BIOLOGICAL PEST CONTROL

Janet Wallace, August 2021

Organic farmers can control pests by providing habitat to support beneficial organisms, using trap crops, releasing biocontrol agents or applying biopesticides (pesticides made from natural sources, such as microorganisms, plants, animal tissue or minerals).

Biocontrol (biological control) agents are living organisms that are introduced or supported by humans with the intent to harm invertebrate pests. Biocontrol agents are sometimes called “enemies” because they attack pests. Biocontrol agents include predators, parasitoids, parasites and pathogens of pests.

Above: Ladybeetles and their larvae are voracious predators of many pests, particularly aphids.

HIGHLIGHTS

In this bulletin, you will find:

- *Who eats what* - a table of pests and the beneficial organisms that attack them
- *How to attract beneficial organisms* - a list of beneficial organisms and tips on their preferred habitat
- Examples of successful biocontrol in greenhouses
- The latest research on habitat manipulation to manage food sources for predators and parasitoids
- Common biological pesticides for managing predators and parasitoids

To keep a strong and stable community of biocontrol agents, farmers can provide ‘SNAP’ - Shelter, Nectar, Alternative prey and Pollen. Throughout the year, including the winter, organisms need shelter, such as untilled areas, mulch, perennial plantings, hedgerows or wild areas.

To provide pollen and nectar, growers can plant insectary strips: flowering plants with different floral characteristics and blooming times. Wild areas and flowering strips can provide habitat for pollinators, which can lead to higher crop yields.

Farmers can concentrate pests by growing trap crops, plants that attract pests. This can divert pests from commercial crops and make it easier to kill pests by mowing or tilling the trap crop or applying a botanical pesticide.

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On organic farms, pest control is partially accomplished by invertebrates – predators and parasitoids of pests. Organic farms tend to host a greater abundance and diversity of such organisms than non-organic farms[1]. While the wasps, beetles and others are responsible for killing the pests, farmers play a pivotal role by providing habitat for these biocontrol agents and ensuring crops are healthy. When such preventative measures are inadequate, producers can release organisms to attack pests or apply biopesticides.

Organic farmers have an ever-increasing range of biocontrol options, thanks in part to the Organic Science Cluster (OSC). In OSC studies across Canada since 2009, scientists explore how organic farmers can control pests by providing habitat to support beneficial insects, releasing biocontrol agents and applying biopesticides. The choice of method depends on the type of pest and level of pest pressure, the growing system (field crop, market garden or greenhouse) and the operator's preference.

RELEASING BIOCONTROL AGENTS

Farmers can release predators, parasites or parasitoids to attack pests. The choice of agent depends on the situation. For example, farmers can choose between generalist predators that attack several types of pests, or specific parasitoids to attack one pest species.

Biocontrol is particularly well suited for greenhouse production where pest outbreaks can be severe due to the lack of wild beneficial organisms. Also, the greenhouse itself inhibits dispersal of introduced organisms.

Examples of successful biocontrol in greenhouses include[2]:

- Herbivorous mites controlled by predatory mites (*Amblyseius spp., Galendromus occidentalis, Neoseiulus californicus* and *Phytoseiulus persimilis*), predatory mirids sold under the brand name Mirical (*Macrolophus pygmaeus*) and spider mite destroyers (*Stethorus punctillum*).

- Thrips controlled by cucumeris mite (*Neoseiulus cucumeris*), another predatory mite (*Gaeolaelaps aculeifer*), the minute pirate bug (*Orius*) and parasites (*Steinernema*).

- Aphids controlled by various parasitoids (*Aphelinus abdominalis, Aphidius colemani , Aphidius ervi,* and *Aphidius matricariae*) and predators including aphid midge (*Aphidoletes aphidimyza*), two-spot ladybird (*Adalia bipunctata*), lacewings (*Chrysoperla carnea* and *Chrysoperla ryfilabris*) and convergent lady beetle (*Hippodamia convergens*).

- Whiteflies controlled by the parasitoids, the chalcidoid wasps (E*ncarsia formosa, Eretmocerus mundus* and *Eretmocerus eremicus*), and by predators including Whitefly lady beetle (*Delphastus catalinae*), Swirski-mite (*Amblyseius swirskii)* and mirids (*M. pygmaeus, M. caliginosus* and tobacco capsid, *Nesidiocoris tenuis*).

In terms of field releases, if the organisms disperse after being released, the farmer's investment just flies away. Less mobile biocontrol agents, such as ladybird larvae rather than adult ladybirds, are less likely to disperse. However, field releases of biocontrol agents

The 2020 Canadian Organic Standards permits the following biocontrol agents[3]:

BIOLOGICAL ORGANISMS:
Biological organisms (living, dead or as extracts), such as viruses, bacteria, protozoa, phages, fungi, insects and nematodes. Pharmaceuticals derived from or by biological sources, such as natamycin, penicillin and streptomycin, are prohibited even if registered as pesticides.

INVERTEBRATES:
Worms, insects (including sterile insects), nematodes, arthropods and other invertebrates.

MICROORGANISMS & MICROBIAL PRODUCTS:
Microorganisms, such as viruses, bacteria, protozoa, phages, and fungi, are permitted living, dead or as extracts. Examples include the following: rhizobium bacteria; mycorrhizal fungi; azolla; yeast; *Bacillus thuringiensis*; virus and virus sprays (e.g., granulosis); and spinosad.

	Description	Pros	Cons	Ideal situation
Releasing organisms	Releasing predators, parasitoids or parasites	• Simple • Can be highly effective, particularly for eggs and larvae • Can target one or several pest species	• Organisms may leave the crop • Can be expensive • Often a lag time for delivery of commercial product • Lag time between application and effect • Can create new problems (e.g., beneficials become pests) • Can harm other beneficials • Released organisms might not reproduce and frequent releases are needed	• High value crops • Closed environment (greenhouse)
Providing habitat for beneficials	Providing year-round supply of food and shelter to maintain populations of wild beneficials	• Can support many types of beneficial organisms • Provides other benefits (e.g., attracting pollinators; improving biodiversity; may reduce erosion) • Can be self-sustaining for years • Can be free or inexpensive	• Long lag time between creating habitat and effect on pests • Might provide habitat for other pests • Often not targeted at one pest • Efficacy varies -- unpredictable • Can be difficult or costly to get perennial insectary established	• Works in various environments from fields to market gardens to greenhouses • Most valuable in preventing pest outbreaks
Biopesticides	Applying a substance derived from natural sources that harms the pests	• Simple to apply • Can be highly effective at various life stages of the pests • Fast-acting • Can target one pest or a group of pests • Can be stored - ready to use when needed	• Can harm beneficial organisms • Can be expensive • Effect is short-lived • Pests may develop resistance to biopesticide	• High-value crops • Serious outbreaks • Most effective when applied to immature pests

Table 1: Forms of biocontrol

are used, such as the release of parasitoids by drones over corn fields to control the European corn borer.

The effect of the release is temporary unless the introduced organisms become established. Frequent releases can keep pest populations low and help prevent serious outbreaks. If the agents are released once an outbreak has occurred, there will be a lag time between the release and their effect on the pests. This is particularly significant with parasitoids – as they, unlike predators, don't immediately kill the pests.

A challenge in relying on biocontrol is the ability to get the beneficial organisms when needed – when the pest numbers are increasing. This involves constant monitoring of pest populations, such as the use of yellow sticky traps. Another approach is to provide habitat to support the predators and parasitoids when pest numbers are low. For example, Alyssum and black-eyed Susan provide habitat for pirate bugs when pests are not abundant.

Operators can also breed their own parasitoids. Many companies that sell beneficial organisms also sell "banker plant" systems, which involve growing harmless aphids to feed parasitoids when pests aren't abundant[4]. Operators can also breed their own parasitoids. Many companies that sell beneficial organisms also sell "banker plant" systems, which involve growing harmless aphids to feed parasitoids when pests aren't abundant.

Above: Cosmos provide habitat for beneficial organisms including Chalcid wasps, several types of spiders and praying mantis.

Predators of Lygus

A significant pest in many fruits and vegetables is the tarnished plant bug (*Lygus lineolaris*). Its saliva is toxic to plants and when the bug feeds on a plant, it leaves substantial damage (e.g., necrotic lesions on celery, damaged midribs in lettuce). With strawberries, the damage (stunted/deformed strawberries) is so common that Lygus poses a serious barrier to transition to organic production[5].

In an OSC study, two generalist predators, damsel bugs (*Nabis americoferus*) and minute pirate bugs (*Orius insidiosus*), were released to control Lygus in greenhouse and strawberry fields[6].

After releasing the predators in strawberry fields, the population of Lygus dropped for about two weeks. Even though these predators are common on organic farms, the researchers conclude that a series of well-timed releases is the most effective way to control Lygus. The damsel bugs attack adult and larval Lygus. Pirate bugs consume eggs and small nymphs. The scientists also released damsel bugs in greenhouses and successfully controlled Lygus on cucumbers.

Both predators are generalists and eat a variety of pests. In addition to Lygus, damsel bugs also attack aphids and minute pirate bugs feed on small pests, such as thrips, spider mites and whiteflies. Having food sources other than the targeted pest means that the generalist predators can survive when the specific pest is not abundant. However, food webs are complex; these predators can attack other beneficials and even be cannibalistic.

ORGANISMS

Pests: this article focuses on insects and other invertebrates that damage crops. The Canadian Organic Standard defines a pest as an "organism causing damage to humans or to resources used by humans, such as certain viruses, bacteria, fungi, weeds, parasites, arthropods and rodents."

Beneficial organisms: organisms that help crops, including pollinators, symbiotic soil life and biocontrol agents.

Biocontrol (biological control) agents: living organisms that are introduced or supported by humans with the intent to harm invertebrate pests. Biocontrol agents are sometimes called "enemies" because they attack pests. Biocontrol agents include:

- Predators: organisms that eat pests. Examples: birds, ground beetles, damsel bugs and pirate bugs.
- Parasitoids: organisms, usually parasitic wasps or flies, that lay their eggs in the adult bodies, pupae, larvae or eggs of pests. When parasitoids hatch, they consume the pest from the inside out. Many parasitoids start consuming non-essential tissue before attacking the internal organs of the pests; this gives them time to feed before emerging as adults. Examples: Braconid wasps, Chalcid wasps and Tachinid flies.
- Parasites: organisms that feed on, but generally don't kill, living hosts. Parasitoids are sometimes called parasites. Examples: parasitic mites and parasitic nematodes.
- Pathogens: Microorganisms (bacteria, fungi, viruses, protozoa, etc.) that cause disease in pests. Certain pathogens are also parasites. Examples: *Beauveria bassiana* and *Bacillus thuringiensis (Bt)*.

Controlling Spotted Wing Drosophila

Spotted Wing Drosophila (SWD) is an invasive fruit fly, which has become a major pest across North America. Unlike native fruit flies which lay eggs in soft or rotten spots in fruit, SWD (*Drosophila suzukii*) lay eggs in sound immature fruit. When the larvae hatch, they consume the fruit. The result is damaged fruit containing maggots. Vulnerable fruit include berries, grapes and tomatoes.

OSC researchers identified two parasitic wasps that lay eggs inside SWD larvae: Samba (*Ganaspis brasiliensis*) and ronin wasps (*Leptopilina japonica*). Surprisingly, the wasps, which are native to Asia, are already established in south-coastal BC[7]. The wasps may have been accidentally introduced in imported fruit containing SWD parasitized by the wasps. It is possible that the wasps can provide a self-sustaining form of pest control in coastal BC.

The fact that the wasps were living in wild fruit, in addition to crop fields and orchards, highlights the need for year-round habitat for beneficials – wild and cultivated areas that are not sprayed with insecticides (including biopesticides).

HABITAT MANIPULATION

Likewise, biocontrol agents need food throughout their life. Most pests aren't abundant during the entire growing season from early spring to late fall so alternative food sources are needed at certain times. Nectar and pollen provide food for adult parasitic wasps and many predators. Alternative prey (i.e., invertebrates that are not pests) can provide another food source for predators and parasitoids. This can be provided by providing habitat for other insects in flowers, wild areas or other plants. There's a risk, however, because this can provide habitat for other pests. This highlights a challenge of biological pest control.

Also, biological control is less predictable in the face of climate change. As weather patterns change, the natural synchronized timing of pest-predator cycles may be disrupted[8].

Insectary strips

To provide pollen and nectar, growers can plant insectary strips: flowering plants with different floral characteristics and blooming times (see Table 2). Wild areas and flowering strips can provide habitat for pollinators, which can lead to higher crop yields. Also, insectary strips and wild areas fulfill the new biodiversity requirement of the 2020 Canadian Organic Standards to take "measures to promote and protect ecosystem health on the operation."[9]

Insectary strips can provide habitat for other predators, such as ground beetles. An OSC prairie study found more than three times the number of ground beetles in the floral strips when compared to the grassy edges of the control field[10]. Ground beetles consume a great diversity of pests, including aphids, mites, beetle larvae and slugs. They are long-lived and adaptable – being able to switch to a diet of weed seeds when invertebrate prey is scarce.

The OSC scientist recommended that growers put time into preparing a weed-free site before seeding insectary strips[12].

CHALLENGES OF INSECTARY STRIPS

Harbouring pests. Habitat for beneficials might provide food and shelter for pests or be a source of weed seed.

- *Solution:* Monitor strips. Mow or till if they harbour many pests or before weeds set seed.

Challenge the establishment. Creating a perennial stand of insectary plants can be costly to establish. It is also challenging to maintain the desired species composition. Perennials need to survive the winters and spread; annuals need to self-seed; and the more aggressive plants (or weeds) can't dominate the mix.

- *Solutions:* Site preparation. Wait until the site is relatively free of weeds, particularly perennial weeds, before planting. Use nurse crops.

A shot in the dark. While it is known that flowering strips provide habitat for beneficials, they might not provide the food and shelter for the enemies of the pests attacking your crops.

- *Solution*: Choose appropriate flowers (see Tables 2 and 3).

Table 2: Plants to attract beneficials[11]

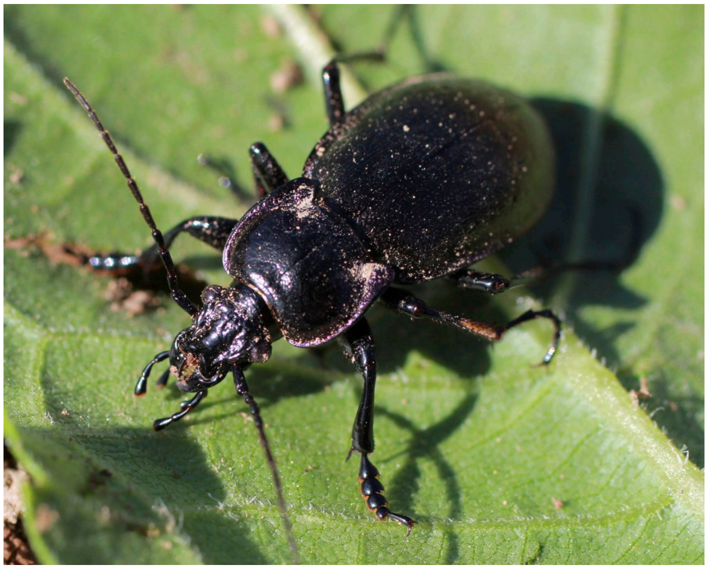
Beneficial	Pests	How to attract/conserve	
		Plants	Actions
Aphid midge (*Aphiodoletes aphidimyza*) (Larvae are aphid predators)	Aphids	Dill, mustard, thyme, sweet clover	Shelter garden from strong winds Provide water in a pan filled with gravel
Aphid parasites (*Aphidius matricariae* and others)	Aphids	Nectar-rich plants with small flowers (anise, caraway, dill, parsley, mustard family, white clover, Queen Anne's lace, yarrow)	Don't use yellow sticky traps
Assassin bug (Reduviidae family)	Many insects, including flies, tomato hornworms, large caterpillars	Permanent plantings for shelter (e.g., hedgerows)	
Bigeyed bugs (*Geocoris spp*. of Lygaeid Family)	Many insects, including other bugs, flea beetles, spider mites, insect eggs and small caterpillars. Also eats seeds	Berseem and subterranean clovers, common knotweed	
Braconid wasp (Braconidae family)	Armyworms, cabbageworms, codling moths, gypsy moths, European corn borers, beetle larvae, flies, aphids, caterpillars, other insects	Nectar plants with small flowers (caraway, dill, parsley, Queen Anne's lace, fennel, mustard, white clover, tansy, yarrow), sunflower, hairy vetch, buckwheat, cowpea, common knotweed, crocuses, spearmint	
Chalcid wasps (many families, including Trichogrammatidae)	Spruce budworms, cotton bollworms, tomato hornworms, corn earworms, corn borers, codling moths, other moths	Diversity of plants, including dill, anise, caraway, hairy vetch, spearmint, Queen Anne's lace, buckwheat, common knotweed, yarrow, white clover, tansy, cowpea, fennel, cosmos, chervil. For orchards: clover and flowering weeds	
Damsel bug (Nabidae family including Nabis spp.)	Aphids, thrips, leafhoppers, treehoppers, small caterpillars	Sunflower family**, alfalfa	
Ground beetle (Carabidae family)	Slugs, snails, cutworms, cabbage root maggots, other moth larvae; beetle larvae Some prey on Colorado potato beetles, gypsy moth and tent caterpillars	Amaranth, white clover	Permanent plantings; mulching
Lacewing, Neuroptera Family (*Chrysoperla* and *Chrysopa spp*.)	Soft-bodied insects including aphids, thrips, mealybug, scale, caterpillars, mites and whiteflies, small caterpillars	Carrot family*, sunflower family**, buckwheat, corn, holly leaf cherry	Provide water during dry spells
Ladybird beetle or ladybug (*Hippodamia spp*. and others)	Aphids, mealybugs, spider mites, soft scales, whiteflies, small caterpillars	Carrot family*, sunflower family**, crimson clover, hairy vetch, grains and native grasses, butterfly weed, black locust, buckwheat, rye, hemp sesbania, buckthorn, black locust	Once aphids leave a crop, ladybird also leave. To retain active ladybirds, maintain cover crops or other hosts of aphids or alternate prey
Mealybug destroyer (*Cryptolaemus montrouzieri*)	Mealybugs	Carrot family*, sunflower family	

Table 2 continued: Plants to attract beneficials

Beneficial	Pests	How to attract/conserve	
		Plants	Actions
Parasitic nematodes	Nematodes	Marigolds, chrysanthemum, gaillardia, helenium, *Eriophyllus lanatum*, horseweed, hairy indigo, castor bean, *Crotalaria spp*., *Desmodium spp*., sesbania, lupines, *Phaseolus atropurpurens*	
Praying mantis (*Mantis spp.*)	Any insect (including beneficials)	Cosmos, brambles	Protect native species by avoiding pesticides
Predatory mites (*Typhlodromus spp*.)	Spider mites		Different species have particular ecological requirements, especially with respect to humidity and temperature. Avoid insecticides. Provide habitat for alternate prey (i.e., non-pests) of the predatory mites.
Predatory thrips (Thripidae family)	Spider mites, aphids, thrips, Oriental fruit moths, codling moths, bud moths, peach twig borers, alfalfa weevils, whiteflies, leafminers, scale		Have non-crop populations of plant-feeding mites (e.g., European red mite, two-spotted spider mite), scales, aphids, moth eggs, leafhoppers and other thrips.
Rove beetles (Staphylinidae family)	Aphids, springtails, nematodes, flies; some are parasitic on cabbage root maggots		Permanent plantings; interplant strips of rye, grains, and cover crops; mulch beds; make stone or plant walkways in garden to provide refuges.
Spiders	Many insects	Caraway, dill, fennel, cosmos, marigold, spearmint	
Spider mite destroyers (*Stethorus spp*.)	Spider mites	Carrot family*, mustard family (sweet alyssum, candytuft, etc.)	
Spined soldier bugs (*Podisus maculiventris*)	Fall armyworm, sawflies, Colorado potato beetles, Mexican bean beetles	Sunflower family**, bishop's weed	Maintain permanent plantings.
Syrphid flies (Hoverflies)	Aphids, small caterpillars, thrips	Carrot family*, the sunflower family**, candytuft, sweet alyssum, ceanothus, holly-leaved cherry, buckwheat, scabiosa, spearmint, knotweed, California lilacs, soapbark tree, meadow foam, baby-blue-eyes	
Tachinid flies	Beetle and fly larvae, caterpillars. Cutworms, armyworms, tent caterpillars, cabbage loopers, gypsy moth; some attack sawflies, Japanese beetles, May beetles, squash bugs, green stink bugs, sowbugs	Carrot family*, goldenrod, sweet clover, Phacelia spp., sweet alyssum, buckwheat, amaranth, buckthorn, *Heteromeles arbutifolia*	
Tiger beetles (Cicindelidae family)	Many insects		Maintain permanent plantings and some exposed dirt or sand areas.
Whitefly parasitic wasps (*Encarsia formosa*)	Greenhouse whiteflies, sweet potato whiteflies	Carrot family*, sunflower family**	

**Carrot family: Queen Anne's lace, dill, fennel, caraway, tansy, parsley, coriander, etc.*

*** Sunflower (aster) family: coreopsis, Gloriosa daisy, yarrow, cosmos, sunflower, marigolds, goldenrod, daisies, golden marguerite (*Anthemis*), dandelion etc.*



Above: Ground beetles thrive in insectary strips, undisturbed land and mulched soil. They consume slugs, cutworms, cabbage root maggots and the larvae of many pests (including Gypsy moths and tent caterpillars).

TIPS FOR PROVIDING HABITAT FOR BIOCONTROL AGENTS:

Be on the edge. The greatest diversity and abundance of beneficials is found on field borders where cultivated and wild areas meet.

Small is beautiful. The smaller the fields, the more edges and "fringe benefits" in terms of greater species richness and numbers of insects that attack pests. Try to reduce the distance beneficials need to travel from their habitat to crops.

Plant flowers. Flowers provide food (pollen, nectar and alternative prey) for parasitoids and predators. The ideal flowering strip has various flowers blooming throughout the growing season. Certain plants are more effective than others (see Table 2)

Avoid physical distancing. Don't let your crops stand alone. Intercrop with green manures, flowers, other crops or even weeds.

Stop spraying. The fewer agrochemicals that are used, the better. Even biopesticides that are permitted in organic production can kill beneficial organisms.

At the Rodale Institute, scientists took time to create insectary strips in cucumber fields. They started with a nurse crop of oats and alfalfa. Into this, they transplanted insectary plants (dill, sacred basil, resin calendula, alyssum, lemon balm, fava bean, peas and sunflowers) to give the insectary plants an advantage over weeds.

The insectary strips attracted predators and parasitoids, including tachinid flies, ladybird beetles, minute pirate beetles and ground beetles. Cucumber beetles were parasitized by the tachinid flies that were attracted to the insectary strips, and the beetles had lower survival rates and were less abundant compared to fields without flowers. Plants in fields with flowers also had lower rates of bacterial wilt, a disease transmitted by cucumber beetles[13].

Focused floral companion planting

A targeted approach to pest control is to plant flowers to attract certain predators or parasitoids. For example, an OSC study suggests, that for ladybird beetles (ladybugs), you would be most successful by planting marigolds, nasturtiums, cosmos and yarrow (in that order) rather than coriander, sweet alyssum, alfalfa, petunia, phacelia or mustard[14]. Ladybirds voraciously consume soft-bodied pests, including aphids, mealybugs, whiteflies and thrips.

However, the flowers also attracted pests. Lygus was found in phacelia and flea beetles were found in sweet alyssum, mustard and nasturtiums.

Another OSC study looked at the effects of various cover crops in vineyards and found that sweet alyssum attracted more parasitoids than other cover crops[15]. Sweet alyssum, as well as coriander, also attracts hoverflies, which prey on many pests[16].

Trap crops

Trap crops are plants that attract pests, thereby diverting pests from commercial crops. By concentrating pests – like rounding up the enemy – farmers can destroy them by mowing or tilling the trap crop or applying a botanical pesticide. Another approach is to let the predators and parasitoids in the trap crop attack the pests.

The success of this approach depends on the vigour of the trap crop, as OSC researchers discovered. They were trying to reduce flea beetle damage in organic baby greens by planting trap crops (coreopsis, zinnias and chrysanthemums and a mix of amaranth, rapeseed and mustard). In weedy and/or dry conditions, trap crops struggled to get established. Even when trap crops were robust, they were less effective in weedy conditions because the pests preferred certain weeds over trap crops. The researchers conclude it is important to have good weed management and irrigation to use trap crops to control pests[17]. Overall, the flowers attracted flea beetles more than the other plants and, most importantly, drew flea beetles away from the spinach. The more diverse the trap crop, the more pests it attracted[18].

Trap crops can be used to reduce tarnished plant bug (Lygus) damage on strawberries. An OSC study found that in the summer, buckwheat, mustard and canola were effective trap crops for Lygus, and mullein (a weed) and sunflower are good autumn hosts. Having trap crops for both summer and fall is the most effective approach. Certain trap crops, such as mullein, are hosts for predators of Lygus, such as damsel bugs. The trap crop drew pests away from the strawberries – once in the trap crop, Lygus was attacked by damsel bugs.

Planting alfalfa around strawberries can also lure Lygus away from strawberries[19]. Tractor-mounted vacuums then suck up the pests from the alfalfa[20].

Trap crops can be managed to manipulate the movement of pest predators and parasitoids by mowing trap crops when these organisms are needed in the crop. For example, both hops and fava (faba) beans will attract aphids. Organic hop growers have planted favas among hops to attract the natural enemies of the hop aphid, which will arrive after the aphids become established[21]. Once aphids were detected in the hops, the growers cut the neighbouring fava plants. The organisms that had been attacking aphids in the favas lost their habitat and quickly moved into the hops. The result: greater aphid control in the hops plus the benefits of a green manure.

BIOPESTICIDES

"Biopesticides" are pesticides made from natural sources, such as microorganisms, plants, animal tissue or minerals. A common example is pyrethrum, which is made from crushed chrysanthemum flowers. (Note pyrethrum is permitted in organic production, unlike its synthetic counterpart, permethrin.)

Many plants that provide habitat for predators and parasitoids also have insecticidal or repellent compounds. In addition to intercropping with these plants (e.g., buckwheat, coriander, oregano and clove basil), operators can make crude extracts from their foliage. Spraying these biopesticides on crops may repel or even harm pests[22].

Microbial biopesticides may contain viruses, bacteria, fungi or nematodes. OSC researchers are investigating the control of wireworms by the soil fungus, *Metarhizium brunneum* LRC112, sold as Attracap[23.] Other species of Metarhizium can be used against other pests.

To control caterpillars in brassicas, many organic growers use Dipel or other commercial products containing soil bacteria (*Bacillus thuringiensis var. kurstaki*). Unfortunately, many pests have developed resistance to Bt. Alternatives are being studied by OSC scientists, who found that applications of the fungi *Beauveria bassiana* (BotaniGard), as well as certain viruses, can control diamondback moths, cabbage loopers and imported cabbageworms[24].

Right: Calendula can attract beneficial organisms such as ladybird beetles, lacewings and hoverflies.

Table 3: Pests and associated beneficials[25]

Pest	Beneficial that attacks it
Alfalfa weevil	Predatory thrips, *Bathyplectes* wasps, *Tetrastichus incertus*
Aphid	Aphid midge, aphid parasitoids, syrphid fly, ladybirds, parasitic wasp, big-eyed bug, damsel bug, mealybug destroyer, soldier beetle, lacewing, braconid wasp, predatory thrips, rove beetle
Armyworm	Big-eyed bug, braconid wasp, spined soldier bug, tachinid fly
Beetles	Braconid wasp
Bud moth	Predatory thrips
Cabbage looper	Tachinid fly
Cabbage-root maggots	Ground beetle, rove beetle
Cabbageworm	Braconid wasp
Caterpillars in general	Assassin bug, lacewing, Trichogramma and braconid wasps, damsel bug, minute pirate bug
Codling moth	Braconid wasp, predatory thrips, Trichogramma wasp
Colorado potato beetle	Ground beetle, spined soldier bug
Corn earworm	Big-eyed bug, minute pirate bug, Trichogramma wasp, lacewing
Cotton bollworm	Trichogramma wasp
Cutworms	Ground beetle, tachinid fly
European corn borer	Braconid wasp, Trichogramma wasp
Flea beetles	Big-eyed bug
Flies	Braconid wasp
Green stink bug	Tachinid fly
Gypsy moth	Braconid wasp, ground beetle, tachinid fly
Japanese beetle	Tachinid fly
Leafhopper	Big-eyed bug, damsel bug, minute pirate bug
Leafminer	Predatory thrips
Looper	Big-eyed bug, parasitic wasps
Lygus	Big-eyed bug, braconid wasp, *Anaphes iole*, minute pirate bug, damsel bug
May beetle	Tachinid fly
Mealybugs	Ladybird, big-eyed bug, mealybug destroyer, lacewing
Mexican bean beetle	Spined soldier bug
Mites	Ladybird, big-eyed bug, lacewing, minute pirate bug, predatory mites, mirids
Nematodes	Rove beetle
Oriental fruit moth	Predatory thrips
Peach twig borer	Predatory thrips
Psyllids	Big-eyed bug
Sawfly	Spined soldier bug, tachinid fly
Scales	Lacewing, predatory thrips
Slugs	Ground beetle, parasitic nematodes
Snails	Ground beetle
Soft scales	Ladybird
Sowbug	Tachinid fly
Spider mite	Ladybird, minute pirate bug, predatory mite, predatory thrips, spider mite destroyer
Springtails	Rove beetle
Spruce budworm	Trichogramma wasp

Table 3 continued: Pests and associated beneficials

Pest	Beneficial that attacks it
Squash bug	Tachinid fly
Tent caterpillar	Ground beetle, tachinid fly
Thrips	Ladybird, minute pirate bug, big-eyed bug, damsel bug, lacewing
Tomato hornworm	Big-eyed bug, assassin bug, Trichogramma wasp
Treehoppers	Damsel bug
Whiteflies	Lacewing, predatory thrips, whitefly parasitic wasp (*Encarsia spp.*)

CONCLUSION

Based on the OSC research findings, the key to successful biological control of pests appears to be a multi-pronged approach. If providing habitat through insectary strips isn't sufficient, consider introducing organisms that attack pests. If that isn't enough, consider pheromone disruption or plant-based pesticides.

Another approach, recommended by Dr. Helen Atthowe, is accepting a certain level of pest damage as "ecological tithing," an acceptable cost to the many advantages of supporting biodiversity on the farm[26].

Above: Parasitized aphid used in a banker plant system for greenhouses. A banker plant system involves growing harmless aphids to feed parasitoids when pests aren't abundant.

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ABOUT THE ORGANIC SCIENCE CLUSTER

organic SCIENCE CLUSTER

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CANADIAN AGRICULTURAL PARTNERSHIP
OFC FBC ORGANIC FEDERATION OF CANADA FÉDÉRATION BIOLOGIQUE DU CANADA
Linking Organic Knowledge OACC Organic Agriculture Centre of Canada
DALHOUSIE UNIVERSITY
Canada

ENDNOTES

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