological Control Company Supplier Representative** – If you have an established relationship with a biological control supplier, they may be able to help with pest identification issues. Some suppliers even offer on-site support to help growers address pest problems in person.

## Crop Check: How Your Plants Affect Augmentative Biocontrol Effectiveness

Not all crops create the same environment for beneficial insects and mites. Understanding the physical and biological traits of your crops can help you predict how successful augmentative biocontrol is likely to be, and how to adapt your program accordingly.

### Features of Crops That Work Well

Crops that support successful augmentative biocontrol programs tend to share some of these characteristics:

- **Open or accessible canopy:** Easier for both scouting and even distribution of BCAs.
- **Smooth leaf surfaces:** Beneficials can move freely and hunt effectively.
- **Longer crop cycles:** More time for biocontrol agents to establish and maintain control.
- **Consistent microclimate:** Stable temperature and humidity can support beneficial insect survival and reproduction.
- **Predictable pest pressure:** When common pests are well known and arrive on a schedule, it's easier to plan timely releases.

Examples might include leafy greens, many herbs, or floriculture crops with compact growth.

### Features of Crops That Pose Challenges

Other crops may require more effort to manage with augmentative biocontrol due to traits like:

- **Heavy trichome coverage:** Dense, sticky hairs (as on cannabis or some ornamentals) can physically trap or block beneficials.
- **Tall, vining, or sprawling growth habits:** Make it difficult to scout thoroughly and release BCAs evenly.
- **Short production cycles:** Don't allow enough time for BCAs to establish and impact pest populations.

- **Highly variable microclimates:** Can reduce survival or performance of sensitive beneficial species.

These crops aren't necessarily incompatible, but they may require specialized tools, modified release methods, or tighter integration with other control strategies to be successful.

## Pesticide Use & Augmentative Biocontrol

Using Augmentative Biocontrol does not mean you have to entirely stop pesticide use, however you will need to take several factors into consideration. These include, but are not limited to:

### Pesticide and Biocontrol Agent Suitability

The vendor or supplier of BCAs should provide a compatibility chart. For example, the brand Koppert has historically maintained a side effects database that is free and searchable online.

### Timing of Release and Pesticide Application

- Consider residual activity – what has been sprayed in the past and how long is it lasting on the plants
- Check propagated materials for older chemistry and potential residue
- Potential for pesticide spray to drift into an area with active biocontrol agents
    - Resources:
        - Compatibility: Pesticides and Natural Enemies of Pests (Cornell Blog Post): blogs.cornell.edu/biocontrolbytes/2020/05/12/compatibility-pesticides-and-natural-enemies-of-pests/

## Budget Considerations When Comparing Augmentative Biocontrol Costs

When evaluating the cost of implementing augmentative biocontrol, it's important to consider not only the direct expenses but also the related costs associated with traditional pesticide use, such as:

- Pesticides and adjuvants
- Pesticide application equipment (sprayers, nozzles, hoses)
- Personal protective equipment (PPE) required for pesticide application

Additional factors that can complicate pesticide use include:

- Potential phytotoxicity to your crops
- Reentry interval times that limit labor availability
- The often-higher cost of a reactionary pest management approach

For a more detailed breakdown and to help with your budgeting, see the comprehensive budget section below in step 3.

# Step 2: Manage Your Expectations of Augmentative Biocontrol

## Overview

Unfortunately, there is no “silver bullet” in pest control. While augmentative biocontrol has the potential to save money in the long run, transitioning to this system requires an initial investment in time and effort. Key considerations for adopting augmentative biocontrol include understanding its complexities, adapting current systems, and starting small.

- **Read, Research, and Network** – Gain a solid understanding of the complexities and limitations of augmentative biocontrol (e.g., purchasing demand).
- **Adapt Current Systems** – Transitioning to biocontrol will be a stepwise process. Adapt one crop at a time.
- **Start Small** – Avoid a drastic shift. Don’t go “cold turkey” on insecticides.

## Understand the Limitations of Augmentative Biocontrol

There are several limitations to consider when using augmentative biocontrol, including:

- **Purchasing Demand** – What if your area doesn’t have enough purchasing demand for biocontrol agents?
- **Regional Availability** – Some biocontrol agents may not be available in your region due to environmental factors, shipping constraints, or regulations.
- **Species-Specific Effectiveness** – Not all pests are equally susceptible to biocontrol. Certain pests may not respond to available biocontrol agents, or they may only be partially controlled, requiring supplemental measures.

- **Climate and Environmental Conditions** – Biocontrol agents may not thrive in certain environmental conditions, such as extreme temperatures, humidity levels, or fluctuating weather patterns, limiting their effectiveness.
- **Cost and Financial Constraints** – While biocontrol can be cost-effective long term, the initial investment in purchasing agents and setting up a new system may be prohibitive for some operations, particularly smaller growers.
- **Slow Response Time** – Biocontrol agents often take time to establish and build up populations, meaning that pest control may not be as immediate as with conventional chemical methods.

# Step 3: Build Your Augmentative Biocontrol Toolbox & Network

## Overview

Once you have decided which crop and pest you will target first with augmentative biological control, you can build your "Augmentative Biocontrol Toolbox." This toolbox includes:

## Crucial Networking

### Building a Network With Other Growers

Building a network with nearby growers who have had success with augmentative biocontrol can really help when you are troubleshooting. The following list has some ideas on how to connect with other growers:

- **Area or crop-specific email listserv options** – for example, in Vermont, there is a vegetable and berries listserv hosted by the University of Vermont. University Extension agents in your location should be able to help you find a listserv.
- **Farming associations** – search for farming associations in your location, and if you are in one, consider creating a subcommittee for growers who use augmentative biocontrol!
- **Networking at educational meetings** – look for educational meetings and conferences put on by University Extension or State Agricultural agencies. Both may also have email newsletters you can subscribe to for notification of upcoming events

### Building a Relationship With Potential Suppliers

- First, you need to find what suppliers will ship to your area. A good place to start is the Association of Natural Biocontrol Producers (ANBP) website: anbp.org

- Once you have a list of suppliers to reach out to, you should call and "interview" each to find a supplier to work with. Some considerations when choosing a supplier include:
    - Cost – in money and risk – Sometimes it is more expensive to get things from a local distributor, but a downside of lower cost may be longer shipping times and differences in understanding local environmental factors.
    - Do they provide technical support?
    - Are they easy to reach through different methods (phone, text, email, etc.)?
    - Relationship – it is essential to have a cordial relationship with your supplier. Ease of communication and matching styles of communication is an important piece of this decision.

### Develop a Relationship With Shipping Services (e.g., FedEx, UPS, etc.)

Building a strong relationship with your shipping carrier is essential for the smooth transportation of biocontrol agents. By establishing clear communication and understanding, you can ensure that shipments are handled properly and arrive on time.

- **Identify the Best Shipping Service for Your Needs** – Research different carriers to determine which service is best suited for shipping biocontrol agents. Some carriers may have specialized services for handling live organisms or perishable goods, which could be critical for ensuring the safe and timely delivery of your biocontrol agents.
- **Discuss Shipping Requirements** – Have a detailed conversation with your carrier about the specific needs of shipping biological products. This could include temperature control, special handling instructions, or packaging requirements to ensure the survival and viability of the biocontrol agents during transit.

- **Clarify Delivery Times and Schedules** – Ensure that your carrier understands the importance of timely delivery, as delays could compromise the effectiveness of the biocontrol agents. It may also be helpful to set up a tracking system for your shipments so you can monitor progress in real time.
- **Plan for Contingencies** – Discuss potential issues, such as delays, lost packages, or damage during transit, and establish a contingency plan. Knowing how your carrier handles such problems can help minimize disruptions to your pest management program.
- **Understand Costs and Shipping Terms** – Be clear on shipping costs, especially if shipping live organisms, as these may be higher than standard rates. Ensure you are aware of any additional fees or terms that could affect your budget.
- **Establish Regular Communication** – Keep in regular contact with your carrier to ensure that both parties are on the same page regarding upcoming shipments. Establishing a good working relationship can help resolve any issues quickly and efficiently.
- **Ask About Special Services** – Some carriers may offer additional services, such as priority shipping or insurance for live shipments. Inquire about these options to ensure that your biocontrol agents receive the best care during transit.

## Standard Operating Procedures for Staff

### Monitoring and Recordkeeping System

Set up a system that everyone on your team is trained to use. This helps make sure pests are tracked the same way across your facility. A simple notebook can work, but using a spreadsheet like Excel or Google Sheets makes it easier

to spot trends and review how things are going over time. You can build your own system in-house using tools you already have.

There are many scouting apps available that can help with monitoring and recordkeeping. Some may work well for your facility, while others may not. Before choosing one, make sure you understand the pricing and whether the features match your needs. Try asking the company for a reduced-cost trial or a short-term plan so you can test it out before spending too much.

### Receiving Packages

Talk with your staff about the best times to receive and handle biocontrol shipments. It takes time to check the quality and get them released into the crop. Make sure packages don't arrive right before the weekend or a holiday, since live organisms should not sit around waiting to be used.

### Quality Control Checks

- **Company Quality Control Checks** – Have a discussion with your company representative about the quality control measures in place at the distributor level. Understand their processes for ensuring the quality of the biocontrol agents before they are shipped.
- **Shipment Quality** – Upon receiving the shipment, verify the shipment date to ensure it aligns with your order. Check the temperature within the box immediately after opening, as it should be within the optimal range for the specific species. The company should provide this ideal temperature range; for example, *Dalotia* spp. should be kept between 10 and 30 °C.
- **Quantity Verification** – Confirm that the quantity of biocontrol agents matches your order. You can verify this through:

    - Cross-checking the package labeling with your receipt
    - Measuring the weight of the shipment and comparing it with previous shipments
    - Grid counting the organisms by placing them on a dish with a grid, counting the number in one square, and multiplying by the number of squares to estimate the total.
- **Quality Assessment** – Organisms can die during transit if not kept in proper conditions. The distributor should provide specific quality control instructions for each species. Common quality checks include:
    - Inspecting for movement to confirm that the organisms are alive.
    - Conducting small test runs, such as offering a predatory species prey under a microscope and observing for feeding behavior, to ensure they are behaving properly.

### Storage

It's best to use biocontrols right away, or within 24 hours of receiving them. But if you need to store them, make sure they are kept at the right temperature. Use an infrared thermometer to check. Your supplier should give you temperature guidelines for each species.

### Releases

Make sure your supplier gives you clear instructions on how to release the biocontrols. Go over these steps with your staff so everyone understands what to do. Depending on your space and setup, you might need to get creative with how you release them. A trip to the hardware store can help you find simple tools like scoops or spoons that work well. This is a great chance to involve your whole team, share ideas, and try out different methods to see what works best.

## Team Meetings: Make Regular Reviews Part of Your Routine

One of the most important parts of a successful augmentative biocontrol program is taking the time to check in regularly. These reviews can happen weekly, monthly, quarterly, or at the end of each growing season. The goal is to talk honestly about what is working, what is not, and what can be improved.

Start with a short weekly check-in. This can be a quick staff meeting to go over your scouting records, pest pressure, and how the most recent biocontrol release went. Some agenda items could include:

- Are the pests under control?
- Is the method of release working?
- Was the timing right?

Use the data you've collected in your spreadsheet or scouting app to help guide the discussion. This also helps everyone learn from each week's results and spot patterns early.

Monthly and quarterly reviews can go a little deeper. Use these to compare trends over time, check if your storage or handling methods are working, and see if your budget is on track. It's also a great time to talk about your relationship with your supplier:

- Are you getting the support and information you need?
- Do you have clear release protocols for each species?
- Are staff comfortable using them?

At the end of a season or year, plan a bigger review. This is your chance to look at the whole picture—how well the pests were managed, how efficient the system was, and how the staff felt about the process. Ask questions like:

- Did our scouting and recordkeeping system work?
- Were there delays or problems with shipping or storage?

- What deployment tools or techniques were most effective?
- Are there better ways to train new staff?
- What feedback did customers have?

Encourage everyone to share their thoughts. A strong program depends on communication and teamwork. Frontline staff often have the best ideas about how to improve things, as they're the ones scouting, releasing, and seeing what works in real time. Create a culture where staff feel safe and encouraged to suggest changes or point out challenges. You might even hold a "creative solutions" brainstorming session where everyone brings ideas, tools, or homemade release hacks they've tried.

Remember, biocontrol is not a one-size-fits-all solution. It requires constant learning, adapting, and fine-tuning. These regular reviews help you stay flexible and make sure your program keeps getting stronger, season after season.

## Choosing Which Biocontrol Agents To Use

### Meet the BCAs!

There are many kinds of beneficial insects and organisms that can help manage pests. These are called **BCAs** (short for biological control agents), and they include a variety of predators, parasitoids, and pathogens that target specific pests. Some of the most commonly used groups include:

- **Parasitoids:** Tiny wasps that lay eggs inside or on pests like aphids or whiteflies. The pest eventually dies as the wasp larva grows.
- **Predators:** Insects or mites that eat pests directly—like lady beetles, predatory mites, or lacewing larvae.
- **Entomopathogenic nematodes:** Microscopic roundworms that hunt and kill soil-dwelling pest insects.

To dive deeper into specific groups of BCAs, visit Cornell's sidebar on the biology behind biocontrol (cals.cornell.edu/integrated-pest-management/eco-resilience/biocontrol/biology-behind-biocontrol), where you can browse examples and learn how each type works.

For a practical overview of commercially available BCAs and what pests they target, this MSU Extension guide (E3299, 2024 edition, www.canr.msu.edu/floriculture/uploads/files/E3299_COMMERCIALLY_AVAILABLE_BIOLOGICAL_2024.pdf) is a fantastic reference.

## Interactions Between BCAs

Some BCAs work well together and others don't. A few things to keep in mind:

- Some predators will eat other beneficial insects if they're not carefully selected to coexist.
- Some parasitoids may target different stages of the same pest, making them complementary.
- Releasing the wrong mix of BCAs can reduce effectiveness or waste time and money.

For help navigating these interactions, suppliers and IPM professionals can offer guidance, and you can also explore BCA compatibility tips from trusted sources like Cornell's Biocontrol Agents resource hub (cals.cornell.edu/new-york-state-integrated-pest-management/eco-resilience/biocontrol/biocontrol-agents).

## Purchasing Considerations

Biocontrol agents aren't a "one-click" kind of product. Here's what to keep in mind before buying:

- Work with a trusted supplier
- Always purchase through a reputable company and talk with a representative. They can help you:
    - Select the best species for your facility and pest pressure.
    - Understand how your facility's environment might affect BCA performance.

    - Avoid accidentally buying low-quality or illegally sourced organisms.
- Avoid unverified online sellers, especially those offering native lady beetles. Collecting wild insects harms ecosystems, often leads to low-quality products, and is sometimes illegal.

### Location Matters

BCAs produced in climates with drastically different day lengths or conditions (like further south or in greenhouses overseas) may not perform well when introduced into Maine's unique seasonal light and temperature patterns. Always ask where the BCAs were reared and how well they adapt to your environment.

### Follow the Law

Regulations differ by country and sometimes by state. For example:

- Canada has species that are legal there but not in the U.S., and it is illegal to import them across the border.
- Buying online from unknown sources could result in the delivery of banned or invasive species.
- Some species require special permits or paperwork.

Working with a reputable U.S.-based supplier helps ensure you stay legal and protect the environment. Biocontrol agents are living organisms, and each state has specific regulations regarding which species can be imported, possessed, and released.

For example, Maine maintains an unrestricted list and classifications for species that can be legally used. You can review Maine's current regulations here: www.maine.gov/ifw/fish-wildlife/captivity/index.html.

Because regulations vary widely by state, it's essential to:

- Check your own state's policies before purchasing or releasing any biological agents.
- Work closely with suppliers who understand and comply with these rules.

Generally, state agencies involved in regulating biological control agents include:

- **Department of Agriculture or Plant Industry Division:** Oversees the introduction and use of pest control organisms, including BCAs, and issues permits when necessary.
- **Department of Natural Resources, Fish and Wildlife, or Environmental Conservation:** Manages wildlife regulations, including captive or introduced species that may affect native ecosystems.
- **State Department of Environmental Protection or equivalent:** Sometimes involved in permitting or environmental impact assessment for introducing non-native species.

For example, in Maine, the Department of Inland Fisheries and Wildlife oversees captive wildlife permits and ensures introduced species do not harm native populations.

Always contact your state's relevant agency to if you are unsure before ordering biocontrol agents, especially for species not native to your area.

## Augmentative Biocontrol Toolbox

Augmentative biocontrol programs often rely on creativity, adapting your unique facility, ideas, and expectations. Some items below are "ready to go," while others may require a little more creativity and thought.

### Ready-To-Go Purchasing List

(*Examples only; no specific endorsements*)

**Pest Scouting & Identification Tools:**

- **Identification Books and Keys**
- **Sticky Cards:** Sticky cards are a foundational scouting tool for monitoring flying and crawling pests. Here are key considerations for selecting and using them effectively:

- **Color Considerations:** different colored sticky cards attract different pest species. Choose card colors based on the target pest you're monitoring. Consult online factsheets or extension resources for specific recommendations.
- **Size & Quality:** Choose cards large enough to catch multiple specimens but easy to place throughout your facility. Sizes typically range from 3x5 inches to 5x7 inches or larger. Stickiness quality varies by manufacturer and over time. Store cards properly before use to maintain tackiness.
- **Verification and Inspection:**
    - Inspect sticky cards regularly to ensure they are effectively trapping pests. If thrips or other insects are seen crawling freely on the cards, it indicates the adhesive may have degraded and the card should be replaced.
    - Avoid using cards with crushed or heavily damaged specimens, as these are difficult to identify accurately.
    - Save important or unusual specimens for expert verification by carefully placing them in small envelopes or plastic sleeves for transport.
    - Replace sticky cards on a regular basis (typically weekly) to avoid double counting pests and to maintain reliable monitoring data.
- **Mailing for Verification:** When sending sticky card samples for expert ID, protect cards from crushing in the mail (e.g., using rigid envelopes or small boxes). Label clearly with date, location, and crop info.
- **Additional Resources:**
    - *Goopoff* or a like product is recommended by some growers to improve removal of sticky residue.

        - Catchmaster's pest ID posters (catchmasterpro.com/pages/pest-identification) or like products can help train staff in recognizing common pests on cards.
- **Clipboards** – sturdy for knocking pests off plants for collection.
- **Mite Brushing Machine** – useful for certain crops to dislodge mites for monitoring.
- **Hand Lens** – essential for quick in-field inspection.
- **Reading Glasses or Optivisors** – improve clarity and reduce eye strain during ID work.
- **Microscopes**
    - USB or Bluetooth microscopes (e.g., Dinolite) offer portability and easy image capture.
    - Dissecting microscopes (desk or handheld, like Nikon Field Microscopes) provide higher magnification for detailed ID.
- **Fanny Pack** – handy for carrying tools while scouting.
- **Soft-touch Tweezers** – useful for handling delicate insects without damage; can be purchased online or made DIY by cutting from recycled soda cans using available templates.

**Augmentative Biocontrol Quality Control Tools:**

- **Infrared Gun Thermometer** – critical for checking storage and release temperatures of biocontrol agents, ensuring viability.

**"DIY" Augmentative Biocontrol Solutions:**

- **Rearing Containers:** Some augmentative biocontrol agents can be reared or held in-house after purchase. For example:
    - *Delosia* boxes (for predatory mites) can be made from repurposed materials like old Styrofoam coolers or plastic containers. This approach reduces costs and allows you to acclimate BCAs before release.

**Creative Tools for Releases:**

- Use spoons, scoops, or other hardware store items repurposed as release tools.
- Encourage staff brainstorming and trial-and-error for developing easy, efficient release methods adapted to your facility.

**Innovative Examples:**

Some growers adapt **leaf blowers** to broadcast biocontrol agents mixed with bran flakes onto foliage, allowing quick and uniform distribution over large areas.

Another cool method involves a system designed to **constantly agitate nematodes** suspended in a bucket during application, ensuring even distribution and preventing nematode clumping or settling.

## Augmentative Biocontrol Budget

### Onetime Purchases

These are the initial investments necessary to establish your augmentative biocontrol program. Examples include scouting and identification tools (like microscopes, hand lenses, sticky cards), storage containers, monitoring equipment, and any specialized release tools. Investing in quality equipment upfront ensures accurate monitoring and effective releases, which can save money and effort later.

### Recurring Purchases

These costs depend largely on your facility's pest pressure and management strategy. Augmentative biocontrol agents, sticky cards, replacement parts for monitoring tools, and consumables like BCA carriers fall under this category. Regular purchases may also include maintenance supplies or replacement of worn equipment.

## Budgeting Considerations

Though augmentative biocontrol programs may seem costly at first, they emphasize prevention rather than reaction. Investing in consistent monitoring and timely releases reduces severe infestations, minimizing the need for expensive corrective measures such as chemical treatments or crop losses. In the long run, this preventative approach can lead to substantial savings and improved crop health, making the upfront budget commitment worthwhile.

# Step 4: Prepare Your Facility and Staff

## Overview and Scheduling for Augmentative Biocontrol Programs

Successful augmentative biocontrol requires careful planning, clear communication, and consistent execution. Developing a structured schedule and training your team are critical components that help ensure your biocontrol efforts run smoothly and achieve desired outcomes.

## Schedule & Timing

Create a detailed weekly schedule incorporating augmentative biocontrol-related tasks, with estimated time allocations for each. This helps ensure regular attention and reduces the risk of rushed or overlooked activities. Consider including:

- **Pest Scouting and Biocontrol Success Monitoring:** Set dedicated time for thorough scouting to observe pest populations and signs of biocontrol agent activity. This is a key indicator of your program's effectiveness and informs future decisions.
- **Receiving and Processing Biocontrol Shipments:** Coordinate staff availability to prioritize receiving shipments promptly. Processing includes unpacking, quality checks, and preparing agents for release. Biocontrols are live organisms, so minimizing delays (especially over weekends or holidays) is essential.
- **Backup Plans for Shipment Delays:** Develop contingency protocols in case shipments are delayed or damaged. This may involve adjusting release timing, communicating with suppliers, or temporarily increasing alternative pest management measures.
- **Quality Control Assessments:** Allocate time for careful inspection of shipments upon arrival, including verifying species, checking for damage or mortality, and measuring storage conditions such as temperature.

- **Release of Biocontrol Agents:** Schedule release activities following supplier protocols and internal best practices. This may require coordinating across shifts and allocating adequate time for proper deployment.
- **Data Assessments and Trend Analysis:** Regularly review scouting data and biocontrol performance metrics to identify successes or failures. Weekly or monthly reviews allow for adaptive management including tweaking strategies based on observed results.
- **Troubleshooting and Problem-Solving:** Set aside time to address unexpected issues, whether related to pest outbreaks, biocontrol agent performance, or operational hiccups. Encourage open discussion and documentation of challenges and solutions.

## Staff Training on Pest Scouting

Effective biocontrol depends heavily on well-trained staff who understand pests, biocontrol agents, and scouting procedures.

- **Clear Expectations:** Emphasize that scouting is a priority task that requires careful attention and should not be rushed. Quality over speed ensures reliable data.
- **System Training:** Teach your team how to use scouting systems or logbooks, record observations consistently, and adhere to data management protocols.
- **Response Protocols:** Make sure staff know the steps to follow if increasing pest pressure is detected, including when to escalate issues to supervisors or adjust biocontrol applications.

## Delivery Day Protocols

Receiving and processing biocontrol shipments efficiently is critical to maintaining agent viability.

- **Prioritization:** When shipments arrive, processing and deploying biocontrol agents should take precedence over other tasks.
- **Communication:** Make sure staff know how to handle and store shipments immediately upon arrival, including temperature checks with infrared thermometers and following supplier storage guidelines.

## Deployment Methods

- **Supplier Collaboration:** Ask your biocontrol supplier if release instructions come with shipments or if they offer in-person (or video) demonstrations. This hands-on training can clarify proper techniques and improve success rates.
- **Centralized Instructions:** If instructions are not supplied, create a well-organized, easy-to-access central location (physical or digital) where staff can find deployment protocols, tips, and troubleshooting advice.
- **Encourage Creativity:** Depending on your facility layout, staff may need to adapt or invent deployment tools or methods. Encourage brainstorming and trial-and-error within guidelines to optimize agent release.

## Handling and Storage

- **Storage Guidelines:** Review recommended temperatures and conditions for any biocontrol agents in use. Use tools like infrared thermal guns to verify storage conditions are maintained.
- **Limit Storage Time:** While immediate use is best, if storage is necessary, do so only for the recommended duration and conditions to maintain agent health.

## Communicating Biocontrol Use to Customers

Educating your customers about augmentative biocontrol can build trust and support for your sustainable practices.

- **Marketing Biocontrol:** Consider advertising your use of biocontrol agents as part of your commitment to sustainability and reduced chemical inputs. Posters, flyers, or social media posts can help spread the word.
- **Develop Talking Points:** Work with your team to prepare simple, clear explanations about biocontrol to share with customers, including how it works and its safety.
- **Addressing Concerns:** Be ready to reassure customers who may worry about “bugs” being released in your facility or “wasps” (parasitoids). Clear, honest communication can alleviate fears and turn curiosity into appreciation.

# Step 5: Begin Augmentative Biocontrol in One Crop

## Overview: Starting in One Crop

Starting with one crop allows you to trial augmentative biocontrol on a manageable scale before expanding to other areas. This step is about building experience, testing systems, and identifying what works well in your specific environment.

## Start Small

Choose one crop to begin your augmentative biocontrol program. Starting small reduces risk and helps build confidence and knowledge in your team. This also allows for fine-tuning your program without overwhelming your scouting or release systems.

## Pre-Release Scouting

Before releasing biocontrol agents, scout the crop carefully to assess:

- Pest pressure and species present
- Pest distribution and hotspots
- Presence of other natural enemies
- Existing damage

Accurate scouting informs release timing, choice of agents, and release rates. It also provides a valuable baseline for evaluating post-release success.

## Recordkeeping

Use consistent data collection methods before and after releases. Good records help:

- Track pest and biocontrol trends
- Make informed decisions about future releases
- Troubleshoot problems
- Communicate program progress to your team or customers

Recordkeeping tools can include scouting datasheets, spreadsheets, or apps designed for greenhouse IPM.

## Quality Control: Before Release

Purchased biocontrol agents should arrive with storage and quality control instructions. Before release:

- Inspect shipments immediately
- Verify viability (Are they alive and moving?)
- Check for obvious damage or contamination
- Use an infrared thermometer to confirm that temperature remained within the recommended range during shipping
- Contact suppliers if shipments arrive compromised as they may offer replacements or guidance

Refer to supplier-provided resources and MSU's temperature compatibility guide (www.canr.msu.edu/floriculture/uploads/files/E3299_COMMERCIALLY_AVAILABLE_BIOLOGICAL_2024.pdf) to ensure appropriate storage and handling.

## Post-Release Quality Control Scouting

Scouting after release is critical to assess whether your biocontrols are active and effective. Depending on the species, evidence may include:

- **Direct observation** (e.g., walking predators or flying parasitoids)

- **Indirect signs** (e.g., mummified aphids, parasitized whitefly pupae, or reduced pest pressure)
- **No visibility** – some agents, like nematodes, may not be visible post-release

Train scouts to ask:

- Are the biocontrol agents alive and active?
- Is there visual evidence of their work?
- What does successful control look like for this pest?
- How long after release are effects typically visible?

Incorporate this scouting into your existing pest scouting systems. Encourage staff to document timelines (e.g., "Mummified aphids observed 5–7 days after *Aphidius colemani* release").

## Assess Your Program Regularly

Hold weekly or biweekly check-ins to review:

- Scouting data
- Pest trends
- Agent performance
- Emerging issues or delays

Encourage open discussion and documentation of successes and failures.

## Troubleshooting When Biocontrols Don't Seem To Be Working

If you're not seeing the expected results, consider the following:

- **Are your expectations realistic?** Biocontrol is preventative and gradual, not an instant knockdown.

- **Have pesticides been used recently?** Check pesticide-biological compatibility using resources like Koppert's Side Effects database.
- **Are environmental conditions suitable?** Consider temperature, humidity, air movement (fans), and lighting.
- **Have deployment methods been effective?** Confirm that agents were released near pest hotspots and with appropriate frequency.
- **Are you targeting the correct pest species?** If pest pressure continues despite biocontrol releases, recheck pest ID or consider whether new pest species have emerged.
- **Is the pest population too high for biocontrol alone?** Inundative releases or compatible interventions may be needed when the pest-to-natural enemy ratio is too high.

# Step 6: Scaling and Strengthening Your Biocontrol System

## Overview

Once you've successfully piloted augmentative biocontrol in one crop, the next step is to scale up. Expansion should be strategic, based on data, staff capacity, and pest pressure across your facility. This phase also involves staying informed on new tools and assessing your support systems.

Scaling up your augmentative biocontrol program requires both logistical coordination and ongoing education. Growth should be driven by what's working, and a willingness to adjust what isn't. As you expand:

- Build on lessons learned from initial crops
- Use past scouting and post-release data to inform decisions
- Involve your team in adapting schedules and responsibilities
- Continue investing in staff training and recordkeeping

## Stay Informed: New Research, Tools, and Technology

Biocontrol is a rapidly evolving field. Expanding your program successfully means staying up to date while avoiding overhyped or misapplied tools.

- **Attend webinars, conferences, and supplier training events regularly.**
- **Subscribe to university extension updates**, supplier newsletters, and trade publications.
- **Consult regional experts**, such as university specialists or Cooperative Extension personnel, for recommendations suited to your growing conditions.

## Be Critical of New Technologies

New tools like digital insect ID apps, AI pest detection, or drone release systems may be advertised as game-changers. Evaluate new technologies carefully:

- Does the tool solve a real problem in your system?
- Is it accurate and proven under greenhouse conditions?
- Will it help staff work more effectively, or add complexity?
- Is it compatible with your current recordkeeping system?

For example, some AI image-recognition apps claim to identify pests to species level. While this might be convenient, accuracy can be limited, and identification mistakes may lead to poor decisions. Use such tools with caution and verify findings with trained staff or expert ID support.

## Grow Your Internal Capacity

Scaling up isn't just about ordering more biocontrols—it's about making sure your internal systems can support the growth.

- **Schedule regular refresher training** as new pests, staff, or crops are introduced.
- **Update SOPs (standard operating procedures)** for scouting, release, and quality control as needed.
- **Ensure adequate time and labor** are dedicated to scouting and deployment tasks.
    - Scouting often gets rushed as responsibilities grow. Safeguard it with scheduled time blocks.

## Assessing Your Supplier Relationship

Your biocontrol supplier should be a trusted partner as you scale your program. Ask yourself:

- Are shipments arriving reliably and on time?

- Are the organisms viable and healthy?
- Do they offer technical support when you have questions or problems?
- Are they transparent about product limitations?
- Do they notify you of delays or substitutions promptly?

If the relationship isn't meeting your expectations:

- Provide feedback to the supplier.
- Consider trying a small shipment from another supplier for comparison.
- Talk with peers or regional experts about who they work with and trust.

## Plan for Continued Monitoring and Evaluation

Expanding a program doesn't mean "set it and forget it." Regular evaluation is essential. As you scale:

- Continue weekly meetings or reviews of biocontrol performance
- Review long-term pest trends and biocontrol effectiveness across crops
- Adjust tactics based on what's working (or not)
- Update records and tracking tools to match the scale of the program

## Prepare for Seasonal Review

As your augmentative biocontrol program expands, it's important to build in moments of reflection. Consider scheduling a seasonal or annual review during your slowest production time. Use this opportunity to:

- Compare biocontrol success across crops and time
- Identify bottlenecks in scouting, release, or training
- Update SOPs or digital tracking systems

- Invite feedback from staff on what's working and what's not

Doing this prep work sets the stage for a meaningful annual review process, which is covered next.

Each season brings new lessons. A formal, annual review helps consolidate what you've learned, so your biocontrol program becomes smarter, more efficient, and more resilient over time.

Questions to guide your annual review:

- Are pests being controlled effectively across all crops?
- Where did you see the most biocontrol success? The least?
- Are staff confident and comfortable with the system?
- What could be streamlined next season?

## Biocontrol: The Pest Is Yet To Come

Adopting augmentative biocontrol is not just a shift in pest management, it's a meaningful investment in the future of your operation. Each step you take, from piloting one crop to scaling across your facility, strengthens your team's skills, builds resilience into your production system, and supports a more sustainable industry. While there will always be challenges to troubleshoot, this journey is full of innovation, discovery, and collaboration. As more growers share their tools, observations, and creative solutions, the collective knowledge around biocontrol continues to grow. Whether you're just beginning or refining an established program, you are part of a movement that's reshaping what pest management looks like, crop by crop, season by season.