Cover Crops as Insectary Plants to Enhance Above and Below Ground Beneficial Organisms

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Cover crops are plants grown between cycles or during the cycle of regular cash crop production to prevent soil erosion, improve soil structure, provide soil fertility, and help farmers to manage several pests including weeds, arthropods, nematodes, and various other pathogens. Careful selection of cover crops to meet your farming needs could depend on climate, season, nutrient requirement, location of the farm, crops planted, or your farming practices. The current

Fig. 1. Some beneficial arthropods and nematodes that can be enhanced by planting cover crops in agroecosystems.

Lady Beetle
Photo: K.-H.Wang

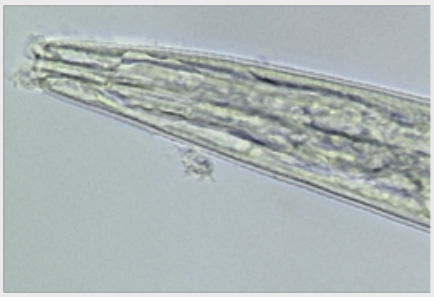
Lynx spider
Photo: C.R.R. Hooks

Isopods and millipedes
Photo: S. Marahatta

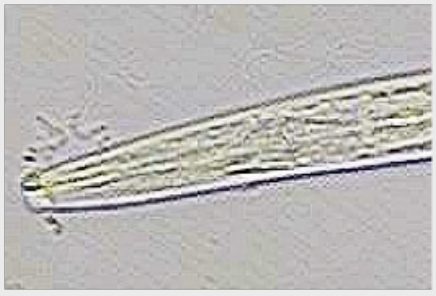
Honey bee collecting corn pollen.
Photo: K.-H.Wang

Leaf cutter bee visiting a sunn hemp flower. Photo: K.-H.Wang

Carpenter bee on kabocha squash flower. Photo: K.-H.Wang



Bacterivorous nematode
Photo: K.-H.Wang



Fungivorous nematode
Photo: K.-H.Wang

Omnivorous nematode
Photo: K.-H.Wang

article will focus on selecting cover crops to manage beneficial organisms including natural enemies, pollinators, and soil nutrient recyclers in agroecosystems in Hawaii. This article will focus on discussing cover crops that can serve as insectary plants, living mulch, green manure, or those that can convert into organic mulch. For a detail description on how to select cover crops for your farm please refer to "Managing Cover Crops Profitably" published by Sustainable Agriculture Network (Clark, 2007).

Table 1. Natural enemies of insect pests or beneficial arthropods and plants that attract them (insectary plants).

Beneficial arthropods	Insectary plants
Various parasitoids and predators	Fennel, dill, coriander (cilantro), parsley, carrot, wild carrot (Queen Anne's-lace), angelica, yarrow (milfoil), sow thistle, dandelion, zinnia, tansy, marigold, sunflowers
Predatory wasps, hoverflies	sweet alyssum, buckwheat, mustard, Cuban oregano, sage, salvia, lavender, oregano, thyme, marjoram, perilla.
Lady beetles	Dill, marigold, Mexican tea, morning glory, oleander, yarrow.
Lacewing	Carrot, oleander, red cosmos, wild lettuce, tansy
Minute pirate bug	Carrot, Mexican tea, oleander, sunn hemp, cowpea
Ground beetles	Low-growing plants: thyme, rosemary, mint or mulches
Spider	Marigold, yellow-sweet clover, white clover

Beneficial Organisms of Interest

Planting cover crops can increase several distinct groups of beneficial organisms. These include natural enemies of insect pests, pollinators and soil nutrient recyclers. Natural enemies of insect pests that are of interest to attract into agroecosystems include hoverflies, various insect parasites or parasitoids (e.g. Tachinid fly, Trichogramma, Braconid wasp, etc.), lady beetles, lacewings, spiders, assassin bugs, minute pirate bugs, and ground beetles. Careful timing of cover crop planting can help enhance population densities of pollinators to increase crop production. Besides these above ground organisms, many below ground organisms also play important roles in the sustainability of crop production. These include soil mesoarthropods and free-living nematodes. Soil mesoarthropods such as isopods, mites, and collembola are detritivores that feed on decomposing plant and animal parts as well as organic fecal matter. Their presence helps speed up the decomposition process of organic matter. When organic matter is decomposed by bacteria and fungi, soil nutrients can still be tied up in this microbial biomass. Free-living nematodes are microscopic round worms that graze on different microorganims in the soil. They can be bacteriavores, fungivores, omnivores or predators. By grazing on different groups of soil microorganisms, these nematodes help to further mineralize nutrients from these microorganisms, making the nutrients more available for plants to uptake. Therefore, soil mesoarthropods and free-living nematodes play important roles in soil nutrient cycling.

Insectary Plants

Insectary plants are plants that attract beneficial insects. They provide nectar and pollen for many beneficial insects. Nectar and pollen are critical for the survival, development and reproductive success of many natural enemy species such as hoverflies and parasitoids (Cowgill et al., 1993; Lavandero et al., 2005; Hogg et al., 2011), and can be a supplemental food source for spiders (Taylor and Pfannenstiel, 2008). Conventional farming practices that involve intensive tillage, monoculture, and extensive weed control, or even some innovative alternative farming practices such as high tunnel shade house crop production, hydroponic and aquaponic practices often lack the insectary plant resources beneficial to agroecosystems. Introducing insectary plants into these systems could be one approach to attract beneficial insect allies back into our farming system.

Some criteria on selecting insectary plants include: 1) attractiveness to beneficial insects; 2) an early and long blooming period; 3) low potential to host plant viruses; 4) ability to out-compete weeds; 5) low potential to become a weed; 6) low attractiveness to pest species; and 7) low cost of seed and establishment (Hogg, et al, 2011).

Families of plants commonly found to be attractive to various beneficial insects mentioned above include, but are not limited to, Apiacea (Umbelliferae), Asteracea (Compositae), Lamiaceae and Fabaceae.

Apiacea includes fennel (*Foeniculum vulgare*), dill (*Anethum graveolens*), cilantro or coriander (*Coriandrum sativum*), carrot (*Daucus carota* subsp. sativus), wild carrot or Queen Anne's-lace (*Daucus carota* subsp. Carota). These Apiacea are excellent insectary plants as they provide great numbers of tiny flowers required by parasitic wasps.

Asteracea known to be attractive to parasitoids include zinnia (*Zinnia peruviana*), creeping zinnia (*Sanvitalia speciosa*), marigold (*Tagetes* spp.), sunflower (*Helianthus annuus*), etc. These plants produce showy composite flowers that are favorable for many parasitoids as well as predatory insects.

Lamiaceae (mint family) include many herbs such as basil (*Ocimum basilicum*), mint (*Mentha* spp.), rosemary (*Rosmarinus officinalis*), sage (*Salvia officinalis*), marjoram (*Origanum marjorana*), oregano (*Origanum vulgare*), thyme (*Thymus* spp.), lavender (*Lavandulla spica*), and perilla (*Perilla frutescens*). These plants attract wasps, hoverflies and other beneficials. Planting these insectary plants may provide additional economic incentive for farmers to set aside land for harvestable herbs. In addition, low-growing Lamiaceae such as thyme, rosemary, or mint also provide shelter for ground beetles that are predators of insect pests or weed seeds.

Among Fabaceae, sunn hemp (*Crotalaria juncea*), cowpea (*Vigna unguiculata*), white clover (*Trifolium repens*), and yellow sweet clover (*Melilotus officinalis*) are most commonly used as cover crops in Hawaii. White clover and yellow sweet clover had been documented to increase the abundance of spiders when planted as living mulch, intercropping with broccoli (Hooks and Johnson, 2004). At the flowering stage, sunn hemp and cowpea increased numbers of beneficial insects such as the *Trichogramma* wasp and the minute pirate bug when planted as living mulch in corn fields (Manandhar, personal communication). In addition to serving as insectary

plants, this plant family is the most favorable cover crop group as it also fixes nitrogen, reducing the need for additional nitrogen inputs into the agroecosystem.

One factor to take into consideration when selecting insectary plants is the length of time for the plants to bloom. Buckwheat (*Fagopayum esculentum*) and mustard are early blooming plants, but their flowering period is short. On the other hand, wild arugula and tansy phacelia might take longer time to bloom, but their flowering period last for a long time (Hogg et al., 2011).

Table 1 summarizes natural enemies of insect pests that are attracted to but not limited to these insectary plants. More information may be obtained from Organic Garden Info.com, Hooks and Johnson (2004), and personal observation.

How to Integrate Insectary Plants or Cover Crops into an Agroecosystem

Ever since the green revolution in the 60s and 70s, farmers are accustomed to monoculture cropping systems. Integrating insectary plants during the cropping season will be an especially challenging practice for farmers to adopt. Understanding the benefits of enhancing various beneficial organisms can provide some incentive for farmers to incorporate cover cropping into their farmscapes. Many approaches to integrate cover cropping with cash crop production have already been practiced. These include planting cover crops as 1) border crop or barrier crop; 2) living mulch intercropping with cash crop; 3) undersown ground cover; 4) pre-plant rotation crop followed by conservation tillage, i.e. serve as surface mulch or organic mulch after mowing, crimping or natural die back of cover crop; 5) preplant cover crop followed by strip-tilling, and clipping for surface mulch; and 6) trap crop. Farmers can select cover cropping practices based on target pests, occurrence of beneficial organisms, and compatibility of the cover crop to their cash crop production practices.

Various research projects conducted in Hawaii on the use of cover crops to manage above and belowground organisms are summarized in pictures with brief descriptions below. For more details on these various studies, please refer to CTAHR Extension Publications or the journal articles cited below.

Research projects conducted in Hawaii on the use of cover crops to manage above and below ground organisms	
	**Cover crop as a living mulch intercropped with a cash crop** Buckwheat (*Fagopayum esculentum*) intercropped with zucchini reduced population densities of whiteflies and aphids, thus reducing silver leaf symptoms and aphid-transmitted viruses such as papaya ring spot virus on zucchini (Hooks et al., 1998).

Research projects conducted in Hawaii on the use of cover crops to manage above and below ground organisms	
	Yellow sweet clover (*Melilotus indicus*) intercropped with broccoli reduced imported cabbageworm and cabbage looper numbers on broccoli heads, but did not increase insect pest predation (Hooks and Johnson, 2001). In a follow up study, yellow sweet clover and white clover (*Trifolium repens*) intercropped with broccoli resulted in late season increase in the abundance of spiders and overall reduction of lepidopteran pests on broccoli foliage (Hooks and Johnson, 2004).
	Sunn hemp (*Crotalaria juncea*) attracts insect parasitic wasp, *Trichogramma*, indirectly by attracting the Lycaenidae butterfly to lay eggs on its flowers. The wasp is then drawn to sunn hemp flowers to parasitize the eggs of Lycaenidae. By intercropping sunn hemp with cash crops that have lepidopteran pests will indirectly increase natural enemies in this agroecosystem (Roshan Manandhar, personal communication).
	When sunn hemp or marigold (*Tagetes patula*) were intercropped with cucumber in a strip-till system as living mulch followed by clipping to provide organic mulch (Wang et al., 2011), abundance of spiders in the agroecosystem were higher in these cover crop plots than cucumber planted in the bare ground plots.

Research projects conducted in Hawaii on the use of cover crops to manage above and below ground organisms	
	Sunn hemp and marigold in the strip-till cover cropping system followed by clipping to provide organic mulch also significantly increased abundance of soil mesoarthropods such as oribatid and predatory mites, collebola, and isopods (Wang et al., 2011). In addition, this sunn hemp cover cropping practice also increased the abundance of bacterivorous, fungivorous, and omnivorous nematodes throughout the cropping cycle of cucumber (Wang et al., 2011).
	Intercropping sunn hemp with zucchini significantly reduced silver leaf symptoms as compared to zucchini plants planted in bare ground treatment.  *Zucchini plants planted in bare ground plots showing silver leaf symptoms.*

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