Farmscaping with Cover Crops or Insectary Plants for Pest Management

Koon-Hui Wang, Ph.D.
University of Hawaii
Alternatives to pesticides are in need

- Insecticide resistant pest populations are increasing.
  - Bt only kill 25-33% of Bt-resistant diamondback moth compare to 100% kill of the susceptible population (Tabashnik 1990).

- Some insect pests are cryptic
  - pickleworm

- Effective fruit flies management require area-wide collaboration (Vargas et al., 2008).

- For organic farmers, lack of effective OMRI certified insecticide for an effective pesticide rotation program.

(Tabashnik et al. 2008)
Farmscaping with

- Insectary plants
- Cover crops
Insectary Plants

Plants that attract insects, either by producing abundant flowers with pollen and nectar for beneficial insects, or by luring insect pests away from the cash crop.

Hoverflies on buckwheat and cilantro

Sunn hemp flowers attracts Lycaenidae butterflies that drawn Trichogramma wasps to lay eggs on the Lepidopteran eggs.

Uhaloa attracts wasps and bees

Lady beetles on Aweoweo
Functions of insectary plants

• **Provide nectar and pollen** for many beneficial insects which 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),

• **Ground cover** type insectary plants provide habitats for ground surface arthropods, which are **food for spiders** (Taylor and Pfannenstiel, 2008).

• Some plants produce **Extra-Floral Nectaries** (nectar glands not associated with flowers). Parasitic and predatory insects use extrafloral nectaries as food sources and mating sites during periods when few plants are in bloom (drought or early spring). Peonies, sweet potato, bachelor button and lima bean are examples of plants with extrafloral nectaries located on various parts of the plant.

Extra-floral Nectarines

- **Extra-Floral Nectarines** = nectar glands not associated with flowers.
- Good for attracting beneficial insects when most flowers are not in bloom.

Partridge pea
Parasitic /Parasitoid of Insect Pests

- Tachinid fly larvae are endoparasites (internal parasites) of caterpillars of butterflies and moths, larvae and adult of beetles, and etc.
- Trichogramma wasps: Female wasps inject their own eggs into the egg of > 200 spp. of insect pests (mostly moths or butterflies), and her larvae consume the embryo and other contents of the egg.

(J.K. Clark UC IPM Project)
Braconid Wasp

• The Braconid wasp is among the most important of the aphid parasites, as well as, the larvae of butterflies, Sawflies, moths and many beetles. If you see any hornworms or caterpillars with cocoons covering it, don't remove it from your garden, it has been parasitized. This wasp will attack various caterpillars or aphids. The adults feed on the nectar from the flowers of weeds and flowers of the daisy (Chrysanthemum) and carrot (Umbelliferae) families.
Lady beetle (Cycloneda sp.)

- The lady beetle, both the larvae and adult, eat aphids, scales, and mealybugs.

Plants that attract lady beetle:
- Marigolds
- Mexican Tea (Chenopodium ambrosioides)
- Morning Glory (Convolvulus minor)
- Oleander (Nerium oleander)
- Yarrow (Achillea spp.)
- Cilantro (Coriandrum sativum)

HainaAi V15: Not all lady beetles are created equal
Green Lacewing (Chrysopa sp.)

- The lacewings, both the adult and the larvae eat aphids, various larvae and the eggs of other insects.

Plants attract lacewing

- Carrot (Daucus sp.)
- Oleander (Nerium oleander)
- Red Cosmos
- Wild Lettuce (Lactuca sp.)

http://www.organicgardeninfo.com/beneficial-insectary-plants.html
Hover Fly

- Syrphid (Hover) fly larvae feed on soft-bodied insects, particularly aphids. Adults feed on pollen, nectar, or aphids’ honeydew.
Minute Pirate Bug (Orius sp.)

Adult, and nymph of minute pirate bug will eat aphids, spider mites, thrips, small caterpillars.

Macaranga plant

Thrips are always found associated with flowers of macaranga plant in Hawaii. Thrips help pollinate the flowers, but also serve as preys of minute pirate bugs. Thus, minute pirate bugs are commonly found on macaranga flowers, especially the male flowers.
Criteria of Ideal Insectary Plants

- Attractiveness to beneficial insects present in the agroecosystem
- Early and long blooming period
- Low potential to host crop viruses or attract pest species
- Low potential to become weeds
- Low seed cost and easy establishment
- Ability to trap or lure insect pests from cash crop, while attracting natural enemies of insect pests to feed on the target preys

(Hogg et al., 2011)
Farmscaping

- Farmscaping is designing and managing farm landscapes to achieve a specific purpose, such as creating habitat for beneficial arthropods that provide crop pollination or crop protection, rotating crops to break pest cycles or enhance on-farm diversity, or managing buffers to protect water quality or reduce soil erosion.
Farmscaping to Enhance Biodiversity

- Insectary plant corridors penetrate the vineyard, contiguous with the adjacent natural vegetation. The corridors serve beneficial insects both as a habitat and a “biological highway,” allowing them to move from their refugia in non-agricultural areas deep into the vineyard (Nicholls, Parrella, and Altieri, 2000).

- Monoculture production has lead to low biodiversity in agroecosystem.
- Low plant biodiversity often resulted in low diversity and abundance of natural enemies.
How to Integrate insectary plants into farms?

1. As border crop
   - Sunn hemp and corn
   - Buckwheat and zucchini
   - Sunn hemp no-till (surface mulch) & Cowpea & buckwheat as border crop in onion plot

2. As intercrop

3. Insectary plant corridors (Nicholls, Parrella, and Altieri, 2000)
1. Insectary Border For Hydroponic/Aquaponics Production

- Buckwheat attracts hoverflies
- Sunn hemp attracts Trichogramma wasps
- Wasp nesting block attracts keyhole wasps
WASPS NESTING BLOCK

Pollinators

Leaf cutter bee

Hylaeus bee

Predators

Key-hole Wasp
http://bugguide.net/node/view/241212

Untreated wood

Aphid-collecting Wasp
COMPARING INSECTARY SETTINGS AND METALLIC REPELLANT FOR HYDROPONIC BRASSICA

Insectary

Metalic board

Imported cabbage

Imported cabbage web worm larva

Aphids

Whiteflies
Beneficial Insects Found In Insectary Treatment

- Hoverfly larvae eating an aphid
- DBM pupae parasitized by parasitoid wasp
- Parasitized aphids
- Hoverfly eggs among aphids

Insectary setting suppressed aphids and caterpillar damage.
Insectary Settings Reduced Unmarketable Pak Choi, but did not protect it against Thrips and Whiteflies
How to Integrate insectary plants into farms?

1. As border crop

2. As intercrop

   a. Low living mulch

   b. Tall living mulch

3. Insectary corridor

4. Surface organic mulch

Buckwheat and zucchini
Virus Sink Hypothesis
Sunn hemp serves as trap crop for whiteflies, thus reducing silverleaf symptomatic zucchini.
Effect of Sunn Hemp Living Mulch on Silver leaf and Viral Symptomatic Plants on Zucchini

Silver Leaf Symptomatic Plants

Mean silver leaf infestation rate

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<th>21 DAP</th>
<th>28 DAP</th>
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<td>Sunnhemp</td>
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Plants showing viral symptom

% of plants with virus symptoms

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<tr>
<td>Sunnhemp</td>
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<td>80</td>
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How to Integrate insectary plants Into farms?

1. As border crop

2. As inter-crop
   a. Low living mulch
   b. Tall living mulch

3. Insectary corridor

4. Surface organic mulch

Buckwheat and zucchini
**Intercrop as Living Mulch**

Sunn hemp

- Lycaenidae butterfly is a common pest of sunn hemp. It lays eggs on sunn hemp flower. However, this attracts Trichogramma wasp to come and parasitize Lycaenidae eggs.
- Thus, sunn hemp act indirectly as an insectary plants for this parasitic wasp, *Trichogramma*.

Eggs of Lycaenidae being parasitized by Trichogramma inside sunn hemp flower

Lycaenidae butterfly on sunn hemp

Trichogramma wasps lay eggs on a corn earworm egg.

(Roshan Manandhar)
3. Intercropping SH with Corn

Better timing on flowering

• If sunn hemp is intercropping with corn so that sunn hemp blooms during the time when corn are establishing, % parasitism of corn ear worms by *Trichogramma* is significantly increased compared to corn planted in the bare ground (Manandhar, personal communication).
How to Integrate insectary plants Into farms?

1. As border crop

2. As inter-crop

   a. Low living mulch

   b. Tall living mulch

3. Insectary corridor

4. Surface organic mulch

Buckwheat and zucchini
4. Insectary border & Surface Organic Mulch

Hover flies on buckwheat flower

Cowpea and buckwheat serve as insectary borders
Sunn hemp terminated by flail mowing serve as surface organic mulch
Insectary border & Surface Organic Mulch

Reduced insect pests and purple blotch caused by water splashing of *Alternaria porri*.

\[
\text{Contrast Analysis} \quad P \\
\text{SH vs NoSH} \quad 0.01 \\
\text{Till vs No-Till} \quad 0.01
\]

\[
\text{Contrast Analysis} \quad P \\
\text{SH vs NoSH} \quad 0.05 \\
\text{Till vs No-Till} \quad 0.05
\]

\[
\text{Contrast Analysis} \quad P \\
\text{SH vs NoSH} \quad \text{NS} \\
\text{Till vs No-Till} \quad 0.05
\]

% Damage = % leaves with damage symptom

- BG = bare ground/till/insecticides spray
- SH = sunn hemp cover cropping/no-till/insectary borders
- Sol = till/solarization
- SHSol = sunn hemp cover cropping/till/solarization (with insectary borders)
Insectary border & Surface Organic Mulch

Increase beneficial arthropods that are natural enemies of pests and helping in nutrient cycling.

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Insectary border & Solarization Mulch
Reduced weed seed bank and avoid weed seeds flying in to the green onion plot.
Insectary border & Surface Organic Mulch

Hover flies on buckwheat flower

Cowpea and buckwheat serve as insectary borders

SH (No-till)

SHSol

Solarization reduce weed seed bank. Insectary border reduce weed seeds encroaching from outside the plot.
Insectary border & Surface Organic Mulch

Solarization reduced plant-parasitic nematodes initially, but not at harvest.

PPN = Total plant-parasitic nematodes
BG = bare ground/till/insecticides spray;
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Insectary border & Surface Organic Mulch

Sunn hemp (till or no-till) enriched soil nutrient cycling as indicated by nematode community indices (EI=enrichment index) throughout 2013 onion crop, solarization reduced EI in 2014.

<table>
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<th>EI (%)</th>
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<tr>
<td>SH vs No SH</td>
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<tr>
<td>Till vs No-Till</td>
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<td>EI 2013</td>
<td>At harvest</td>
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<tr>
<td>SH vs No SH</td>
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<tr>
<td>EI 2014</td>
<td>Entire crop</td>
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<tr>
<td>Sol vs No Sol</td>
<td>0.05</td>
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Insectary border & Surface Organic Mulch

Nutrient enrichment and arthropod pest suppression from sunn hemp (till or no-till) with insectary borders improved onion yield.
Other benefits of insectary plants?

Pollinators visiting sunn hemp flowers:
- Carpenter bee
- Sweat bee
- Leaf cutter bee
- Leaf cutter + Sweat bee
- Green bee
- Leaf cutter + honey bee
Farmscaping with

• Insectary plants

✓ • Cover crops against plant-parasitic nematodes
Cover Crops with Allelopathic Compounds against Plant-parasitic Nematodes

Sunn hemp
*Crotalaria juncea*
-- monocrotarine

*Brassica juncea* -- glucosinolate

Brown mustard

*T. erecta* and *T. polynema* are resistant to root-knot but very susceptible to reniform nematodes.

French Marigold
*Tagetes patula*
-- α-terthinyl

Sorghum-sudangrass

--- Dhurrin
Biofumigation

‘Caliente 199’ Brown mustard
(\textit{Brassica juncea})

Good for soil health

Tissue maceration allow for myrosinase to hydrolyze glucosinolate and generate isothiocynate gas = Biofumigation

‘Sod Buster’ Oil radish
(\textit{Raphanus sativus})
Mechanisms of Brassicaceae cover crops against plant-parasitic nematodes

• Biofumigation
• Trap cropping
• Soil health improvement
Terminate cover crop here to trap nematodes

Heat units to reach egg-laying female = 274.5 DD (3.5 wks)
Trap Cropping

Root-knot nematode (*Meloidogyne* spp.)

Important to terminate trap crop prior to nematode reaching egg-laying female stage (4-5 weeks after planting mustard or oil radish).
Biofumigation

Cover cropping for 4-5 weeks

Tissue maceration

Soil incorporation

Solarization

Tarping
Web resources

Videos

• Part I: https://www.youtube.com/watch?v=BsN_3IC35wg&feature=youtu.be

• Part II: https://www.youtube.com/watch?v=1stOru5l-a0&feature=youtu.be
Straw Bale Gardening!