



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

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Lady beetle



Braconid wasp



Trichogramma wasps



Green lacewing



Hover fly



Tachinid fly



Assassin bug



Minute pirate bug



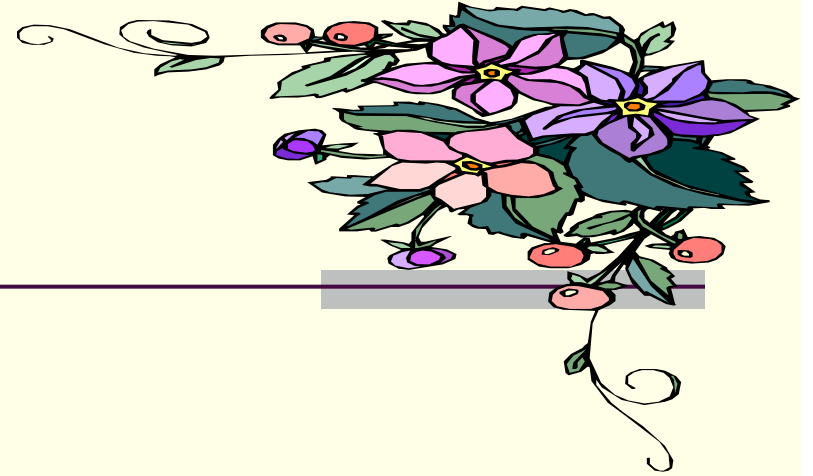
Practices that are not Supporting the Establishment of Natural Enemies of Arthropod Pests

- Broad spectrum insecticides.
- Even some organic insecticides (Johnson 2004)
 - Spinosad on parasitoids
 - Neem products on predatory insects
- Isolating crop production from flowering weeds/plants
 - Weed mat
 - High tunnel screen house



High tunnel screen house

Outline



- What is insectary plant?
- Examples of insectary plants and their function.
- How to use insectary plants for vegetable crops.
- Enhancement of other beneficials by cover cropping

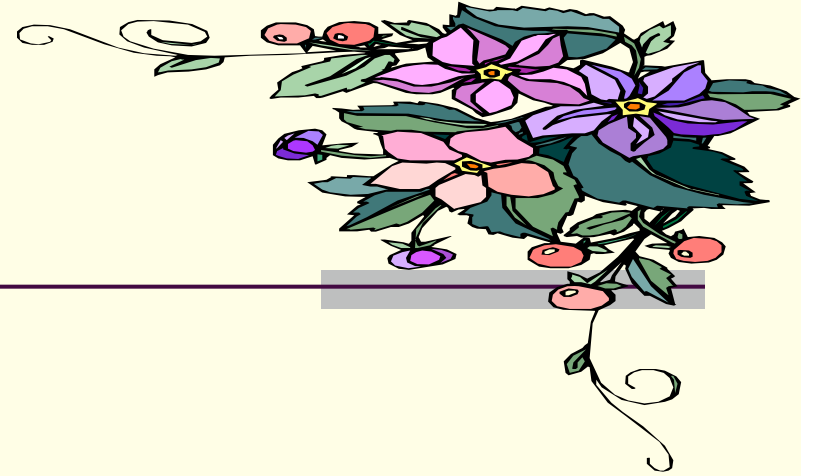
Insectary Plants



- Insectary plants are plants that attract insects.
- Beneficial insectary plants are intentionally introduced into an ecosystem to:
 1. increase pollen and nectar resources required by the natural enemies of insect pests such as hoverflies and parasitoids (Cowgill et al., 1993; Lavandero et al., 2005; Hogg et al., 2011).
 2. attract pollinators.
 3. supply food source for spiders (Taylor and Pfannenstiel, 2008).
 4. act as trap crops for insect pests.



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Insectary Plants for Parasitic Insects or Parasitoids

Apiacea (Umbelliferae)

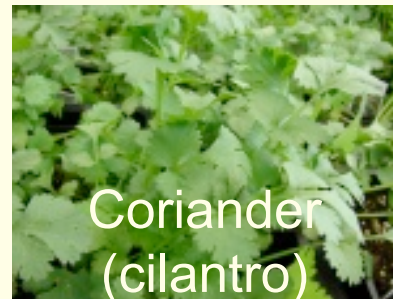
- Excellent insectary plants as they provide great numbers of tiny flowers required by parasitic wasps.
- Examples are fennel, angelica, coriander, dill, and wild carrot.



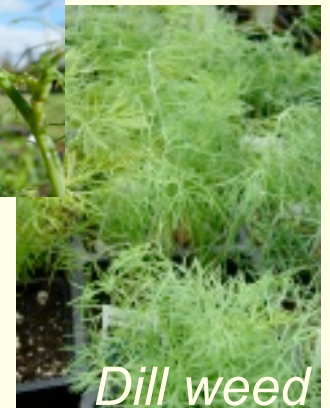
Fennel
*Foeniculum
vulgare*



angelica



Coriander
(cilantro)
*Coriandrum
sativum*



Dill weed
*Anethum
graveolens*



Wild carrot
(Queen Anne's-lace)
Daucus carota subsp. *Carota*

(Picture: Forest & Kim Starr)

Insectary Plants for Parasitic Insects or Parasitoids

Asteracea (Composites)

- Produce showy composite flowers that are favorable for many predators and parasitoids.
- Examples: chrysanthemum, dandelion^w, lettuce, marigold, sow thistle^w, sunflower, yarrow^w, zinnia.



yarrow, milfoil
Achillea millefolium



Sow thistle
Sonchus oleraceus



Creeping zinnia
Sanvitalia speciosa



Zinnia, pua pihi
Zinnia peruviana



Taraxacum officinale
Common dandelion, laulele

(Picture: Forest & Kim Starr)

Insectary Plants for Parasitic Insects or Parasitoids

Mint family (Lamiaceae)

- Include many herbs eg. basil, rosemary, sage, salvia, savory, marjoram, thyme, lavender, and perilla.
- Attract predatory wasps, hoverflies, and robber flies.



Cuban oregano
Plectranthus amboinicus



Salvia splendens
Scarlet sage



Lavandula sp.
Lavender

(Picture: Forest & Kim Starr)

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^w (*Chenopodium ambrosioides*)
- Morning Glory (*Convolvulus minor*)
- Oleander (*Nerium oleander*)
- Yarrow (*Achillea* spp.)



Mexican Tea^w
(*Chenopodium ambrosioides*)

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.*)



Plants that attract Assassin bugs, Bigeye Bug and Minute Pirate Bugs

- Carrot (*Daucus carota*)
- Mexican Tea (*Chenopodium ambrosioides*)
- Oleander (*Nerium oleander*)
- Sunn hemp (*Crotalaria juncea*)
- Cowpea (*Vigna unguiculata*)



Assassin bug



<http://www.organicgardeninfo.com/beneficial-insectary-plants.html>

Plants that Attract Ground Beetles

- Low-growing plants, such as thyme, rosemary, mint provide shelter for ground beetles.
- Practicing no-tillage or retaining some weed borders around the main cash crop can also provide favorable niche for ground beetles.

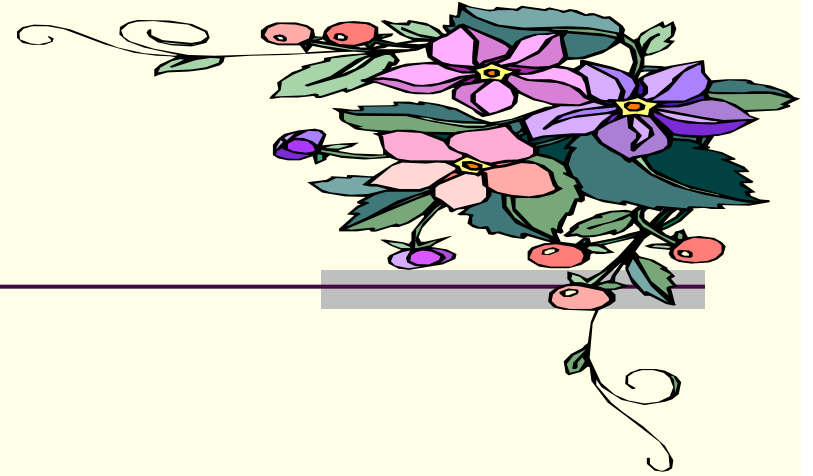


Some ground beetles feed on both weed seeds as well as insect pests.

Criteria of Ideal Insectary Plants

- Select plants for their attractiveness to beneficial insects
- Choose plants with an early and long bloom period
- Select plants with low potential to host crop viruses or attract pest species
- Choose plants with low potential to become weeds
- Consider low seed cost and easy establishment

Outline



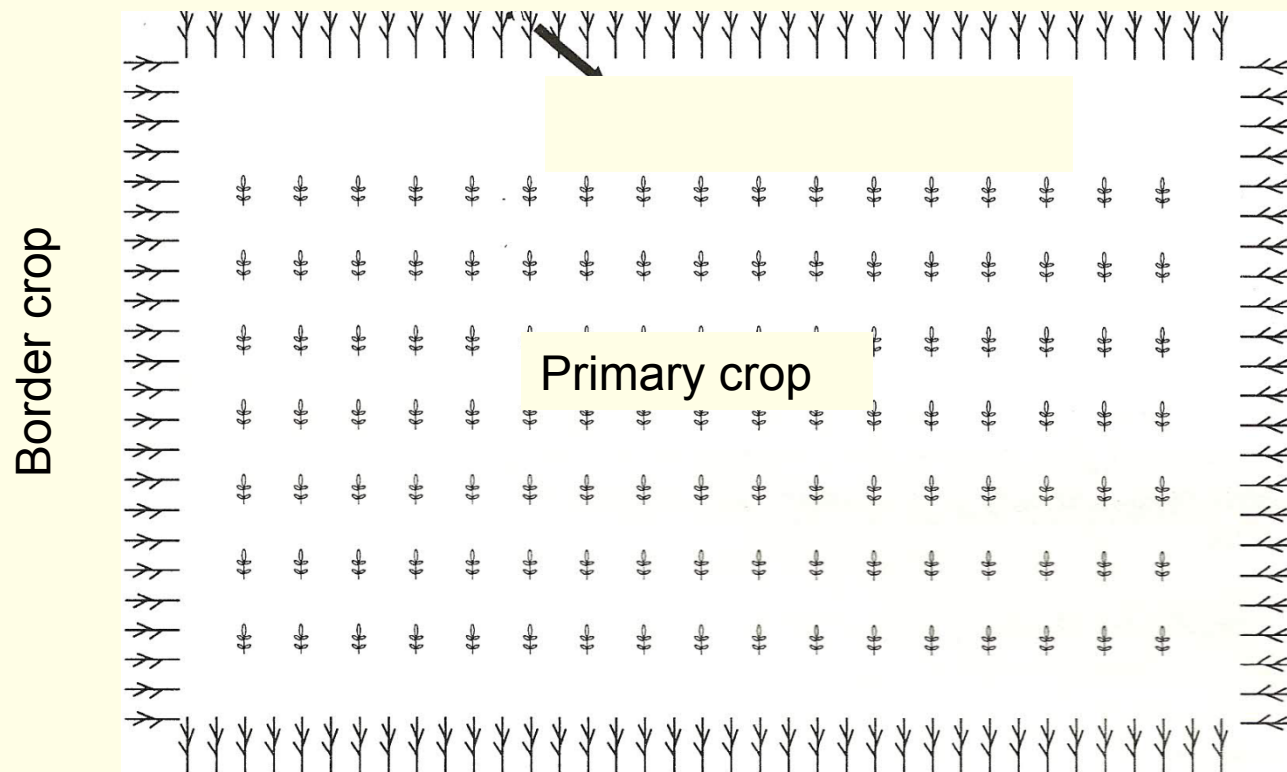
- What is insectary plant?
- Examples of insectary plants and their function.
- ✓ ■ How to use insectary plants for vegetable crops.
- Enhancement of other beneficials by cover cropping

How to use insectary plants?

- Border crop
- Intercropping as living mulch
- Undersown as ground cover
- Pre-plant rotation crop followed by conservation tillage i.e. serve as surface mulch/ organic mulch
- Integrated approach: Strip-till cover cropping followed by clipping for surface mulch
- Trap crop

Border Crop

- Insectary plants can be grown alongside of the desired cropping area.
- The insects attracted to the insectary plants will also help the other nearby crops or garden plants.



Intercrop as Living Mulch

Buckwheat

(Fagopyrum esculentum)

Intercropping buckwheat with zucchini:

- Reduced the density of whitefly, thus reduced silverleaf symptom on zucchini.
- Reduced aphids thus reduced aphid-transmitted virus such as PRSV on zucchini.

(Hooks et al., 1998)



C.R.R. Hooks

Intercrop as Living Mulch

Yellow Sweet Clover (Melilotus indicus)

- Intercropping YSC with broccoli
 - Reduced plant growth of broccoli, but broccoli head yield were not reduced.
 - Reduced imported cabbageworm and cabbage looper numbers on broccoli head.
 - Did not increase insect pest predation.

(Hooks and Johnson, 2001)



Biennial, flower in the 2nd yr

Did not flower during cropping,
no insectary function



C.R.R. Hooks

Pit Fall and Limitation of living mulch

Use of insectary plants do not always work. It depends on:

- Time of flowering
- Competitive with cash crop: planting densities, distance, needs of trimming. Can overcome by strip-kill with herbicide (Hooks et al, 1998);
- Beneficial insects present: generalist vs specialist (generalist could feed on non-target insects in the cover crop zone, thus not protecting cash crop).

Intercrop as Living Mulch

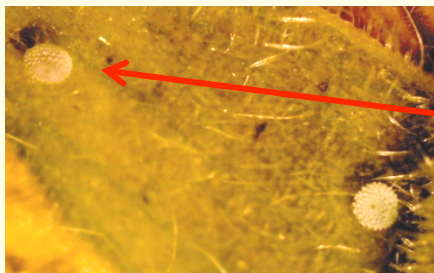
Sunn hemp

- 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.



Wang, K.-H

Lycaenidae butterfly
on sunn hemp



(Roshan Manandhar)

Eggs of
Lycaenidae being
parasitized by
Trichogramma
inside sunn hemp
flower



(J.K. Clark UC IPM Project)

Trichogramma
wasps lay eggs
on a corn
earworm egg.

Intercrop as Living Mulch

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 increased compared to corn planted in the bare ground (Manandhar, personal communication).



(Roshan Manandhar)

Sunn hemp
intercropping
with corn

Intercrop as Living Mulch

*Cowpea (*Vigna unguiculata*)*

- Similar to results from sunn hemp trial, intercropping of cowpea with corn significantly increase *Trichogramma* and *Orius* (minute pirate bugs).



(Roshan Manandhar)

Cowpea intercropping with corn

How to use insectary plants?

- Border crop
- Intercropping as living mulch/Undersown as ground cover
- ✓ ■ Pre-plant rotation crop followed by conservation tillage i.e. serve as surface mulch/ organic mulch
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Organic mulch/ Surface mulch

- Riechert and Bishop (1990) used grass hay mulch to increase spider densities in two brassica species.
- Manure and straw applied on the soil surface between cabbage plants increased the abundance of carabid beetles which prey on eggs of root flies (Humphreys and Mowat, 1994).



Organic mulch/ Surface mulch

Eggplant planted in Bare Ground



Eggplant planted in Crimson clover
(*Trifolium incarnatum*)



Perillus sp.



Podisus maculiventris



Coleomegilla maculata



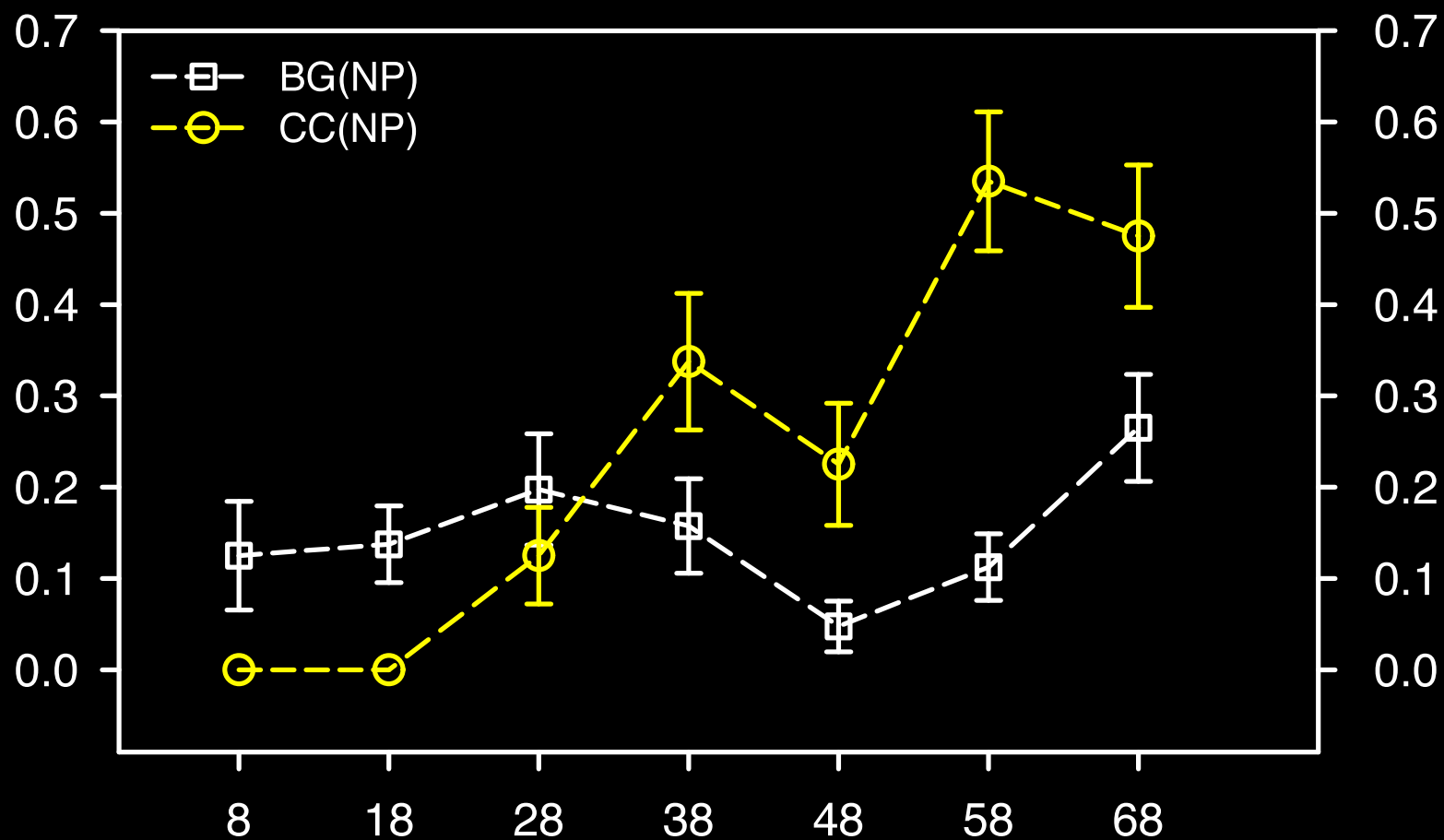
Peggy Greb

Lebia grandis



Peggy Greb

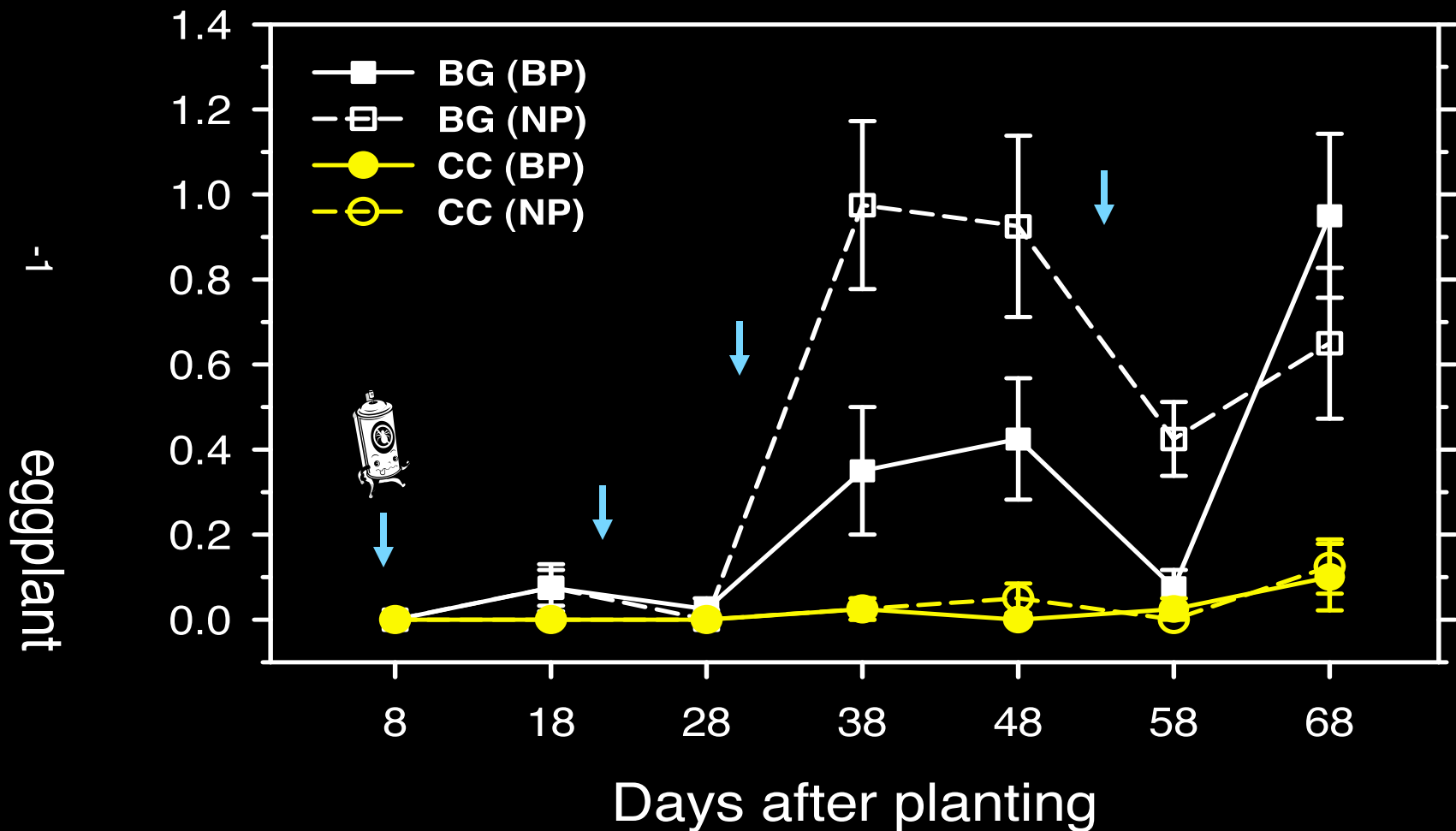
Effect of crimson clover cover crops on some generalist predators



Days after planting

Hooks & Hinds

Effect of crimson clover cover crops on Colorado Potato Beetles



How to use insectary plants?

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- Intercropping as living mulch/Undersown as ground cover
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Strip-Till Cover Cropping (STCC)

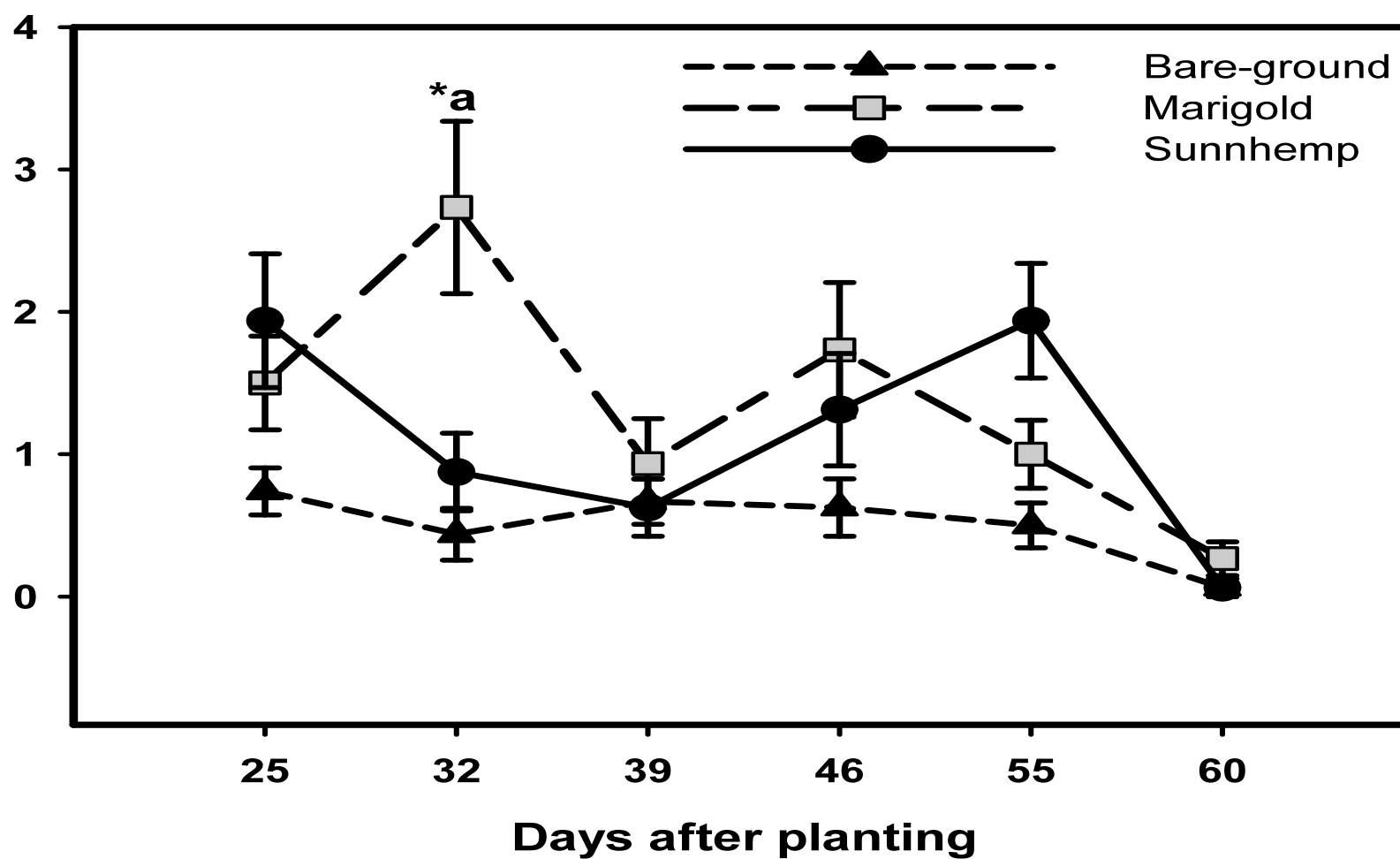
Sunn hemp



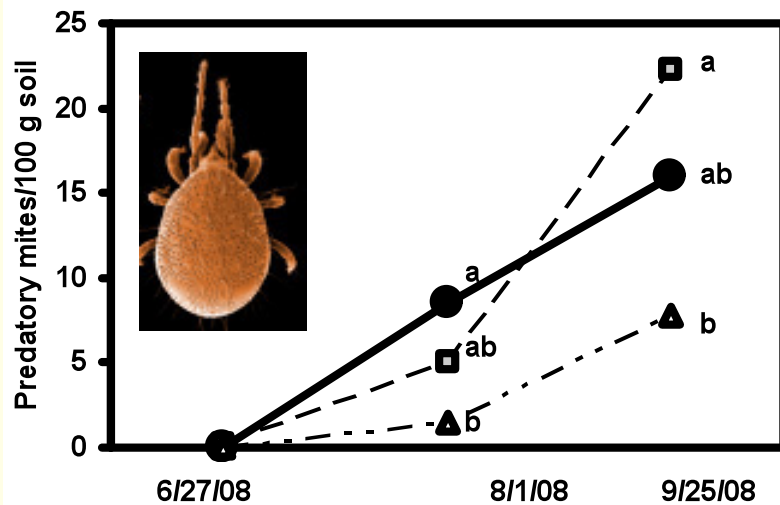
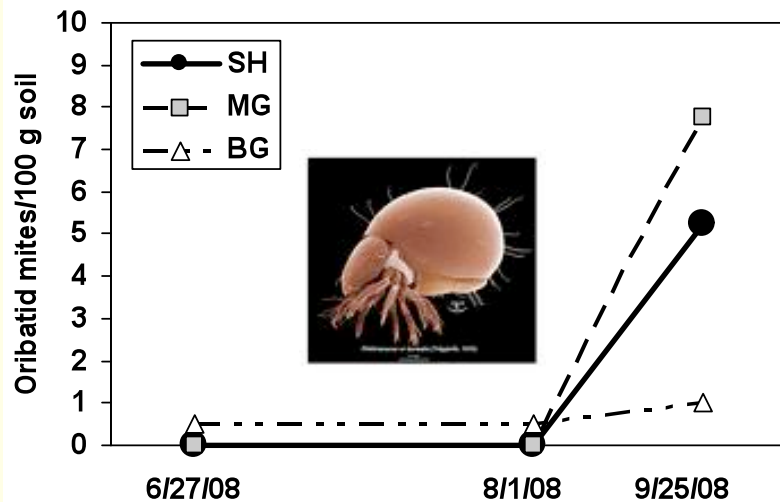
- Advantage:
 - STCC reduced tillage.
 - Periodical clipping of the living mulch as surface mulch provide additional inputs of organic matter over time.

(Wang, Hooks, et al., 2011)

Effect of sunn hemp and marigold as living mulch on spider



Below Ground Beneficial Insects Involved in Soil Nutrient Cycling



(Wang, Hooks, et al., 2011)

Beneficial Arthropods on Soil surface



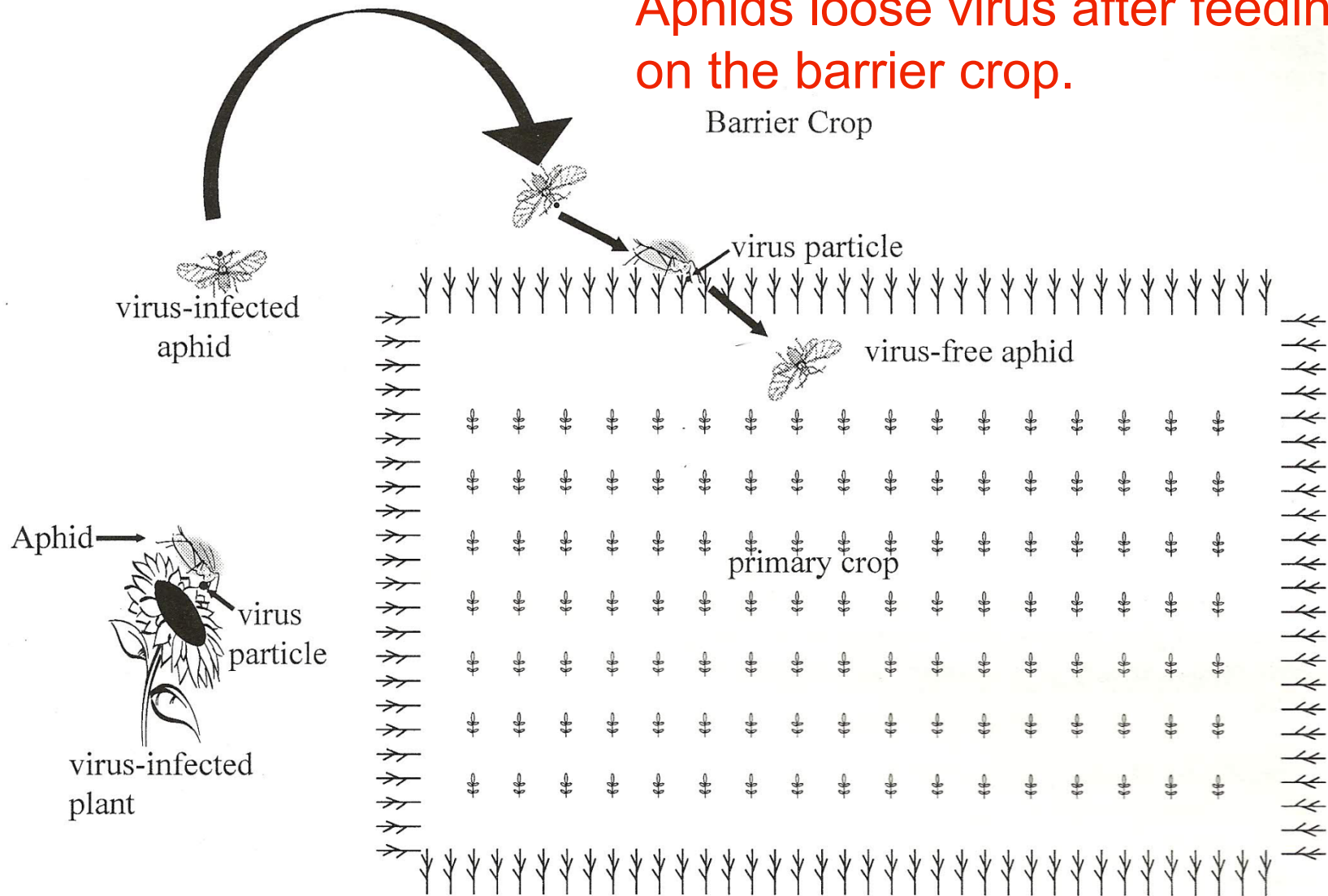
SH maintains soil nutrient cycling conditions.

How to use insectary plants?

- Barrier crop
- Intercropping as living mulch/Undersown as ground cover
- Pre-plant rotation crop followed by conservation tillage i.e. serve as surface mulch/ organic mulch
- Integrated approach: Strip-till cover cropping followed by clipping for surface mulch
- ✓ ■ Trap crop

Virus Sink Hypothesis

Aphids loose virus after feeding on the barrier crop.



(Hooks, 2007)

*Sunn hemp serves as trap crop for whiteflies,
thus reducing silverleaf symptomatic zucchini*



Zucchini intercropped with sunn hemp.

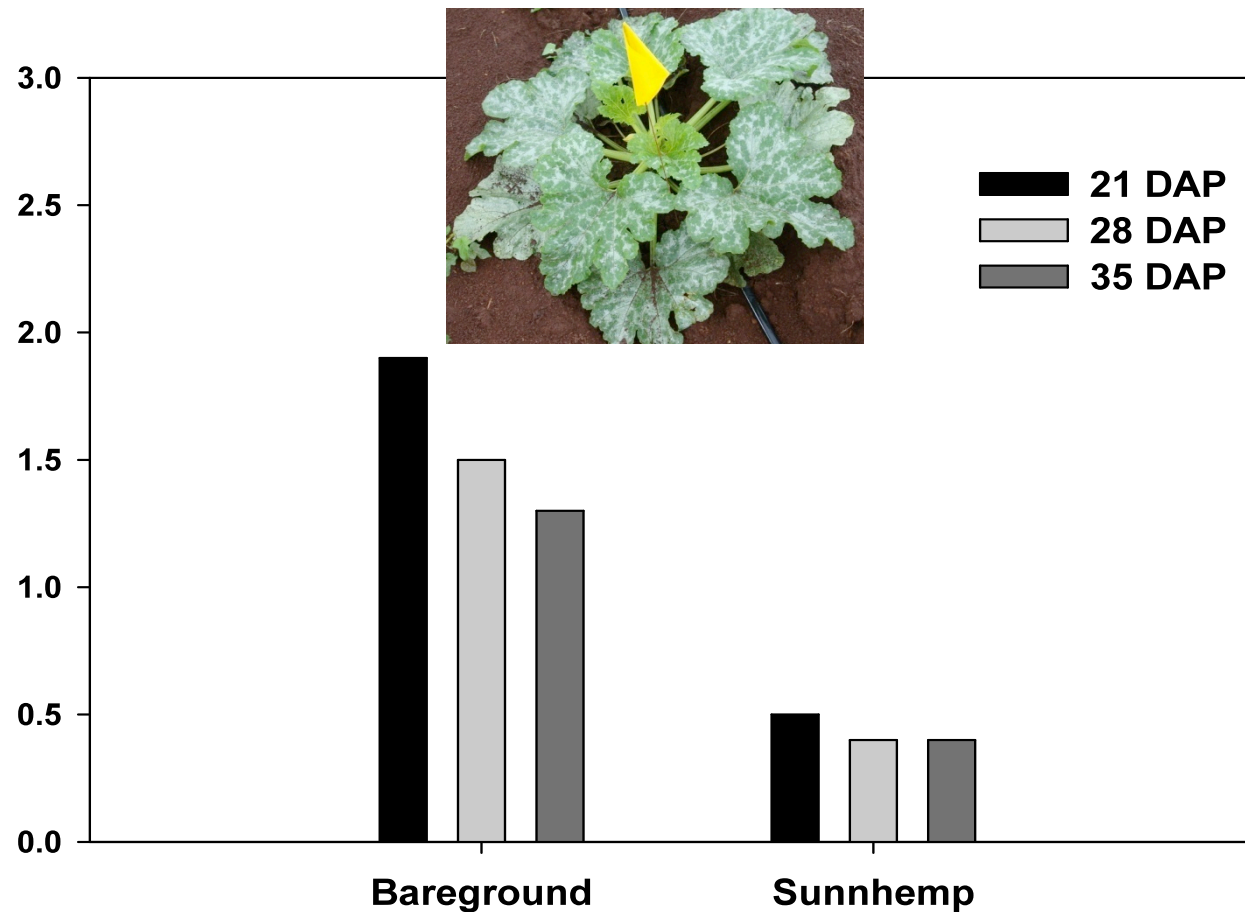


Zucchini in bare ground

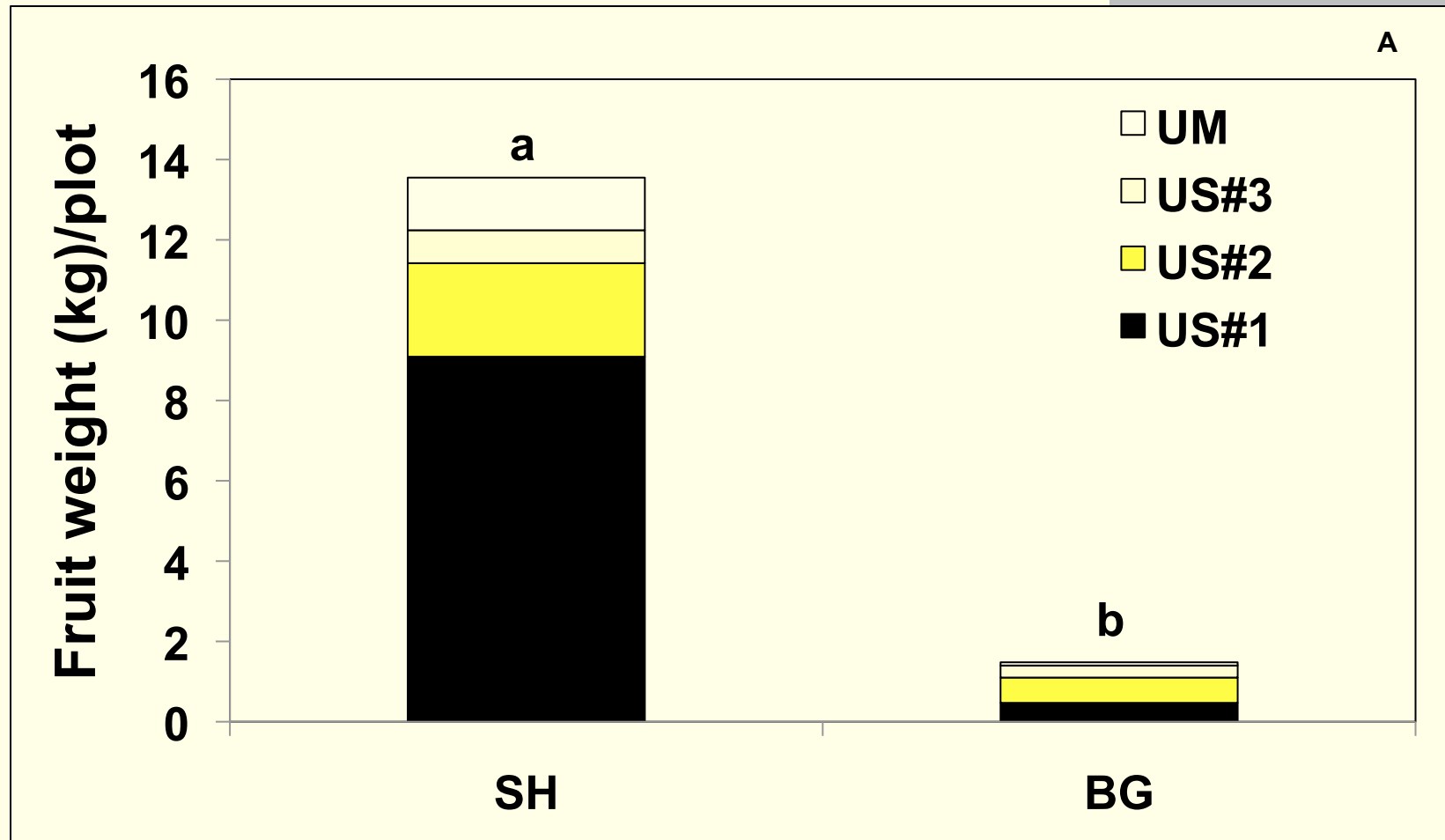
Silverleaf symptoms



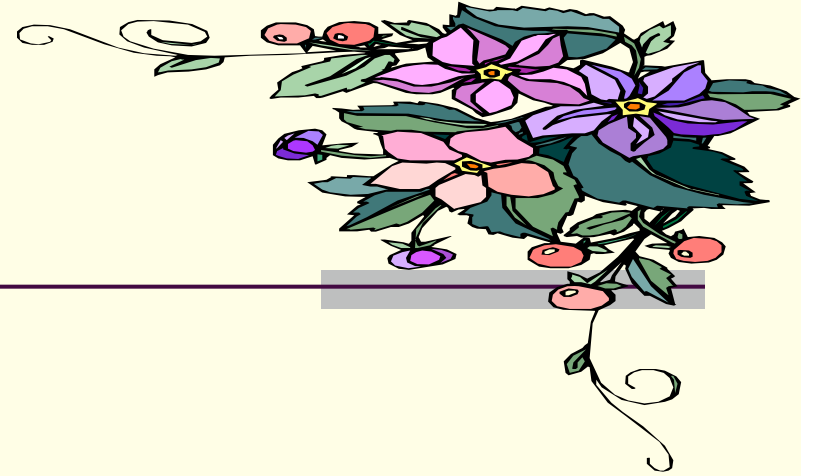
Effect of Sunn Hemp Living Mulch on Silver leaf Symptom on Zucchini plant



Effect of Sunn Hemp Living Mulch on Zucchini yield



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Border weeds or cover crops serve as food source for pollinators before the cash crop is producing flowers



a



b

a Honey bee visiting *Crotalaria spectabilis* (weed).

b Honey bee visiting flower head of *Amaranth* sp. (pigweed).



c

c. Sunn hemp flowers are frequently visited by leaf cutter bees and carpenter bees.

Free-living Nematodes play important roles in Soil Nutrient Cycling



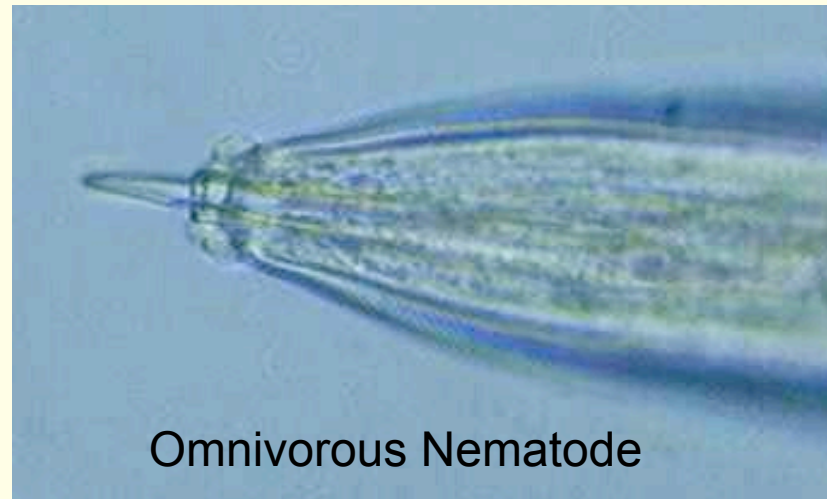
Bacteria Feeding Nematode



Fungal Feeding Nematode

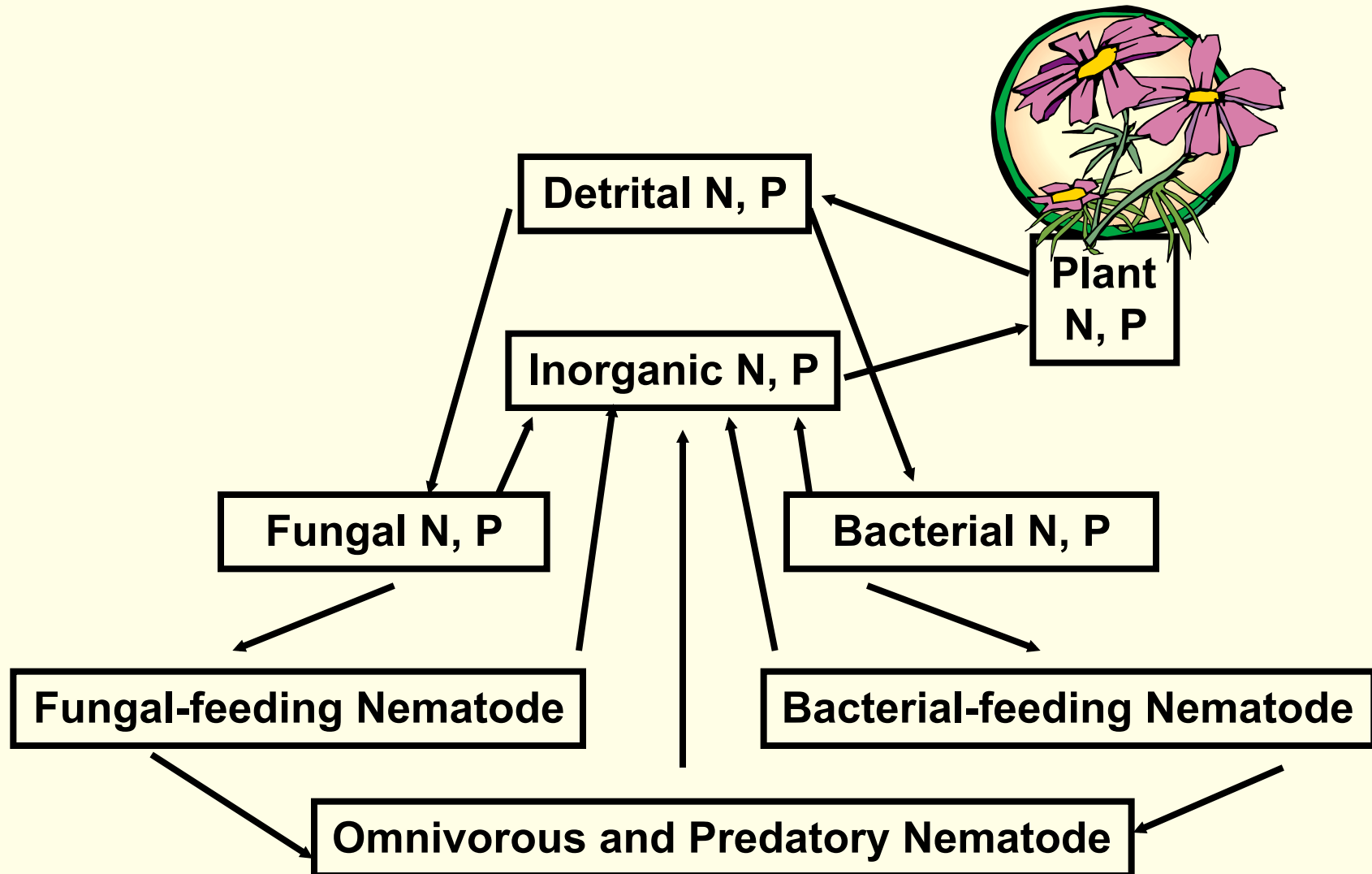


Plant-parasitic Nematode



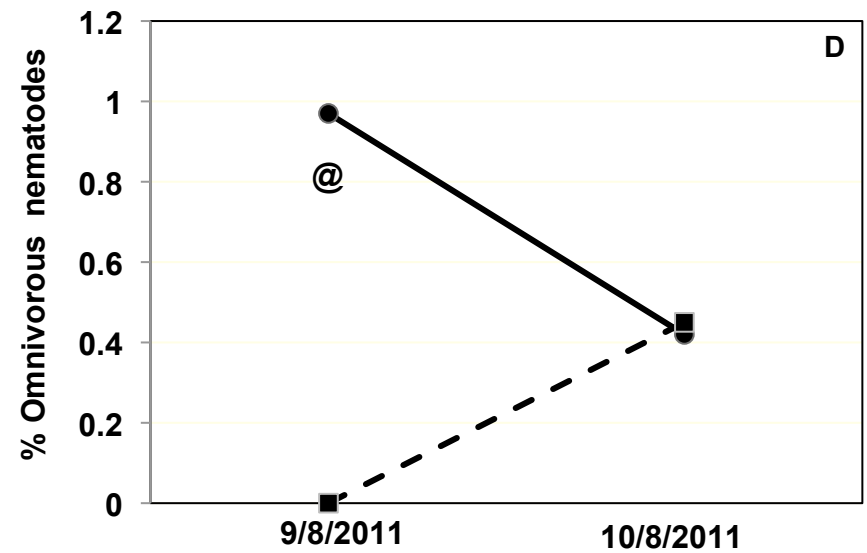
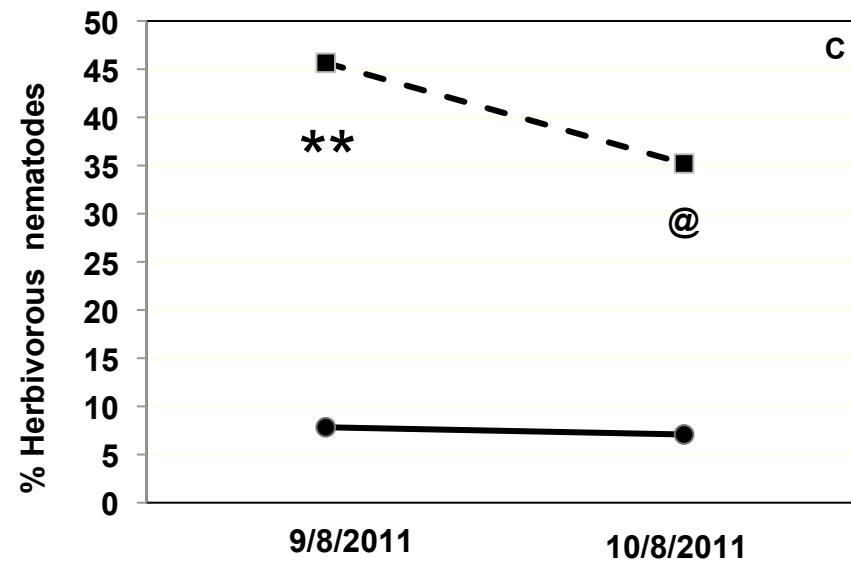
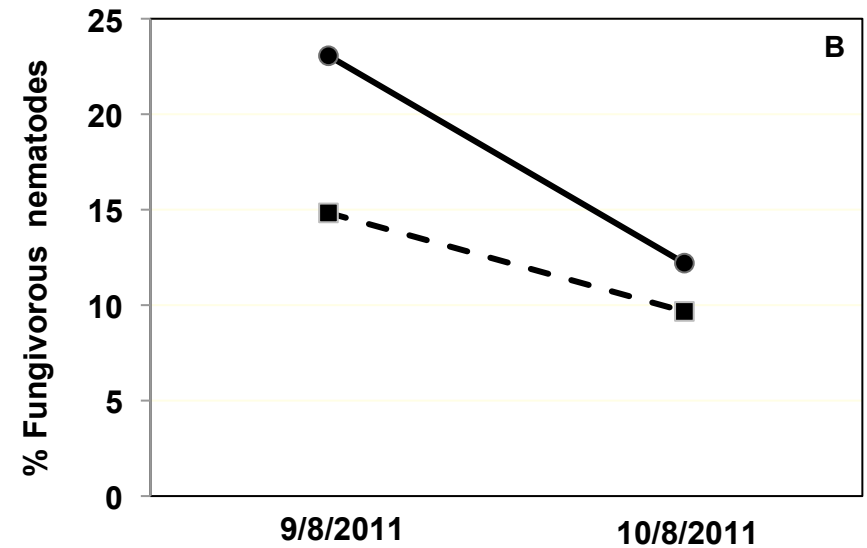
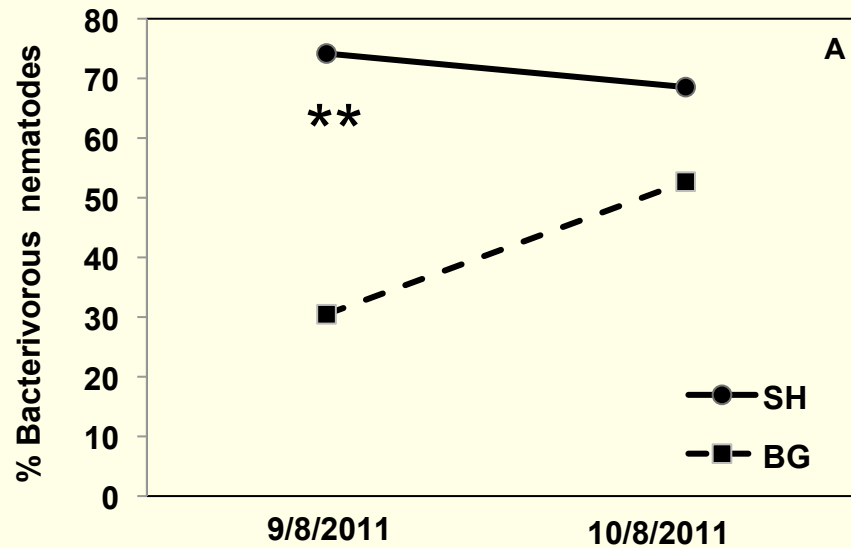
Omnivorous Nematode

Roles of Nematodes in Soil Nutrient Cycling



(modified from Ingham *et al.*, 1985)

Effect of Sunn Hemp Living Mulch on Nematodes



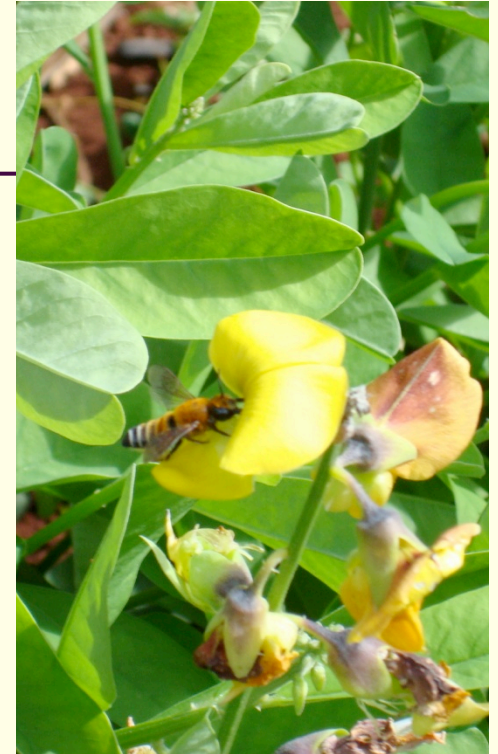
Summary

Cover Crops used in Hawaii for Insectary Purposes

- Yellow mustard (*Brassica juncea*)
- Buckwheat (*Fagopyrum esculentum*)
- White Clover (*Trifolium repens*)
- Yellow Sweet Clover (*Melilotus alba*)
- Sunn hemp (*Crotalaria juncea*)
- Cowpea (*Vigna unguiculata*)

Summary

- Insectary plants provide pollen and nectar sources for many beneficial insects.
- Insectary plants can be weeds in the border of your field or can be planted intentionally through intercropping, or they can be killed and serve as surface mulch to provide favorable niches for beneficial soil arthropods.
- Careful planning on cover crop planting date to synchronize flowering with insect pests infestation, could save cost on pesticide use.
- Cover crop also enhances many below ground beneficials, thus could save cost on fertilizer use.



Farmscaping



(Nicholls, Parrella, and Altieri, 2000)



(Wang)



Acknowledgement

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- Roshan Manandhar (CTAHR PEPS Grad Student)