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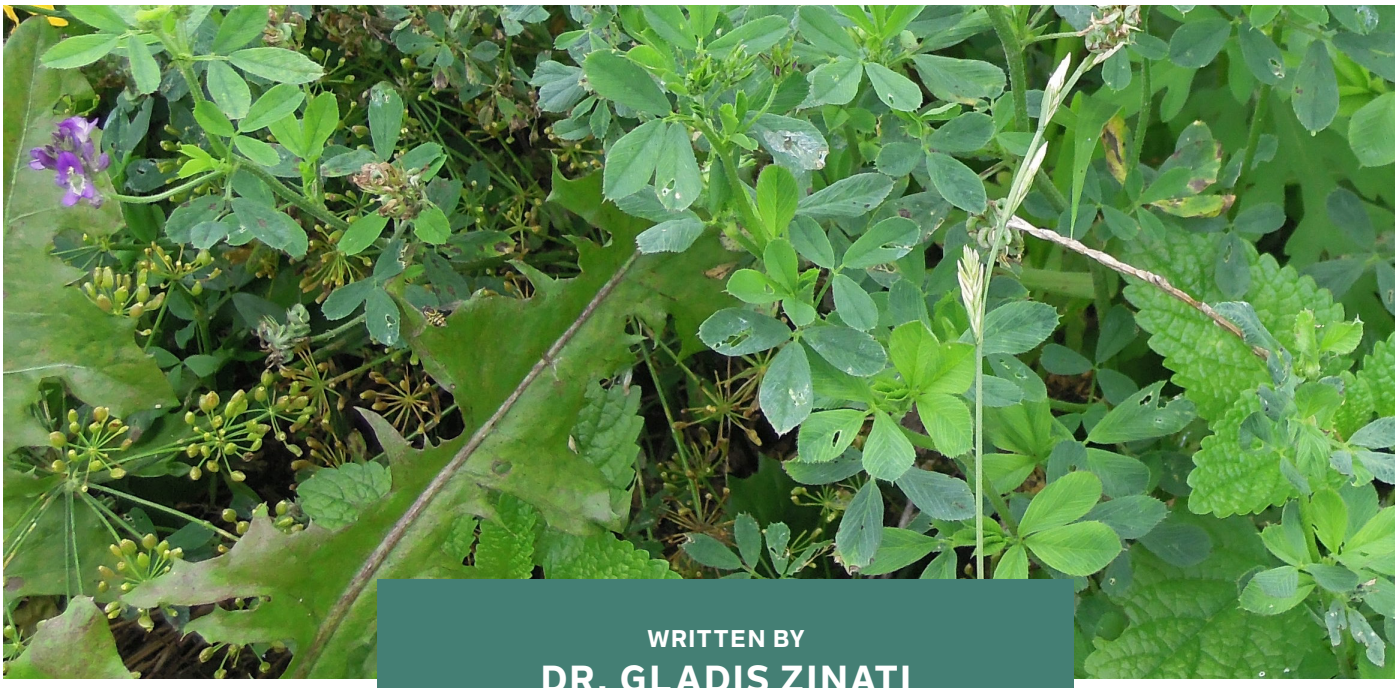
INVITE INSECT ALLIES *to your* FARM USING INSECTARY STRIPS:

FIELD GUIDE TO CONTROL STRIPED CUCUMBER BEETLES



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Rodale Institute is a 501(c)(3) nonprofit organization dedicated to pioneering organic farming through research and outreach. Rodale Institute is committed to groundbreaking research in organic agriculture, advocating for policies that support farmers, and educating people about how organic is the safest, healthiest option for people and the planet.

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IMAGE

Striped Cucumber Beetle Adult
Photo Credit: iStock

This field guide represents a pragmatic and systematic approach to organic pest management systems for cucumber crop production. It is an indispensable reference for vegetable growers, naturalists, conservationists, botanists, land management professionals, and students and scholars. The guide **conveys information that helps in establishing and maintaining insectary strips** and use of cover crop mulch for no-till management systems as well as **highlights key research findings** that support the systematic approach. It **provides practical guidelines for establishing, maintaining and assessing** the usefulness of insectary plantings on your farm.

Weeds and insects are two of the biggest challenges to competitive organic vegetable production. As herbicide is not an option in organic vegetable production, cucurbit growers rely heavily on tillage and black plastic mulch for weed control and use of organic pesticides to control striped cucumber beetles which damage cucumber fruits and transmit bacterial wilt disease.

Organic vegetable growers often use tillage for pre-plant soil preparation as a means of managing established weeds and incorporating crop and cover crop residues and fertilizers. Tillage is not only expensive but also has negative consequences on soil health and the environment. Repeated tillage breaks down soil organic carbon, exposing it to oxygen and releasing stored carbon back to the atmosphere as CO_2. In addition to exposing soil to wind and water erosion, frequent tillage can also alter the physical structure and biological activity of soil over time.

Black plastic mulches are relatively inexpensive and provide warmer soil conditions for early planting and cucurbit production. However, black plastic has its downsides. It is a petroleum-based product and is difficult to recycle, so it often ends up in landfills.

For managing striped cucumber beetle (SCB), organic growers use row cover as a preventive tool to protect cucurbit transplants from being attacked by the SCB adults during the early stages of production. However, during the growing season, growers rely heavily on organic pesticides to control the beetle from damaging cucumber fruits and transmitting bacterial wilt disease. Organic insecticides are costly and have negative impact on the diversity and densities of beneficial and predatory insects. Additionally, researchers have shown the use of systemic neonicotinoids is harmful to vegetable crop pollinators.

The current awareness of soil health and the ecosystem has resulted in increasing efforts to find effective organic and sustainable insect pest and weed management systems to improve the competitiveness of organic vegetable growers in Pennsylvania and around the world. Specialty organic cucurbit growers are interested in adopting environmentally-friendly approaches that improve soil health while eliminating the use of pesticides and improving marketability of cucumber fruits. The development of the roller-crimper allows organic vegetable growers to begin to reduce tillage within production systems by rolling and crimping a cover crop and converting it into a mulch layer, a dense mat of residue covering the soil surface that aids weed suppression. In addition, **the integration of flowering insectary strips as a means of natural biological control for pests** allows organic cucurbit growers to reduce or omit pesticide applications and rely on natural enemies (beneficial insects) to control SCB populations.

A three-year project (2015-2018) was funded via grants from the Pennsylvania Department of Agriculture, the Orange County Community Foundation, and the Pennsylvania Vegetable Growers Association. The overall goal of the project was to improve organic specialty crop growers' competitiveness by assessing the impact of integrated systems on weed management, soil health, pest management, and cucumber yield and quality compared to standard practices. These integrated systems included rolled cover crop mulches and insectary strips as compared to plastic mulch and no insectary strips.

DR. GLADIS ZINATI

Research Director for the Vegetable Systems Trial

Dr. Gladis Zinati directs the Vegetable Systems Trial, a long-term, side-by-side comparison of organic vs. conventional produce systems. She evaluates studies on no-tillage, carbon sequestration, nutrient density, compost formulations, and pest management. She has undergraduate degrees in General Agriculture and Agriculture Engineering, M.S. degree in Horticulture from the American University of Beirut, and a Ph.D. in Soil Fertility from Michigan State University. She has 26 years of experience in sustainable and organic production.

The Pest:

STRIPED CUCUMBER BEETLE

Striped cucumber beetle (SCB) (Acalymma vittatum) is a serious pest of cucurbit crops in eastern North America. The SCB larvae feed on roots and stems while adult beetles feed on and defoliate cucurbit plant leaves, flowers and fruits; interfere with pollination and fruit set; and cause scars on cucurbit fruits that impact marketability.

PEST LIFE CYCLE

Striped cucumber beetle adults are about 1/4-inch long, have black undersides, and two yellow and three black stripes on top. The three black stripes on the wings have distinct straight edges. Larvae are approximately 3/8-inches long, have white worm-like bodies with brown heads and three tiny pairs of legs.

Striped cucumber beetles overwinter as adults in protected sites in wooded areas or within the field under old crop debris. When temperatures exceed 55 °F (12.7 °C) in spring, striped cucumber beetles emerge from overwintering sites and feed on the pollen of wild flowering plants. Once cucurbit crops are transplanted into the field, the SCB migrate to plants and aggregate to feed and mate. Ten to 20 days after mating, the beetles lay eggs in the soil at the base of cucurbit plants, which hatch a week later. Larvae take 2 to 4 weeks to mature, and then pupate in the soil over the next 7 days. The adults continue to move from one field to another.

In Pennsylvania, later in the summer the adults emerge and feed on flowers, foliage or on the surface of cucurbit fruits. The second generation of SCB will eventually leave the fields to feed on pollen and overwinter until next spring.

IMAGES

From top to bottom: Striped cucumber beetle adults on cucurbit leaf; feeding damage on leaves; scarring damage on cucumber fruit by SCB.
Photo Credit: Gladis Zinati

IMAGE

Adult cucumber beetles can be identified by two yellow and three black stripes on top.
Photo Credit: Katja Shulz

THE PATHOGEN AND THE DISEASE

The SCB is also considered the principle vector of *Erwinia tracheiphila*, the causal agent (bacterium pathogen) of bacterial wilt of Cucurbitaceae. But the feeding and scarring damage is minimal compared to losses due to bacterial wilt. Bacterial wilt disease is characterized initially by rapid wilting of plants foliage and eventually the collapse of the whole plant, especially those exhibiting cucumber beetle injury. Cucumber and muskmelon are highly susceptible to bacterial wilt with yield losses of up to 80% reported, while squash and pumpkin are moderately susceptible.

The bacterium that causes the wilt overwinters in the gut of some of the striped cucumber beetles. In spring the adults begin feeding and spread the bacterium either through their feces or from contaminated mouth parts. Lesions from chewing damage on plant leaves open entry points for the pathogen to be quickly transmitted and multiply through the plant's vascular system, affecting water movement in the water conducting vessels and consequently, producing blockages that cause the leaves and the entire vine to wilt and die. The infected beetles continue to infect new healthy plants with the bacterium causing wilt as they move from one plant or field to another.

IMAGE

Collapse of cucumber plant due to bacterial wilt disease.
Photo Credit: Missouri Botanical Garden

COMMON PEST MANAGEMENT OPTIONS PRACTICED BY CUCURBIT GROWERS

Organic cucurbit growers use a diverse array of pest management strategies to maintain striped cucumber beetle populations below economic thresholds (1 SCB/plant). These strategies include:

- Exclusion using row covers;
- Planting resistant varieties;
- Bordering fields with trap crops such as Hubbard squash, nasturtiums, etc.;
- Use of predatory nematodes (insect-feeding nematodes) to curtail immature stages; and
- Use of botanical sprays such as neem.

Each of the listed approaches has advantages and disadvantages and none of these tactics help in minimizing the feeding injuries, beetle populations, and/or transmission of bacteria.

IMAGE

Row covers to protect young cucurbit seedlings from SCB attack
Photo Credit: Gladis Zinati

For example, the exclusion of young plants by **row covers** may prevent SCB adults from feeding on cucurbit plant foliage in early spring, but the practice increases weed growth and weeding costs, and prevents pollinators and other "beneficial insects' access to plants." Similarly, if **systemic neonicotinoids** are applied closer to flowering of cucurbit plants, research studies have presented evidence that higher residues of these chemicals are present in pollen and nectar which become harmful to vegetable crop pollinators such as honey bees. Therefore, **none of these approaches provide a long-term effect and sustainable, environmentally-friendly ecosystem to reduce SCB damage and improve productivity of organic cucurbit crops.**

Organic cucurbit growers are interested in adopting more environmentally-friendly approaches which improve soil health while eliminating the use of pesticides and improving marketability of cucumber fruits. Because striped cucumber beetles are attacked by many natural enemies, one effective approach is to target the pest itself through its natural biological agents. To do so, it is important to **protect natural enemies from disturbances such as pesticides and tillage** by establishing and **maintaining permanent landscape habitats.** With time, such habitats will enhance the performance and increase populations of natural enemies that are used as biological control against SCB.

RESEARCH AND RESEARCH RESULTS

At Rodale Institute, field experiment trials were conducted between 2015 and 2017 as a response to organic cucurbit growers' interest in finding environmentally-friendly and practical approaches to reduce losses to bacterial wilt disease. In particular, researchers looked to eliminate the use of plastic mulch, tillage and pesticides for organic cucumber production. The goal of this project was to assess the impact of integrating insectary strips and reduced tillage on striped cucumber beetle pest density and beneficial insect populations, as well as on fruit production and quality of organic cucumbers. Striped cucumber beetle is a pest that feeds on flowers, leaves and fruits of cucurbit plants and a is a vector for a bacterial pathogen *(Erwinia traheiphila)* that causes plant wilting and has the potential to eliminate an entire crop within a few days.

THE PURPOSE

The idea is to design production systems that keep natural enemies in the system to manage the striped cucumber beetle pest and improve soil health by reducing tillage frequency. The purpose of integrating insectary strips into organic cucumber production systems is to attract beneficial insects that predate on striped cucumber beetles by providing habitat for ground predators (ground beetles and wolf spiders) and aerial beneficial insects including soldier beetles, lady bugs, honey bees, bumble bees, and two cucumber beetle parasitoids, a tachinid fly, and a braconid wasp.

The purpose of using rolled cover crop mulch is to identify a potential system that can be used as an alternative to plastic mulch for weed management, conservation of soil health, and determination of insects and pests under these management systems.

FIELD SETUP

Insectary strips, each 5-ft wide by 30-ft long, were established in fall 2015 with alfalfa as a base plant and oats as a nursing crop. A suite of plants such as **bouquet dill, sacred basil, resin calendula, alyssum, lemon balm, fava bean, peas, and sunflower** was transplanted throughout April and May of 2016 and 2017. Insectary strips were placed every 25 feet of cucumber beds. Plants without insectary strips were also included in these trials.

Two cover crop mixtures were tested in this project: a rye/hairy vetch (R/HV) and a rye/field pea (R/FP) mixture. These mixtures were planted in fall 2015 and 2016. In spring of 2016 and 2017 the biomass of these mixtures were either rolled-crimped with a roller-crimper or tilled-in and covered later with plastic mulch.

Cucumber plants of the 'Ministro' variety were first started in the greenhouse and transplanted into tilled plastic mulch beds using a water wheeler transplanter or no-till transplanter on roller-crimped mulches without using any additional fertilizers.

IMAGES

Top: Roller-crimping of hairy vetch cover crop. Bottom left: Rolled cover crop versus tilled mulch. Bottom right: No-till transplanter.
Photo Credit: Gladis Zinati

After transplanting the cucumber seedlings in plastic and rolled mulch, floating row covers were installed to protect the young seedlings from any attack by early visitors of adult striped cucumber beetles. The row covers were removed approximately one month after transplanting (cucumber flowers started to bloom) to allow pollinators and beneficial insects to reach the plants.

MONITORING SCB AND BENEFICIAL INSECTS

Monitoring of pests and beneficial insects started immediately after the removal of row covers. Yellow sticky traps and pitfall traps were installed in the middle of the insectary strip and in the middle of each cucumber bed (each bed has 17 cucumber plants). Striped cucumber beetle pest and beneficial insects such as ladybeetle, parasitoids, and minute bug were monitored periodically. No organic pesticides were used during these field trials. Yellow sticky traps were monitored on a weekly basis whereas the ground beetles were monitored every two weeks.

RESULTS IN A NUTSHELL

- Roller-crimped cover crops covered the soil surface well throughout the season and reduced weeds biomass.
- Irrespective of cover crop mixture, cucumber yields were optimum and ranged between 400 and 670 bushels/acre in plastic much and plants in roller-crimped beds would require additional fertilization to achieve maximum yields.
- Significantly lower densities of the striped cucumber beetle were found in rolled mulch compared to plastic in 2016 (**Figure 1, page 26**). The SCB density ranged between 2 to 5 beetles per trap. However, in 2017, SCB pressure was lower than in 2016. Density of SCB population was about 0.9 beetles per trap in plastic mulch compared to 0.7 beetles per trap in rolled-crimped mulch.
- Ladybeetle and minute pirate beetles were the most dominant beneficial aerial insects identified on yellow sticky traps. The densities of these beneficial insects were 0.9 per trap for ladybeetle and about 0.3 per trap for minute pirate bug in 2016 (**Figure 2, page 26**). These densities, however, increased by 1.5 times and 4 times for ladybeetle and minute pirate bug, respectively in 2017 (**Figure 3, page 27**).
- Ground beetle populations were highest in insectary strips, the grass perimeter, and in rolled mulch with and without insectary strips in 2016 (**Figure 4, page 27**). There was no significant difference in ground beetle population per trap between treatments, but the number of ground beetles increased 6 times more in 2017 and was highest in the insectary strips (**Figure 5, page 28**).
- Major ground beetle species identified during this two-year project included *Chlaenius tricolor, Harpalus pensylvanicus, Scarites subterraneus* **(page 18)** and *Poecilus chalcite.*
- More importantly, the cucumber plants did not show any symptoms of wilting in 2016 and 2017 production seasons. The yellow sticky traps revealed that flowering plants in the insectary strips attracted tachinid flies that parasitized striped cucumber beetle adults, as evidenced by the molecular techniques used during the two-year research trials.

IMAGE

Clockwise from left: Parasitized SCB adult, raptured parasitized SCB adult (top), tachinid fly pupa (bottom) and tachinid fly adult (center), viewed under microscope.

Photo Credit: Gladis Zinati

RECOMMENDATIONS

- Results deduced from the two-year research showed that the integration of insectary flowering strips aided in inviting a diverse array of beneficial insect species, including ground beetle, ladybeetle, tachinid fly and minute pirate bug.
- The presence of these beneficial insects such as ground beetles, ladybeetles, and tachinid flies reduced survival of striped cucumber beetle.
- The use of roller-crimped mulch enhanced the presence of ground beetles and wolf spiders.
- In roller-crimped mulch treatments, supplementing cucumber plants with organic fertilization was necessary at the beginning of the season (after removal of row cover).
- By enhancing the environmental habitat for beneficial insects that control striped cucumber beetle, the culprit for transmitting the bacterial wilt disease, the latter can potentially be controlled by using natural biological systems (insectary strips and rolled-crimped mulch) without the use of pesticides.

IMAGE

Insectary strip
Photo Credit: Gladis Zinati

Proposed Pest Management Options:

PERMANENT HABITAT FOR BENEFICIAL INSECTS

PERMANENT HABITATS

Permanent habitats are pesticide-free zones or landscapes within and/or along arable fields that offer suitable habitat for beneficial insects. These habitats include meadows, hedgerows and flowering insectary strips. **This field guide focuses on insectary strips to target the striped cucumber beetle.**

Flowering insectary strips are a conservation biological control approach that provides supplemental nectar, pollen, and habitat to improve the performance and survival of natural enemies while enhancing the rate of parasitism and predation of all life stages of striped cucumber beetle pest.

What follows are key considerations for designing, selecting and maintaining insectary plants and key findings from a two-year research project on the uses of insectary plants for enhancing populations of certain beneficial insects that target SCB.

IMAGE

Lady beetle larvae on black-eyed Susan flower.
Photo Credit: Gladis Zinati

INSECTARY PLANTS

Insectary flowering plants are plants that are grown to attract, feed, and shelter beneficial insects that aid in biological pest control at the farm. Insectary plants can be a combination of perennial and annual flowering plants. Flowering plants are particularly important to adults of natural enemies of the SCB, such as wasps and flies, which require nectar and pollen sources to reproduce the immature larval stages that parasitize or prey on insect pests. Similarly, bees and plant pollinators take advantage of nectar and pollen and use the plants as shelter.

CONSIDERATIONS FOR SELECTING INSECTARY PLANTS

A random selection of flowering plants may favor pest population over beneficial organisms. When selecting insectary plants, first identify:

- **The pest you are targeting**
- **The beneficial insects you want to populate**
- **The duration of the flowering time per plant species**
- **The structure of the plants and type of flowers they produce**
- **The soil conditions where the insectary plants will grow**
- **The management practices that best support populations of beneficial organisms**

Deliberately design insectary mixtures that effectively support targeted natural enemies and avoid insectary-plant species that host arthropod pests or plant pathogens that can move to damage nearby crops or ornamentals.

IMAGE

Insectary Strip
Photo Credit: Gladis Zinati

Designing your insectary strips:

KEY CONSIDERATIONS

1. SITE SELECTION

It is important to first collect information on and/or consider some biological and farm management factors when planning for insectary plantings. Growing the right combination of plant species that flower sequentially throughout the year will provide continuous shelter and feed sources. Choose plant species that are compatible with the growth of other desirable plant species and well-adapted to your soil and growing environment. Provide the best possible growing conditions, including adequate water, nutrients and sunlight.

For **drought-tolerant conditions, Rocky Mountain Penstemon** (*Penstemon strictus*), a native perennial insectary plant belonging to the Plantaginaceae family, has showy violet-blue flowers on tall stems that blooms in June. These flowers attract hoverflies, ladybugs and bees in addition to hummingbirds.

IMAGE

Rocky Mountain Penstemon
Photo Credit: Shutterstock

IMAGE

Goldenrod
Photo Credit: Gladis Zinati

Goldenrod (*Solidago spp.*) is another native drought-tolerant perennial plant and belongs to the aster family. It produces bright lemon-yellow flowers in August through September in Pennsylvania, providing nectar for beneficial insects such as the Pennsylvania leatherwing soldier beetle (*Chauliognathus pennsylvanicus*). The females mate once in early summer and lays eggs in the soil, where larvae feed on the eggs and larvae of striped cucumber beetles and other insects, while the adults feed on pollen, nectar and aphids. Other beneficial insects attracted to this plant are ladybeetles and wasps. These plants are easy to grow. Seed them in rows 6-8 weeks before the last frost date. They are hardy in zones 4-9.

In **moist-tolerant soil conditions,** include insectary plants that belong to Asteraceae family such as **marigold** (*Tagetes tenuifolia*), which attracts minute pirate bugs and wasps in addition to bees. **Bachelor's button or cornflower** (*Centaurea cyanus*) has leaves that release nectar even when the flowers are not blooming. This nectar is attractive to ladybeetles, lacewings and wasps. The plant is easy to grow either in fall or early spring. It reseeds itself every spring.

IMAGE

Moist-tolerant flowering plants—marigold with showy orange flowers.
Photo Credit: Shutterstock

IMAGE

Moist-tolerant flowering plants—bachelor's button with bluish flowers.
Photo Credit: Shutterstock

2. PLANTING PATTERN

Certain crops including edible landscapes and aesthetically pleasing ornamentals can serve as insectary plants. For small-scale production (garden size and less than a quarter of an acre) planting small patches or "islands" of flowering plants around the crop-growing area will provide shelter and feed for beneficial insects. However, for large scale farm production, larger and more interconnected patches of resource are better than small patches. For large-scale agriculture, strip intercropping may be more suitable than mixed intercropping. Strip intercropping is where two or more crops are grown together but in separate rows to reduce restrictions on cultivation, whereas mixed intercropping is where two or more plant species are planted in random order. You may arrange the planting pattern by interplanting insectary plants in strips of 3-5 feet wide for every 6-8 rows of cash crop or including a border of flowering plants on one side of the field. However, the latter pattern may limit the dispersion of beneficial insects especially those with low dispersion capabilities such as lady bug, ground beetles and parasitic wasps (see Table 1) compared to hover flies, syrphids and tachinid flies that can disperse beyond ¼ mile distance.

TABLE 1

Dispersion capabilities of some common beneficial insects.

LOW DISPERSION Stay in or Near Field	MEDIUM DISPERSION: ~ 1/4 mile	HIGH DISPERSION: > 1/4 mile
Ground beetles	Medium-size parasitic wasps	Syrphid and hover flies
Lady beetles	Predatory wasps	Dragonfiles, tachinid flies
Small parasitic wasps	Predatory bugs (hemipterans)	Large parasitic wasps

Adapted from Zehnder G. 2013. Farmscaping: Making Use of Nature's Pest Management Services.

3. FLORAL STRUCTURE

Due to differences in mouth part size and structure of beneficial insects, not all flowers are equally accessible to all insect species. Planting a mixture of plant species with diverse flower sizes and shapes (e.g. tubular vs. disk), colors, and blooming periods attracts and maximizes the abundance and diversity of beneficial insects. Select plant species that are inexpensive, readily available, and easy to grow. Choose plants from different families with different heights, shapes, sizes, and foliar and flower types.

The **floral structure** is an important consideration in planting insectary plants. Flowering plants with upright, stalky structures and long bloom periods provide ideal habitat for insect predators. For example, when allowed to bolt, lacy plants with flowers of umbel shape (Apiacea family) such as **coriander, dill, fennel, parsley, and Queen Anne's lace,** have upright stalks with tiny, shallow flowers. These provide easy access to pollen and nectar, favored by predatory flies, tiny parasitic wasps, lacewings, and ladybugs (refer to pages 22-24 to learn more about the plants and the predatory insects they attract).

Researchers have shown that insect predator abundance increases with increasing density of inflorescences (cluster of flowers on a branch) and extrafloral nectaries. **Extrafloral nectaries** are glands located outside of flowers that secrete nectar, a sugar-rich liquid, as a source of energy. Plants that possess extrafloral nectaries such as **fava beans, cowpeas, vetch, sunflowers,** and several native ground covers, serve diverse ecological functions by providing beneficials with easy access to an important food source in addition to the nectar and pollen of their flowers. In particular, **tiny predatory flies and wasps** spend more time on plants with nectar and pollen, used as source of food and energy, for reproducing immature larval stages that feed on plant pests. Consequently, a higher rate of parasitism of host pests in the area is expected. Sites with flowering plants that don't provide sufficient food for parasitoids (parasitic wasps and flies) will force the insects to disperse from target areas in search for food and thus the rate of parasitism of host pests will decline. Refer to Table 2, page 22, for list of plants that attract beneficial insects.

IMAGES

Top to bottom: Dill flower; Sunflower
Photo Credit: Shutterstock, Gladis Zinati

Similarly, allowing a few short-term **brassicas (e.g. pak choi or mizuna)** to flower provides a nectar source for honeybees and other pollinators. Bolting of these brassicas releases chemical signals that draw parasitoid wasps, syrphid flies, and ladybugs right into the foliage of your main crop plants, where they hunt the leaves for insect pests.

You can **increase the rate of parasitism and population density of beneficial insects by enhancing plant diversification of flowering plants throughout and beyond the crop growing season.** For example, early-nectar source plants such as **dill, fava bean and sweet alyssum** provide many pollinators and parasitic wasps with nectar and pollen early in the season and habitat for shelter in early summer time. **Yarrow and goldenrod** (late-season nectar-source plants) encourage the development of large beneficial insect females, which are more capable of overwintering. Those females then emerge early the following spring from diapause (periods of reduced metabolic activity) ready to attack the first wave of pest insects, reducing populations for the whole summer. Refer to pages 22-25 for plant, predator and pest information.

Increase beneficial insects by enhancing the diversity of flowering plants on your farm throughout and beyond the crop growing season.

4. SCENTED PLANTS

Perennial flowering plants with strong scents and flavors and showy, bright-colored flowers are known to attract beneficial insects. For example, **lemon balm** is a good tea herb with lemon-scented leaves and its flowers attract tachinid flies, tiny parasitic wasps, and hoverflies. **Black-eyed Susan** is another perennial flowering plant with golden-yellow, daisy-like flowers. Upon blooming, the plant leaves produce scent that attracts lacewings and bees. Refer to Tables 2 and 3, pages 22-23, for more information on scented plants and the types of predators they attract.

IMAGE

Black-Eyed Susan

5. INVITE GARDEN ALLIES: PREDACEOUS GROUND BEETLES AND WOLF SPIDERS

In designing insectary strips and patches, consider including plants that attract not only flying beneficial insects but also soil-dwelling predators such as ground beetles and wolf spiders. These insects are nocturnal predators that feed on the eggs and larvae of pests—especially those of the striped cucumber beetle. Researchers documented that predators like wolf spiders have been shown to feed heavily on striped cucumber beetles in cucurbit crops. Just presence of such spiders cause SCB to avoid feeding on the crop even when the spiders do not actually kill them. Ground beetles feed on adult cucumber beetles. Thus, **a biodiverse community of predators may be important for biological control of cucumber beetles rather than relying on any single predator species.**

Ground beetles are a diverse group of insects with 2,000 species inhabiting North America. Adult ground beetles range in size from about 1/8 inch to 1 ¼ inch (2mm to over 35mm). The long legs of ground beetles allow them to move rapidly to capture prey and avoid other predators. They are opportunistic feeders and feed on aphids, moth and beetle larvae, caterpillars, plants, and weed seeds. However, prey preferences can change throughout their life cycle based on nutritional needs or a change in the resources or environment. Their habitat includes meadows, crop fields and woodlands. They hunt at night and climb plants to find prey. During the day these beetles can be found under logs, stones, and leaf litter.

To encourage and maintain ground beetle population, provide dark, damp, and sheltered habitat. Start by seeding alfalfa, a perennial leguminous plant, in rows within the insectary strips in the fall. In spring, plant/transplant annuals and perennial flowering plants into the insectary strips. Alfalfa will grow and cover soil surface between flowering rows and serve as a shelter for ground beetles.

IMAGES

Top to bottom: Scarites subterraneus, Harpalus pensylvanicus, and Chlaenius tricolor.
Photo Credit: Katja Shulz, Ilona L., Wikimedia.org

IMAGE

Wolf spider
Photo Credit: Patrick Kavanagh

Wolf spiders are members of the family Lycosidae. These spiders are often big, ranging in size from 5/64 inch to 1 ¼ inch (2 mm-35 mm), and hairy, which alarms some people, but they are primarily nuisance pests. Over 100 species of wolf spiders are found in the United States and Canada. Most wolf spiders are nocturnal although some do hunt during the morning.

Unlike most spiders, wolf spiders are solitary creatures that hunt without forming webs. They actively chase their prey on the ground or on plant foliage using their fast running ability at night.

Mulches from rolled or cut leaves and stems, cover crops, grass clippings and leaves at base of shrubs are considered suitable habitats for providing shelter and food source for attracting and maintaining a population of wolf spiders.

6. INSECTARY ESTABLISHMENT AND MAINTENANCE

In addition to insectary establishment—including the cost of ground preparation, planting and maintenance for at least one year following establishment—equipment needs for installation and maintenance should be included as key considerations in designing the insectary. Another key factor is weather. In designing the insectary, consider a flexible approach in order to adjust beneficial habitat according to weather variations. Include in the planting mixture diverse plant species that are tolerant to drought, heat and wet feet.

7. PLANTING TIME

Many perennial insectary plants can be sown in the fall about 6-8 weeks before first frost. Annual flowering and herbaceous insectary plants can be either transplanted or sown directly in the spring. Those that bloom early in spring to attract beneficial insects may be started in the greenhouse and transplanted early into the insectary strips. Those that bloom during the summer and early fall can be sown in rows into insectary strips soon after the soil is workable in spring (April- May). Refer to Table 2, page 22, to learn about plant classification, habitat requirement and blooming period.

Scouting for Pests and Beneficial Insects

POST-ESTABLISHMENT OF INSECTARY STRIPS

After you plant insectary strips within the vegetable production site, here are three scouting methods you can use on your farm to determine what kind of pests and beneficial insects you've attracted:

INSECT SWEEP NETS

These nets are 12 and 15-inch diameter with either muslin or polyester material. Muslin nets are lighter in weight, good for general sweeping in grasses. Polyester nets are made of tough polyester and are designed for aerial applications. These nets can be purchased from several vendors such as Gempler's, sweepnet.com, Great Lakes IPM, and BioQuip.

You can sweep a net, like a butterfly net, two to three times through the flowers to catch insects flying or hidden. Collect the insects into a glass jar and close it. Similarly, you can sweep the net over the vegetable plants to catch and identify the pests that are feeding on your plants.

IMAGE

Insect Sweep Net
Photo Credit: Shutterstock

YELLOW STICKY TRAPS

A 3 inch x 5 inch yellow sticky trap can be valuable for vegetable growers for monitoring pests and predators that flowering and vegetable plants are attracting. These yellow sticky trap cards can be purchased from vendors such as Gempler's, Walmart, and Johnny's Seeds.

Early in the growing season, install these yellow sticky traps by peeling the covers on the sticky card traps and mount them on a 3-ft long bamboo stick (can be purchased at Ace Hardware) using a clothing pin. Come back after 24 or 48 hours, collect the trap, and identify the insects caught.

IMAGE

Yellow Sticky Trap
Photo Credit: Gladis Zinati.

PITFALL TRAPS

These traps are used to catch ground-dwelling insects such as spiders and ground beetles. To build these traps, dig a hole in the ground the size of a 16 oz. plastic cup by using a bulb planter (available at Ace Hardware).

Note: If you plan to monitor these ground-dwelling insects in several locations, you may label the cup using a marker to indicate the location of collection.

IMAGE

Pitfall Trap
Photo Credit: Gladis Zinati.

BUILD A PITFALL TRAP

You'll need: Two 16oz. plastic cups and a plastic plate for a lid

STEP ONE

Insert two cups (with 3-4 pin holes in the bottom to allow rain to run through). The rim of the cups should be flush with the soil surface to allow easy access for ground insects. The top cup will be the one you remove to view insects. The bottom cup will remain in the hole for future use.

STEP TWO

Cover the cups with a water-proof lid (plastic plate) held about 0.5 inch above the cup rim using two metal stakes to protect insects from rain during the trapping period.

STEP THREE

Monitor the traps after 24 or 48 hours and identify the types of ground beetles and spiders collected in the trap. Release the insects to nature afterwards to enhance population density of these insects.

TABLE 2

Habitat, flower type and time of blooming for various flowering insectary plant species.

PLANT SPECIES	HABITAT AND FLOWERING TIME	FLOWER TYPE AND TIME OF BLOOMING	IMAGE OF PLANT
Alfalfa *(Medicago sativa)*	Perennial leguminous plant. Tolerates cold sites. Direct seeding in strips, establish in the fall.	Stems with raceme purple flowers blooms in the summer.	
Calendula 'Resina' *(Calendula officinalis)*	Annual flowering plant. Tolerates fairly cool weather. Seed directly in the fall or start in the greenhouse 6 weeks before last frost and then transplant.	Aromatic leaves and showy orange flowers that bloom between May and June.	
Dill 'Bouquet' *(Anethum graveolens)*	Annual plant. Start in the greenhouse 2 weeks before last frost and transplant after mid-May.	The tiny yellow dill flowers open in a large umbel inflorescence and bloom in July.	
Fava Bean *(Vicia faba L.)*	Annual leguminous plant. Transplant seedlings 6 inches apart in mid-to-late April. Seed directly in late April to avoid frost damage.	The white or purplish flowers are born in clusters on short stalks in the axils of the leaves. They bloom in May.	

IMAGES

Photo Credit: Gladis Zinati

PLANT SPECIES	HABITAT AND FLOWERING TIME	FLOWER TYPE AND TIME OF BLOOMING	IMAGE OF PLANT
Goldenrod *(Solidago spp.)*	Perennial plant tolerates drought.	The spike-shaped flowers bloom between August and September. They serve as source of fall nectar to insects.	
Holy Basil *(Ocimum tenuiflorum)*	Perennial plant. Tolerates cool weather. Seed early in spring and thin or transplant 8-12 inches apart.	Flowers between June and August.	
Lemon Balm *(Melissa officinalis)*	Herbaceous perennial plant. Start in the greenhouse 6-8 weeks prior to last frost in spring for transplanting.	Flowers between May and August.	
Sweet Alyssum *(Lobularia maritima)*	Annual flowering plant. Requires cool weather. Start in the greenhouse in March and transplant 3-4 inches apart in April.	Flowers in the fall, spring and summer.	

IMAGES

Photo Credit: Gladis Zinati

TABLE 3

Insectary plants and the beneficial insects they attract.

INSECTARY PLANT	BENEFICIAL INSECTS
Alfalfa	Ground beetles, wolf spiders, lacewings, ladybeetles, minute pirate bugs, damsel bugs
Alyssum	Hoverflies
Amaranthus	Ground beetles
Calendula	Ladybeetles, hoverflies, butterflies, bees
Dill	Ladybeetles, lacewings, Ichneumon wasp
Fava bean	Ladybeetles, bees, pirate bugs
Goldenrod	Latherwing soldier beetle, hoverflies, and butterflies
Lemon balm	Parasitic wasps, tachinid flies
Marigold	Ladybeetles and lacewings
Parsley	Parasitic wasps, hoverflies, tachinid flies
Queen Anne's Lace	Lacewings, ladybeetles, hoverflies
Shasta Daisy	Minute pirate bugs, beneficial mites
Sunflower	Pirate bugs

BENEFICIAL INSECTS

Ladybeetle

Hoverfly

Tachinid fly (parasitoid)

IMAGES

Photo Credit (left to right): Shutterstock, Neil Mullins, Katja Shulz

TABLE 4

Beneficial insects and pests they attack.

BENEFICIAL INSECTS	PESTS
Hoverflies	Aphids, small caterpillars, thrips
Ground beetles	Moth and beetle larvae, slugs
Ladybeetles, lacewings, Ichneumon wasp	Aphids, mites and whiteflies. The wasp lays eggs and larvae feed on host such as beetle.
Lacewings, ladybeetles, hoverflies	Aphids, small caterpillars, soft bodied insects
Parasitic wasps, tachinid flies	Beetle and fly larvae, caterpillars
Parasitic wasps, hoverflies, tachinid flies	Moth, beetle and fly larvae, whiteflies
Minute pirate bugs, beneficial mites	Thrips, aphids, mites, scales, whiteflies
Minute pirate bugs	Moth, beetle and fly larvae, whiteflies
Ladybeetles and lacewings	Aphids, mites and scales

BENEFICIAL INSECTS

Lacewing adult

Lacewing larvae

Lacewing eggs

Minute pirate bugs

Leatherwing soldier beetle

IMAGES

Photo Credit: Shutterstock

FIGURE 1

Mean population of striped cucumber beetle per trap in plastic and rolled mulch management systems in insectary and no insectary, Kutztown, PA 2016

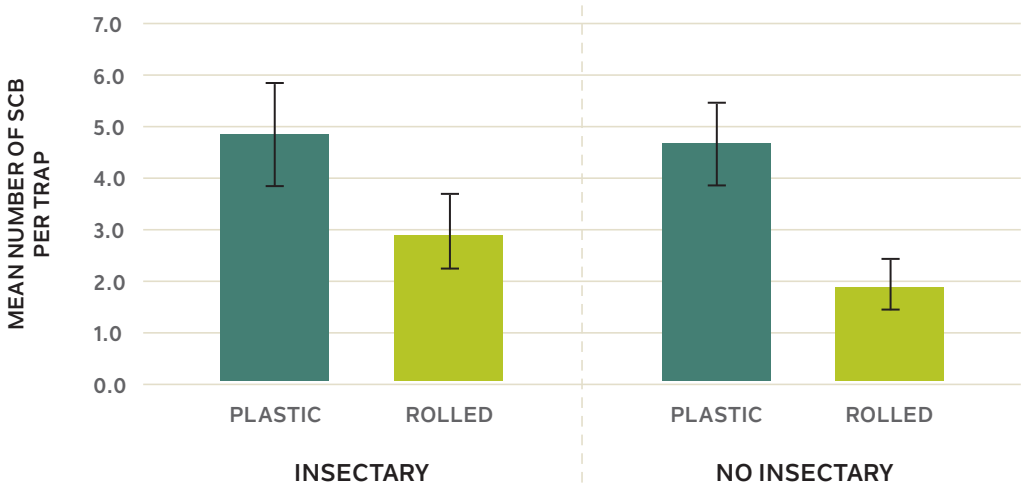


FIGURE 2

Mean densities of SCB, lady beetle, and minute pirate bug in insectary strip and cucumber with and without insectary, 2016

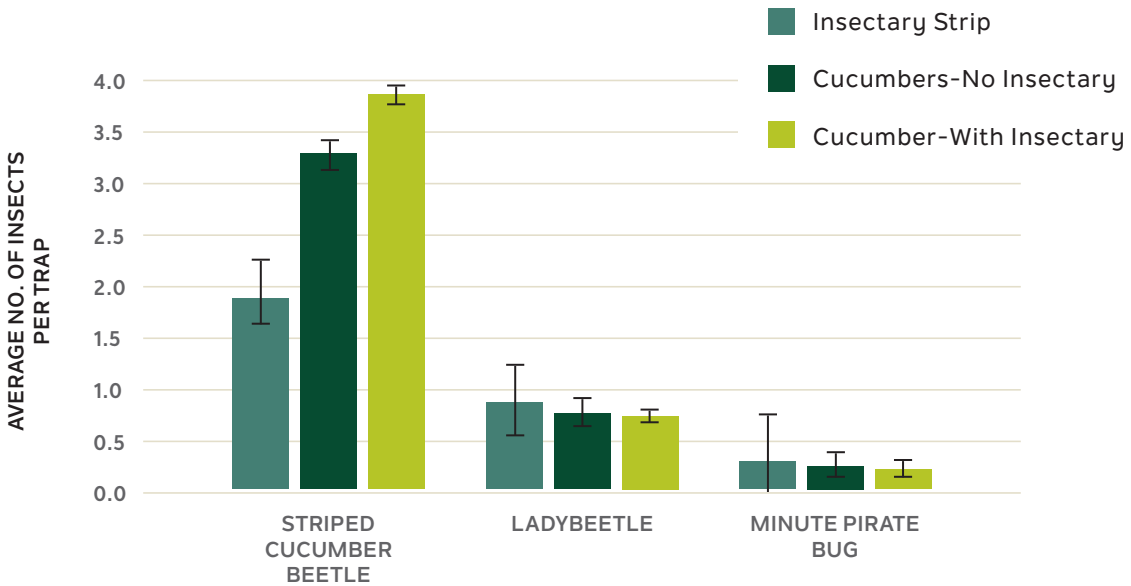


FIGURE 3

Mean densities of SCB, lady beetle, and minute pirate bug in insectary strip and cucumber with and without insectary, 2017

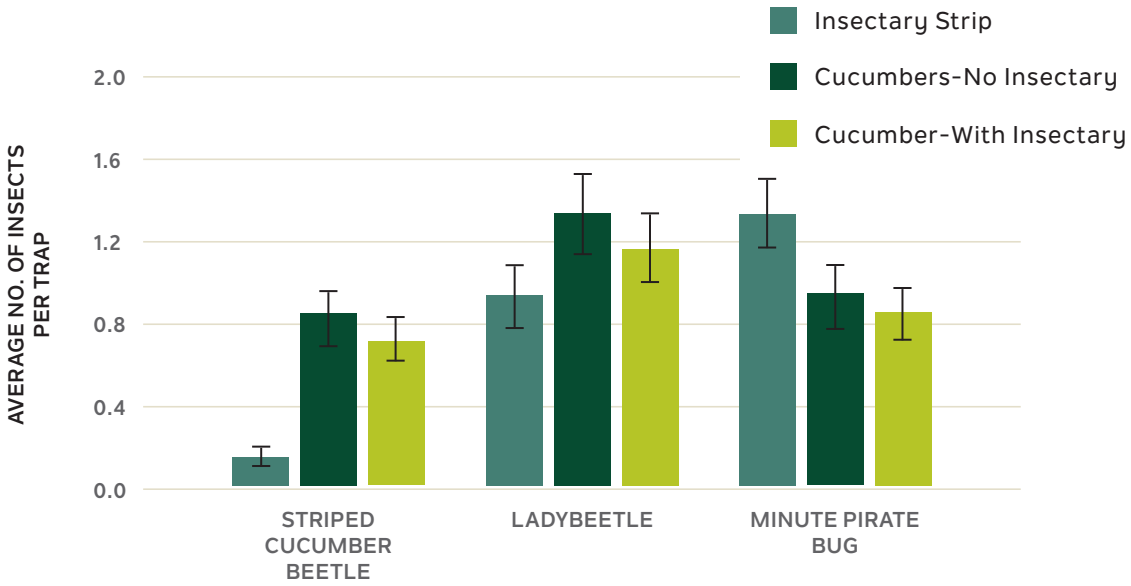


FIGURE 4

Mean number of ground beetles in cucumber beds with rolled and plastic mulch, insectary strips and grass perimeter, 2016

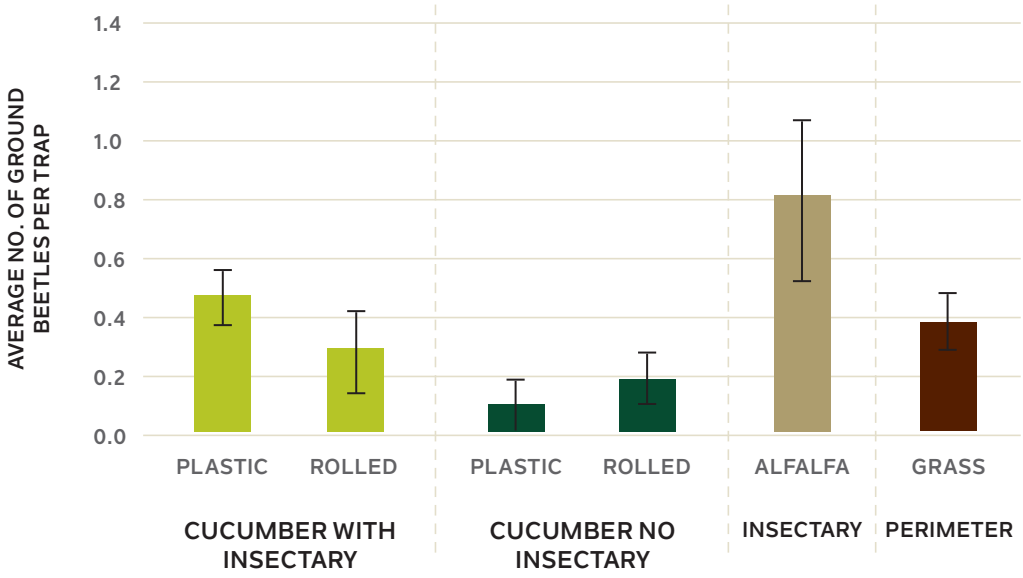
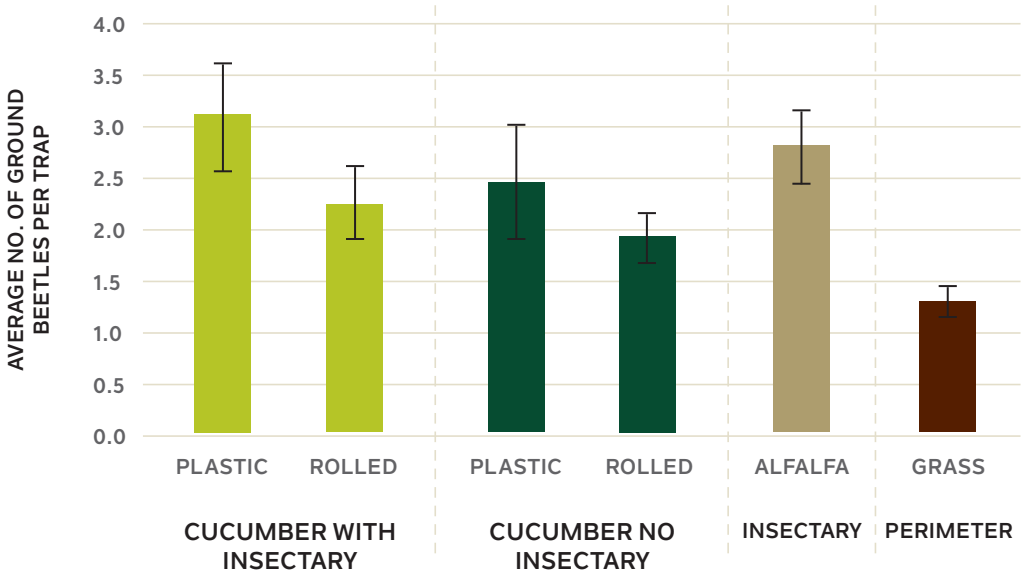


FIGURE 5

Mean number of ground beetles in cucumber beds with rolled and plastic mulch, insectary strips and grass perimeter, 2017



IMAGE

Cucumber on rolled crimped mulch.
Photo Credit: Gladis Zinati

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